Great Salt Lake
Wetland Condition Assessment

By Diane Menuz, Ryhan Sempler, and Jennifer Jones

Utah Geological Survey
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Executive Summary

Great Salt Lake wetlands are internationally recognized for their importance to migratory waterfowl and locally valued for the recreational opportunities and ecological services they provide. These wetlands have been subject to extensive anthropogenic manipulation for over 100 years, including groundwater pumping, water diversions, impoundment, and water quality contamination from urban run-off and sewage treatment plants. In 2013, the Utah Geological Survey (UGS), with a grant from the Environmental Protection Agency (EPA), began an assessment of the condition and presence of stressors in Great Salt Lake wetlands. We assessed wetlands in the area of Great Salt Lake's floodplain that contains mapped wetland data, which includes most of the northern, eastern, and southern lake shores.

There are three major components to this project, each corresponding to the EPA's "three-tier framework" for wetland assessment. We conducted rapid wetland condition assessments at sites to obtain information on the condition of emergent wetlands in the study area and to test three rapid assessment protocols to inform on-going development of a state protocol (EPA Level II assessment). We obtained detailed information on the distribution and abundance of plant species found at survey plots (EPA Level III assessment). Lastly, we conducted a preliminary landscape-scale analysis to determine the types of stressors present and the degree to which they affect wetland condition (EPA Level I assessment). To evaluate the degree to which the assessments at different levels capture similar information, we constructed models and examined correlations between metrics in each of the three levels.

We conducted rapid assessment and plant community surveys at a total of 44 sites around Great Salt Lake. Thirty-three sites were from a sample frame of spatially balanced, randomly selected survey points, and 11 additional sites were added from outside the sample frame to broaden the diversity of site conditions sampled. Surveys were conducted in four HUC8 watersheds, including Curlew Valley (n=3 sites), Jordan (n=8), Lower Weber (n=16), and Lower Bear-Malad (n=17) and were almost evenly divided between impounded and unimpounded sites.

Based on metrics recorded for the rapid condition assessment protocols, almost all sites were surrounded by wide buffers with intact soil conditions, though many buffers had poor vegetation condition due to the presence of the invasive plant species *Phragmites australis* ssp. *australis* (common reed). Sites frequently received low scores for hydrologic condition metrics due to altered hydroperiods, low hydrologic connectivity, and unnatural water sources, though hydrologic metrics were difficult to assess in the field and may need to be reconsidered for Great Salt Lake wetlands. Sites also scored very poorly for metrics related to topographic complexity, horizontal interspersion, vertical biotic structure, and plant community complexity. These low scores could either be the result of actual impaired conditions or reflect the fact that these metrics may need to be better calibrated to our study system. Sites generally had high aquatic connectivity, little evidence of nuisance algal growth and turbidity, and few signs of substrate disturbance. Whereas sites generally had few species designated as noxious weeds, the non-native plant species *Phragmites australis* ssp. *australis* and the aggressive native *Typha* spp. (cattail) were often common and abundant. For overall wetland condition scores, the majority of sites were rated as B (slight deviation from reference) by two of the rapid condition assessment

protocols tested and as C (moderate deviation) by the third tested protocol. Only one of the tested protocols rated any of the sites as A (reference condition) or D (significant deviation).

We recorded 82 unique plant species during surveys, with a mean of 11.4 species and a range of 3 to 28 species recorded per site. We found 4 non-native and 10 native species at one quarter or more of the study sites, with *Distichlis spicata* (saltgrass), *Typha* spp. (cattail), *Phragmites australis* ssp. *australis* (common reed), *Schoenoplectus americanus* (chairmaker's bulrush), and *Lemna minor* (common duckweed) both common and abundant where found. We recorded two species found on Utah's list of noxious weeds during field surveys, *Lepidium latifolium* (broadleaved pepperweed, n=11) and *Tamarix* spp. (Tamarisk, n=4), though cover of both species at sites was low. The mean coefficient of conservatism (C-value) at sites was 2.5, indicating that plant communities were composed primarily of species that are fairly disturbance-tolerant. Floristic quality assessment (FQA) metrics were similar between impounded and unimpounded sites. Differences in FQA metrics among HUC8 watersheds were more pronounced; in general, Curlew Valley had the best scores, Weber had the worst, and scores for Jordan and Lower Bear-Malad fell in the middle.

We tabulated information on potential site stressors both by recording stressors observed near sites while in the field and through a geographic information system (GIS) analysis. In the field, we recorded a mean of 4.6 stressors within a 200 m buffer area surrounding each site, and every site had at least one stressor. Cover of non-native species and hydrologic modifications, including dikes and ditches, were some of the most common and most severe buffer stressors recorded. Cover of nuisance filamentous algae, vegetated dikes, gravel roads, trash, and pugging from grazing were also common buffer stressors. Heavy algae or *Lemna* spp. (duckweed) surface mats and trampling or wallowing by domestic animals were the most common stressors observed directly within sites, each documented at over one quarter of all sites. A GIS-based landscape analysis showed that land cover within 1 km of sites was predominantly wetland, water, and barren, except for at two sites that had over 50% cover of developed, cultivated, and pasture lands. Development and agriculture were more common at larger scales, with 6 sites having over 50% cover of these cover types within 5 km, though wetland, water, and barren land were still dominant at most sites at this scale. Sites were generally far from mines and Utah Pollutant Discharge Elimination System (UPDES) storm water permit holders (mean distance ≥ 8 km) and much closer to roads; almost 80% of sites were within 1 km of a road and none were more than 2 km from a road.

Generally strong relationships exist between wetland condition rapid assessment scores and FQA metrics, measures of stressors, and landscape data, indicating that wetland condition assessment scores appropriately reflect other measures of wetland condition. Overall wetland condition scores had correlations as high as 0.56 with FQA metrics. Total recorded stressors adjusted for extent and severity correlated negatively with overall site scores for all three protocols, with correlations between -0.49 and -0.76. Data related to both anthropogenic and natural features were important in landscape models of overall site scores. Distances to the nearest mine and nearest UPDES permit holder, density of nearby roads, and percent agricultural land cover were variables in at least one of the final models of overall wetland score. Variables related to natural landscape variability, including climate data and percent barren, water, and wetland, were also included in at least one model. Final models of overall site scores versus landscape data had adjusted R^2 values ranging from 0.22 to 0.74.

Field experience, data, and analysis from this Great Salt Lake wetlands assessment project will be used to inform the on-going work to develop a single rapid assessment protocol for use in all Utah wetlands. We will select a subset of metrics from the three tested protocols and refine those metrics that were difficult to use in the field. We will also ensure that the unique conditions experienced by Great Salt Lake wetlands, particularly in terms of hydrologic modifications, can be adequately captured by the state protocol. New versions of the state protocol will be tested and refined through additional wetland surveys around Great Salt Lake. This initial assessment work around Great Salt Lake provides us with a substantial amount of information that will be instrumental as protocol development moves forward.

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1.0 Introduction

1.1 Project Background and Goals

Wetlands are an important component of the Utah landscape, providing beneficial services including flood control, water purification, and wildlife habitat. The largest concentration of wetlands in the state is along Great Salt Lake, a hypersaline terminal lake in northern Utah. Great Salt Lake wetlands are internationally recognized for their importance as migratory and breeding bird habitat and are one of only 23 areas considered wetlands of hemispheric importance (the top designation) by the Western Hemisphere Shorebird Reserve Network (http://www.whsrn.org/sites/list-sites). These wetlands are also socially and economically important for the hunting and bird-watching opportunities they provide (U.S. Fish and Wildlife Service and U.S. Census Bureau, 2013).

Great Salt Lake wetlands have been subject to high levels of anthropogenic manipulation, beginning most prominently with groundwater pumping and water diversions that severely reduced wetland acreage by the early 1900s. Extensive sections of the remaining wetlands have been impounded to allow for close control over the water that is still present. Many of the wetlands are located in areas that have undergone, and are continuing to undergo, rapid urbanization, with over 45% population growth forecast between 2010 and 2040 for the three most urban counties adjacent to the wetlands (Davis, Salt Lake, and Weber, http://governor.utah.gov/DEA/projections.html). Urbanization contributes additional stress related to water availability and water quality. The invasive grass species, *Phragmites australis* ssp. *australis* (common reed), is another important stressor that that has replaced much of the native wetland vegetation around Great Salt Lake (Kulmatiski and others, 2011).

In 2013, the Utah Geological Survey (UGS), with a grant from the U.S. Environmental Protection Agency (EPA), undertook an assessment of the current condition and presence of stressors at Great Salt Lake wetlands to better understand this important and threatened ecosystem. The project was specifically focused on palustrine emergent wetlands, which are nontidal wetlands characterized by primarily perennial, erect, rooted, herbaceous hydrophytic vegetation that is present for most of the growing season (Cowardin and others, 1979). Data were collected at sites using a rapid assessment method designed to evaluate important indicators of wetland health during a short field survey. Additional information was obtained from more intensive vegetation data collection. This assessment work occurred in conjunction with two related projects, which focus on developing a rapid assessment protocol for use on wetlands throughout the state and developing a model of surface flow paths around Great Salt Lake. Much of the data collected for this project will be used to inform on-going work on these related projects.

This project has three major components:

1. **Conduct a field-based assessment of the condition of palustrine emergent Great Salt Lake wetlands at sites experiencing a broad range of natural and anthropogenic states.**
   Approach: Surveyed sites using the rapid assessment protocols that are being tested and developed by UGS. Selected a random sample of sites to survey and supplemented with additional, subjectively chosen sites in order to ensure that we captured variability in management regimes, surrounding land use, and other states.

- *Goal 1: Collect information on the condition of Great Salt Lake wetlands and surrounding land use.*
- *Goal 2: Use field experience to inform on-going rapid assessment protocol development by, for example, determining which metrics are difficult to evaluate or not relevant for Great Salt Lake wetlands.*
- *Goal 3: Evaluate the relationship between stressors observed in the field and components of wetland condition, such as hydrologic and vegetation condition.*

2. **Obtain detailed plant community data at field sites.**
   Approach: Collected data on the presence and percent cover of all plant species found in survey plots.
   - *Goal 1: Contribute data on wetland plant species distribution and abundance to a database for further development of plant-based metrics in the state of Utah, including state-specific coefficient of conservatism values.*
   - *Goal 2: Evaluate the relationship between plant community metrics and site attributes, including natural and anthropogenic variables and wetland condition as evaluated in component 1.*

3. **Apply a landscape approach to evaluate potential threats and stressors to Great Salt Lake wetlands.**
   Approach: Developed a model of wetland stressors at surveyed field sites using available spatial data for predictor variables.
   - *Goal 1: Determine the types of stressors evident on the landscape that may affect wetland condition.*
   - *Goal 2: Evaluate the relationship between landscape stressors at different spatial scales and field survey data, including overall wetland condition and plant community metrics.*
   - *Goal 3: Use information obtained from this analysis to inform development of an approach to modeling wetland condition at the landscape level that can be applied to all Great Salt Lake wetlands.*

1.2 Overview of Wetland Condition Assessments

1.2.1 Definition of Wetland Condition

This project focuses on the ecological condition of Great Salt Lake wetlands. Ecological condition can be defined as "the ability of a wetland to support and maintain its complexity and capacity for self-organization with respect to species composition, physico-chemical characteristics, and functional processes as compared to wetlands of a similar type without human alterations" (Fennessy and others, 2007). Condition is often evaluated in terms of degree of deviation from what is known or expected to occur at sites without any anthropogenic alteration (i.e., reference sites). Condition assessments differ from functional assessments in that the latter specifically focus on the functional aspect of condition, such as the ability of a wetland to attenuate flood waters or provide wildlife habitat, without regard to the overall naturalness of a site.

1.2.2 Environmental Protection Agency Framework

The EPA has a three-tiered approach to wetland monitoring and assessment (U.S. Environmental Protection Agency, 2006). Level I assessments are generally applied broadly across a landscape and use geographic information systems (GIS) and remotely sensed data to evaluate the abundance, distribution, and surrounding land use of wetlands. These assessments can provide a coarse estimate of wetland condition based on calculated metrics in the surrounding watershed, such as road density, percent agriculture, and presence of point source discharges. Level I assessments are relatively inexpensive and efficient for evaluating wetlands across broad geographic areas, but cannot provide specific information about the on-site condition of any particular wetland. Level II assessments evaluate wetland condition in the field using a rapid assessment approach. These assessments are intended to take two people no more than four hours of field time, plus up to half a day in the office for preparation and subsequent analysis, and often rely primarily on qualitative evaluation. Level II assessments can be used to understand ambient wetland condition, to determine sites appropriate for conservation or restoration, and, in some cases, for regulatory decision making. Level III assessments are detailed, quantitative field evaluations that more comprehensively determine wetland condition using intensive measures such as invertebrate or plant community enumeration or water quality measurements. These assessments require the most professional expertise and sampling time, including in some cases repeat visits to a site. Information from Level III assessments can be used to develop performance standards for wetland conservation and restoration, support development of water quality standards, determine causes of wetland degradation, and refine rapid assessment methods.

This project analyzed the relationships between data at all three EPA-defined levels using a landscape analysis, rapid assessment, and quantitative plant evaluation. In principal, the detailed Level III data can be used to calibrate Level I and Level II assessments. However, components of the Level III analysis often have to be calibrated themselves, such as by developing species-specific coefficient of conservatism values that indicate the ability of species to tolerate disturbance. Level III analysis was not the principle focus of this project, and thus we did not collect enough data at that scale to fully develop robust Level III metrics. Instead, we used data from all three levels to evaluate the inter-relatedness of the methods and to begin to determine possible approaches of calibration.

1.3 Rapid Assessment Methods

Although several wetland functional assessments have been developed for Utah (Keate, 2005; Johnson and others, 2006), there is currently no widely used condition assessment protocol for the state. As part of a separate project, UGS is developing a rapid condition assessment method suitable for the state. Development began by applying three methods to wetlands across the state, including the wetlands surveyed for this project. Utah Wetlands Ambient Assessment Method (UWAAM) was recently developed for the state through adaptation primarily of methods used by California and Ohio (Hoven and Paul, 2010). UWAAM altered metrics to specifically address unique aspects of Great Salt Lake and added a habitat component absent from other protocols. However, the method has not been widely adopted for use in the state or validated with landscape or detailed quantitative data. The EPA developed a rapid assessment protocol (USA-RAM) used in conjunction with more detailed surveys carried out as part of the 2011 National Wetland Condition Assessment (www.epa.gov/wetlands/survey). USA-RAM is a standardized method that has been applied to wetlands nationally, but its broad application may limit its ability to properly address issues of local or regional importance. Colorado Natural Heritage Program (CNHP) developed a rapid condition assessment protocol (CNHP-EIA) based on the Ecological Integrity Assessment developed by NatureServe (Faber-Langendoen and others, 2008). CNHP-EIA focuses on evaluating wetland condition within a single ecological system and has been refined through several iterations of field testing (Lemly and Gilligan, 2013). For this project, we evaluated wetlands using a field method based on metrics from CNHP-EIA, USA-RAM, and UWAAM applied during a single field visit.

All three rapid assessment methods are similar in their general structure and interpretation of results. Each method is composed of between 12 and 19 individual metrics that are organized into categories that capture important aspects of wetland condition. Categories evaluated by all three methods include the buffer or landscape context, hydrology, plant community, and physical or physiochemical structure. However, methods differ in the types of metrics included in each category. For example, some methods include structural components of vegetation in the physical structure category while others include it as a plant community metric. UWAAM includes an additional habitat category, and CNHP-EIA evaluates wetland size, though this is not used for final site evaluation. USA-RAM includes two main types of metrics in its evaluation: those that directly evaluate wetland condition and those that tabulate potential stressors in an area. We divided the metrics used by each protocol into the following six categories:

1) **Landscape Context**: Ability of surrounding landscape to buffer wetland from adjacent stressors and provide intact habitat for species.

2) **Hydrologic Condition:** Degree of hydrologic functioning related to water source, connectivity to adjacent areas, hydroperiod, and evidence of water quality degradation.

3) **Physical Structure:** Quality of physical structure including complexity of structural features and degree of physical alteration.

4) **Vegetation Structure:** Presence of structural vegetation components, including horizontal and vertical interspersion and natural woody and herbaceous litter accumulation.

5) **Plant Species Composition:** Intactness of plant community based on species richness and presence of desirable and undesirable species.

6) **Habitat:** Presence of threats to wildlife and landscape features that provide habitat for wildlife.

Wetlands can be scored for individual metrics, categories, and overall site condition. Numeric scores can be converted to categories or ranks to ease interpretation. CNHP-EIA uses the letter grades A through D to denote wetland condition ranging from pristine or reference condition to severely altered wetlands that may have little conservation value and be very difficult to restore (Table 1). Similarly, UWAAM divides wetlands into Category I through Category IV designations that reflect rarity, quality of habitat provided, and ecological function of each wetland (Table 1). USA-RAM does not currently have fully developed methods for scoring sites and interpreting scores. For ease and standardization of presentation, we use letter grades to portray the results of each method.

Table 1. Definition of assessment ratings from CNHP-EIA and UWAAM. CNHP-EIA values range from A to D and UWAAM categories range from I to IV.

Value/ Category	CNHP-EIA Description[1]	UWAAM Description[2]
A / I	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.	Wetlands are high quality and rare in occurrence. They may provide: primary habitat for federally listed or proposed threatened or endangered species; represent a high quality example of a rare wetland type; provide irreplaceable ecological function; exhibit exceptionally high flood attenuation capability; or score high for all of the metrics assessed.
B / II	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.	Wetlands are more common than Category I wetlands, and can provide habitat for sensitive plants or animals, provide a high level of ecological services for wildlife habitat, are unique to a given region, or score high in many of the metrics assessed.
C / III	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.	Wetlands are more common and generally less diverse than Category I and II wetlands. They can provide many ecological services, but do not score as high in as many metrics as Category I and II wetlands.
D / IV	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.	Wetlands lack vegetative diversity, provide little ecological services to wildlife and are often directly or indirectly disturbed.

[1]From Table 1 in Lemly and others (2011)
[2]From Hoven and Paul (2010)

1.4 Landscape Analysis

Landscape analyses are important tools for assessing wetland condition. They can be used to explore relationships between field observations and landscape stressors and are an efficient means to categorize the potential condition of wetlands in a large area, which can aid in identification of reference sites or sites to target for restoration projects. Recent Landscape Integrity Models developed for Colorado and Montana provide good examples of how landscape models can be developed (Vance, 2009; Lemly and others, 2011; Copeland and others, 2010). First, spatial data for stressors to wetlands such as roads, agriculture, urban development, water diversions, and mines are compiled. Next, each stressor is spatially modeled to capture how the stressor's influence decreases with increasing distance from a wetland, using decay parameters established through literature review, best professional judgment, and/or validation with field sampling data. Last, modeled stressors are combined so that areas close to many stressors receive higher scores to indicate higher levels of potential impairment. While the process detailed above relies exclusively on Euclidean distance between stressors and wetlands, it is also possible to develop landscape models that use surface flow path distance and/or watershed-scale variables for analysis. The model developed by CNHP for Colorado includes data on hydrologic modifications in upstream watersheds in addition to Euclidean distance variables (Lemly and others, 2011).

A preliminary effort was made to develop a landscape model of wetland integrity for Great Salt Lake in spring 2013 following the procedure used by CNHP (Lemly and others, 2011), though upstream watershed data were not available for the region. The resulting map did not exhibit much variability or capture expected differences between wetlands. Euclidean distance to stressors was an inadequate means to distinguish between wetlands since most Great Salt Lake wetlands are primarily located within a complex of other wetlands. We determined that watershed-scale and flow path distance data were more appropriate for a Great Salt Lake wetland landscape model. Delineating wetland watersheds and obtaining flow path data were outside the scope of this project due to the substantial effort this would require. In this report, we conducted an initial evaluation of the scale at which major landscape stressors affect wetland condition. Scales evaluated included both full-360° and higher-elevation-only buffers at three distances from sites as well as U.S. Geological Survey's (USGS) 12-digit Hydrologic Unit Code (HUC12) watersheds (http://nhd.usgs.gov/wbd.html).

2.0 Study Area

2.1 Geography

Great Salt Lake is a high-salinity terminal lake located in northern Utah on the eastern edge of the Great Basin. It is the largest lake that remains of ancient Lake Bonneville that once covered roughly 51,800 km^2 of the eastern Great Basin until a natural dam failed and drained much of the lake 14,500 years ago (Oviatt, 1997). Large lake surface area and shallow topographic relief create a highly transitory shoreline along present-day Great Salt Lake. In a typical year, the shoreline can migrate up to 800 m in some locations, and it has been estimated that with a change of 0.3 m in the lake's water level, approximately 178 km^2 of ground surface is inundated or exposed lake-wide (estimated as 1 foot and 44,000 acres by Aldrich and Paul, 2002). In recent history, lake levels have fluctuated up to 6 m with a record high of 1283.5 m and low of 1277.5 m, in 1986 and 1963, respectively (estimated as 4211.85 feet and 4191.35 feet by Arnow and Stephens, 1990). The mean lake level during the 2013 water year (October 1 to September 30) in which this study was conducted was 1278.9 m (http://waterdata.usgs.gov/nwis), below the historic long-term mean of 1280.2 m (Miller and others, 2009).

Great Salt Lake's watershed encompasses approximately 55,000 km^2, with the majority of the area within Utah but also including areas of southern Idaho and southeastern Wyoming (Figure 1). Areas of the Basin and Range Province in eastern Nevada and the west desert of Utah contribute a small flux

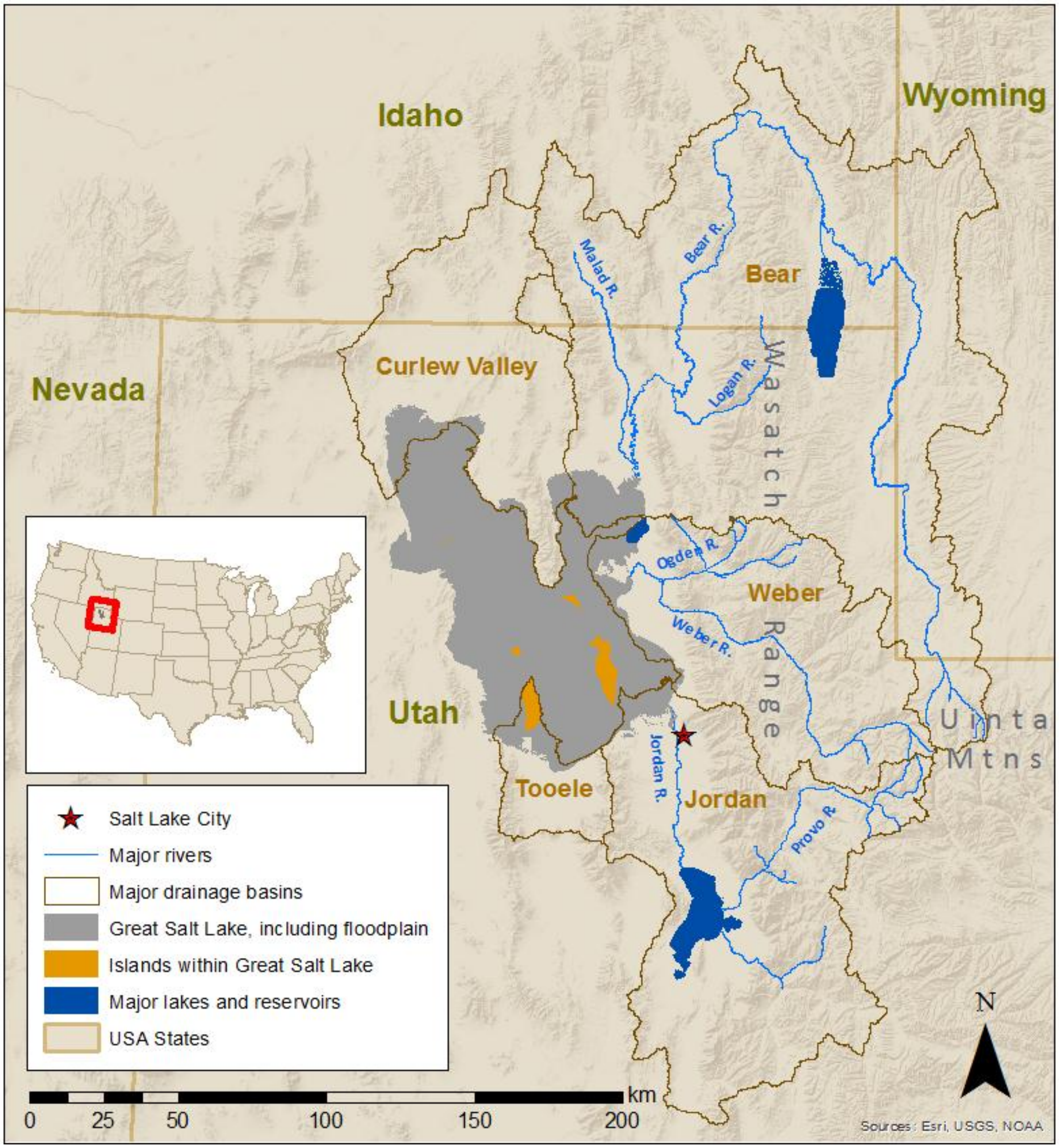

Figure 1. Major drainage basins contributing water to Great Salt Lake and associated wetlands. Basins on the western edge of the lake do not have mapped wetlands and are not shown on this map.

of groundwater as well (Miller and others, 2009). The Uinta Mountains and Wasatch Range to the east of the lake provide the majority of water, via surface flow. This project focused on wetlands in Great Salt Lake's floodplain, except for those on the western shoreline where mapped wetland data are not available. Our study area encompasses five USGS 8-digit Hydrologic Unit Code (HUC8) subbasins adjacent to Great Salt Lake (http://nhd.usgs.gov/wbd.html). Three of the HUC8 units contribute water, largely via major rivers originating in the Uinta Mountains including: (1) the Lower Bear-Malad, primarily fed by the Bear River and to a lesser extent the Logan and Malad rivers, (2) the Lower Weber, fed mostly by the Ogden and Weber rivers and (3) the Jordan, fed primarily from the Jordan and Provo rivers. The

Curlew Valley and Rush-Tooele Valleys HUC8 units primarily provide freshwater to Great Salt Lake in the form of groundwater discharge, with some overland flow. Our study area also includes a sixth HUC8, the Great Salt Lake HUC8 itself. However, we classified wetland sites within this HUC8 as members of the nearest HUC8 contributing water to the lake for the sake of evaluation. This was justified because 1) sites in the Great Salt Lake HUC8 were within 102 m of contributing HUC8s and 2) contributing HUC8 membership is more informative for understanding water- source differences between sites.

2.2 Hydrology

The inflow of water into Great Salt Lake comes from three sources: surface flow from streams and rivers (66%), direct precipitation on the lake's surface (31%), and groundwater discharge (3%) (Arnow and Stephens, 1990). The Bear, Weber, and Jordan rivers contribute 59%, 20%, and 13% of the surface flow entering Great Salt Lake , respectively, and the remaining streamflow enters the lake via 10 smaller tributaries along the eastern and southern shores (Arnow and Stephens, 1990). Historically, the Bear, Jordan, and Weber rivers ended in deltas along the eastern shore of Great Salt Lake, creating extensive complexes of wetlands.

Upon settlement of Salt Lake Valley and surrounding areas, agricultural development and associated water use beginning in the mid to late 1800s (Jackson, 1978a) and subsequent groundwater pumping led to drastic reductions in the amount of water reaching Great Salt Lake and dewatering of associated wetlands. Without human water consumption, the current lake elevation would be approximately 1.5 m higher than it is today (estimated as 5 ft by Arnow, 1978). Impoundments for wetland maintenance and waterfowl habitat conservation began to be built along the lake in the early 1900s, and currently very little surface flow enters Great Salt Lake without first passing through ditches and/or impoundments (CH2M HILL, 2009). While wetland hydrology in the region is still influenced by natural processes including spring run-off in headwater streams, groundwater discharge from springs, and natural climate fluctuations, the timing, duration, and amount of water reaching Great Salt Lake wetlands are strongly influenced by upstream and adjacent impoundments, agricultural withdrawals and return flows, urban runoff, and management decisions related to the movement of water through impoundment systems.

2.3 Climate

Great Salt Lake has a cold desert climate, with summer temperatures reaching above 38°C and winter temperatures as low as -18°C (Paul and Manning, 2002a). Daily temperatures can be quite variable with relatively strong insolation during the day and rapid cooling at night. Temperatures to the north of the lake are somewhat cooler than to the south; mean annual temperatures are between 9 and 10.5°C in the north and 11 and 12° C in the south (Daly and others, 2008; see water year calculations under "Section 3.4 Calculation of Landscape Data"). The basin feeding Great Salt Lake experiences a large spectrum of precipitation. The xeric west edge of the lake receives as little as 24 cm of precipitation annually, whereas 46 cm of moisture falls annually on the eastern shore (http://climate.usurf.usu.edu). Due to the great topographic relief between the valley floor and the mountains to the east, orographic effect delivers the majority of precipitation in the local area to the western edge of the Wasatch Range (Wasatch Front) and parts of this area receive over 100 cm, predominately in the form of snow (http://climate.usurf.usu.edu).

2.4 Ecological Context

Great Salt Lake's wetlands fall entirely within the Central Basin and Range Level III Ecoregion (Omernik, 1987). Though mapped wetlands in Great Salt Lake's floodplain overlap six Level IV Ecoregions, the majority of wetland is in the Wetlands Ecoregion, which is characterized by poorly drained and often salty soils with rushes, reeds, and areas of open water (Woods and others, 2001). Rushes (*Juncus* spp.), sedges (*Carex* spp.), and spikerushes (*Eleocharis* spp.) dominate the wet meadows, whereas bulrush (*Schoenoplectus* spp.), cattails (*Typha* spp.), and common reed (*Phragmites* spp.) are common in the emergent marshes. The Salt Deserts Ecoregion also contains substantial wetlands in the form of playas, salt flats, and mud flats with poorly drained clay soils, and is commonly barren or sparsely vegetated with salt-tolerant plant species including pickleweed (*Salicornia* spp.) and saltgrass (*Distichlis* spp.). Mapped differences between these two ecoregions are often inaccurate due to changing boundaries caused by fluctuations in Great Salt Lake's water levels. The majority of the surrounding upland plant communities fall within the Sagebrush Basins and Slopes Ecoregion and Shadscale-Dominated Saline Basin Ecoregion, which consists of plant communities dominated by salt and drought-tolerant species such as greasewood (*Sarcobatus* spp.), sagebrush (*Artemesia* spp.), and saltgrass.

Great Salt Lake's wetlands provide critical habitat for millions of birds as they migrate between northern breeding grounds and winter locations (Paul and Manning, 2002b), serving as an oasis in an area otherwise composed of desert. For example, as many as one million Wilson's phalaropes (*Phalaropus tricolor*), constituting two-thirds of the world's population, use Great Salt Lake wetlands during migration, and more than 2.2 million eared grebes (*Podiceps nigricollis*), over half of the world's population, stage along the lake in the fall (Jehl Jr., 1988). These wetlands provide habitat for a large number of nesting birds as well, playing host to the world's largest breeding population of white-faced ibis (*Plegadis chihi*) and one of western North America's largest breeding colonies of American white pelicans (*Pelecanus erythrorhynchos*) (Paul and Manning, 2002b). Great Salt Lake wetlands are important for other faunal taxa as well. A recent environmental assessment from the Bear River delta found five species of amphibians and reptiles using the wetlands (U.S. Fish and Wildlife Service, 1991). Carp, suckers, and catfish were the most common fishes and muskrats the most common mammals associated with wetlands in the study. Great Salt Lake wetlands also provide habitat for a high diversity of invertebrates in areas with good water quality (Miller and Hoven, 2007).

2.5 Land Use and Land Ownership

Salt Lake Valley was permanently settled in 1847 by a small group of pioneers and by 1869 the population of the valley had grown to more than 60,000. At that time, agriculture was the driving force of land cover change (Jackson, 1978b). Since then, much of the farmland in the valley has given way to development and urbanization, leading to the establishment of major metropolitan areas. As of 2012, 75% (2,187,638) of Utah's population resides along the Wasatch Front, including in Salt Lake City, Utah's capital and largest city (Economic Development Corporation of Utah, 2013). Of the watersheds feeding Great Salt Lake, the Jordan and Weber have the most developed land and the Bear has the most land with cultivated crops (Table 2). Headwater regions of the watersheds associated with the three major rivers feeding Great Salt Lake are generally forested, with rangeland making up a substantial portion of low to mid elevation land cover. Much of Great Salt Lake's watershed is publicly owned. In general, low to mid elevation land is privately owned or part of Bureau of Land Management (BLM) rangelands. The higher mountainous areas are predominantly owned by the U.S. Forest Service. The Weber watershed is the exception, with nearly 82% of the land privately owned (http://gis.utah.gov/data/sgid-cadastre/land-ownership).

Recreational use around Great Salt Lake, such as bird watching, boating, and waterfowl hunting, contributes over $130 million annually to the State's economy (Bioeconomics Inc., 2012). Accordingly, many of the wetlands around Great Salt Lake are owned by public and private entities that manage them for waterfowl hunting and bird usage (Table 3, Figure 2). This includes eight Waterfowl Management Areas (WMAs) owned by the Utah Division of Wildlife Resources and the federally owned Bear River Migratory Bird Refuge. Also, more than 15 privately owned duck clubs manage wetlands for hunting and conservation, and several privately owned preserves focus primarily on conservation. Great Salt Lake wetlands that occur below the surveyed meander line of the lake are considered the State of Utah's sovereign lands and are managed by the Utah Division of Forestry, Fire, and State Lands.

Table 2. Area and land cover of major drainage basins contributing to Great Salt Lake and associated wetlands. Drainage basins are derived from the U.S. Geological Survey's Watershed Boundary Dataset, with internally drained units removed. Land cover is from the National Land Cover Database for the year 2006 (Fry and others, 2011).

Drainage Basins	Area (km^2)	Open water (%)	Wetland (%)	Forest (%)	Shrub, scrub (%)	Grassland (%)	Barren (%)	Pasture (%)	Cultivated crops (%)	Development (%)
Bear	19,463	2.5	3.2	22.6	45.0	6.6	1.3	7.8	8.7	2.3
Curlew	5579	0.3	0.6	4.6	48.0	24.9	9.0	5.4	6.2	1.2
Jordan	9195	5.0	1.8	45.4	22.5	2.9	1.7	6.1	2.7	11.9
Tooele	1258	4.9	3.3	16.4	27.5	18.4	14.9	10.0	1.0	3.8
Weber	6436	2.5	2.5	48.9	29.4	0.3	1.6	5.8	1.6	7.2

Table 3. Percent emergent wetlands and sites surveyed by the UGS by land management class. Some areas are managed by the listed entity but owned by another entity (e.g., state/federal partnerships).

Management type	Emergent wetlands (%)	Surveyed Sites (%)
Private		
Private duck club	11.8	20.5
Private preserve and private mitigation	5.9	6.8
Other private land	14.5	2.3
Federal		
U.S. Fish and Wildlife Service	22.8	15.9
Bureau of Land Management	0.1	2.3
State		
Utah Fire, Forestry, and State Lands	16.4	4.5
Utah Division of Wildlife Resources	27.6	45.5
Other state land	0.9	2.3
Total area of emergent wetlands (km^2), Total number of surveyed sites	**444**	**44**

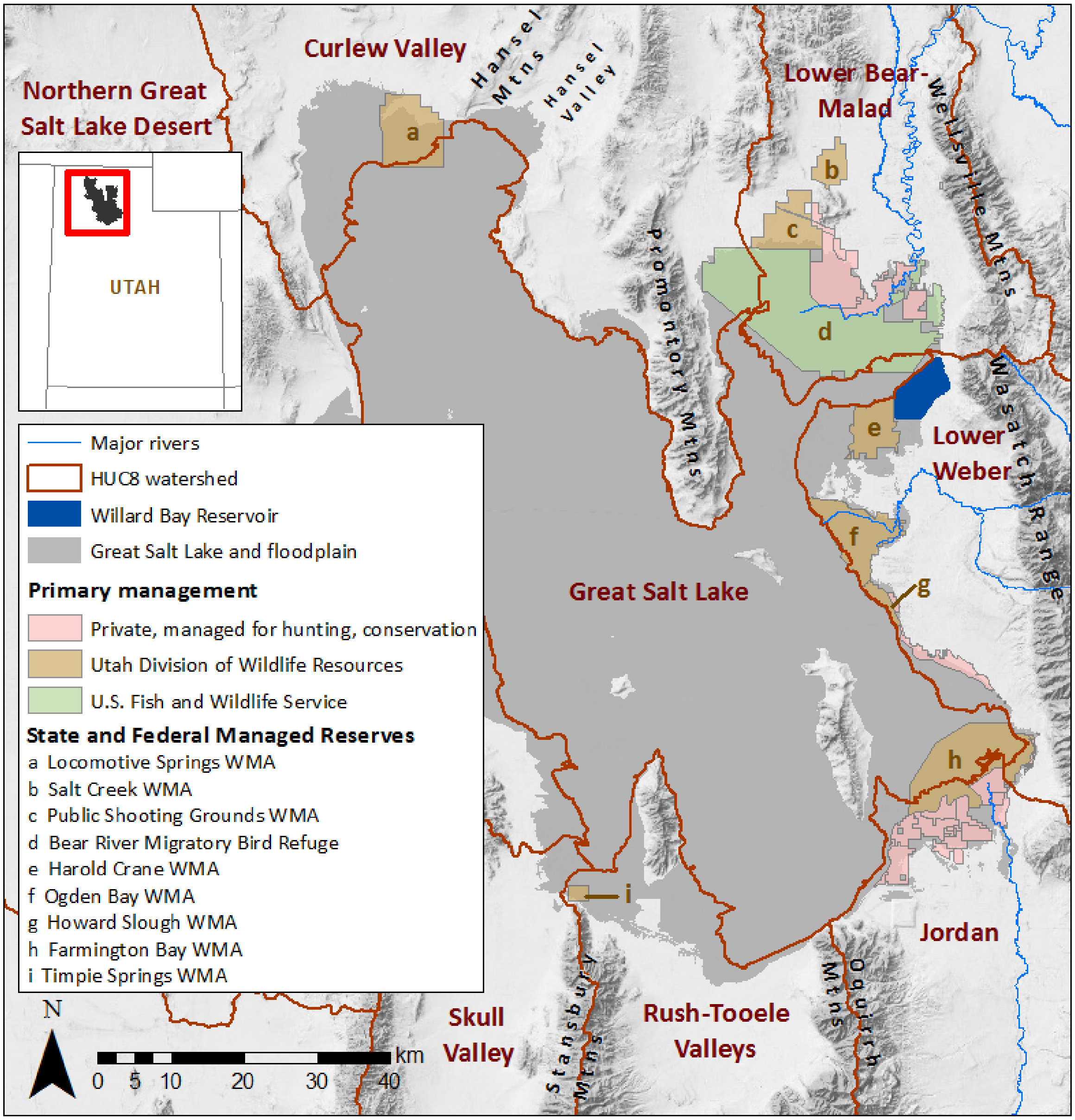

Figure 2. Areas with wetlands managed for hunting and/or bird conservation near Great Salt Lake's floodplain.

3.0 Methods

3.1 Site Selection

We considered our study area to be the floodplain of the eastern shore of Great Salt Lake. Our two goals associated with site selection were to obtain a random sample of palustrine emergent wetlands within our defined study area and to survey across the broadest possible gradient of conditions in order to best test and refine the survey protocol. Accordingly, we used three processes to select study sites. First, we used a Generalized Random Tessellation Stratified (GRTS) survey design to select random spatially balanced sites within the floodplain of Great Salt Lake. Second, we used GRTS to select sites in three regions outside of Great Salt Lake's floodplain in order to include a broader variety of potential conditions. Lastly, we subjectively selected sites during field visits to capture unique conditions that we felt would otherwise be missed or to allow us to survey sites in regions with poorly mapped wetland data. Further explanation of site selection methods is detailed below.

3.1.1 Development of Emergent Wetland Spatial Data Layer

Before selecting study sites, we first had to assess the availability of spatial data showing the presence and type of wetlands around Great Salt Lake. U.S. Fish and Wildlife Service (USFWS) defines wetlands as "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" (Cowardin and others, 1979). Under the USFWS definition, wetlands must have predominantly hydrophytic vegetation, soils with hydric indicators, or nonsoil substrate that is saturated or inundated during the growing season. This definition differs from that of the U.S. Army Corps of Engineers, which requires all three elements to be present at a site. We used the USFWS definition of wetland for the purposes of this study.

The National Wetlands Inventory (NWI) program, run by the USFWS, maps wetland locations throughout the United States and classifies these wetlands using a system developed by Cowardin and others (1979). We obtained digital NWI data for the state of Utah in May 2013 from USFWS and reclassified each wetland polygon using the reclassification scheme developed for this region by Emerson and Hooker (2011). The Emerson and Hooker (2011) reclassification scheme simplifies the 210 unique classes in Cowardin and others' (1979) system into seven classes, including an emergent wetland class, based on geomorphic, hydrodynamic, and vegetation characteristics of importance around Great Salt Lake. Digital NWI data along Great Salt Lake was available for the Lower Bear-Malad, Lower Weber, and Jordan HUC8 watersheds as well as most of the Rush-Tooele Valleys and Curlew Valley HUC8 watersheds. No digital data were available for the Northern Great Salt Lake Desert HUC8 on the western shore or for the Skull Valley Watershed on the south-western shore of Great Salt Lake. The majority of the available NWI data were mapped from imagery from 1981 and updated through ground delineations in 2005, except for an area largely contained within the Jordan watershed that was mapped using imagery from 1997 and 1998. From the NWI data, we created a feature of only those polygons classified as emergent in the Emerson and Hooker (2011) reclassification scheme.

NWI data, while a great resource for consistently mapped wetland information, inadequately represents current conditions around Great Salt Lake due to the age of the imagery used and changing conditions around the lake. We used a map of wetland vegetation developed by Lexine Long at Utah State University to supplement the available NWI data. Long used 1-m-resolution multispectral aerial imagery from May and June 2011 to classify pixels into nine wetland vegetation classes (Long and others, 2012). We reclassified the following of Long and others' (2012) vegetation classes into an emergent class: *Phragmites australis* ssp. *australis* (common reed), *Schoenoplectus acutus* (hardstem bulrush), *Typha* spp. (cattail), and native emergent, and ran a 5 by 5 pixel filter in ArcGIS 10.1 to smooth the data. We did not classify *Salicornia rubra* (red swampfire) and *Distichlis spicata* (saltgrass) as emergent because we associated these species with areas of sparse vegetation, though we found during our field work that both species, and most frequently *Distichlis spicata*, often did occur in areas of dense cover. NWI and Long and others' (2012) emergent wetland data were merged and then dissolved in ArcGIS 10.1. Features ≤1000 m² were removed to maintain a minimum study area size of 0.1 ha.

3.1.2 Delineation of Study Boundaries

Our primary study area of interest was the floodplain of Great Salt Lake. Wetlands within Great Salt Lake's floodplain are periodically subject to shifts in salinity, water levels, and vegetation as lake levels rise and recede. While definitions of Great Salt Lake's floodplain vary, Utah's Division of Forestry, Fire, and State Lands (2013) defines its upper elevation at 4217 ft (1285.3 m), which is based on high lake levels of approximately 4212 ft (1284 m) combined with 3 ft (0.9 m) for wind tide and 2 ft (0.6 m) for wave action. This floodplain definition also agrees with the 100-year floodplain definition generally used by the Federal Emergency Management Agency (Utah Division of Forestry, Fire and State, Lands, 2013). We used digital elevation model (DEM) data at 1-m-resolution where available (http://gis.utah.gov/data/elevation-terrain-data/2011-lidar) and 10-m DEM data elsewhere (http://gis.utah.gov/data/elevation-terrain-data/10-30-meter-elevation-models-usgs-ned) to create a digital feature of areas ≤1285.3 m in the vicinity of Great Salt Lake. The tool Eliminate Polygon Part was run in ArcGIS 10.1 to convert small areas (<10 ha) of higher elevation within the main polygon to areas included within the ≤1285.3 m feature. We used manual editing to remove some small areas of low elevation land separated from the main feature, though not all such areas were removed. The resulting polygon was then clipped to the emergent wetland feature to create the final boundary of emergent wetland within Great Salt Lake's floodplain.

We created a second study boundary of additional areas of interest outside Great Salt Lake's floodplain. These secondary areas including Salt Creek Waterfowl Management Area (SCWMA), Hansel Valley between the Promontory and Hansel Mountains, and the section of Public Shooting Grounds Waterfowl Management Area (PSGWMA) higher than the 1285.3 m floodplain boundary. We were interested in these areas because of the unique conditions they represented. These areas are primarily spring-fed, with substantial contribution from irrigation water in places, and are not subject to the intense invasion by *Phragmites australis* ssp. *australis* as seen in other areas. We manually selected emergent wetland polygons from the vicinity of Hansel Valley and clipped emergent wetland polygons to reserve boundaries for the two waterfowl management areas in order to create the final boundary of the additional emergent wetland features.

3.1.3 Selection of Study Sites

We used the spsurvey package (Tom and others, 2012) in R 3.0. (R Core Development Team, 2013) to select survey sites using a GRTS survey design. GRTS is a statistical method to select random sample locations that are spatially balanced and ordered so that any consecutive sets of samples points are themselves spatially balanced (Stevens and Olsen, 2004). We selected 50 sample and 200 oversample points with an unstratified GRTS design within the floodplain boundary. Oversample points were used to replace any of the primary sample points that could not be surveyed due to lack of permission from landowners or absence of emergent wetland. We used point-based selection rather than polygon-based because our polygons did not represent individual wetlands. We used a stratified GRTS design to select two sample and five oversample points within each of the three strata (Hansel Valley, SCWMA, and PSGWMA) in the additional emergent wetland boundary. We allowed for additional sites outside the sample design to be surveyed when we encountered unique conditions in the field or were missing sites that were in regions of interest.

3.2 Office Site Evaluation and Landowner Permission

We screened sites in the office to determine whether they contained palustrine emergent wetland that was appropriate for establishment of an assessment area (AA). An AA is the bounded wetland area (either whole-wetland or portion of a wetland) targeted for sampling and analysis. We followed an office site evaluation procedure based on "Section 2.2 Defining an Assessment Area (AA)" in Lemly and Gilligan (2013). The CNHP protocol focuses on establishing the target wetland AAs in the field because Colorado has up-to-date mapping of wetlands in their study areas. We relied on initial office screening to increase our field efficiency because of the inherent inaccuracies of our emergent wetland data. In brief, we first generated 40-m-radius buffers around each sample point in ArcGIS and considered this area our initial potential AA. We then evaluated each potential AA for four factors using the best available digital imagery. First, we determined whether the AA contained palustrine emergent wetland. It was generally easy to distinguish emergent palustrine wetland from certain land cover types, such as open water and playa, and when the classification was less certain, we acted conservatively to keep such sites in the sample. Second, we used major breaks in hydrology, such as dikes, roads, and ditches, to determine whether the AA contained a single wetland. Third, we evaluated whether at least 80% of the AA fell into a single Ecological System. Last, we determined whether there was no more than 10% open water and 10% upland within the AA. If an AA did not meet all of these criteria, we moved the edge of the AA up to 60 m from the original sample point (so that the new AA center point would be up to 100 m from the original point). In cases where there was no appropriate location for a 40 m radius circular AA within the specified distance, we created a rectangular (preferred) or freeform AA at least 0.1 ha, but preferably 0.5 ha, in size. If it was still not possible to create an AA meeting the four criteria, the sample point was rejected.

Once sample points were screened, we determined land ownership based on county parcel data and put forth a diligent effort to contact land owners to seek permission to sample sites. The most difficult part of this effort was generally in obtaining contact information for and getting in touch with private land owners. We called unresponsive land owners at least three times, often at more than one phone number, and left at least one message in an effort to obtain permission to survey sites. We rejected all sample points where we were not able to obtain permission.

3.3 Field Methods

3.3.1 Site Screening and General AA Data Collection

Our general field approach, including plot set-up, soil and water chemistry data collection, and vegetation community enumeration, was primarily adapted from CNHP-EIA and is explained in greater detail in *Ecological Integrity Assessment for Colorado Wetlands Field Manual, Version 1.0- Review Draft* (Lemly and Gilligan, 2013). We used the same basic procedure as that detailed above for office evaluation when we needed to move AA locations in the field, though AA movement after office evaluation was rare. We took four photos at every site, usually facing the center of the AA from points directly to the north, east, south and west at the edge of the AA, but occasionally at other well-spaced locations instead. We collected data on elevation, slope, aspect, wetland origin, representativeness of AA to larger wetland, percent of AA with non-target inclusions, and wildlife encountered. We also determined the Ecological System, Cowardin classification, and hydrogeomorphic (HGM) class of each site (see Appendix F for keys to each classification). We identified the zone type, dominant species, and percent of AA occupied for major zones within each AA, generally following the guidelines of CNHP-EIA, which stipulate that each zone is a distinct physiognomic class or open water or bare ground that occupies at least 5% of the AA.

3.3.2 Soil and Water Chemistry Data

We used a sharpshooter shovel and an auger to collect soil samples at the center of the AA, whenever possible, or at another representative location in the AA if the center point was not conducive to sampling (e.g., due to deep water). Soil pits were dug to a depth of at least 50 cm and often over 70 cm in an attempt to reach the depth of the water table. We described each distinct soil horizon using the guidance of the U.S. Natural Resources Conservation Service (2010) field indicators of hydric soils in the United States and the arid regional supplement (U.S. Army Corps of Engineers, 2008). For each layer, we recorded the depth, color of matrix, and secondary features including redoximorphic concentrations (based on a Munsell Soil Color Chart), soil texture, and concentration of coarse material and roots. We also identified the presence of hydric soil indicators within the entire soil sample.

We collected water chemistry data in soil pits whenever possible and occasionally at surface water locations, either as supplementary data or because soil pit groundwater data were not possible to collect. Settling time varied depending on total AA survey time, but was generally between 30 and 240 minutes. If water was evident after the settling period, we recorded the depths to saturated soil and free water and then used a bailer to obtain a water sample from just below the surface level of water in the pit. We used low and high range HANNA waterproof combo testers to measure pH, electroconductivity (EC), and temperature of the water sample. We also obtained a value for total-dissolved-solids (TDS) based on the default meter conversion factor of 0.5 between EC and TDS. Occasionally we could not take EC/TDS measurements in one or both devices because the values were out of range for the meters. We tested meter accuracy in known EC and pH solutions and calibrated them as needed.

3.3.3 Vegetation Community and Ground Cover Data

We recorded a list of all plant species found within the AA after thoroughly searching the area for no more than one hour. For each species found, we recorded predominant height as one of six cover classes, aerial cover as one of ten cover classes, and phenology as vegetative, flowering, fruiting, or standing dead (from current year only). Plants not recorded to species in the field were collected for later identification in the office or at local herbaria.

We recorded ground cover data for each major zone within the AA as well as for the AA overall. Ground cover data collected include bare ground, litter, and water cover at different depths and with different types of vegetation cover. We also recorded litter depth, water depth, and the cover of bryophytes, lichens, algae, and various types of woody debris.

3.3.4 Rapid Assessment Metrics

We based our rapid condition assessment metrics on metrics collected by CNHP-EIA, USA-RAM, and UWAAM. We combined metrics from the three protocols into a single form organized by metric category rather than by protocol to facilitate efficient data collection in the field. We use the following categories throughout this report: Landscape Context, Hydrologic Condition, Physical Structure, Vegetation Structure, Species Composition, Habitat, and Size. We also modified metrics in order to (1) increase field efficiency by combining similar metrics from different protocols into a single metric, (2) address the fact that some metrics were designed to be evaluated across entire wetlands instead of fixed area plots, (3) establish a scale to use when evaluating metrics, and (4) better capture conditions of importance in our study region. In some cases metrics or metric options were split for ease of use in the field and then recombined for scoring purposes. Some USA-RAM metrics are formed through tabulation of stressors particular to specific features, such as stressors to the buffer or stressors to physical structure. We supplemented the USA-RAM list of stressors with additional stressors from the CNHP-EIA protocol and from stressors witnessed in the field in order to have a more complete list of stressors at sites, though we evaluated USA-RAM stressor metrics only using the USA-RAM specific stressors. For each stressor present, we recorded the extent of the evaluated area where the stressor was present as well as the degree of severity as one of three qualitative categories (low, moderate, high).

The best reference for each metric evaluated in this study is the source protocols developed for the original metric (Appendices A, B, and D). These protocols describe aspect of wetland condition captured by each metric as well as the field procedure for evaluation. Table 4 provides a crosswalk between metric name and category used in the source protocol and metric name and category that will be used in this report. It is important to note that none of the metrics evaluated in this report should be assumed to be identical to those in any of the source protocols because field personnel did not receive protocol-specific training and many metrics can be interpreted in multiple ways, though an effort was made to ascertain the original intention whenever possible. Specific details about protocol changes are described in Appendix E. Field forms used by the UGS can be found in Appendix F. The most significant changes in the protocols were:

- Assessment areas were fixed plots of 0.5 ha whenever possible, as stipulated by USA-RAM and CNHP-EIA, instead of whole wetland as used by UWAAM.
- Buffer width and condition were evaluated up to 200 m from AAs for all protocols, but scored using width thresholds specific to each protocol.
- UWAAM habitat data were evaluated within the AA and in buffer 200 m from sites in order to account for the fact that we used a fixed area and not whole wetland AA.
- EIA and UWAAM hydrologic connectivity was evaluated in buffer 200 m from sites instead of immediately adjacent to the site's edge.
- For some metrics in the UWAAM protocol, playas and areas managed for wildlife habitat objectives automatically receive the highest possible score regardless of underlying condition. We instead scored all UWAAM metrics based on the actual condition regardless of wetland type.
- The species list obtained from the vegetation community data was used to calculate most of the species composition data and some of the vegetation structure data. In some cases, limitations of percent cover and plant height classes prohibited us from calculating anything more than approximate versions of the original metrics.

3.4 Calculation of Landscape Data

We calculated a number of site and landscape variables for each site to determine landscape attributes that may be missed by field visits and evaluate the relationships between these attributes and wetland condition metrics. At the site scale, we calculated mean assessment area elevation using 1-m-resolution DEM data wherever available (http://gis.utah.gov/data/elevation-terrain-data/2011-lidar) and 10-m-resolution DEM data elsewhere (http://gis.utah.gov/data/elevation-terrain-data/10-30-meter-

Table 4. Rapid wetland condition assessment metrics collected by Utah Geological Survey and their protocol of origin. Utah Metric Name and Utah Category are names and categories that will be used throughout this report to refer to the metric. Original Metric Category and Original Metric Name are taken from Table 4 in Appendix A, Table 1 in Appendix B, and Table 1.1 in Appendix D. Metric Description briefly describes each metric as collected by Utah Geological Survey.

Utah Metric Name	Source	Original Metric Category	Original Metric Name	Metric Description
Utah Category: Landscape Context				
Percent Buffer- EIA	CNHP-EIA	Landscape Context	Buffer Extent	percent of area on the edge of AA with buffer land cover
Percent Buffer- USA-RAM	USA-RAM	Buffer	Percent of AA Having Buffer	percent of area on the edge of AA with buffer land cover
Percent Buffer- UWAAM	UWAAM	Buffer	Percent Buffer	percent of area on the edge of AA with buffer land cover
Buffer Width- EIA	CNHP-EIA	Landscape Context	Buffer Width	mean width of buffer land cover surrounding AA, evaluated up to 200 m
Buffer Width- USA-RAM	USA-RAM	Buffer	Buffer Width	mean width of buffer land cover surrounding AA, evaluated up to 100 m
Buffer Width- UWAAM	UWAAM	Buffer	Buffer Width	mean width of buffer land cover surrounding AA, evaluated up to 200 m
Buffer Condition- Vegetation[1]	CNHP-EIA	Landscape Context	Buffer Condition- Vegetation	condition of vegetation in buffer, with particular focus on nativity of species
Buffer Condition- Soil[1]	CNHP-EIA	Landscape Context	Buffer Condition- Soil	condition of soil in buffer
Buffer Condition- UWAAM	UWAAM	Buffer	Intactness	condition of vegetation and soil in buffer
Landscape Fragmentation	CNHP-EIA	Landscape Context	Landscape Fragmentation	size of unfragmented landscape within which AA is embedded, evaluated in 500 m radius area around site
Stressor Checklist- Buffer	USA-RAM	Buffer	Stress to the Buffer Zone	checklist of stressors to the buffer zone
Utah Category: Hydrologic Condition				
Water Source- EIA	CNHP-EIA	Hydrologic Condition	Water Source	forms or places of direct inputs of water into AA
Water Source- Hydrologic Alterations[2]	UWAAM	Hydrology	Water Source	degree of hydrologic alterations affecting flow
Water Source- Water Quality[2]	UWAAM	Hydrology	Water Source	naturalness and potential for water quality degradation of incoming water
Hydrologic Connectivity- EIA[3]	CNHP-EIA	Hydrologic Condition	Hydrologic Connectivity	extent to which rising waters within AA have access to adjacent areas
Hydrologic Connectivity- UWAAM[3]	UWAAM	Hydrology	Downstream Connectivity	extent to which rising waters within AA have access to adjacent areas
Upstream Connectivity[4]	UWAAM	Hydrology	Upstream Connectivity	potential value of hydrologic connectivity given the landscape context

Utah Metric Name	Source	Original Metric Category	Original Metric Name	Metric Description
Hydroperiod- EIA[5]	CNHP-EIA	Hydrologic Condition	Alterations to Hydroperiod	degree of alteration to hydroperiod
Hydroperiod- UWAAM	UWAAM	Hydrology	Hydroperiod/Stability	naturalness of hydroperiod in respect to patterns of inundation and drawdown
Aquatic Connectivity	UWAAM	Hydrology	Landscape Connectivity	percent of area within 500 m of sites with aquatic features (e.g., other wetlands, stream channels)
Turbidity/ Pollutants	CNHP-EIA	Physiochemical Condition	Turbidity/ Pollutants	visual evidence of water quality degradation at site, for sites with water present
Algal Growth	CNHP-EIA	Physiochemical Condition	Algal Growth	extent of algal growth at site, for sites with water present
Stressor Checklist- Water Quality	USA-RAM	Hydrology	Stress to Water Quality	checklist of stressors affecting water quality
Stressor Checklist- Hydroperiod	USA-RAM	Hydrology	Alterations to Hydroperiod	checklist of stressors affecting hydroperiod
Utah Category: Physical Structure				
Topographic Complexity- USA-RAM	USA-RAM	Physical Structure	Topographic Complexity	presence of macro- and micro- relief structural features within AA (e.g., animal burrows, hummocks, soil cracks)
Topographic Complexity- UWAAM	UWAAM	Structural Integrity	Structural Patch Richness	presence of macro- and micro- relief structural features within AA (e.g., animal burrows, hummocks, soil cracks)
Substrate/ Soil Disturbance	CNHP-EIA	Physiochemical Condition	Substrate/ Soil Disturbance	degree of alteration of soil within AA
Physical Alteration	UWAAM	Structural Integrity	Physical Alteration	degree of alteration to physical intactness of AA
Stressor Checklist- Substrate Alterations	USA-RAM	Physical Structure	Habitat/ Substrate Alterations	checklist of alterations to substrate in AA
Utah Category: Vegetation Structure				
Horizontal Interspersion- EIA[6]	CNHP-EIA	Vegetation Condition	Horizontal Interspersion/ Complexity	complexity of abiotic and biotic patches within AA
Horizontal Interspersion- USA-RAM[6]	USA-RAM	Physical Structure	Patch Mosaic Complexity	complexity of abiotic and biotic patches within AA
Horizontal Interspersion- UWAAM[6]	UWAAM	Structural Integrity	Horizontal Interspersion	complexity of abiotic and biotic patches within AA
Vertical Biotic Structure- USA-RAM	USA-RAM	Biological Structure	Vertical Complexity	number of plant strata (defined by functional class and height breaks) covering at least 10% of AA
Vertical Biotic Structure- UWAAM	UWAAM	Structural Integrity	Vertical Biotic Structure	number and extent of overlapping plant layers
Litter Accumulation	CNHP-EIA	Vegetation Condition	Litter Accumulation	naturalness of litter accumulation (compared to excessive or little litter)
Woody Debris[7]	CNHP-EIA	Vegetation Condition	Coarse and Fine Woody Debris	degree of woody debris input at site, if woody species are not unnaturally uncommon or absent
Woody Species[7] Regeneration	CNHP-EIA	Vegetation Condition	Regeneration of Native Woody Species	age class structure of woody species at site, if not unnaturally uncommon or absent

Utah Metric Name	Source	Original Metric Category	Original Metric Name	Metric Description
Stressor Checklist- Vegetation	USA-RAM	Biological Structure	Vegetation Disturbance	checklist of stressors to vegetation
Utah Category: Plant Species Composition				
Plant Community Complexity- USA-RAM	USA-RAM	Biological Structure	Plant Community Complexity	number of species with at ≥10% relative cover within strata (for species in strata with ≥10% cover)
Plant Community Complexity- UWAAM	UWAAM	Plant Community	Plant Layers/ Species Richness	number of plant strata present (submerged/floating and height classes) and species richness
Relative Cover Native Species	CNHP-EIA	Vegetation Condition	Relative Cover of Native Plant Species	relative percent cover of native species in AA
Absolute Cover Aggressive Species	CNHP-EIA	Vegetation Condition	Absolute Cover Aggressive Native Species	absolute cover of aggressive native species as defined by CNHP-EIA
Absolute Cover Noxious Weeds	CNHP-EIA	Vegetation Condition	Absolute Cover Noxious Weeds	absolute cover of species listed as noxious in the state of Utah
Absolute Cover Invasive Species	USA-RAM	Biological Structure	Percent Cover of Invasive Species	cover of species listed as invasive in USA-RAM protocol
Relative Cover Invasive/ Introduced Species	UWAAM	Plant Community	Vegetative Condition	representation of native, introduced, and invasive species within AA
Mean C	CNHP-EIA	Vegetation Condition	Mean C	mean coefficient of conservatism value for all species encountered at a site
Utah Category: Habitat				
Water Presence	UWAAM	Habitat	Water Presence	percent of AA with aquatic habitat features in place and functioning
Ecological Services	UWAAM	Habitat	Ecological Services	number of ecological services (primarily defined as habitat features) provided within AA
Threats	UWAAM	Habitat	Threats	presence of threats to wildlife (e.g., American bullfrog, common carp, Chytrid fungus)
Utah Category: Size[8]				
Relative Size	CNHP-EIA	Size	Relative Size	percent reduction in natural wetland size due to human modification
Absolute Size	CNHP-EIA	Size	Absolute Size	absolute size of wetland within a single Ecological System

[1] CNHP-EIA aggregates separate evaluations of soil and vegetation conditions into a single buffer condition metric.

[2] UWAAM has a single metric that considers both aspects of water source; Utah created two separate metrics and took the mean between them for the final scoring.

[3] EIA and UWAAM connectivity were recorded in the field and score identically and will be reported only once as Hydrologic Connectivity.

[4] Utah excluded this metric from evaluation because it is based on a checklist of ecological services rather than wetland condition.

[5] Utah split metric into metric for heavily managed sites and metric for more natural sites, but scores were recombined for final scoring.

[6] Interspersion was recorded and scored identically for all three protocols and will be reported only once as Interspersion.

[7] Study sites naturally lacked woody inputs and all were scored as Not Applicable for both metrics.

[8] Data not used by CNHP-EIA for site scoring and not included in this report.

elevation-models-usgs-ned). We also used monthly climate data from PRISM Climate Group (Daly and others, 2008) to calculate survey-year (2013) and 30-year-mean temperature and precipitation values at each site. We calculated 30-year means (for water years 1983 to 2012) across the water year (October 1 to September 30) instead of the calendar year because water year is a more hydrologically relevant measure. Specifically, we calculated mean and maximum water-year temperatures and mean daily precipitation, then took the mean of these values across the 30-year period of interest. We also calculated the difference between each 2013 climatic value and the corresponding 30-year-mean value to determine the degree of deviation from climate norms during our study period.

We calculated the distance between each site and the nearest Utah Pollutant Discharge Elimination System (UPDES) storm water permit holder for the following type of facilities: concentrated animal feeding operation (CAFO), publicly owned treatment works (POTW), biosolids (i.e., sewage sludge) discharger, and any discharger classified by the EPA as a major discharger (which includes facilities with the capacity to discharge more than one million gallons per day and those with EPA- or state-approved industrial pretreatment programs). Data on point source dischargers were downloaded from the EPA's Online Tracking Information System (OTIS). We also calculated distance from each site to the nearest road. We used two sources of road data for calculations. First, we obtained the Road Centerlines dataset from Utah Automated Geographic Reference Center (AGRC). Second, we obtained a dataset of dikes and roads manually digitized from aerial imagery by technicians in the Wetland Ecology Lab at Utah State University. While the latter dataset includes some dike features that are not frequently driven upon, we felt that in many ways the dikes represented a disturbance similar to roads and should be included in the analysis. We obtained data on oil and gas wells from the SGID ArcSDE connection provided through AGRC; however, the nearest active well was over 45 km from any survey site, and we therefore did not use this variable in model analysis. Mine location data were obtained from the Utah Department of Natural Resources, Division of Oil, Gas, and Mining. We calculated the distance from every site to the nearest permitted major mine (mine that creates more than five acres of surface disturbance in an incorporated area or more than 10 acres in an unincorporated area).

We calculated land cover and road density at seven different spatial scales for each site. Land cover data were obtained from the National Land Cover Database (NLCD) for the year 2006 (Fry and others, 2011), and road data were obtained by merging the road layers mentioned above. We knew from our previous effort to model landscape integrity in the region that few land use stressors occur close to Great Salt Lake wetlands. Therefore, we decided to evaluate land cover and road density one, three, and five km from each site. In addition, because we expected surrounding land use to affect wetlands in a different manner than land use confined to a wetland's watershed, we looked at these variables within buffers fully surrounding each site ("full buffers") and in buffers only in areas higher in elevation than the mean elevation of each site ("higher elevation buffers"). This latter calculation is a very coarse estimate of watershed land cover because high elevation land within a buffer can be cut off from a site by intervening low land. Nonetheless, we thought this approach would allow us to make some initial observations of the utility of full buffers versus higher elevation buffers only and inform future work that may more finely model site watersheds. Lastly, we calculated land cover and road density data in HUC12s, the finest scale of watershed delineation available in the USGS Watershed Boundary Dataset (http://nhd.usgs.gov/wbd.html). For each of our seven scales, we calculated the road density and the percent land cover in the following classes: barren, wetland, water, pasture, agriculture, and development. Each of these land cover classes is an individual cover class in NLCD, except wetland, which was obtained by adding cover in the woody and emergent herbaceous wetland classes, and development, which is the summation of four classes, open space and low to high intensity development (http://www.mrlc.gov/nlcd06_leg.php).

3.5 Data Analysis

3.5.1 Rapid Condition Assessment Scoring

We scored metrics and overall site condition using scoring procedures outlined by each protocol. However, we report metric category scores based on categories used in this report rather than the categories used in the original protocols. For CNHP-EIA, each individual metric is assigned a score between 1 and 5. Metric scores are then combined into category-specific scores using metric weighting. To calculate overall CNHP-EIA site scores, we used metric weights from Table 6 of CNHP's *Ecological Integrity Assessment for Colorado Wetlands Field Manual, Version 1.0- Review Draft* (Lemly and Gilligan, 2013) and the following category weights (L. Gilligan, CNHP, written communication, 2013): 0.2 for landscape context, 0.3 for hydrologic condition, 0.1 for physiochemical condition, and 0.4 for vegetation condition. Cut-offs between A and B, B and C, and C and D sites were, respectively, 4.5, 3.5, and 2.5.

Individual UWAAM metrics are assigned a minimum score of 1 and a maximum score between 5 and 7, depending on the specific metric. Final site scores are based on the summation of all scores minus 2 points for each threat to wildlife detected at a site. Because we did not evaluate one of the UWAAM metrics, upstream connectivity, we subtracted that metric's maximum value (6) from the overall site evaluation cut-offs so that final cut-offs between A and B, B and C, and C and D sites were, respectively, 84, 59, and 29.

The final procedure for USA-RAM scoring is currently in the process of development through analysis of data from the *National Wetland Condition Assessment* (G. Serenbetz, EPA, written communication, 2013). We used provisional scoring developed by EPA and documented in 2012 datasheets used by The Nature Conservancy in the state of Wyoming to score each USA-RAM metric (Appendix C). Individual metrics were assigned a score between 3 and 12. USA-RAM also does not have thresholds developed to evaluate overall site scores. We set preliminary thresholds that, for a site to receive a particular grade, required the site to have an overall score equivalent to receiving that grade on at least seven metrics and the grade one below that grade on the remaining five metrics. In other words, to receive an overall A, a site must have the equivalent number of points equal to seven A scores (7 x 12) and five B scores (5 x 9), or 129 points. Similarly, we used a cut-off of 93 between B and C and 57 between C and D. Development of USA-RAM scoring for Utah data will be further explored in an upcoming report on the development of URAP.

3.5.2 Rapid Assessment and Stressor Results

We summarize rapid assessment scores for each metric and lists of stressors at sites by presenting the number of sites with each score and with each stressor. We acknowledge, however, that rapid assessment metrics have not yet been verified and calibrated for our region. Verification is a general assessment of whether metrics are measuring wetland condition as intended, and calibration is the determination of the scientific validity of metrics through correlation with more intensive measures of condition (Sutula and others, 2006). Aspects of verification that must be conducted on a regional basis include determining whether metrics and statements within metrics comprehensively capture all wetland states found in the region, determining if metrics are sensitive to the disturbance gradient particular to the region, and adjusting the scaling of individual metrics based on data obtained in regional high and low quality wetlands. Calibration further refines metrics through the use of independent and more intensive wetland condition data (e.g., plant or invertebrate index of biotic integrity). Due to lack of regional metric verification and calibration, site scores presented in this report do not necessarily indicate true site condition, though they can provide a general understanding of the types of conditions present in the study area. We will also use the data to indicate which metrics may not be appropriately developed for our study region, which will inform the associated project of developing a final rapid assessment method for use in Utah. It is important to note that, due to lack of appropriate metric verification and calibration, site scores do not necessarily indicate true site condition.

Lack of adherence to the random sample frame prevents us from extrapolating our findings to the entire study area. Additionally, we refrained from conducting statistical tests of differences between, for example, impounded and unimpounded wetlands or wetlands in different HUC8 watersheds. We do, however, present information on interesting trends observed in our results in a qualitative manner in order to provide the basis for hypotheses in future research.

3.5.3 Characterization of Wetland Vegetation

Plant species that were not able to be identified in the field were pressed in newspaper, brought to the office, and dried in a drying oven set to approximately 38°C for at least 24 hours. We used a dissecting microscope, standard set of plant dissection tools, and several plant treatments to aid with identification, including *A Utah Flora* (Welsh and others, 2003), all volumes of the *Intermountain Flora* series (see introductory volume, Cronquist and others, 1972), *Vascular Plants of Northern Utah* (Shaw and others, 1989), *Field Guide to Intermountain Sedges* (Hurd and others, 1998), and *Flora of North America* (http://floranorthamerica.org). Specimens that were particularly difficult to identify were taken to Utah State University's Intermountain Herbarium for comparison with known specimens and for consultation with herbarium staff. We used species scientific names as listed in U.S. Natural Resources Conservation Service's *Plants Database* (http://plants.usda.gov). *Phragmites australis* ssp. *australis* was the one exception to the names used; *Phragmites* subspecies are not listed in the Plants Database, but are listed in the Grass Manual on the Web developed from the *Manual of Grasses for North America* (http://herbarium.usu.edu/webmanual). The subspecies *americanus* refers to the native North American genotype of *Phragmites* and the subspecies *australis* refers to the non-native European genotype. Species identification problems are detailed in Appendix G.

Plant community composition data from this study are a first step towards better understanding the distribution of wetland plant species and their relationship to different wetland and landscape conditions. We provide summary information on the distribution and abundance within our study area of common plant species and species of management concern. We also present summary values from a Floristic Quality Assessment (FQA) similar to that developed by CNHP (Lemly and Gilligan, 2013). An important aspect of the FQA method is the use of "coefficients of conservatism" (C-values). Species are each assigned a C-value between 0 and 10, with low values indicating high tolerance and high values indicating low tolerance to disturbance. The value of 0 is assigned to all non-native species. C-values from all species present at a site can then be summarized in a variety of ways to estimate site integrity. We present FQA values including species richness, mean C value across species, Floristic Quality Index (FQI) and adjusted FQI. FQI incorporates information about both degree of conservatism and species richness into a single measure so that, all else being equal, sites with more species receive a higher rating. Adjusted FQI calculates a measure of site conservatism that only slightly weights species richness and adjusts values based on nativity of species present. Values for all species and native-species-only as well as cover-weighted values were calculated for many of these attributes. See Rocchio and Crawford (2013) and Rocchio (2007) for a more in-depth discussion of FQA metrics and their specific formulae.

Ideally, C-values are developed for individual states or regions to capture the regional variability in how species respond to disturbance. However, the development of state-specific C-values requires substantial time and effort from a panel of experts and is ideally supported by qualitative field data that span the whole area of interest across a broad range of conditions. There are no C-values currently developed for the state of Utah. We instead contacted botanists and wetland scientists in surrounding states to determine which states had assigned C-values to species. We received C-value lists from Colorado (Rocchio, 2007), Montana (Jones, 2005), and Idaho (C-values used by the state of Idaho are from values developed for eastern Washington's Columbia Basin region (Rocchio and Crawford, 2013)). We assigned Utah species the mean C-value of the three states' lists. We then made sure that every non-native species, and no native species, had a C-value of 0. Seven species with a total of 13 occurrences were not assigned C-values and, of these, only one occurrence was recorded with more than 1.5% cover.

We used non-metric multidimensional scaling (NMDS) with the "vegan" package (Oksanen and others, 2013) in R 3.0.0 (R Core Development Team, 2013) to explore plant community composition data. NMDS can be used to reduce complex multivariate data, such as plant abundance values, to a few primary axes that describe most of the variation found among sites. Axes can then be overlain with vectors showing the strength (represented by vector length) and direction (represented by vector orientation) of correlation between environmental variables of interest and species composition data. We used the wrapper function metaMDS within vegan to transform and standardize data, calculate a dissimilarity matrix using Bray-Curtis distance, run NMDS multiple times with random starts to avoid local optima, and rotate the axes of the final configuration so that the variance of points was maximized on the first dimension. Plant abundance data were transformed using a Wisconsin-style double standardization where taxa are normalized to percent abundance and then abundances are normalized to the maximum for each species. Species that occurred at only one site and most species only identified to genus were dropped from analysis. We determined the appropriate number of axes to use by obtaining stress values for ten replicate NMDS runs for each number of dimensions between one and ten. We set the maximum number of random starts for each run at 500. We selected as the final number of dimensions the lowest number of axes that had a stress value ≤0.20, based on rules of thumb for the threshold of usable results (McCune and Grace, 2002).

We fit site attribute data to the species NMDS axes using the envfit function in the vegan package. We looked at site attribute data including climate and landscape data described in "Section 3.4 Calculation of Landscape Data" of this report as well as HUC8 membership, impoundment status, whether a site was located in Great Salt Lake's floodplain, and whether hydric indicators were present in the soil. We looked only at land cover data within the 3 km full buffer for the sake of simplicity. We also looked at several variables obtained from site visits, including total CNHP-EIA, USA-RAM, and UWAAM site scores as well as a site stressor score. Site stressor scores were calculated as the summation of the extent category (1 to 5) of each stressor times the severity category (except that stressors in category 3 were multiplied by 4 instead of 3). We removed hydrologic stressors recorded in the buffer stressor checklist to avoid duplication with hydrologic stressors recorded in the hydroperiod checklist. We looked at two variables related to sampling effort, including the total area of the AA and the day of the year for each survey, converted to a number between 1 (indicating the first day of sampling) and 83. We tested the strength of evidence for each site attribute variable and each species using 10000 permutations in envfit.

3.5.4 Relationships between Condition, Stressors, Vegetation, and Landscape Data

A wetland condition score ideally is calibrated to reflect the degree to which important components of a wetland have been affected by stressors and unnatural processes. Accordingly, we can evaluate the relationship between wetland condition scores and information on nearby stressors or landscape modifications in order to gauge the degree to which scores are capturing that stressor information. Wetland condition can also be affected by historic stressors that are no longer evident on the landscape and by stressors that are not readily apparent to observers. Plant community composition data can potentially provide insight into otherwise invisible processes that have affected wetlands because plant composition can be indicative of both past and on-going disturbances such as hydrological alterations, sedimentation, vegetation removal, nutrient enrichment, and physical disturbance (Rocchio and Crawford, 2013).

We conducted a preliminary analysis of the relationships between stressors and wetland condition, stressors and plant FQA metrics, and FQA metrics and wetland condition by examining Pearson correlations between variables (Stein and others, 2009). Our assumption is that stressors affect both wetland condition and wetland vegetation and that true wetland condition affects wetland vegetation, though measures of plant community composition may better capture true wetland condition if wetland condition scores are not calibrated. Correlation analysis cannot provide information about cause and effect, but can provide insight into the degree to which stressors, plant community composition, and wetland condition are interrelated. Analysis is somewhat circular, since, for example, USA-RAM wetland condition scores are heavily influenced by values on stressor checklists and plant community composition data are a component of wetland condition scores for all three protocols. Nonetheless, this preliminary analysis provides a quick check of the degree to which wetland condition scores reflect other measures of potential wetland condition and a starting point for further protocol development and calibration. Stressor scores in each subcategory (buffer, hydrologic, site-specific [site physical, vegetation, and water quality stressors], and total stressors) were calculated as the summation of the extent category (1 to 5) of each stressor times the severity category (except that stressors in category 3 were multiplied by 4 instead of 3). We looked at overall wetland condition scores from all three protocols and individual category scores for CNHP-EIA. We did not look at USA-RAM and UWAAM category scores for the sake of simplicity and because scoring within categories is not as emphasized in these protocols.

We used linear regression to model the relationship between landscape data and overall site scores from the three protocols as well as a subset of the FQA metrics. The FQA metrics we chose to model include mean C, cover-weighted mean C, adjusted cover-weighted FQI, native species richness, non-native species richness, and percent of species that are non-native. These metrics were chosen because they were frequently and strongly correlated with site condition and/or site stressor values, or because of their ease of interpretability (for richness values). We initially screened the large number of potential predictor variables using correlations between variables and response variables of interest and simple scatterplots to determine the most appropriate scale to use in regression model development. We chose one to two scales per variable, based on strength and consistency of relationships between that variable and either the site scores or the FQA metrics (i.e., we evaluated the relationship between a variable, such as percent pasture, and all FQA metrics or site scores for all three protocols, and chose the scale(s) that were most appropriate for all response metrics). We also evaluated three derived metrics: percent agriculture (as the sum of pasture and cultivated land), percent aquatic (as the sum of wetland and water), and distance to the nearest UPDES facility for the UPDES facility types for which we had calculated data.

Once we selected the appropriate scales for each variable, we next examined scatterplots between selected predictor variables and the response variables and variable histograms to determine whether variables needed to be transformed. We also looked at Pearson correlations between chosen predictor variables and determined which variables could not co-occur in the same model because of strong (≥0.70) correlation. Elevation and all of the climate variables were strongly correlated. We reduced these variables to uncorrelated axes using principal components analysis (PCA) with the function princomp in R 3.0. We used the first two axes, which captured 67% and 16% of the variance, as predictors in the landscape models. Next, we created separate linear regression models with the lm function in R 3.0 that contained all predictor variables that could co-occur (i.e., excluding those with strong correlation and those that were essentially redundant because they were either the same variable at different scales or the components of the same variable (i.e., wetland and combined aquatic). We then used the step function in R with both forward and backward selection to select subsets of variables from each model that minimized the Akaike Information Criterion (AIC). We selected as the final model the reduced model with the lowest AIC value.

In general, variable direction and strength were similar for wetland condition scores among the three protocols. We selected variables at the following scales to explore model development for wetland condition scores: combined agriculture at 1 km full buffer; barren, cultivated, water, and combined aquatic at 3 km full buffer; road density at 3 km higher elevation buffer; pasture, water, combined agriculture, development, and road density at 5 km higher elevation buffer; and wetland at 5 km full buffer. We also chose to look at the distance to the nearest UPDES site rather than distance to any individual facility type. The HUC12 scale had the strongest correlation between pasture, cultivated land, and development for some wetland condition scores. However, we chose not to use this scale because correlations were not substantially stronger and because many sites are co-located within the same HUC12.

Correlations and scatterplots showed that the examined FQA metrics differed greatly in which variable scales they were most strongly related to. We therefore selected a subset of variables to examine for each FQA metric rather than a subset of variables to examine for all FQ metrics. We then constructed models using only combinations of the subset of variables selected for each response variable. In general, more full buffer variables were selected than higher elevation buffer variables, though percent development was more frequently selected from the higher elevation buffer. Combined agriculture was generally selected at the 1 km scale, water and road at the 3 km scale, and wetland at the 5 km scale. Percent non-native species and cover weighted mean C tended to be most strongly related to variables at larger scales whereas other response variables showed more heterogeneity in the selected scales.

4.0 Results

4.1 Sites Surveyed

4.1.1 Sites Selected for Survey

We evaluated 95 sites within the floodplain sample to determine appropriateness for surveying. Of these, 2 were rejected for having large inclusions of upland or deep water, 6 were rejected because we were not able to get permission to survey, and 29 were rejected because they had no target wetland; all but 1 were rejected based on office rather than field evaluation. We surveyed 33 of the remaining 58 sites, though not strictly based on the order laid out by the GRTS sample. We visited sites out of order to (1) survey adjacent sites to increase field efficiency, (2) broaden the diversity of ownerships and landscape factors included in the sample, and (3) avoid repeatedly sampling sites completely overtaken by *Phragmites australis* ssp. *australis.*

In the additional emergent wetland sample, we rejected three sites in the SCWMA stratum due to lack of target wetland and surveyed the subsequent two oversample sites for a total of two sites in this stratum. We surveyed the first and third site within the PSGWMA stratum. None of the sites in the Hansel Valley stratum were surveyed due to their general inaccessibility and lack of clear presence of target wetland in imagery.

We surveyed seven sites that were selected manually in the field and/or in ArcGIS and then confirmed in the field. Two of these sites were at Locomotive Springs Waterfowl Management Area (LSWMA). We wanted to capture conditions in this area because it is minimally impacted by adjacent urbanization and agriculture (though heavily impacted by upslope groundwater withdrawal). Unfortunately, available spatial wetland data were grossly inaccurate in this region and thus none of the sample points that fell into this region contained target wetland. We also manually added two sites in Layton Preserve Wetland Marsh and one site each in Hansel Valley, Inland Sea Shorebird Reserve, and SCWMA. All of these sites were added to capture conditions we felt were not sampled elsewhere or to broaden the diversity of land managements included in our survey.

4.1.2 General Attributes of Surveyed Sites

We surveyed a total of 44 sites around Great Salt Lake, 37 of them selected through the GRTS sample frame. Twenty-eight of the sample frame site locations were moved in the office in order to meet the AA criteria. Surveyed sites included 33 40-m-radius circular plots, 7 freeform plots, and 4 rectangular plots. All of the circular plots had an area of 5027 m^2, the freeform plots ranged in area from 1744 to 3943 m^2, and the rectangular plots ranged in area from 4386 to 5656 m^2.

The majority of sampled sites were on land managed for waterfowl protection and hunting opportunities, including privately owned duck hunting clubs, state-owned waterfowl management areas, and a federally owned bird refuge (Table 3). Surveys were fairly evenly distributed between impounded and unimpounded sites and were conducted in four HUC8 watersheds (Table 5, Figure 3). No sites were surveyed in the Rush-Tooele Valley HUC8 though wetlands in this watershed were included in the sample frame.

Table 5. Surveyed sites by impoundment status and watershed membership. Watershed units are based on HUC8 watersheds, with the Lower Bear- Malad HUC8 abbreviated to Lower Bear and divided into two categories to designate sites within and outside Great Salt Lake's floodplain.

Watershed Unit	Unimpounded	Impounded	Total
Curlew Valley[1]	2	1	**3**
Jordan	1	7	**8**
Lower Bear floodplain	8	4	**12**
Lower Bear outside floodplain	4	1	**5**
Lower Weber[2]	8	8	**16**
Total	**23**	**21**	**44**

[1]Includes one site outside and two sites inside Great Salt Lake's floodplain.

[2]Includes two sites in the Great Salt Lake HUC8 that are immediately adjacent to the Lower Weber watershed boundary.

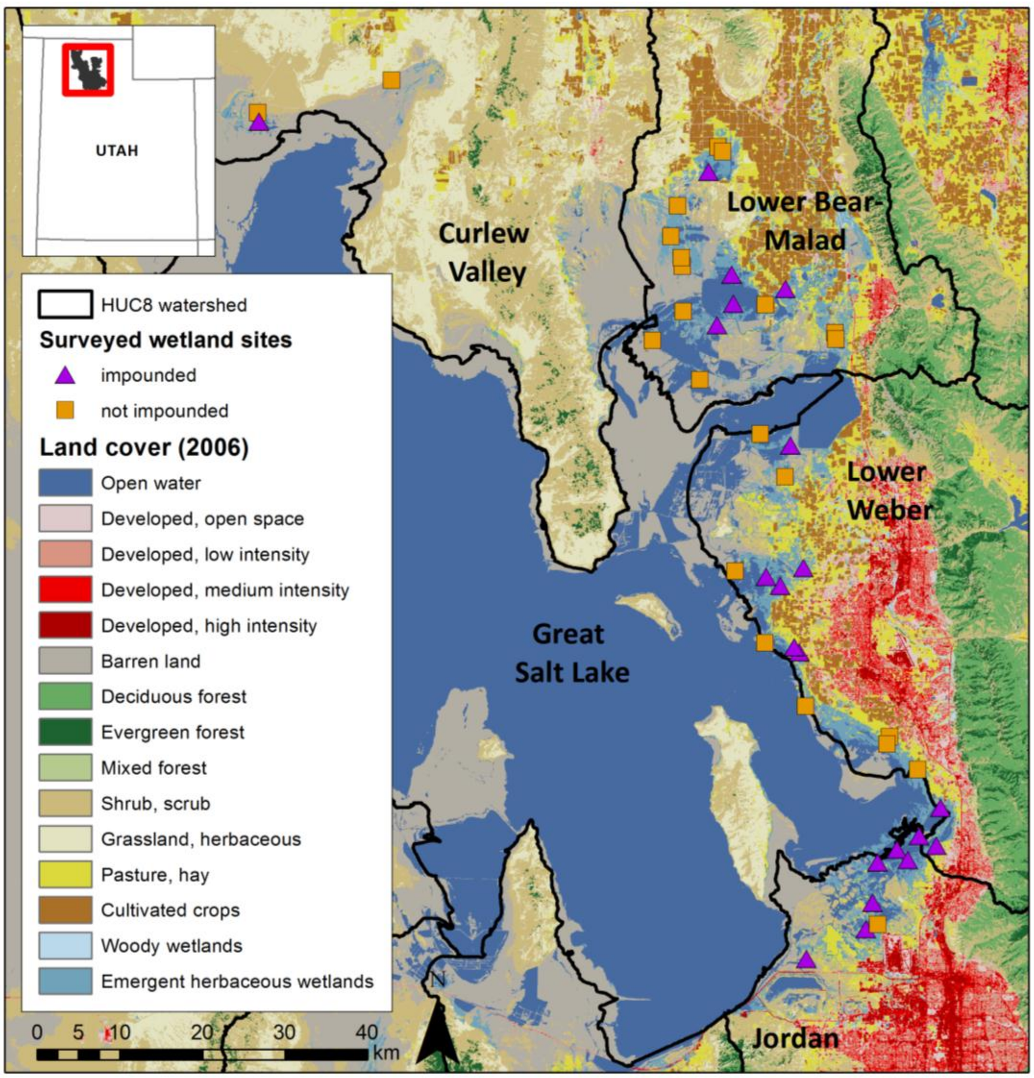

Figure 3. Surveyed wetland sites by impoundment status with associated HUC8 watersheds and land cover. Land cover data are from the 2006 National Land Cover Database (Fry and others, 2011).

Soil samples from soil pits in 34 sites had hydric soil indicators, with depleted matrix (n=21) and hydrogen sulfide odor (n=17) the most common indicators present (Figure 4). Unimpounded sites overall appeared to be drier than impounded sites based on frequency of hydric soil indicators (Figure 4) and the fact that 57% of unimpounded sites had no free water present in soil pits versus only 10% of impounded sites. However, three sites had water present in a soil pit but no hydric soil indicators, and eight sites had no water present but at least one hydric soil indicator. This data serves as a reminder that hydrologic information collected at a single point in space and time has only a limited ability to provide information about typical site conditions.

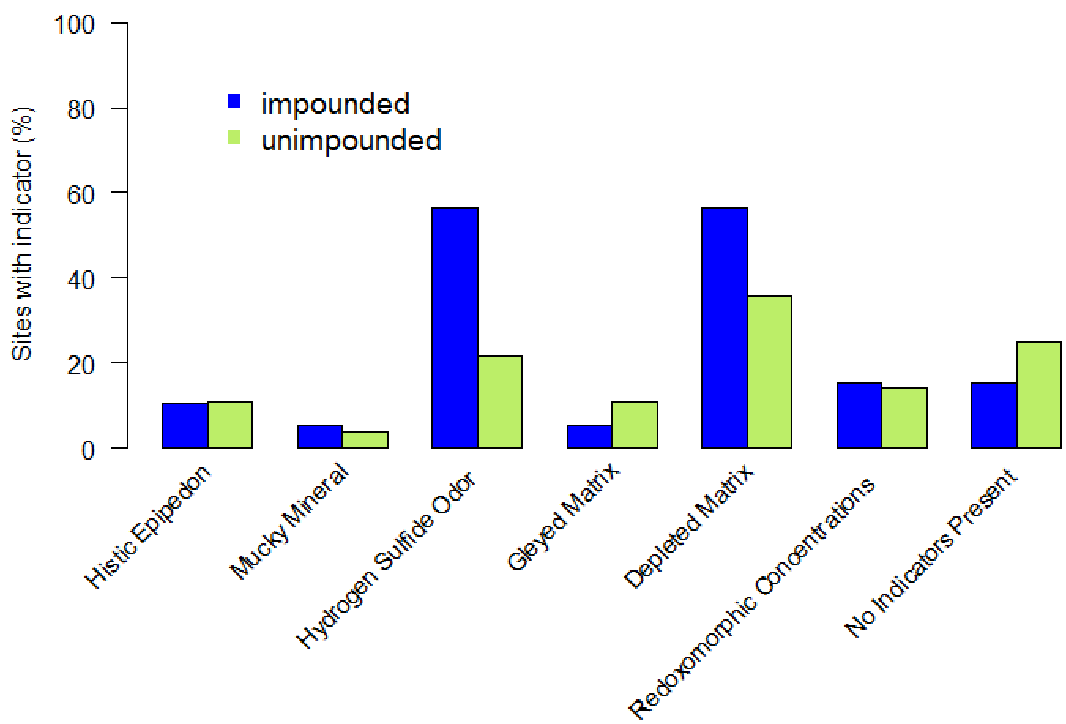

Figure 4. Proportion of soil samples with hydric soil indicators present, by site impoundment status. Study included 21 impounded and 23 unimpounded sites.

4.2 Rapid Assessment Results

As stated in the methods, it is important to note that the following discussion of site rapid condition scores is based on metrics that are not fully developed and calibrated for the study area. In many cases, site scores are indicative of site condition, but some metrics may require further refinement in order to accurately capture wetland condition.

Every site received an A score for the percent of the site surrounded by buffer land, and only one site received a score lower than A- for mean buffer width (Table 6). Sites were generally surrounded by large complexes of wetlands, which are considered buffering landscape unless they are divided by roads or dikes that are frequently driven upon. There was more variability in site scores for the Landscape Fragmentation metric, which is evaluated in a larger buffer, with 21 sites receiving a score of B or below. Condition of buffer vegetation was almost evenly divided between grades and primarily driven by the distribution of *Phragmites australis* ssp. *australis* on the landscape, whereas condition of buffer soil was generally higher. The majority of sites had a grade of C or D for the buffer stressor checklist due in large part to the high number of hydrologic stressors on the landscape.

Table 6. Number of sites by score (converted to a letter grade) for each rapid condition assessment metric in the Landscape Context category for 44 sites on the eastern shore of Great Salt Lake.

Protocol	Metric Name	A	A-	B	C	D
CNHP-EIA	Percent Buffer- EIA	44	*NA*	0	0	0
USA-RAM	Percent Buffer- USA-RAM	44	*NA*	0	0	0
UWAAM	Percent Buffer- UWAAM	44	*NA*	0	0	0
CNHP-EIA	Buffer Width- EIA	29	14	1	0	0
USA-RAM	Buffer Width- USA-RAM	44	*NA*	0	0	0
UWAAM	Buffer Width- UWAAM	44	*NA*	0	0	0
CNHP-EIA	Buffer Condition- Vegetation	12	*NA*	10	10	12
CNHP-EIA	Buffer Condition- Soil	29	*NA*	13	2	0
UWAAM	Buffer Condition- UWAAM	11	*NA*	15	18	0
CNHP-EIA	Landscape Fragmentation	23	*NA*	10	10	1
USA-RAM	Stressor Checklist- Buffer	12	*NA*	6	12	14

In the Hydrologic Condition category, sites almost always scored A or B for Aquatic Connectivity, Turbidity/Pollutants, Algal Growth, and both stressor checklists (Table 7). We found a broader range of scores for Water Source, both hydroperiod measures, and Hydrologic Connectivity. The majority of sites received a score of C or below for these metrics, excluding Hydrologic Connectivity. Hydroperiod and Water Source metrics were difficult to assess in the field because they rely on assessment of natural conditions, which have not been present in much of the study area for over 100 years, as well as interpretation of management practices, which are difficult to ascertain in the field.

Table 7. Number of sites by score (converted to a letter grade) for each rapid condition assessment metric in the Hydrologic Condition category for 44 sites on the eastern shore of Great Salt Lake.

Protocol	Metric Name	A	B	C	C-	D
CNHP-EIA	Water Source- EIA	9	1	33	1	0
CNHP-EIA/UWAAM	Hydrologic Connectivity	22	9	12	*NA*	1
CNHP-EIA	Hydroperiod- EIA	5	6	11	20	2
UWAAM	Hydroperiod- UWAAM	6	12	10	*NA*	16
UWAAM	Aquatic Connectivity	43	1	0	*NA*	0
EIA	Turbidity/ Pollutants[1]	18	4	1	*NA*	0
EIA	Algal Growth[1]	14	4	5	*NA*	0
USA-RAM	Stressor Checklist- Hydroperiod	40	3	1	*NA*	0
USA-RAM	Stressor Checklist- Water Quality	28	15	1	*NA*	0

[1]Only recorded at sites with surface water present.

Sites scored poorly in several of the metrics related to physical and vegetation structure, including topographic complexity, horizontal interspersion, and vertical biotic structure (Table 8). Low scores were driven in part by (1) UWAAM scoring applied to fixed-area AAs rather than whole wetland as intended, and (2) lack of appropriate calibration of metrics to our study area. Other metrics related to structure indicate that the majority of sites have intact soil and are not impacted by stressors to substrate or vegetation. Sites generally scored A or B in metrics in the Habitat category, though 9 sites received a D for Water Presence. Threats to wildlife recorded within 500 m of sites included American bullfrog (*Lithobates catesbeianus* , n=1), common carp (*Cyprinus carpio*, n=7), and mammalian predators (n=4). Actual threats present were probably more common but not observed during field surveys.

Table 8. Number of sites by score (converted to a letter grade) for each rapid condition assessment metric in the Physical Structure, Vegetation Structure, and Habitat categories for 44 sites on the eastern shore of Great Salt Lake.

Protocol	Metric Name	A	B	C	D
Physical Structure					
USA-RAM	Topographic Complexity- USA-RAM	0	0	8	36
UWAAM	Topographic Complexity- UWAAM	0	0	2	42
CNHP-EIA	Substrate/ Soil Disturbance	32	7	5	0
UWAAM	Physical Alteration	27	7	9	1
USA-RAM	Stressor Checklist- Substrate Alterations	34	9	1	0
Vegetation Structure					
all three	Horizontal Interspersion	1	11	21	11
USA-RAM	Vertical Biotic Structure- USA-RAM	0	0	16	28
UWAAM	Vertical Biotic Structure- UWAAM	1	15	8	20
CNHP-EIA	Litter Accumulation	33	0	6	5
USA-RAM	Stressor Checklist- Vegetation	35	8	0	1
Habitat					
UWAAM	Water Presence	25	3	7	9
UWAAM	Ecological Services	17	26	1	0
UWAAM	Threats	34	8	2	0

Scores in the Species Composition category varied among metrics even for those metrics that were similar to one another (Table 9). For example, most sites were scored A for Absolute Cover Noxious Weeds and A or B for Absolute Cover Invasive Species, but were almost equally divided between the four grades for Relative Cover Invasive/Introduced Species. Differences in scores were driven by the exact species considered for each metric and metric-specific thresholds used for distinguishing between grades. Sites generally scored poorly for plant community complexity metrics and Mean C, and scores for Relative Cover Native Species and Absolute Cover Aggressive Species were well distributed across all possible grades.

All sites received an overall USA-RAM grade of B except three impounded sites that each received a C. Thresholds used for dividing USA-RAM into grades are very preliminary; however, boxplots of site scores also show that USA-RAM had the smallest range of scores of the three protocols tested (Figure 5). While the majority of sites received B or C grades under CNHP-EIA, two unimpounded sites scored A and two impounded sites scored D. Curlew Valley sites tended to receive the highest scores whereas Jordan sites scored the lowest (Table 10). Unimpounded sites and sites outside Great Salt Lake's floodplain also tended to have higher overall site scores (Figure 6). Over three-quarters of sites received a B in the UWAAM protocol and the remaining all received a C (Table 10). Similarly to CNHP-EIA, sites in Curlew Valley received higher scores than sites in other watersheds, but other differences between sites based on watershed, impoundment status, and floodplain location were minimal (Figure 7). Differences in USA-RAM scores between watersheds, impoundment status, and floodplain location were smaller than for the other protocols and are not presented. Pearson correlations were significant (≤0.05) among overall site scores for all three protocols, with CNHP-EIA and UWAAM the most related (correlation coefficient 0.65), followed by CNHP-EIA and USA-RAM (0.49) and then USA-RAM and UWAAM (0.39).

Table 9. Number of sites by score (converted to a letter grade) for each rapid condition assessment metric in the Plant Species Composition category for 44 sites on the eastern shore of Great Salt Lake.

Protocol	Metric Name	A	B	C	C-	D
USA-RAM	Plant Community Complexity- USA-RAM	0	0	17	*NA*	27
UWAAM	Plant Community Complexity- UWAAM[1]	16	*NA*	28	*NA*	*NA*
CNHP-EIA	Relative Cover Native Species	7	7	9	7	14
CNHP-EIA	Absolute Cover Aggressive Species	17	7	7	*NA*	13
CNHP-EIA	Absolute Cover Noxious Weeds	31	12	1	*NA*	0
USA-RAM	Absolute Cover Invasive Species	19	24	1	*NA*	0
UWAAM	Relative Cover Invasive/ Introduced Species	11	9	10	*NA*	14
CNHP-EIA	Mean C	0	1	8	17	18

[1]Sites are given one of only two possible scores for this metric.

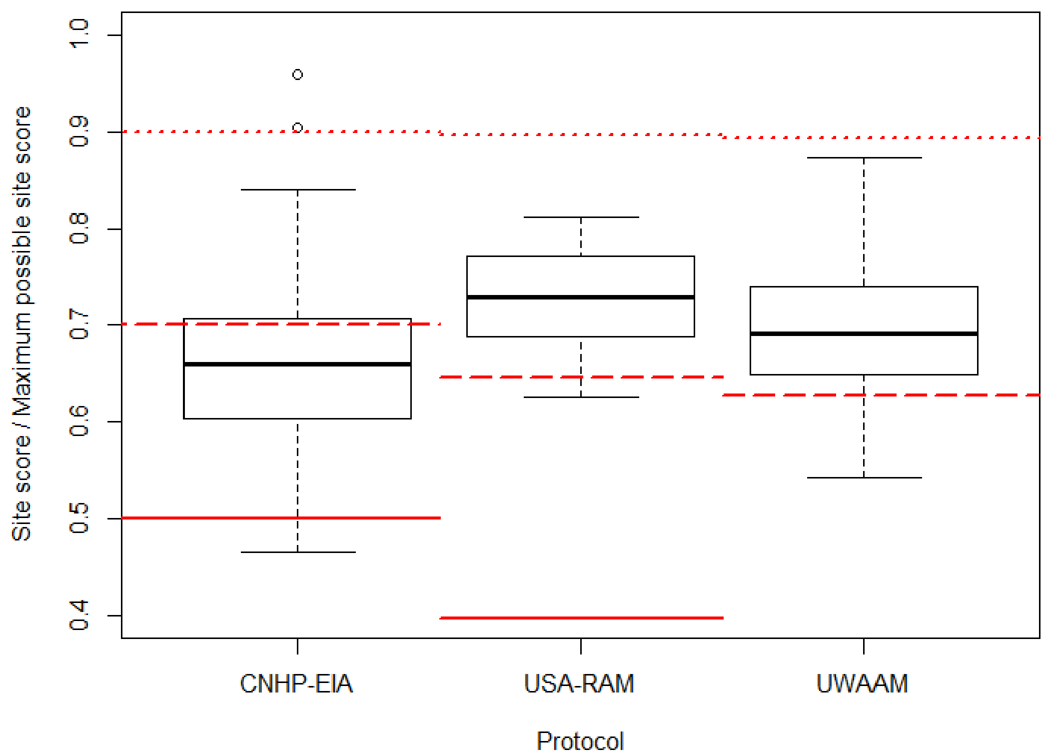

Figure 5. Overall site wetland condition scores, shown as site score divided by maximum possible site score, by rapid assessment protocol. Values used as thresholds between A and B, B and C, and C and D scores for each protocol are shown by the dotted, dashed, and solid red lines, respectively. The C and D cut-off for UWAAM is below the scale of the y-axis and therefore not shown.

Table 10. Proportion of sites within each HUC8 watershed receiving each overall site score (converted to a letter grade) for CNHP-EIA and UWAAM rapid condition assessment protocols.

Watershed/ Grade	**A**	**B**	**C**	**D**	**# Sites**
CNHP-EIA					
Curlew Valley	0.33	0.67	0	0	**3**
Jordan	0	0	0.88	0.13	**8**
Lower Bear- Malad	0.06	0.29	0.65	0	**17**
Lower Weber	0	0.13	0.81	0.06	**16**
Total CNHP-EIA	0.05	0.20	0.70	0.05	**44**
UWAAM					
Curlew Valley	0	1	0	0	**3**
Jordan	0	0.63	0.38	0	**8**
Lower Bear- Malad	0	0.82	0.18	0	**17**
Lower Weber	0	0.75	0.25	0	**16**
Total UWAAM	0	0.77	0.23	0	**44**

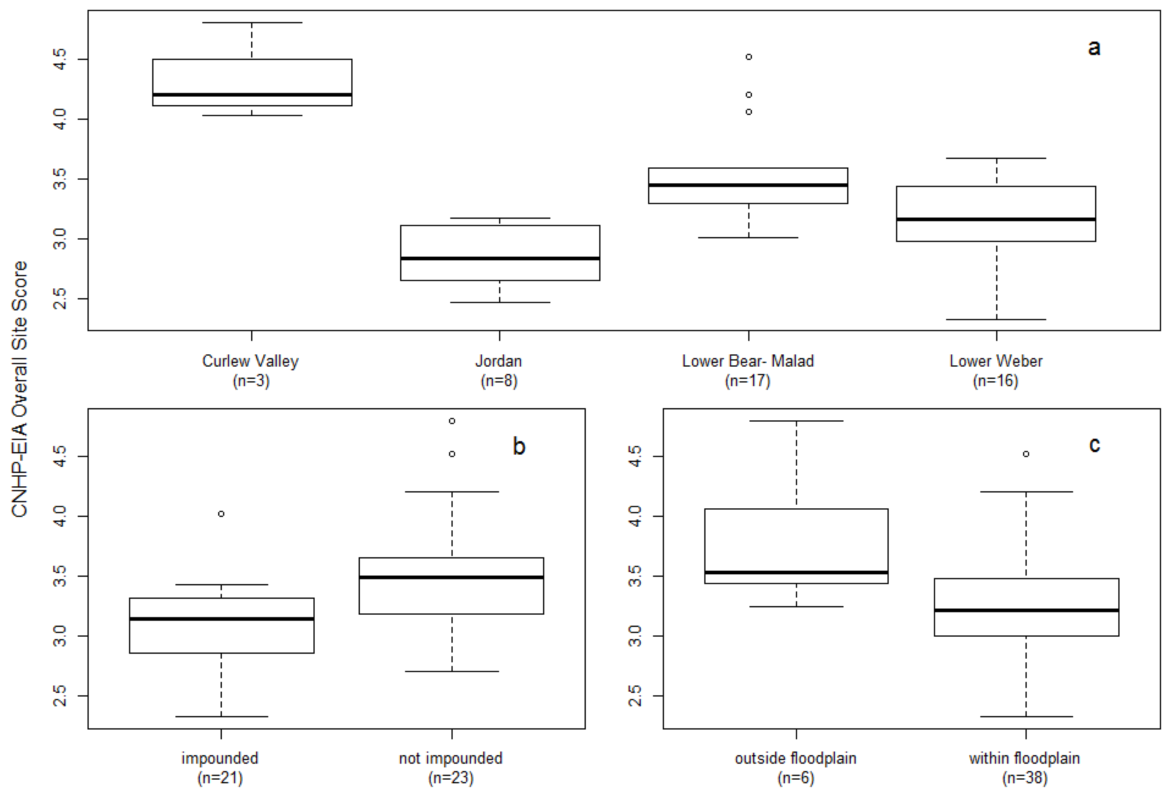

Figure 6. Boxplots of overall site scores calculated from CNHP-EIA protocol and HUC8 watershed (a), impoundment status (b), and location in respect to Great Salt Lake's floodplain (c).

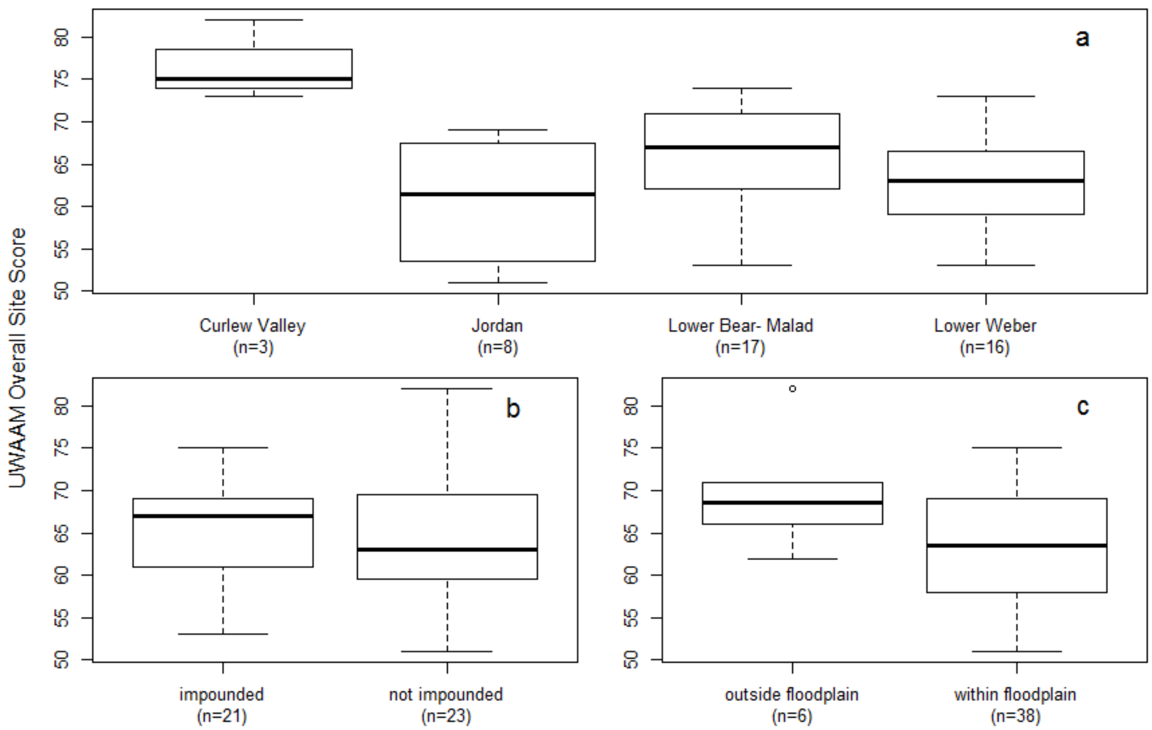

Figure 7. Boxplots of overall site scores calculated from UWAAM protocol and HUC8 watershed (a), impoundment status (b), and location in respect to Great Salt Lake's floodplain (c).

4.3 Stressors on the Landscape

4.3.1 Stressors Recorded in the Field

At least one stressor was recorded in each site's surrounding 200 m buffer; the mean number of stressors was 4.6 and the range was 1 to 12. Hydrologic modifications, including dikes and ditches, and cover of non-native species were common and among the most severe stressors recorded (Table 11). Other common stressors included filamentous algae cover, vegetated dikes, gravel roads, trash, and pugging from grazing. Stressors related to site management other than management of hydrology included managed grazing (n=2), chemical vegetation control (n=3), burning (n=4), and mowing (n=2). These management strategies may be more prevalent than recorded, but are not always readily observable during field surveys. We also recorded the presence (though not the extent and severity) of hydroperiod stressors in a 500 m area surrounding each site. Unimpounded sites tended to have stressors related to drying conditions, such as upslope dikes and encroachment of upland plants whereas impounded sites had stressors related to both increases and decreases in water quantity (Figure 8).

We recorded stressors present directly in the AA in four categories: hydroperiod, water quality, vegetation, and physical structure. Twelve sites had no stressors recorded in any of these four categories, and no sites had stressors in all four categories present. Hydroperiod stressors were the least common within the AA (Table 12), though, as noted above, very common and often severe in the surrounding landscape. Heavy algal or *Lemna* spp. (duckweed) surface mats and trampling or wallowing by domesticated animals were both found at over a quarter of the sites, whereas other stressors were less common.

Table 11. Stressors present in the 200 m buffer around wetland assessment sites, with the degree of severity and extent of area covered by the stressor

Stressor	Extent	≤10%			>10 - 50%			>50 - 100%			Total
	Severity	Low	Mod.	High	Low	Mod.	High	Low	Mod.	High	
Hydrologic Stressor											
Dikes, dams, levees, road beds		0	4	16	0	0	0	0	0	0	20
Ditches, drains, channelization		1	9	9	0	0	0	0	0	0	19
Water level control structure		1	3	5	0	0	0	0	0	0	9
Formation of filamentous algae		1	5	0	0	4	0	0	0	1	11
Sediment input		0	0	0	1	0	0	0	0	0	1
Development and Human Use											
Road – gravel		7	2	0	0	0	0	0	0	0	9
Road – 1 or 2 lane paved		0	1	0	0	0	0	0	0	0	1
Power lines or utility corridors		2	0	0	0	0	0	0	0	0	2
Substrate disturbance (vegetated levees, ATVS)		19	0	0	5	1	0	1	0	0	26
Trails		1	0	0	0	0	0	0	0	0	1
Trash/ dumping		15	0	0	0	0	0	0	0	0	15
Agriculture and Grazing											
Pasture / rangeland		1	1	0	2	1	0	0	2	0	7
Managed grazing		0	0	0	2	0	0	0	0	0	2
Heavily grazed grasses		1	0	0	2	3	0	0	1	1	8
Trampling, pugging from grazing		3	0	0	4	3	0	3	4	0	17
Irrigation (irrigated land)		0	1	0	0	0	0	0	0	1	2
Agriculture- small grains		1	0	0	0	0	0	0	0	0	1
Other Stressors											
Soil subsidence, surface erosion		1	1	0	0	1	0	0	0	0	3
Cover of non-native species		2	4	2	1	6	9	3	6	5	38
Chemical vegetation control		2	0	0	0	1	0	0	0	0	3
Recently burned grassland		0	0	0	0	2	0	2	0	0	4
Mowing		1	0	0	0	0	1	0	0	0	2
Other mechanical plant removal		0	0	0	0	0	0	0	1	0	1
	Total	59	31	32	17	22	10	9	14	8	202

4.3.2 Stressors Determined in Landscape Model

Site elevations ranged from 1281 to 1298 m, and have a mean of 1285 m (Table 13). Sites were generally far from UPDES discharge points and mines (mean ≥ 8 km) and much closer to roads; almost 80% of sites are within 1 km of a road and none are more than 2 km from a road. At smaller scales, sites were generally surrounded by water, wetland, and barren land cover. These land cover types still dominated at larger scales, but agriculture and development become more common. Agriculture and development were more prevalent when looking at the higher elevation buffers rather than full buffers. For example, mean percent development was 5.9% and 10.5% and mean percent cultivated crops was 6.0% and 10.5% in the full and higher elevation buffers at 5 km, respectively. Conversely, percent water and barren was lower in the higher elevation buffer, and percent wetland was similar between buffer types.

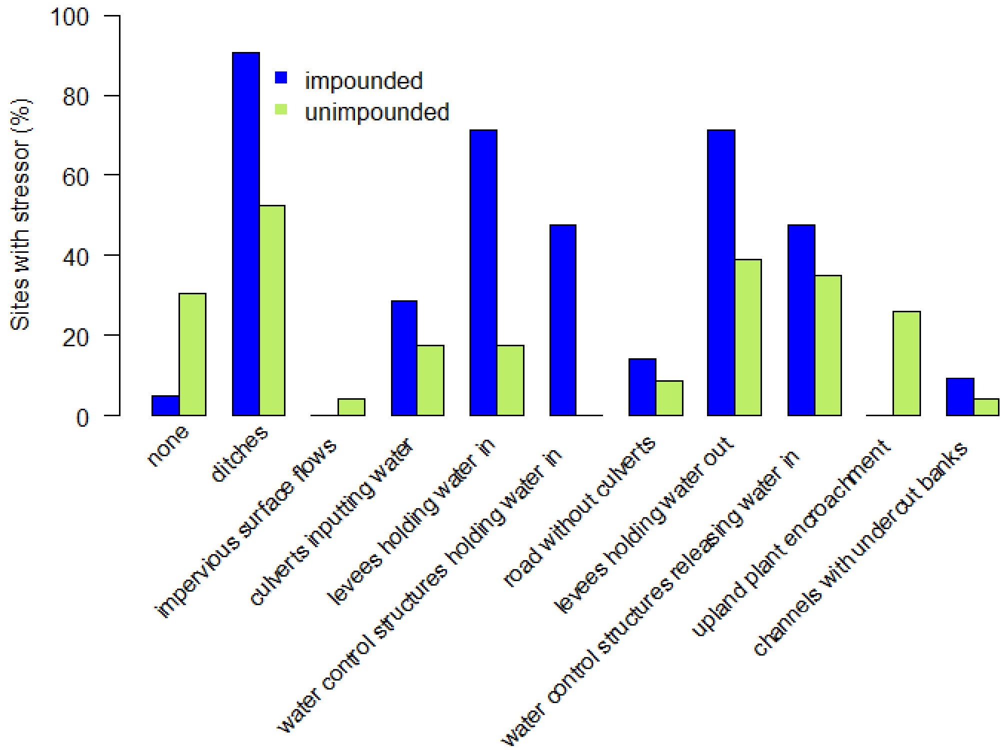

Figure 8. Proportion of impounded and unimpounded sites with hydroperiod stressors present within 500 m. Study included 21 impounded and 23 unimpounded sites.

Table 12. Stressors present within AA and their associated severity (low, medium, and high). Number following each stressor category indicates the number of sites with at least one stressor recorded in the indicated category.

Stressor/ Stressor Severity	Low	Mod.	High	Total
***Water Quality* (n=23)**				
Debris lines on plants, trees or silt-laden vegetation	5	1	0	6
Turbidity in the water column	1	2	0	3
Formation of heavy algal or *Lemna* surface mats	2	7	6	15
Obvious increases in dissolved salts	3	0	0	3
***Hydroperiod* (n=8)**				
Berms, dikes, levees that block flow into or through AA	1	1	0	2
Berms, dikes, levees that hold water in the wetland	0	1	0	1
Channels with deeply undercut banks or bank slumps	0	1	0	1
Upland plant species encroaching	4	2	0	6
***Vegetation* (n=17)**				
Mowing	0	0	1	1
Chemical vegetation control	0	0	1	1
Recreation/human visitation	7	0	0	7
Grazing by domestic or feral animals	2	4	1	7
Evidence of intentional burning	2	2	0	4
***Physical* (n=17)**				
Soil subsidence, scour or surface erosion	3	1	0	4
Off-road vehicles, mountain biking, trails cut, etc.	2	1	0	3
Trampling, wallowing by domesticated/ feral animals	4	8	0	12
Soil compaction by human activity (parking by cars, etc.)	3	0	0	3
Dumping of garbage or other debris	1	0	0	1
Total	40	31	9	80

Table 13. Summary of landscape data associated with surveyed wetland sites around Great Salt Lake. Road density and land cover data are summarized from 1 km and 5 km buffers that extend around the entire assessment area (i.e., *full*). More information about the sources of landscape data can be found in the methods section under "Section 3.4 Calculation of Landscape Data."

Site variable	**Mean**	**SD**		
Mean site elevation (m)	1284.7	3.9		
Distance to nearest POTW (m)	18,787.8	13,964.3		
Distance to nearest CAFO (m)	18,592.9	14,574.9		
Distance to nearest biosolid site (m)	13,490.2	13,784.0		
Distance to nearest major UPDES site (m)	11,925.4	9238.7		
Distance to nearest UPDES site (m)	8198.3	8424.2		
Distance to nearest road (m)	618.7	547.9		
Distance to nearest mine (m)	11,210.8	5405.2		
Landscape Variable	**1 km full**		**5 km full**	
	Mean	**SD**	**Mean**	**SD**
Road density (m/km^2)	839	875	1260	1049
% Barren	13	16	17	17
% Cultivated	1	5	6	9
% Pasture	8	12	11	9
% Agriculture (cultivated + pasture)	9	13	17	16
% Water	27	23	26	18
% Wetland	43	21	22	9
% All aquatic (water + wetland)	70	21	48	19
% Development	1	2	6	8
Climate Variable	**Water year 2013**		**Mean 30-year water year**	
	Mean	**SD**	**Mean**	**SD**
Maximum site temperature (°C)	34.1	0.3	33.3	0.4
Mean site temperature (°C)	10.7	1.1	10.7	0.8
Mean site precipitation (cm)[1]	35.0	5.8	41.9	4.7

[1]Based on 365 days/year

4.4 Wetland Vegetation

We recorded 451 encounters with 82 unique plant species, including 32 species found only at one site. We were not able to identify to species 55 of the plants we encountered, including 47 identified to genus only and 8 not identified. Unidentified species were generally not found in fruit or flower and were commonly members of the Asteraceae and Chenopodiaceae families, two plant families that frequently flower from late summer to early fall. Number of species recorded per site ranged from 3 to 28, and the mean was 11.4 species. Fourteen species were found at least at one-quarter of all sites (Table 14). Species including *Distichlis spicata* (saltgrass), *Typha* spp. (cattail), *Phragmites australis* ssp. *australis* (common reed), *Schoenoplectus americanus* (chairmaker's bulrush), and *Lemna minor* (common duckweed) were both common and abundant where found, whereas other common species had less than 6.5% cover. Seven species of concern were detected during field surveys, including two species on Utah's noxious weed list (Table 15).

FQA values were very similar between impounded and unimpounded sites, with almost identical mean values for most of the metrics. For example, both types of sites had native richness of 7, non-

Table 14. Plant species found at ≥25% of surveyed wetland sites with number of sites, mean cover where detected, and plant characteristics. Wetland indicator status is taken from the U.S. Army Corps of Engineers National Wetland Plant List.

Scientific Name (Common Name)	Nativity	C-Value	Wetland Indicator Status	# Sites	Mean Cover (%)
Distichlis spicata (saltgrass)	Native	4	FAC	33	17.7
Typha spp.[1] (cattail)	Native	2	OBL	32	11.0
Phragmites australis ssp. *australis* (common reed)	Introduced	0	FACW	31	25.8
Schoenoplectus maritimus(cosmopolitan bulrush)	Native	6	OBL	28	5.2
Polypogon monspeliensis (annual rabbitsfood grass)	Introduced	0	FACW	26	1.6
Hordeum jubatum(foxtail barley)	Native	2	FAC	25	2.4
Schoenoplectus americanus (chairmaker's bulrush)	Native	4	OBL	21	19.1
Salicornia rubra (red swampfire)	Native	5	OBL	17	1.8
Schoenoplectus acutus (hardstem bulrush)	Native	4	OBL	15	6.2
Chenopodium rubrum (red goosefoot)	Native	3	FACW	15	0.6
Lepidium latifolium (broadleaved pepperweed)	Introduced	0	FAC	11	1.1
Polygonum ramosissimum (bushy knotweed)	Native	1	FAC	11	0.7
Rumex stenophyllus (narrowleaf dock)	Introduced	0	FACW	11	3.9
Lemna minor (common duckweed)	Native	2	OBL	11	20.3

[1]Includes *Typha domingensis* (southern cattail), *Typha latifolia* (broadleaf cattail), and *Typha* specimen that were not identified to species. Nativity, C-Value, and Wetland Indicator Status for all *Typha* species known from the study area are the same and thus are reported even when individuals were not identified to species.

Table 15. Plant species of concern detected during wetland field surveys, with number of sites and mean cover where detected. Species of concern include those on state noxious species lists for Utah (UT) or surrounding states, including Arizona (AZ), Colorado (CO), Idaho (ID), Nevada (NV), and Wyoming (WY), and/or species specifically listed in CNHP-EIA or USA-RAM protocols as species of concern. State listings are followed by state-specific designation, if available.

Scientific Name **Common Name**	**Species Status**	**# Sites**	**Mean Cover (%)**
Bromus tectorum cheatgrass	**States:** CO List C **Protocols:** USA-RAM	1	0.5
Cirsium vulgare Bull thistle	**States:** AZ prohibited, CO List B, ID contain, NV, WY **Protocols:** None	2	0.3
Dipsacus fullonum Fuller's teasel	**States:** CO List B **Protocols:** None	1	0.5
Lepidium latifolium Broadleaved pepperweed	**States:** CO List B, ID contain, UT List B, NV, WY **Protocols:** USA-RAM	11	1.1
Phragmites australis ssp. *australis* Common reed	**States:** None **Protocols**: CNHP-EIA, USA-RAM	31	25.8
Tamarix species[1] Tamarisk	**States:** CO List B, ID contain, NV, UT List C, WY **Protocols:** USA-RAM	4	0.4
Typha species cattail	**States:** None **Protocols:** CNHP-EIA	32	11.0

[1]Utah lists only *Tamarix ramosissimum* (saltcedar), Colorado lists three separate species, and all other lists apply to all species in the genus.

native richness of ~3.6, and Mean C for native species of 3.6. Differences in FQA values between HUC8 watershed were more pronounced, with, in general, Curlew Valley having the best scores and Weber having the worst (Table 16). Jordan and Lower Bear tended to have relatively better scores for FQA metrics calculated only for native species and relatively worse scores for metrics that incorporated all species.

Table 16. Floristic Quality Assessment (FQA) metrics mean and standard deviation (sd) by HUC8 watershed for wetland sites surveyed around Great Salt Lake.

	Curlew Valley (n=3)		Jordan (n=8)		Lower Bear (n=17)		Weber (n=16)	
FQA Variable	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Total Species Richness	8.0	4.4	13.9	4.7	12.3	5.8	9.9	7.0
Native Species Richness	6.7	2.1	8.6	2.7	6.9	3.0	6.8	4.8
Non-native Species Richness	0.7	1.2	4.6	2.3	4.2	3.1	2.6	2.9
Percent Non-Native Species	6.1	10.5	33.7	10.5	32.4	19.0	28.6	12.9
Mean C of all Species	3.7	0.9	2.4	0.5	2.4	0.9	2.4	0.8
Mean C of Native Species	3.9	0.5	3.6	0.3	3.6	0.7	3.4	0.7
Cover-weighed Mean C, all species	4.0	0.1	1.6	1.0	3.3	1.4	1.6	1.1
Cover-weighed Mean C, native species	4.0	0.1	3.4	0.8	4.1	0.7	3.0	0.9
FQI of all species	8.5	0.9	8.2	1.4	7.4	1.8	6.8	3.4
FQI of native species	8.8	1.3	10.2	1.6	9.2	1.9	8.1	3.5
Cover-weighted FQI, all species	9.8	3.1	5.0	2.4	10.4	4.9	5.1	4.3
Cover-weighted FQI , native species	9.4	2.5	9.5	2.5	10.3	2.3	7.0	3.2
Adjusted FQI	37.8	6.9	29.1	4.0	29.5	7.2	28.5	7.4
Adjusted cover-weighted FQI	39.1	2.6	27.2	7.2	33.0	6.6	25.0	8.0

The optimal NMDS solution consisted of three axes and had a stress value of 0.17 (Appendix H, Figure H-1). Strong evidence exists for the relationship between the axes and twenty-three of the 53 species based on permutation testing (Appendix H, Table H-1). Elevation, all climatic data, distance from UPDES facilities, HUC8 watershed membership, position within Great Salt Lake's floodplain, and percent water, development, pasture, agricultural, and barren land cover all exhibited strong relationships with plant community composition (Appendix H, Table H-2). CNHP-EIA and UWAAM overall site scores and summary value of stressors recorded in the field also exhibited a strong relationship with plant community composition.

To facilitate visualization of sites, plant community composition, and site attributes, we plotted each axis versus every other axis rather than try to interpret a 3-dimensional plot (Figures 9 to 11). On the plot of the first two axes, *Phragmites australis* spp. *australis* (common reed) clusters with sites surrounded by more water that are predominantly in the Weber HUC8. *Distichlis spicata* (saltgrass) is associated with sites further from UPDES facilities with more barren land and higher overall wetland condition scores. Two introduced species, *Lactuca serriola* (prickly lettuce) and *Lepidium latifolium* (broadleaved pepperweed), are associated with higher elevation sites predominantly in the Lower Bear-Malad HUC8. The remaining indicator species cluster close to one another at sites with more stressors, cultivated crops, and pasture. In the plot of the first and third axes, hotter, wetter sites with more stressors are more associated with *Phragmites australis* spp. *australis*, whereas sites with *Distichlis spicata* are associated with the Lower Bear-Malad HUC8. The plot of the second and third axes shows the least distinction between HUC8 watersheds. *Schoenoplectus americanus* (chairmaker's bulrush) is

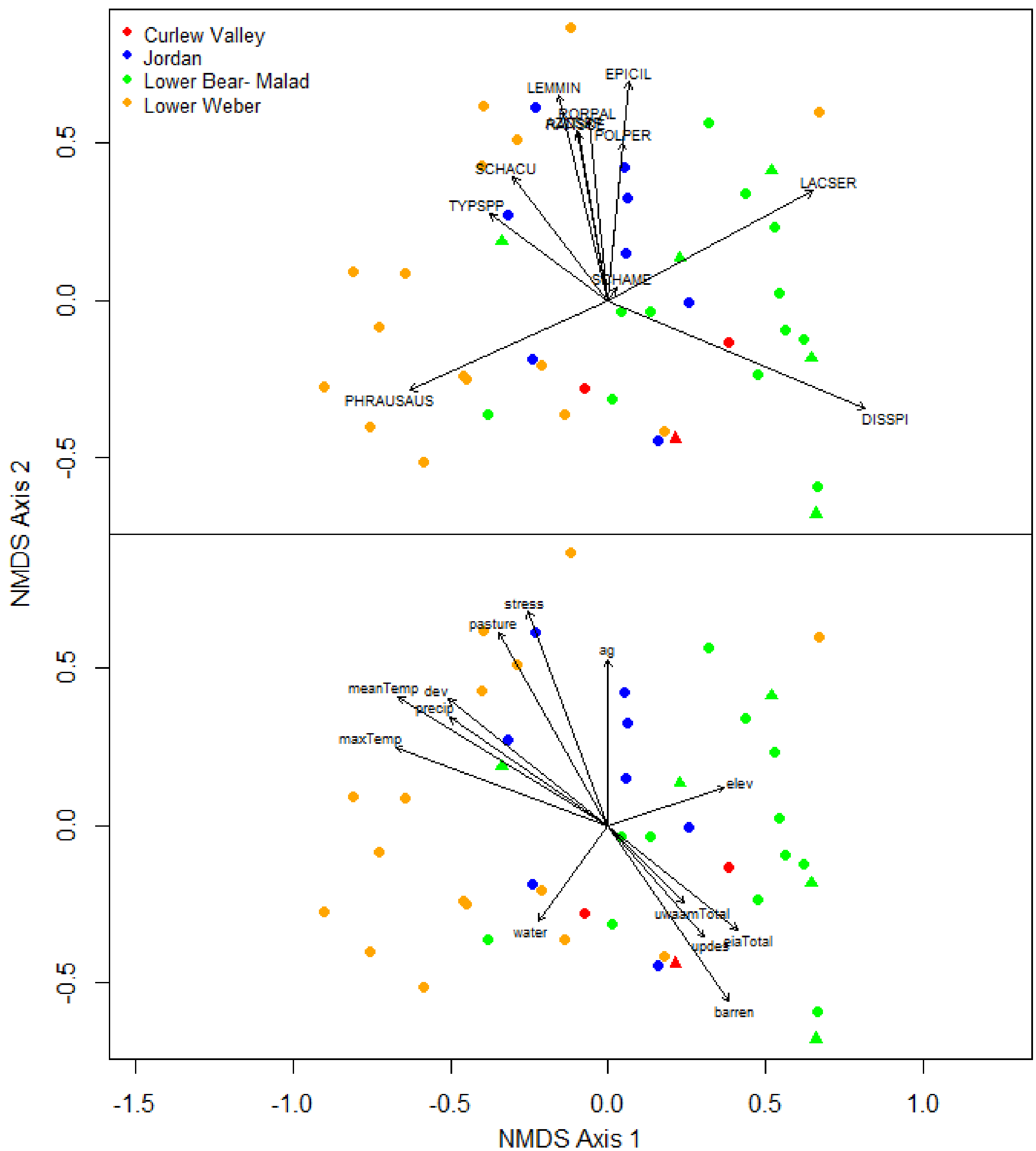

Figure 9. Plot of sites and species scores (top, for species p ≤0.01) and site variables (bottom, for variables p ≤0.05) for first two axes of the plant community composition NMDS. Species and site variables are plotted as vectors proportional to their strength of correlation with the axes. Sites are plotted as points colored by HUC8 watershed, with triangles representing sites outside Great Salt Lake's floodplain. Species identities and variable names are explained in Appendix H.

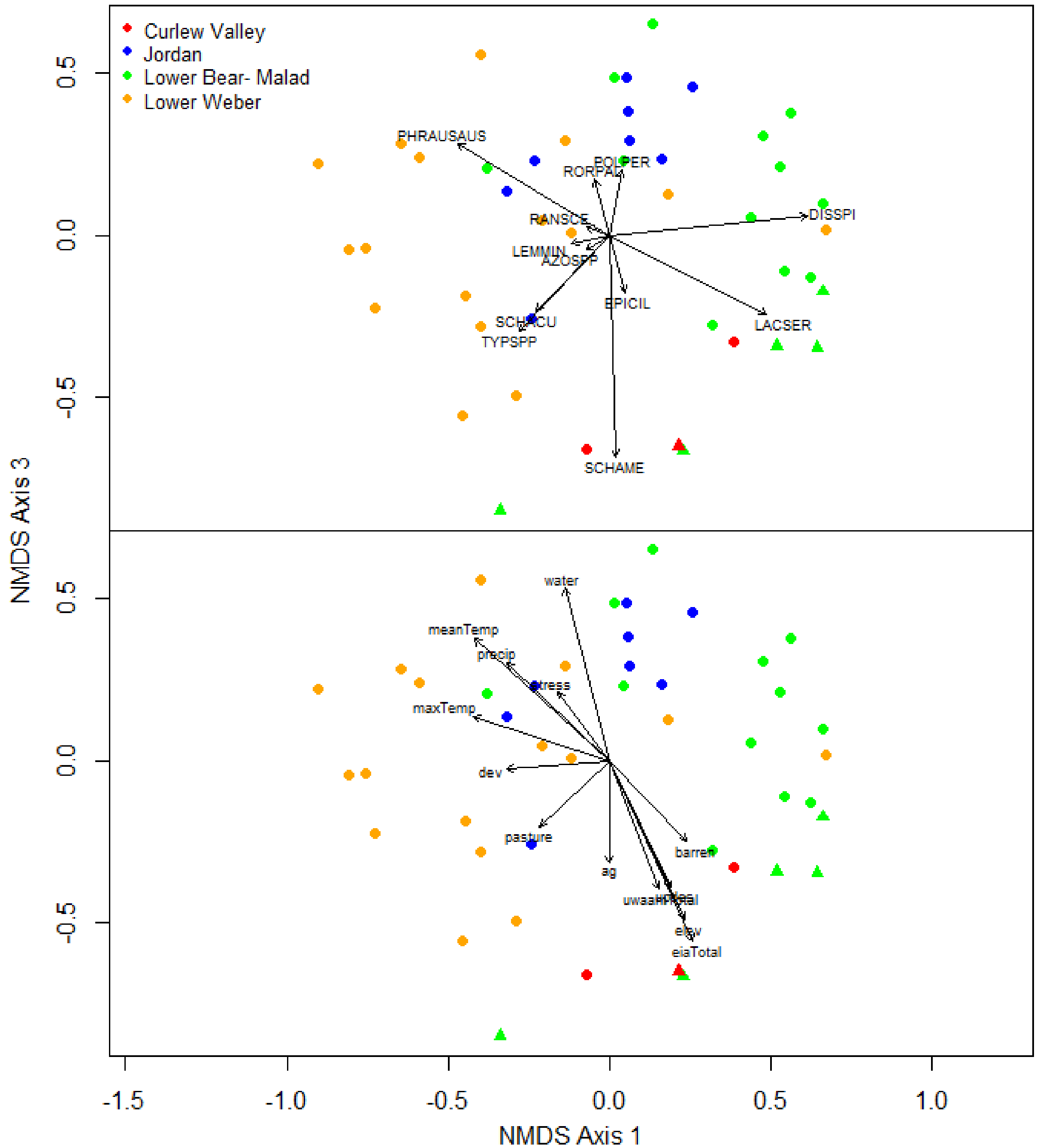

Figure 10. Plot of sites and species scores (top, for species p ≤0.01) and site variables (bottom, for variables p ≤0.05) for axis 1 and 3 of the plant community composition NMDS. Species and site variables are plotted as vectors proportional to their strength of correlation with the axes. Sites are plotted as points colored by HUC8 watershed, with triangles representing sites outside Great Salt Lake's floodplain. Species identities and variable names are explained in Appendix H.

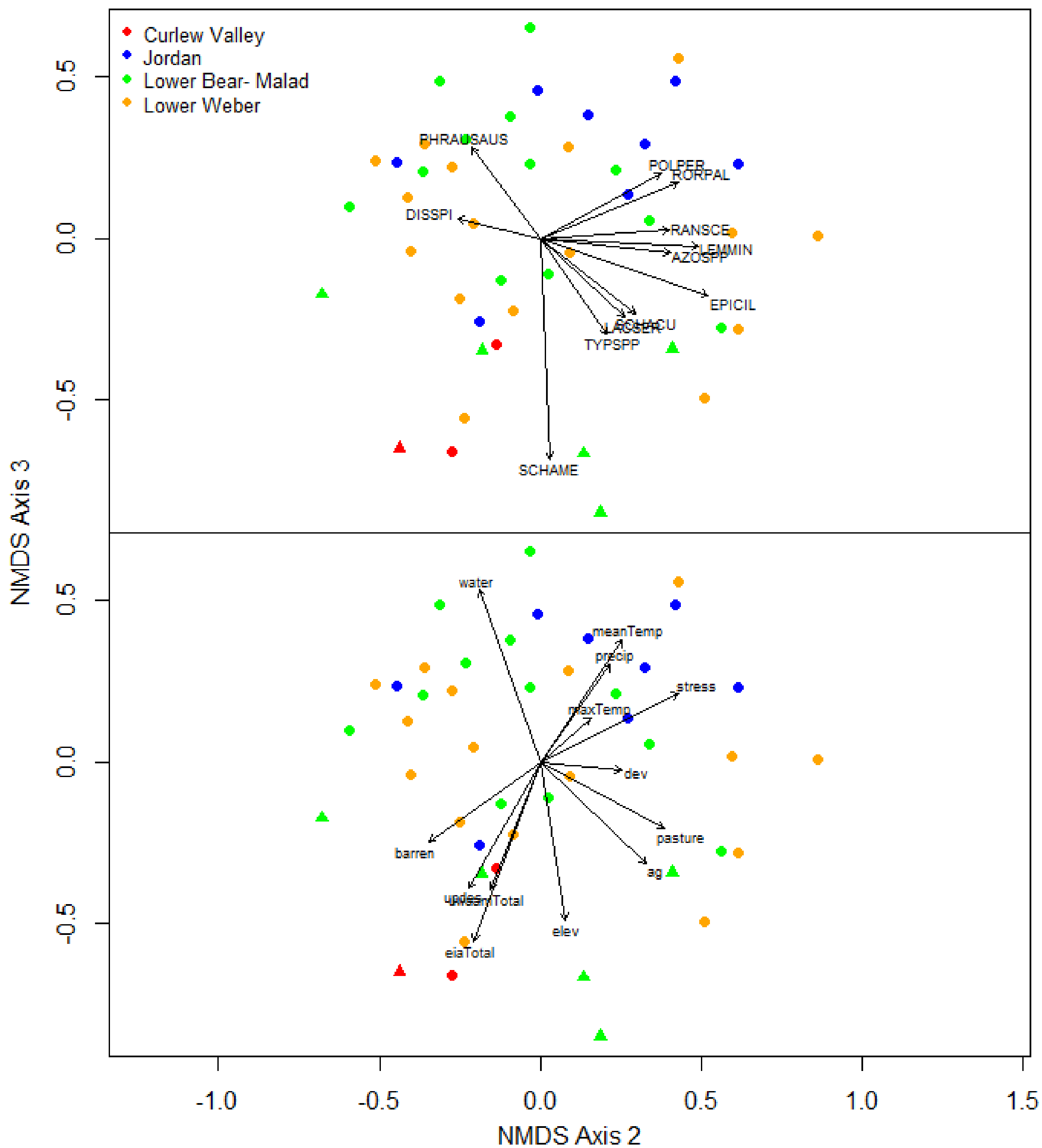

Figure 11. Plot of sites and species scores (top, for species p ≤0.01) and site variables (bottom, for variables p ≤0.05) for axis 2 and 3 of the plant community composition NMDS. Species and site variables are plotted as vectors proportional to their strength of correlation with the axes. Sites are plotted as points colored by HUC8 watershed, with triangles representing sites outside Great Salt Lake's floodplain. Species identities and variable names are explained in Appendix H.

associated with higher site scores and higher elevation and *Phragmites australis* spp. *australis* and *Distichlis spicata* are surrounded by more open water.

4.5 Relationships among Stressors, Plant Community Data, and Wetland Condition

Many plant community metrics were significantly (p≤0.05) correlated with sites' CNHP-EIA vegetation and overall scores and UWAAM overall scores (Table 17). Mean C and cover-weighted mean C of all species and adjusted FQI had the strongest relationships with CNHP-EIA overall and vegetation scores and UWAAM overall scores. Only metrics that were cover-weighted were correlated with CNHP-EIA landscape and USA-RAM overall scores. Two plant community metrics were not correlated with any condition metrics, including both regular and cover-weighted FQI of all native species. Interestingly, CNHP-EIA physiochemical scores were negatively correlated with total species richness and native species richness, meaning that sites with more species and those with more native species had lower scores for physical and water quality metrics.

Table 17. Significant (p≤0.05) Pearson correlation coefficients between plant community composition metrics and wetland condition scores. CNHP-EIA scores include both overall site score and score in hydrologic (hydro.), landscape, physiochemical (physio.), and vegetation (veg.) categories.

Plant Community Metric	CNHP-EIA					USA-RAM	UWAAM
	Hydro.	Landscape	Physio.	Veg.	Total	Total	Total
Total species richness			-0.32				
Native species richness			-0.31				
Non-native species richness				-0.32	-0.31		-0.31
Percent non-native species				-0.57	-0.50		-0.40
Mean C of all species				0.65	0.56		0.45
Mean C of native species				0.44	0.30		0.30
Cover-weighted Mean C, all species				0.69	0.52		0.53
Cover-weighted Mean C, native species		0.36				0.32	
FQI of all species				0.45			
FQI of native species							
Cover-weighted FQI, all species				0.49	0.32		0.32
Cover-weighted FQI , native species							
Adjusted FQI				0.61	0.50		0.42
Adjusted cover-weighted FQI		0.39		0.46	0.47	0.38	

Almost every combination of stressor variable and wetland condition score was significantly correlated, though CNHP-EIA vegetation scores were not significantly correlated with any stressor variables (Table 18). Both the hydrologic and the landscape condition scores were most strongly correlated with hydrologic stressor values. CNHP-EIA and USA-RAM overall scores were most strongly correlated with all stressors combined, whereas UWAAM was most strongly correlated with buffer stressors only.

Adjusted cover-weighted FQI was negatively correlated with all stressor values except for hydrologic stressors and was the strongest correlation for buffer-only and combined stressors (Table 19). Sites with more stressors had higher native species richness, and sites with more hydrologic stressors also had both higher total and non-native richness. Neither percent non-native species nor any of the unadjusted FQI metrics were correlated with stressors.

Table 18. Significant (p≤0.05) Pearson correlation coefficients between aggregated site stressor values and wetland condition scores. CNHP-EIA scores include both overall site score and score in hydrologic (hydro.), landscape, physiochemical (physio.), and vegetation (veg.) categories.

Stressor	CNHP-EIA					USA-RAM	UWAAM
	Hydro.	Landscape	Physio.	Veg.	Total	Total	Total
Buffer	-0.36	-0.50	-0.72		-0.53	-0.61	-0.63
Hydrologic	-0.65	-0.61	-0.35		-0.51	-0.33	
Site Veg., Physical, Water Quality	-0.40	-0.32	-0.72		-0.37	-0.72	
All stressors combined	-0.47	-0.49	-0.81		-0.53	-0.76	-0.49

Table 19. Significant (p≤0.05) Pearson correlation coefficients between plant community composition metrics and aggregated site stressor values.

Plant Community Metric / Stressor	Buffer	Hydrologic	Site	Combined
Total species richness		0.40		
Native species richness		0.36	0.37	0.32
Non-native species richness		0.33		
Percent non-native species				
Mean C of all species	-0.35			
Mean C of native species	-0.32			
Cover-weighted Mean C, all species	-0.43			-0.34
Cover-weighted Mean C, native species	-0.39		-0.32	-0.40
FQI of all species				
FQI of native species				
Cover-weighted FQI, all species				
Cover-weighted FQI , native species				
Adjusted FQI	-0.37			
Adjusted cover-weighted FQI	-0.49		-0.33	-0.46

Landscape regression models were better at predicting CNHP-EIA wetland condition scores (adjusted R2= 0.74) than USA-RAM (adjusted R2= 0.22) and UWAAM (adjusted R2= 0.36) scores. One variable was found in all three models, distance to the nearest UPDES facility, and sites that were farther from UPDES facilities had higher scores (Table 20). Climate PCA axis 2 was associated with lower CNHP-EIA and USA-RAM scores. Sites with high values on this axis have higher maximum temperatures and lower annual precipitation and were generally somewhat wetter and hotter in 2013 than their 30 year mean climate values. Interestingly, barren land cover was related to higher site scores and aquatic features combined or water alone were related to lower scores.

Models of FQA metrics as a function of landscape variables performed similarly to one another (adjusted R^2 values between 0.25 and 0.40). Climate PCA axis 1 was associated with three metrics, with a positive relationship to percent non-native and cover-weighted mean C and a negative relationship with Mean C (Table 21). Sites with high values on this axis are at higher elevation with lower temperatures and less precipitation. The variables distance from UPDES sites and percent agriculture were found in four out of the six models. Sites farther from UPDES sites had higher values of native richness, mean C, and adjusted cover weighted FQI and lower percent non-native species. Higher agricultural cover is related to both more native and more non-native richness, though the overall percent non-native species is lower in areas with more agriculture. Water and wetland land cover were related to lower Mean C and adjusted cover weighted FQI scores as well as higher native and non-native richness.

Table 20. Top landscape models of wetland condition with associated estimates, standard errors, and p-values for landscape variables in final models. Reported R^2 values are adjusted for the number of variables included in each model. More information about the variables reported can be found in Methods, "Section 3.4 Calculation of Landscape Data."

	CNHP-EIA (Adj. R^2= 0.74)		USA-RAM (Adj. R^2= 0.22)		UWAAM (Adj. R^2= 0.36)	
Variable	**Estimate (SE)**	**p**	**Estimate (SE)**	**p**	**Estimate (SE)**	**p**
Intercept	1.76 (0.59)	<0.01	69.68 (12.51)	0.00	52.52 (12.46)	<0.01
Climate PC2	-0.09 (0.04)	0.04	-1.89 (0.9)	0.04		
Nearest UPDES facility	0.22 (0.06)	<0.01	3.82 (1.5)	0.01	2.5 (1.19)	0.04
Nearest mine	0.00001 (0.00001)	0.14				
Road density (3 km higher elev.)	-12.24 (3.24)	<0.01				
% Barren (3 km full)	1.69 (0.33)	<0.01	10.25 (7.33)	0.17		
% Agriculture (1 km full)					-13.95 (8.03)	0.09
% Water (5 km higher elev.)	-1.39 (0.26)	<0.01				
% Aquatic (3 km full)					-14.44 (5.04)	0.01

5.0 Discussion

5.1 Challenges to Wetland Condition Surveys

One challenge to our survey efforts was our inability to survey the randomly generated sample points in the prescribed order. Through examination of aerial imagery, we observed that we would sample predominately *Phragmites australis* ssp. *australis*-dominated sites if we did not skip many points in our sample frame, which would not provide us with much range in site conditions. Even after skipping points, over 70% of surveyed sites contained *Phragmites australis* ssp. *australis*, including 18 sites where the species had over 10% cover. Future sample frames could use Long and others' (2012) wetland vegetation map to stratify site selection by *Phragmites australis* ssp. *australis* cover, though changing species distributions caused by control efforts and species spread would only make this partially effective. The lack of an up-to-date wetland map for the study region confounded our issue of site selection because all sample points in certain regions, such as Curlew and Tooele valleys, were rejected because of lack of target wetland. This led to manual placement of survey sites in order to capture the unique conditions in these locations. Overall, we had to reject 29 of 95 sample points due to lack of target wetland, which suggests that map accuracy is relatively poor.

Another challenge of our survey efforts was the lack of true reference sites within our study area to establish baseline conditions. The region has been subject to strong hydrologic modifications for over a century, with sites affected by groundwater withdrawals (particularly for our Curlew Valley sites), decreased stream flows (particularly for unimpounded sites), and extensive development of dikes and canals. We recorded two or fewer stressors in the field at only four sites. Of these, two are dominated largely by *Phragmites australis* ssp. *australis*, one is located within a very large impoundment, and one is downstream from an impoundment that completely controls its hydrology, suggesting that none of these sites are in reference condition. We also do not find reference condition wetlands when we look at those sites that scored in the 95th quantile for overall site scores for each protocol. For CNHP-EIA and UWAAM, several of these best-condition sites occur outside of Great Salt Lake's floodplain and many are

Table 21. Top landscape models of FQA metrics with associated estimates, standard errors, and p-values for landscape variables in final models. Reported R^2 values are adjusted for the number of variables included in each model. More information about the variables reported can be found in "Section 3.4 Obtainment of Landscape Data."

Variable	Measure	Native Richness (R^2 = 0.33)	Non-Native Richness (R^2=0.25)	Percent Non-Native (R^2= 0.40)	Mean C (R^2=0.32)	CW Mean C (R^2= 0.38)	Adjusted CW FQI (R^2 = 0.26)
Intercept	Estimate (SE)	-9.96 (7.19)	-4.31 (2.33)	120.1 (24.96)	0.99 (1.45)	2.42 (0.17)	1.14 (16.08)
	p-value	0.17	0.07	<0.01	0.50	<0.01	0.94
Climate PC1	Estimate (SE)			2.03 (0.96)	-0.11 (0.06)	0.35 (0.07)	
	p-value			0.04	0.06	<0.01	
Climate PC2	Estimate (SE)	0.61 (0.45)					-1.87 (1.05)
	p-value	0.18					0.08
Distance to nearest UPDES	Estimate (SE)	1.55 (0.76)		-9.51 (2.79)	0.34 (0.14)		4.04 (1.66)
	p-value	0.05		<0.01	0.02		0.02
Distance to nearest mine	Estimate (SE)			0.0007 (0.0004)			
	p-value			0.09			
Road density	Estimate (SE)				-244.6 (111.43)		
	p-value				0.03		
	scale				3 km higher elev.		
% Barren	Estimate (SE)	-7.39 (5.21)	6.629 (3.64)	-47.6 (16.06)			
	p-value	0.16	0.07	<0.01			
	scale	5 km higher elev.	3 km full	1 km full			
% Combined agriculture	Estimate (SE)	21.73 (5.38)	14.92 (4.10)	-64.07 (15.48)			-17.09 (9.21)
	p-value	<0.01	<0.01	<0.01			0.07
	scale	1 km full	1 km full	5 km full			1 km full
% Water	Estimate (SE)		6.71 (2.37)				
	p-value		<0.01				
	scale		3 km full				
% Wetland	Estimate (SE)	10.53 (5.35)	16.25 (5.77)				-23.54 (13.86)
	p-value	0.06	<0.01				0.1
	scale	5 km higher elev.	5 km full				5 km full
% Combined aquatic	Estimate (SE)				-1.65 (0.58)		
	p-value				<0.01		
	scale				3 km full		

affected by water releases from impoundments or other sources of upslope hydrologic modification. Three out of four USA-RAM best-condition sites had high cover of *Phragmites australis* ssp. *australis*, suggesting that they, too, are not in reference condition.

We had a difficult time obtaining access to survey on private land not managed as a duck club. Only one site that we surveyed (2% of sites), compared to over 14% of emergent wetland in Great Salt Lake's floodplain, fell into this land ownership category. Accordingly, almost all of the sites we surveyed were within preserves actively managed for birds and other conservation goals (though not all of the sites themselves were the focus of active management). Conditions at managed sites have the potential to dramatically change between years as managers make decisions such as how to allocate water and whether to graze or burn the area. We may have seen more of a range in certain metrics if we surveyed more sites outside the large complex of managed wetlands. For example, all sites received a high score for buffer width, but privately owned wetlands may be more likely to be embedded in a matrix of anthropogenic land uses.

5.2 General Trends in Great Salt Lake Wetland Condition

Most Great Salt Lake wetlands fall into B or C categories according to CNHP-EIA and UWAAM overall site scores, with wetlands in the Curlew Valley HUC8 in the best condition and those in the Jordan HUC8 in the worst. Though scores are only preliminary until we develop a final URAP protocol, intuitively these results make sense: most sites around Great Salt Lake should probably not be rated as either close to pristine (A) or lacking conservation value (D). Landscape Context scores indicate that almost all sites were surrounded by an adequate amount of buffer land cover, but that buffer condition was affected by the presence of a large number of stressors and invasion by *Phragmites australis* ssp. *australis.* Sites scored poorly overall for some Hydrologic Condition metrics, including water source and hydroperiod, though these metrics were often difficult to interpret and assess in the field.

Several components of Physical Structure, Vegetation Structure, and Species Composition metrics indicate that Great Salt Lake wetlands may have less structural and biotic complexity than other wetlands. The majority of sites received C or D scores on measures of the complexity of topographic features at sites as well as interspersion of plant zones, vertical biotic structure, and plant community complexity. Without appropriate reference sites, it is difficult to determine whether low complexity is a natural condition of Great Salt Lake wetlands or is driven by their long history of anthropogenic disturbance. For example, woody species and species in different height categories may be naturally uncommon or absent from sites. These metrics should be reevaluated to determine thresholds and weighting appropriate to Great Salt Lake wetlands.

Both Species Composition metrics and FQA values indicate that most sites are populated with species that can tolerate disturbance. Only one recorded species (*Triglochin maritima*- seaside arrowgrass, found at five sites) has a C-value above six, indicating that it is obligate to natural areas though it can sustain some habitat degradation. Species Composition scores indicate that introduced species and aggressive species are of particular concern at a majority of sites. Interestingly, sites scored highly on USA-RAM's measure of Absolute Cover Invasive Species; sites can still receive a B in this category if a single invasive species has over 75% cover at a site.

The history of intense hydrologic manipulation around Great Salt Lake leads to an interesting dilemma when it comes to determining site condition. Sites that appeared to be the least disturbed in terms of visible landscape alterations often had the most unreliable water supply and appeared to be water-stressed. Furthermore, it is likely that some formerly emergent sites are so affected by changing hydrologic conditions that they have transitioned to drier wetland types, though we did not observe this in the field because we only surveyed sites that appeared to be emergent wetland in recent aerial imagery. In contrast to these sites, sites with managed water supplies generally have more stable water supplies and may be managed to decrease species of concern and improve wetland condition, at least as far as condition relates to desired functions such as bird habitat. These sites are often surrounded by large numbers of hydrologic modifications and can be subject to management action such as herbicide spraying, inundation, and managed grazing. The dilemma comes in determining how to weigh these different stressors when evaluating wetland condition: is a site that appears more natural but may be in decline due to water pressure actually in better condition than a heavily managed site? Is it possible to weight metrics in the condition assessment in such a manner that the latter site, surrounded by considerable management disturbance, can receive a better score than the former site, and should we? Interestingly, plant community composition data, measured both via FQA metrics and through ordination, did not differ according to impoundment status, and hydrologic stressors were not related to FQA metrics with the exception of richness values. If FQA metrics are taken to be true indicators of wetland condition, then we need to make sure the presence of managed-related stressors on the landscape do not overly impact wetland condition scores. We conducted surveys during a water year with below-average precipitation; multiple years of data under different hydrologic conditions will be necessary to help address these issues.

5.3 Interrelatedness of Different Measures of Condition

Many measures of wetland site condition were correlated with stressors, landscape attributes, and FQA metrics. These relationships show that, even without calibration, wetland condition assessment scores appropriately reflect other measures of wetland condition. Correlations between condition assessment scores and other measures of condition were often similar in strength or stronger than correlations used to assess the California Rapid Assessment Method (CRAM, [Stein and others, 2009]). CRAM, however, used truly independent data to compare to measures of wetland condition whereas the stressor checklists and FQA metrics we used were collected simultaneously with the wetland condition data and are thus not completely independent.

Landscape models were better at predicting CNHP-EIA overall site scores than FQA metrics and stressors, whereas all three comparisons performed similarly for UWAAM. USA-RAM scores were most strongly predicted by the stressor values, which is not surprising because a substantial part of USA-RAM scoring is derived from stressor checklists. Future work will focus on calibrating all measured components of condition in order to maximize interrelatedness. The landscape model in particular is useful because it is our only independent measure of wetland condition. Incorporation of features such as true watersheds, surface flow path distances between stressors and sites, and water quality data should improve model performance.

The relationship between most measures of condition made intuitive sense; for example, sites with more stressors and sites closer to UPDES dischargers generally had lower site scores and poorer FQA metrics. Agriculture and development did not generally have strong relationships with other measures of condition, though agriculture did increase both native and non-native richness at sites and decrease adjusted cover-weighted FQI. Urbanization may have an effect on wetland condition via water quality effects caused by point source dischargers instead of directly through proximity to wetlands. More up-to-date land cover data evaluated in watersheds instead of buffers may also indicate a relationship between anthropogenic land uses and wetland condition.

It is not clear what drives the positive relationship between barren land and wetland condition and the negative relationships between surrounding open water and wetland and wetland condition. These land cover effects may be proxies that indicate generally where within the study area sites are located rather than directly affecting site condition. Sites surrounded by more barren land cover tended to be located in the Curlew Valley and Lower Bear-Malad HUC8s and were less likely to be impounded. Sites surrounded by open water or wetland are more likely to be part of large complexes of intensively managed wetlands or close to the edge of Great Salt lake, where *Phragmites australis* ssp. *australis* dominates. *Phragmites australis* ssp. *australis* was present at 18 of 19 sites that were surrounded by more than 50% combined water and wetland in a 5 km buffer, compared to 13 of 25 sites with less than 50% combined aquatic features.

In general, climate is expected to have a minimal effect on condition scores with a well-calibrated wetland condition assessment tool. Sites with natural, climate-driven variation in underlying attributes should score similarly for condition if they have similar levels of anthropogenic disturbance. On the other hand, climatic conditions can potentially exacerbate the effects of disturbance, leading to actual differences in condition between climatically distinct but otherwise similar sites. The effect of climate we found on FQA metrics and site condition scores may be caused by climate-driven differences or may reflect spatial clustering of sites with similar condition and climate. Further development of URAP should try to minimize the effect that climate has on site scores.

5.4 Development of Wetland Condition Protocol

Our experience testing three rapid wetland condition assessment protocols in Great Salt Lake wetlands is an important component of the development of the statewide URAP protocol. The critically important Great Salt Lake wetlands have unique conditions that make them a challenge to assess. For example, it is difficult to consistently evaluate Hydrologic Condition metrics due to the degree of water manipulation in the region. Another challenge is that, in order to evaluate Great Salt Lake wetlands in respect to wetlands statewide, we lose some of our ability to differentiate between Great Salt Lake wetlands themselves. It may be beneficial to add Great-Salt-Lake-specific components (or potentially metrics specific to heavily managed systems) for some metrics such as Hydroperiod and Water Source. We could add additional metric options with finer, more descriptive categories in order to obtain a more useful comparison among Great Salt Lake wetlands and clearer metric options that better fit Great Salt Lake conditions. We also have the challenge of determining appropriate thresholds for some metrics, such as Mean C scores, without the benefit of comparison to true reference sites. Some potential methods that can be used in lieu of reference sites include evaluation based on least disturbed condition, interpreting historical data to evaluate condition, and extrapolating from empirical models (Stoddard and others, 2006). Evaluating habitat features and functional services in addition to condition may be important so that poor-condition managed wetlands that provide important ecosystem services are not classified as unimportant.

In addition to Great-Salt-Lake-specific considerations, this project also highlights other issues to consider while we develop URAP. For example, we found it easier to think of land as existing on a continuum between non-buffer and buffer rather than having to assign each land cover type to a category. It was particularly difficult to decide whether particular dikes should be considered non-buffer and landscape fragmenting features. We may be able to use coefficients, such as those adopted by Keate (2005), to relate land cover types to their relative degree of contribution to runoff, nutrient and sediment loading, and habitat quality. We could then calculate scores in each category for each site and establish thresholds to distinguish between condition categories. This may lead to more complex calculations in the field, but may also more accurately detail the specific types and severities of disturbances around sites.

Development of URAP requires selection of a subset of metrics from the three tested protocols and calibration to determine appropriate thresholds between condition classes. We find it encouraging that CNHP-EIA and UWAAM site scores were correlated with one another, with landscape and FQA measures of condition, and with plant community composition data evaluated by NMDS. USA-RAM, on the other hand, showed the least range of scores and was not as strongly correlated with the other protocols or other measures of condition. This is not surprising because scoring and evaluation of this protocol is still under development; however, due to these factors, USA-RAM metrics will be the most difficult and least advised to adapt into the URAP protocol at this time. Based on work around Great Salt Lake, we have three recommendations for URAP development. Firstly, we should reword some metric statements to make them more easily understood and consistently scored between observers. Secondly, we should make sure that site scores capture the range of variability present across the state *and* within Great Salt Lake wetlands. Lastly, we should calibrate metrics in a manner that strengthens the relationship between stressors, landscape data, FQA metrics, and the wetland condition scores. With this approach, we will move closer to developing a rapid condition assessment tool that is user-friendly and informative of true wetland condition.

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Appendix A

CNHP-EIA Protocol

Ecological Integrity Assessment for Colorado Wetlands

Field Manual, Version 1.0 – REVIEW DRAFT

May 2013

Ecological Integrity Assesment (EIA) for Colorado Wetlands Field Manual, Version 1.0 – REVIEW DRAFT

Joanna Lemly and Laurie Gilligan
Colorado Natural Heritage Program
Colorado State University
Fort Collins, Co 80523

Based on NatureServe's Ecological Integrity Assessment Framework.

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SECTION 1: INTRODUCTION

1.1 Ecological Integrity Assessment (EIA) for Colorado Wetlands

Ecological Integrity Assessment (EIA) for Colorado wetlands is an assessment method that measures overall wetland condition with an emphasis on biological integrity. The method combines quantitative vegetation metrics with qualitative metrics that evaluate landscape context, hydrology, water quality, and soils into a multi-metric index. Final EIA scores rank a wetland's condition on a four-tiered scale (excellent/good/fair/poor), as compared to unaltered wetlands of the same type.

Purpose of Colorado's EIA Method

Colorado's EIA method can be used for a variety of purposes. For the past five years, the EIA method has primarily been used in a series of river basin-scale assessments that document the current range of wetland condition across each major basin (Lemly et al. 2011; Lemly and Gilligan 2012; Lemly and Gilligan *in prep)*. These studies are intended to inform management, restoration and conservation goals within the target basins, specifically for Colorado Parks and Wildlife (CPW)'s Wetlands Wildlife Conservation Program[1] but also for other conservation and management partners. These studies have also been used by the Colorado Department of Public Health and Environment (CDPHE)'s Water Quality Control Division to describe the condition of wetlands as an aquatic resource in their 2012 Integrated Water Quality Monitoring and Assessment Report (WQCD 2012), submitted to U.S. Environmental Protection Agency (EPA) pursuant to Section 303d and 305b of the Federal Clean Water Act (CWA). For the basinwide assessments, results from EIA sampling are not intended to be used as site-specific information. Instead, each survey point represents a portion of the larger wetland resource in the basin, but no single point is the focus of the study.

Beyond the river basin-scale assessments, however, the EIA method has much wider applicability. The process laid out in the EIA provides land and resource managers with a tool to measure the ecological integrity of wetlands under their jurisdiction. When carried out on a suite of wetlands, it could be used to target sites for restoration (those with lower scores) or further protection (those with higher scores). By focusing on biological integrity, the EIA method could be used to track change in species composition and structure over time after restoration projects have been conducted. Through its use of stressor checklist, it could also be used to identify the most pressing stressors faced by wetlands in a given area, helping managers pinpoint and address the stressors under their control.

The EIA could also be used in wetland mitigation planning, though it does differ from the primary assessment method endorsed for use in mitigation, the Functional Assessment of Colorado Wetlands (FACWet: Johnson et al. 2013).[2] FACWet is currently required for all wetland impact permits and mitigation plans submitted to the U.S. Army Corps of Engineers under Section 404 of the CWA. The EIA, however, with its more rigorous vegetation data collection protocols, could be used to establish mitigation performance standards and be incorporated in post-project monitoring of mitigation sites.

[1] See the CPW Wetlands Program website for more information: (http://wildlife.state.co.us/LandWater/WetlandsProgram/).
[2] For up-to-date information on FACWet, see the webstie: http://rydberg.biology.colostate.edu/FACWet.

Definition of Ecological Integrity and Ecological Integrity Assessments

Building on the related concepts of biological integrity and ecological health, ecological integrity is a broad and useful endpoint for ecological assessment and reporting (Harwell et al. 1999). "Integrity" is the quality of being unimpaired, sound or complete. To have integrity, an ecosystem should be relatively unimpaired across a range of characteristics and spatial and temporal scales. Ecological integrity can be defined as "the structure, composition and function of an ecosystem operating within the bounds of natural or historic disturbance regimes" (adapted from Lindenmayer and Franklin 2002; Young and Sanzone 2002; Parrish et al. 2003). Ecological integrity has also been defined as "the summation of chemical, physical, and biological integrity" or the ability of an ecosystem to support and maintain a full suite of organisms with species composition, diversity, and function comparable to similar systems in an undisturbed state (Karr and Dudley 1981). High ecological integrity is generally regarded as an ecosystem property where expected structural components are complete and all ecological processes are functioning optimally (Campbell 2000). Ecological integrity assessments, therefore, can be defined as a means of assessing the degree to which, under current conditions, a system matches reference characteristics of similar systems with high ecological integrity.

Reference Condition

The Colorado EIA method, like most ecological integrity assessments, is a reference-based approach. Metrics are rated according to deviation from the natural range of variability (i.e., reference standard) expressed in wetlands over the past ~200–300 years (prior to European settlement). Reference standard is specific to wetland type, meaning metrics are rated using thresholds developed for wetlands of the same type. Reference standard is ideally determined using the range of variability observed in wetlands with no or minimal human disturbance (i.e., reference wetlands) that exist on the landscape today. Where field data are lacking or no reference condition wetlands remain, information from the literature is also used to define reference standard.

Natural variability is defined based on the best current understanding of how ecological systems "work" under reference (no or minimal human impact) conditions. An understanding of how each metric responds to increasing human disturbance is necessary in order to establish thresholds. The farther a metric moves away from its natural range of variability the lower the rating it receives. The EIAs use four basic rating categories to describe the status of each metric relative to its natural variability (Table 1). There are two important thresholds associated with these ranks. The B-C threshold indicates the level below which conditions are not considered acceptable for sustaining ecological integrity. The C-D threshold indicates a level below which system integrity has been drastically compromised and is unlikely to be restorable.

Table 1. Overall EIA scores and ranks and associated definitions.

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.

Wetland Classification

Successfully developing indicators of wetland ecological integrity depends on providing a classification framework for distinguishing wetland types, accompanied by a set of keys to identify the types in the field. Classifications help wetland managers to better cope with natural variability within and among types, so that differences between occurrences with good integrity and poor integrity can be more clearly recognized. For over fifteen years, NatureServe and the Network of Natural Heritage Programs have provided international leadership in standardized ecological classification through development of the International Vegetation Classification System (Grossman et al. 1998, NatureServe 2004, Faber-Langendoen et al. 2009) and "Ecological Systems" throughout the United States (Comer et al. 2003).

Ecological Systems provide a finer scale of resolution than traditional wetland classification systems such as the U. S. Fish and Wildlife Service's Cowardin classification (Cowardin et al. 1979) and the hydrogeomorphic (HGM) classification system (Brinson 1993). The Ecological System approach uses both biotic (structure and floristics) and abiotic (hydrogeomorphic template, elevation, soil chemistry, etc.) criteria to define units. These finer classes allow for greater specificity in developing conceptual models of the natural variability and stressors of an ecological system and the thresholds that relate to impacts of stressors.

The Colorado EIA method is built based on the Ecological Systems classification system. A key to wetland and riparian Ecological Systems of Colorado is provided in Appendix A. Several metrics, particularly within the Vegetation Condition category, are specific to Ecological System or refer to typical characteristics of the Ecological System. The unit for assessing condition with the EIA method (the assessment area) is generally constrained to one Ecological System to reduce variability. However, the HGM classification is also used in the EIA method to evaluate Hydrologic Condition metrics, as the HGM classification more tightly controls for variation expected in hydrologic characteristics. Many Ecological Systems are specific to one HGM class, but not all are. Some Ecological Systems can occur in more than one HGM class.

Assessing Ecological Integrity vs. Functional Condition vs. Functional Capacity

There are two main approaches to wetland condition assessment: ecologically based assessments and functionally based assessments. The difference between the two is largely based on the purpose and intended use of the method. Ecological assessments focus on the ecological or biotic response to cumulative stressors over many years. While some stressors may be evident to an observer, others may not. Even when past impacts are not immediately evident, the biota within a wetland often reflects the long term cumulative effect of all stressors and can serve as indicators of its overall health. Ecologically based condition assessments aim to "evaluate a wetland's ability to support and maintain a balanced, adaptive community or organism having a species composition, diversity, and functional organization comparable with that of minimally disturbed wetlands within a region" (EPA 1998). They are typically carried out by measuring or quantifying certain aspects of wetland assemblages (i.e., plant, invertebrate, or faunal communities) along with associated wetland attributes.

The defining characteristic of the ecological/biotic assessment paradigm is that they use plants (or other taxa) as "phytometers" that reflect the quality of the local environment. Vegetative health, as reflected by composition and structure, integrates the myriad of environmental effects into one tangible aspect of the wetland. Ecologically based approaches have the advantage that vegetation health reflects overall wetland health, and vegetation structure and composition respond to factors to which the evaluator may be oblivious. Ecologically based assessment methods can be thought of as being "top down" in perspective (Figure 1), in which a higher-order feature of the wetland is used as an indicator of impairment of basic elements of the wetland, such as hydrology or water chemistry.

Functional assessments focus on physical drivers or processes, such as hydrology and geomorphology. They aim to evaluate the current ability of a wetland to perform certain understood functions typical of a wetland in its class. They are often used to quantify the potential change in functional capacity if certain actions are carried out, such as impacts by development, restoration activities, or changes in hydrologic regime. Functional assessments are carried out by measuring, estimating or otherwise quantifying variables associated with one or more ecosystem functions. Functions normally fall into one of three major categories: 1) hydrologic (e.g., storage of surface water), 2) biogeochemical (e.g., removal of elements and compounds), and 3) physical habitat (e.g., topography, depth of water, number and size of trees) (EPA 1998).

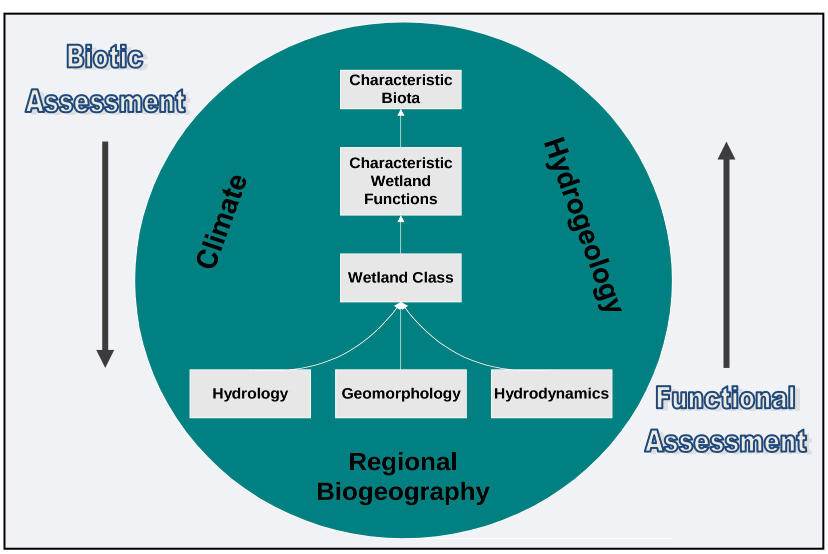

Figure 1. Schematic representation of the top-down and bottom-up approaches used in assessment. Biotic or ecological condition assessments use biological response to infer impacts to basic physical drivers. Functional assessments do just the opposite. Figure from Lemly et al. (2013).

Functionally-based evaluation methods can be considered to be "bottom up" (Figure 1). These methods focus on aspects of the wetland that create higher order functions, including the maintenance of characteristic vegetation. Highlighting the causes of (rather than state of) environmental degradation is the focus of functional methods, while the specific ramifications of impacts, such as changes in species composition, are assumed. This confers the advantage of relieving the evaluator of the need for a high level of taxonomic proficiency, opening them up to a broader audience, but limiting the interpretation of the end state of degradation expressed through vegetation.

The most pure form of functional assessments consider functioning in absolute terms, such as the volume of water stored or the rate of some processes performed. However, these assessments differ from condition assessments in that they evaluate the level or capacity of wetland functions while condition assessments evaluate the condition of key ecological factors or driving ecological processes to indicate ecological integrity. Many functional assessments simply are concerned with the level or capacity of each function regardless of how or whether it relates to ecological integrity (Table 1).

Table 2. Comparison of ecological condition assessments and functional condition assessments.

	Ecological Condition Assessment	*Functional Condition Assessment*
Purpose	Estimate current ecological integrity	Estimate societal value of ecological functions
"Currency"	Condition of key ecological factors	Level of functions and ecological services
Approach	Holistic: ecological integrity = "integrating super function"	Compartmental: each function assessed individually
Method	Combines indicators into conceptual model of key ecological factors	Combines indicators into conceptual model of ecological functions and values
Application	Mitigation, monitoring, state water quality standards, and Heritage Network	Mitigation and monitoring

1.2 Background and Development of Colorado's EIA Method

Level 1-2-3 Framework for Wetland Assessment

Acknowledging that it is impossible to visit every wetland across a landscape to determine the range of condition, EPA developed the three-tiered approach to wetland assessment (Figure 2).[3] Within EPA's Level 1-2-3 Framework, Level 1 assessments are broad in geographic scope and used to characterize resources across an entire landscape. They generally rely on information available digitally in a GIS format or through remote sensing. Goals of Level 1 assessments may include summarizing the extent and distribution of a resource (such as wetland mapping from air photography) or modeling the condition of wetlands based on anthropogenic stressors such as roads, land use, resource extraction, etc. Level 1 assessments can be applied

[3] For more information, see http://www.epa.gov/owow/wetlands/pdf/techfram.pdf.

across a large area and can summarize general patterns, but may not accurately represent the condition of a specific wetland on the ground.

Level 2 assessments are rapid, field-based assessments that evaluate the general condition of wetlands using a suite of easily collected and interpreted metrics. The metrics are often qualitative or narrative multiple choice questions that refer to the condition of various attributes (e.g., buffers, hydrology, vegetation, soil surface disruption) based on stressors present on site. Rapid assessments should be conducted within 1–2 hours of field time and are often used to assess a large number of wetlands on the ground to make an overall estimate of condition or evaluate which sites deserve more intensive monitoring.

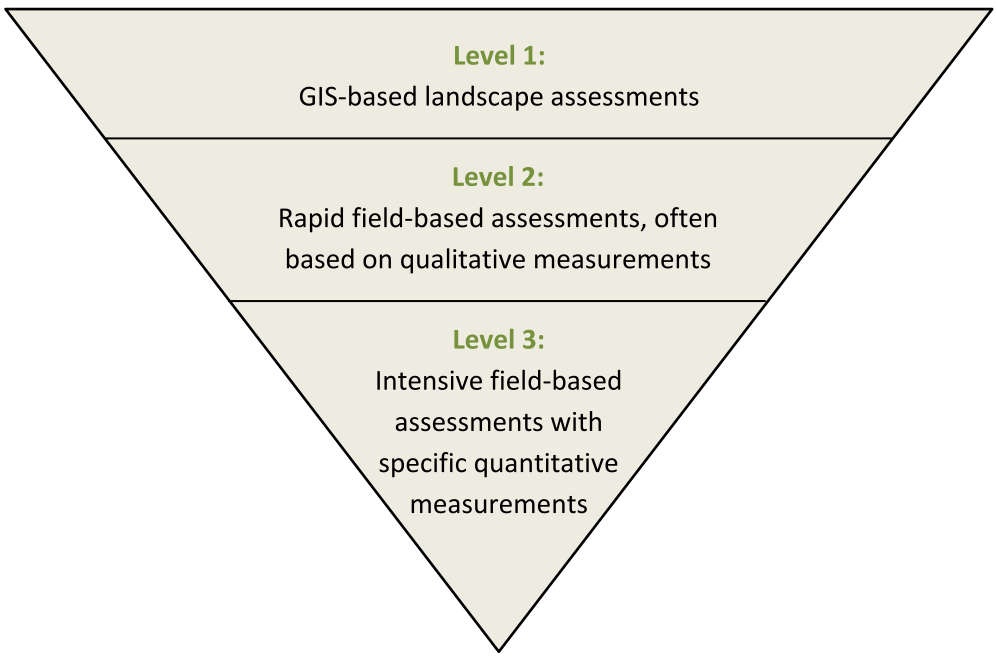

Figure 2. Graphical illustration of the Level 1-2-3 Framework.

Level 3 assessments involve the most intensive, field-based protocols and are considered the most accurate measure of wetland condition. These assessments are based on quantitative data collection and the establishment of data-driven thresholds. They require skilled practitioners to carry out sampling and can take numerous hours for every site. Level 3 protocols are generally developed separately for different wetland attributes, such as vegetation, macro-invertebrates, water chemistry, or hydrology. In some cases, repeat sampling may be necessary to fully capture a wetland's condition.

Within the Level 1-2-3 Framework, data from more detailed levels can be used to calibrate and validate levels above. Level 3 surveys can inform the narrative ratings of Level 2 assessments, and both can help refine Level 1 GIS models. Over time and with sufficient data, coarser level assessments can provide a fairly accurate overview of wetland health across a broad area. However, detailed Level 3 assessments will always provide the most accurate measure of site-specific condition. Many states around the nation are developing wetland assessment tools that fit within EPA's Level 1-2-3 Framework. The EIA method can be used at varying levels of intensity, as described in later sections.

NatureServe's Ecological Integrity Assessment Framework

Development of the Ecological Integrity Assessment (EIA) Framework began in 2004 when NatureServe, the umbrella organization over all Natural Heritage Programs, formed the Ecological Integrity Assessment Workgroup. Members of this group included ecologists for the Arkansas, Colorado, Idaho, and North Carolina Natural Heritage Programs as well as ecologists from NatureServe and The Nature Conservancy. Since the original workgroup was formed, several other states have engaged in developing EIA methods tailored to their states. Additional states include Maine, Montana, New Mexico, New Hampshire, New Jersey, New York, and Washington. In addition, NatureServe has continued to develop their own guidance on EIA methods and have applied those methods in Alaska, Michigan, and Indiana. Two major reports have been published by NatureServe on the EIA Framework (Faber-Langendoen et al 2008; 2013). In addition, NatureServe, along with several partner Natural Heritage Programs, was recently awarded a National EPA Wetland Program Development Grant to compare variations of the EIA methods across several states. Colorado will be part of that project.

The Colorado EIA methods are a direct descendant from the original EIA Framework developed by NatureServe and many of the metrics included in this manual are also included in the two NatureServe reports. However, specific protocols have been modified, and in some case metrics added or dropped, to make the EIA Framework work best in for wetland in the mountains and plains of Colorado.

Colorado Method Development

Ecologists from the Colorado Natural Heritage Program (CNHP) were part of the original NatureServe EIA Workgroup from the very beginning. Concurrently with participation on the NatureServe Workgroup, CNHP began to develop EIA protocols specific to wetland types in Colorado with funding from EPA Region 8 and CPW. The first products developed were conceptual EIA protocols for seven wetland types in the Southern Rocky Mountain Ecoregion (Rocchio 2006a-g). Each report detailed characteristics of the system and identified a range of variables that could be measured to assess ecological integrity, including many at the Level 3 intensive sampling level. With additional funding, CNHP selected protocols from one of the seven systems (Subalpine-Montane Riparian Shrubland) and field tested the protocols as a Level 2 rapid assessment (Lemly and Rocchio 2009a). Through two completed river basin-scale wetland assessment project (Rio Grande Headwaters: Lemly et al. 2011; North Platte: Lemly and Gilligan 2012) and one currently underway (Lower South Platte: Lemly and Gilligan, *in prep*), the conceptual Colorado EIA protocols have been consolidated from seven different documents to one set of metrics that apply to varying degrees to all wetlands found in Colorado. Metrics and scoring procedures have been refined over the years and will likely continue to evolve as more sites are evaluated and input is incorporated form outside partners.

Floristic Quality Assessment (FQA)

At the same time that the Colorado EIA protocols were being developed, CNHP also developed a Floristic Quality Assessment (FQA) tool for use in Colorado. The FQA approach to assessing ecological communities is based on the concept of species conservatism. The core of the FQA method is the use of "coefficients of conservatism" (C-values), which are assigned to all native species in a flora following the methods described by Swink and Wilhelm (1994) and Wilhelm and Masters (1996). 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 pre-European settlement conditions (Table 3). High C-values are assigned to species which are obligate to high-quality natural areas and cannot tolerate habitat degradation, while low C-values are assigned to species with a wide tolerance to human disturbance. Generally, C-values of 0 are reserved for non-native species. The proportion of conservative plants in a plant community provides a powerful and relatively easy assessment of the integrity of both biotic and abiotic processes and is indicative of the ecological integrity of a site (Wilhelm and Ladd 1988). The most basic FQA index is a simple average of C-values for a given site, generally called the Mean C, though more complex indices can be calculated. C-values for Colorado species were assigned by a panel of botanical experts in 2006 (Rocchio 2007a). FQA indices are included as a component of the Colorado EIA protocols, but they can also be used as stand-alone measures of biotic condition.

Table 3. C-value ranges and associated interpretation.

C-Values	*Interpretation*
0	Non-native species. Very prevalent in new ground or non-natural areas.
1-3	Commonly found in non-natural areas.
4-6	Equally found in natural and non-natural areas.
7-9	Obligate to natural areas but can sustain some habitat degradation.
10	Obligate to high quality natural areas (relatively unaltered from pre-European settlement).

1.3 Structure of Colorado's EIA Method

Categories, Attributes and Metrics

The EIA method is based on a three-tiered hierarchical structure. At the highest level, the EIA divides wetland condition into five major **categories**. Within each of those categories, the EIA identifies one or more **key ecological attributes** integral to wetland condition that are feasible to monitor**.** For each of the key ecological attributes, one or more individual **metrics** are selected to be measure in the field (Table 4).

Table 4. Hierarchical structure of the Colorado EIA method.

Ecological Categories	*Key Ecological Attributes*	*Metrics*
Landscape Context	Landscape Connectivity	Landscape Fragmentation Riparian Corridor Continuity[1]
	Buffer	Buffer Extent Buffer Width Buffer Condition
Vegetation Condition	Species Composition	Relative Cover Native Plant Species Absolute Cover Noxious Weeds Absolute Cover Aggressive Native Species Mean C
	Community Structure	Regeneration of Native Woody Species[2] Coarse and Fine Woody Debris[2] Litter Accumulation Horizontal Interspersion / Complexity

Ecological Categories	*Key Ecological Attributes*	*Metrics*
Hydrologic Condition	Hydrology	Water Source Alteration to Hydroperiod Hydrologic Connectivity Bank Stability[1]
Physiochemical Condition	Water Quality	Turbidity / Pollutants Algal Growth
	Substrate / Soils	Substrate / Soil Disturbance
Size	Size	Relative Size Absolute Size

[1] Metric recorded in Riverine HGM wetlands only.
[2] Only applied to sites where woody species are naturally common.

Stressor Checklists

In addition to the condition metrics, the EIA protocol involves collecting data on stressor within each of the major categories (except size). Each stressor is designated with a scope rating, indicating the percent of the AA or landscape that it affects (Table 5). This information allows for correlations between wetland condition and potential stressors. Combining stressor checklists from a suite of wetlands in a given study area will indicate the most pressing stressors observed in the study area. Stressor checklist from a single site can help managers evaluate which stressors they can manage for (and potentially improve wetland condition) and which are beyond their control.

Table 5. Scope and ratings for all stressor categories. The scale of the scope and whether it applies to the landscape or only the AA depends on the stressor category.

Scope of Disturbances	
0	Nil – Little or no observed effect (<1%) on the landscape or AA.
1	Small – Affects a small (1–10%) portion of the landscape or AA.
2	Restricted – Affects some (>10–25%) of the landscape or AA.
3	Moderate – Affects much (>25–50%) of the landscape or AA.
4	Large – Affects most (>50–75%) of the landscape or AA.
5	Pervasive – Affects nearly all (>75%) of the landscape or AA.

Scorecard Reporting

Once EIA metrics have been scores, category and overall ecological integrity scores are calculated based on a set weighting system in a scorecard format (Table 6). Weights are fully explained in Appendix XX.

Table 6. Example EIA Scorecard. Example site is an herbaceous, non-riverine wetland for which size was not considered as a scoring factor.

CATEGORY	Metric			Category			Overall Ecological Integrity	
Metric	Rank	Score	Weight	Rank	Score	Weight	Rank	Score
LANDSCPE CONTEXT				**C**	**3.4**	**0.2**		
Landscape Fragmentation	C	3	0.4					
Buffer Extent	B	5	0.6[1]					
Buffer Width	C	3						
Buffer Condition	B	4						
VEGETATION CONDITION				**B**	**3.8**	**0.4**		
Relative Cover Native Plant Species	C	3	0.2					
Absolute Cover Noxious Weeds	B	4	0.2[2]					
Absolute Cover Aggressive Native Species	A	5						
Mean C	B	4	0.4					
Coarse and Fine Woody Debris	AB	5	0.05					
Litter Accumulation	AB	5	0.05					
Horizontal Interspersion / Complexity	C	3	0.1					
HYDROLOGIC CONDITION				**B**	**4.4**	**0.3**		
Water Source	A	5	0.2					
Alteration to Hydroperiod	B	4	0.6					
Hydrologic Connectivity	A	5	0.2					
PHYSIOCHEMICAL CONDITION				**B**	**4.2**	**0.1**		
Turbidity / Pollutants	A	5	0.25					
Algal Growth	B	4	0.25					
Substrate / Soil Disturbance	B	4	0.5					
SIZE				--	--	--		
Relative Size	A	5	--					
Absolute Size	C	3	--					
							B	**3.9**

[1]The three buffer metrics are combined into a Buffer Index: (Buffer Condition * (Buffer Extent * Buffer Width)$^{1/2}$)$^{1/2}$.

[2]The lowest score between Absolute Cover of Noxious Weeds and Absolute Cover Aggressive Native Species is used in scoring.

SECTION 2: APPLYING COLORADO'S EIA METHOD

2.1 Study Design Considerations

The EIA method can be applied in a variety of different circumstances with varying study design approaches. It is beyond the scope of this manual to fully outline study design options, but a couple main points will be mentioned.

There two major types of study designs, **random sampling** and **targeted sampling**. Random sampling involves sampling a randomly selected, statistically representative set of sites out of a much larger population. The benefit of a random design is that it provides the ability to make statistically defensible statements about the overall condition of wetlands across the population. If the goal of your study is to assess wetland condition across a large area (entire U.S. Forest Service management unit or entire watershed), then a random design is preferable. CNHP has used the EIA method is several large-scale condition assessment projects using random sample study designs and can provide details on the specifics of these designs upon request. Targeted sampling, on the other hand, involves selecting a specific set of site to sample without the need to make estimates about a larger population. Targeted sampling is most appropriate when there is a discrete number of wetlands you wish to assess.

For either type of study design, it is important to identify **available data sources** to help locate your population of interest. These data sources may be U.S. Fish and Wildlife Service (USFWS) National Wetland Inventory (NWI) maps, U.S. Geologic Survey (USGS) topographic maps, Natural Resource Conservation Service (NRCS) soil maps, local vegetation maps that depict wetlands, or aerial photography. There is an abundance of god data sources available online today that can help both identify potential sample sites and assess landscape scale metrics.

The last important consideration is how to define your **target population**. If you are conducting random sampling, understanding the limits of the target population is crucial for setting up an assessment area. If you are conducting a targeted assessment, it is just as important to know when the wetland ends and the upland begins.

There are two primary definitions of wetland to consider using for your target population. The first is the USFWS definition used for NWI mapping (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."*

The USFWS definition is different than the definition of wetland used by the ACOE and the EPA for regulatory purposes under Section 404 of the Federal Clean Water Act (ACOE 1987):

> *"[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 that the Clean Water Act definition requires positive identification of all three wetland parameters (hydrology, vegetation, and soils) while the USFWS definition requires only one to be present. It is important to decide which definition you will use, as the decision has ramification for defining the boundary of your assessment area. In either case, standard wetland identification and delineation techniques can be used to determine inclusion in the target population. Materials produced by the ACOE and the NRCS, such as the *Interim Regional Supplements to the Corps of Engineers Wetland Delineation Manual* (e.g., ACOE 2008) and the *Indicators of Hydric Soils in the United States* (NRCS 2010) are very helpful. However, if using the USFWS definition of wetland, positive identification of only one or two parameters is needed, not all three.

2.2 *Defining an Assessment Area (AA)*

Establishing the Assessment Area

Assessment Areas for Targeted Sampling

The basis of the carrying out the EIA method is identifying and establishing an assessment area (AA) in which data collection is concentrated. For targeted sampling, the AA can be of variable size and shape and can be bound by the entire wetland itself, if so desired. Detailed guidance on defining an AA for non-random targeted sampling will be developed in future iterations of this manual. The remaining discussion will focus on defining AAs for random, point-based sampling.

Assessment Areas for Random Sampling

For random sample designs, it is often preferable to define the AA as a standard area around a fixed point. Because wetlands are so variable in size, random sampling often employs what is called an area-based design. Each AA represents a specific area of wetland and, therefore, a specific proportion of the wetland resource under investigation. The recommended standard AA is a 40-m radius circle (0.5 ha or 5000 m^2) centered on the target random point. However, there can be considerable flexibility in establishing an AA depending on wetland size and shape.

Proper placement of the AA is crucial because it defines the area for most of the data collection. Before heading into the field, users should examine aerial photos of the point and should strategize the most likely placement of the AA based on observed wetland features surrounding the point. Once in the field and the area surrounding the point has been identified to be suitable for sampling, the user will establish the AA to bound further sampling. The AA must be located in the closest possible suitable sample area from the original point. The user should always document the process used to move vegetation plots when the original center point and standard AA are not used.

General Principles

The following are general principles to consider when establishing an AA:

1) The AA should be established in *only one* Ecological System. (Make sure to follow size criteria within the Ecological System Key. Small patches of herbaceous or shrubby vegetation do not necessarily mean multiple Ecological Systems. Changes in dominant soil type or hydrology however, can mean multiple Ecological Systems.)
2) The AA should always be 0.5 ha (5000 m^2) where possible, but can be as small as 0.1 ha (1000 m^2) if necessary.
3) The maximum AA length is 200 m, regardless of shape. The minimum AA width is 10 m, regardless of shape.

4) The AA should contain no more than 10% water > 1 m deep. This includes water in a stream channel. The AA can cross and contain a stream channel that is < 1 m deep (or the depth considered safe to wade by the field user, which may be different for different users and at different stream velocities). The AA *should not* cross streams that are too deep to wade. When sampling a pond fringe with deep water in the center, the AA drawing should specifically indicate the AA edge where water is > 1 m.
5) The AA should contain no more than 10% upland inclusions.
6) Proximity to the original random point generally takes higher priority over retaining a standard 40-m circle AA shape. When there are > 1 wetlands near the original point, but the closest sampleable wetland is smaller than one farther away, the closer wetland should still be sampled. However, do not worry unnecessarily about the exactness of these priorities. If the difference between two potential sites is minimal and one would make that a standard AA is possible, pick the most straightforward sample location. Simply use best professional judgment in the field to survey the original wetland point, in the most standardized way possible, realizing that the goal is to survey the wetland that the random point represents, but that many situations arise in the field that require slight modifications.

AA Layout Protocol in Brief

1) Determine AA shape. This will be a 40-m radius circle, unless size and shape constraints require an alternative shape.
2) For standard circular AAs, take a GPS point the center and record the waypoint number, UTMs and error on the datasheet as the 'AA-Center'. Record elevation, slope, and aspect at the center.
3) For non-standard AAs, you do not need to take a GPS point in the center, as it will be easier to determine in GIS based on the AA polygon. Record elevation, slope, and aspect in a representative area of the AA.
4) Flag AA boundary. For standard circular AAs, flag at least the cardinal directions. For freeform AAs, track boundary using the GPS and flag as often as needed to visualize the AA.
5) Take GPS points and photos at four standard locations on the edge of the AA looking in, either at the cardinal directions for standard AAs or at four logical locations on the edge for freeform AAs. Record the waypoint numbers, UTMs, errors, and photo number on the datasheet.
6) If the site is selected for Level 3 vegetation sampling, layout and flag vegetation plot corners (details to follow in Section 2.4).
7) When AA boundaries are set, draw the AA shape on the color aerial photo. First draw in pencil then trace with a sharpie marker.

Standard AA Layout – 40-m radius circle

The standard AA perimeter is a 40-m radius circle surrounding a center point (Figure 3). Standard AAs may be shifted so the edge of the AA is up to 60 m from the original target point, meaning the center point of a shifted AA can be up to 100 m from the original point (Figure 4).

The perimeter of the AA should be flagged and this process may vary depending on thickness of vegetation. Use judgment to maximize layout efficiency. Further details on flagging the perimeter in open vs. dense vegetation are provided below. In Level 3 plots, veg plots will be flagged simultaneously as the AA boundary is flagged. Site photos can be taken as the AA is flagged (more common in open vegetation) or can be taken after AA is flagged (more common in dense vegetation that is difficult to traverse). Flagging options include biodegradable forestry flagging in visible colors such as pink or orange (easiest in tall vegetation and woody areas) or pin flags (easiest in short vegetation and open water). If it is not possible to stand on the cardinal azimuth of each AA edge (as in deep water), take the reference point UTMs and photos as close as possible to the target position, and note in comments how the reference point(s) are offset.

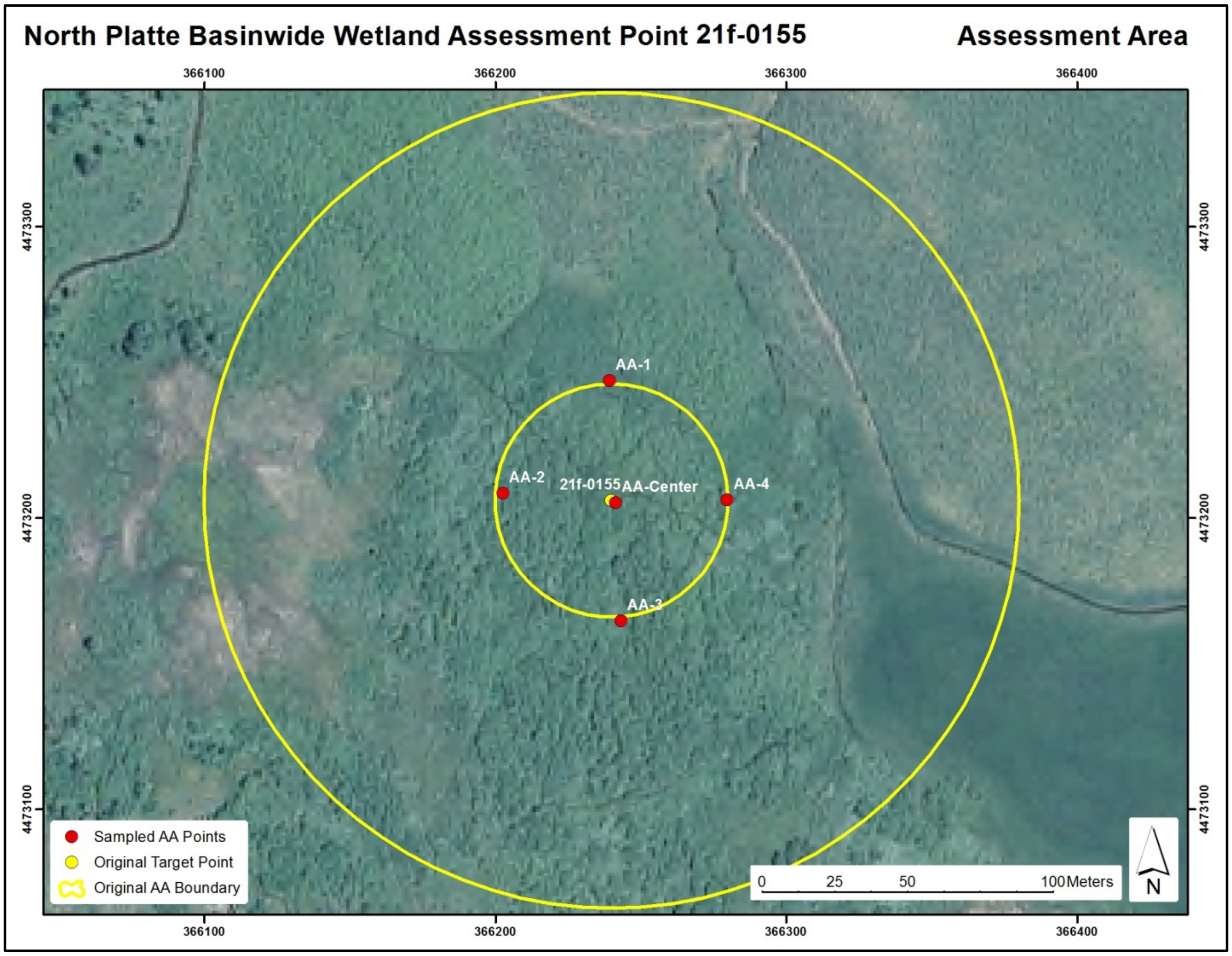

Figure 3. Field map showing a standard 40-m radius circle AA layout centered on the target point. The inner yellow circle is the AA and the outer yellow circle is a 100 m envelope. The yellow point is the original target point and the red points are the AA-center and AA-perimeter points taken in the field.

In open vegetation, a 50-m tape is used to lay out the AA perimeter. One person will stand at the center of the AA holding the end of a 50-m tape, and the other person will walk north from the center of the AA carrying the 50-m tape spool on the left side of their body until they reach 40 m. Use a compass to correct the azimuth to a cardinal direction, looking back at the center point. Once the cardinal direction is flagged, a site photo and waypoint can be taken. For Level 3 plots, vegetation plot corners can be flagged along the tapeline. Then the person at the AA perimeter will walk in a circle, flagging the boundary of the AA with either pin flags or flagging tape until reaching the next cardinal direction. At least four flags should be marked on the AA perimeter, one at each of the cardinal directions (N, E, S, W). In open vegetation, additional perimeter flags can be placed at each of the ordinal directions (NE, SE, SW, NW). More points along the boundary may be marked to aid in visualizing the boundary of the AA, as the user deems appropriate.

If vegetation is dense or difficult to walk through with a 50-m tape, the GPS unit can be a helpful tool to assist with delineating the AA. Mark the center with the GPS, then use the "GO TO" function to measure a 40-m distance from center in a cardinal direction. In Level 2 AAs, the GPS "GO TO" function can be used to delineate each cardinal edge without use of the tape. In Level 3 AAs however, vegetation plots will need to be established at specific distances from center, so it still necessary to use the measuring tape. In these cases, users may need to run the tape at shorter intervals until reaching each veg plot corner. The GPS should not be used to lay out vegetation plots because the GPS accuracy is not good enough to locate veg plot corners separated by only 10 m. Once the last vegetation plot is laid out, the "GO TO" function on the GPS unit can be an easier way to measure the 40 m distance from the plot center the AA edge.

Figure 4. Field map showing a standard 40-m radius circle AA layout shifted from the original target point. The yellow point is the original target point and the yellow circle is the potential AA, which crossed a road. The red circle represents the shifted AA polygon sampled in the field and the red points are the AA-center and AA-perimeter points.

Alternate AA Layout 1 – Rectangle

If a 40-m radius circle does not fit within the wetland area, users may use a rectangular shape to mark out the AA (Figure 5). Compared to free-form AAs, rectangular AAs are easy to layout because the layout is more standardized and the perimeter does not need to be tracked with the GPS. First estimate the required dimensions to reach ~5000 m^2. For example, a square AA should be 70.5 m on each side (70.5 x 70.5 = 4970). If the wetland is 50 m wide, the rectangle should be 50 x 100 m. AAs less than 10-m in width are too narrow to establish vegetation plots, and the feature may no longer confidently qualify as a discrete wetland.

Rectangular AAs may be centered on the point or their edges may be up to 60 m from the point, depending on the wetland area. However, rectangular AAs should only be used where the wetland area is generally straight and the size of the AA is not compromised by bends in the wetland boundary. For this reason, rectangular AAs are not common. GPS waypoints and photos should be taken at each of the four corners of rectangular AAs looking diagonally into the AA.

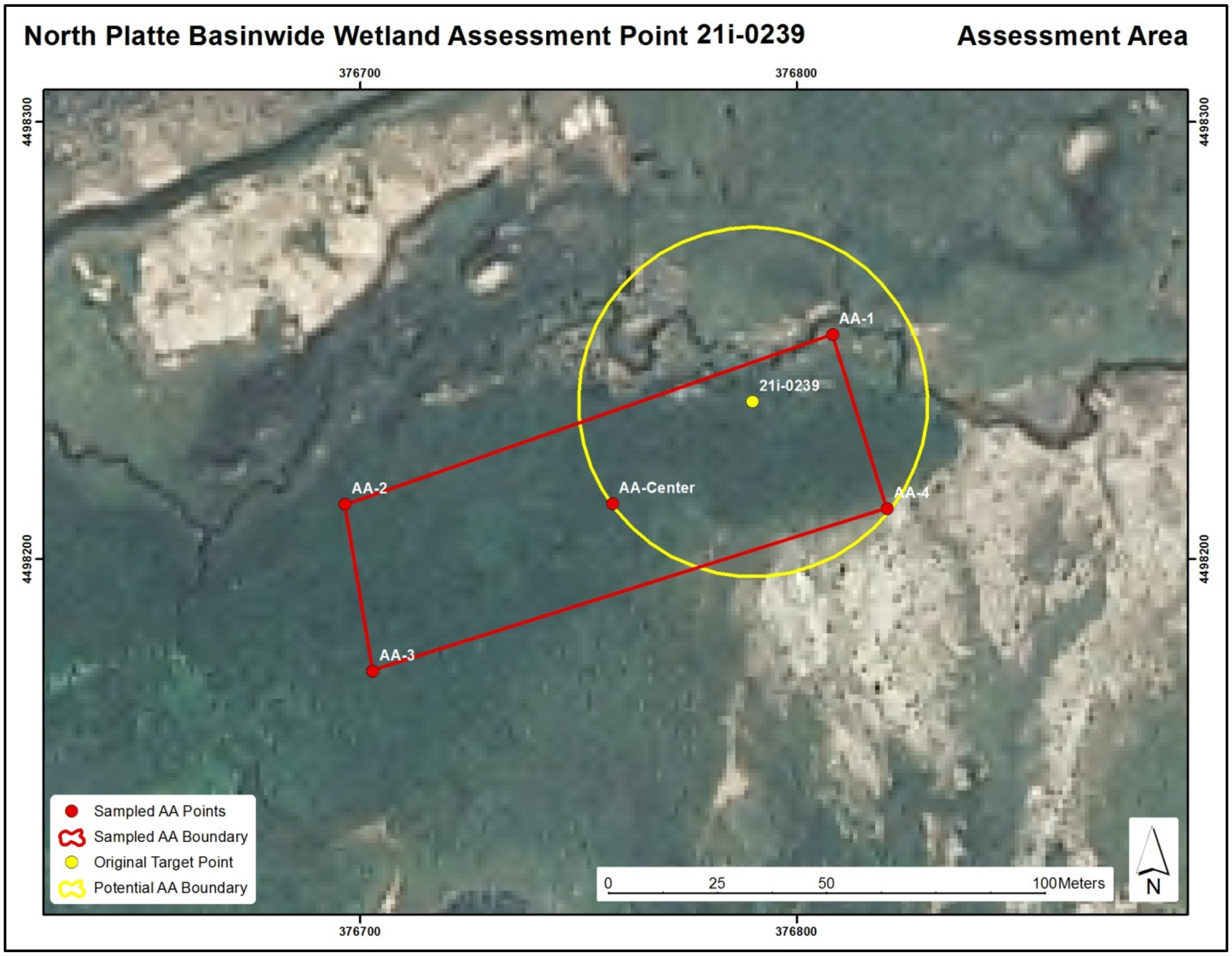

Figure 5. Field map showing a rectangular AA delineated during field sampling. The yellow point is the original target point and the yellow circle is the potential AA, which included unsampleable upland area. The red polygon represents the 5000 m^2 rectangular AA delineated in the field and the red point is the center of the sampled AA.

Alternate AA Layout 2 – Freeform shape

When is not possible to lay out a standard or rectangular AA in 5000 m^2, the AA perimeter is usually confined by 1) the size or shape of the wetland, 2) by Ecological System boundaries, or 3) by deep water. This is considered a freeform AA shape (Figure 6). If the wetland or Ecological System occurrence is small, the entire wetland will become the AA. If the wetland is larger but oddly shaped, the user must first estimate the general dimensions of the wetland using the aerial photos provided and strategize about the best way to lay out a 0.5 ha (5000 m^2) AA. Based on this estimate, the user will walk the perimeter of the AA with the GPS in TRACK mode, flagging the edges as they walk. It is important to visualize the AA layout before walking it out. Once visualized, one crew member leads and flags the AA perimeter while the second crew member follows with the GPS in TRACK mode. This keeps track edges smooth. Before walking the AA track, clear tracks (this action will not clear previously saved tracks). When finished, switch out of track mode, use GPS Area Calculation function to determine AA track size, and record area in m^2. If the AA perimeter ends up significantly larger than 5000 m^2 (~5500 m^2 or larger), the user must determine which portions to exclude to ensure the AA is comparable to others in the study. The GPS track will be saved on the GPS unit and named by the point code.

In cases of wetlands along a pond fringe where the water gets deep (>1m) or substrate becomes dangerously soft towards the center, a donut- or boomerang-shaped free-form AA may be necessary. In some cases, the deepest boundary of the wetland may not be wadeable in areas, and instead of a complete track, the AA is delineated by a partial track, with 2 to 4 extra waypoints along the deep boundary that are also noted on the AA drawing. The AA drawing should also clearly indicate the wetland perimeter, and should describe the portion of the edge that has track data and the portion to edit in office. These resources will be referenced in office to clip any non-target area out of the AA track in GIS.

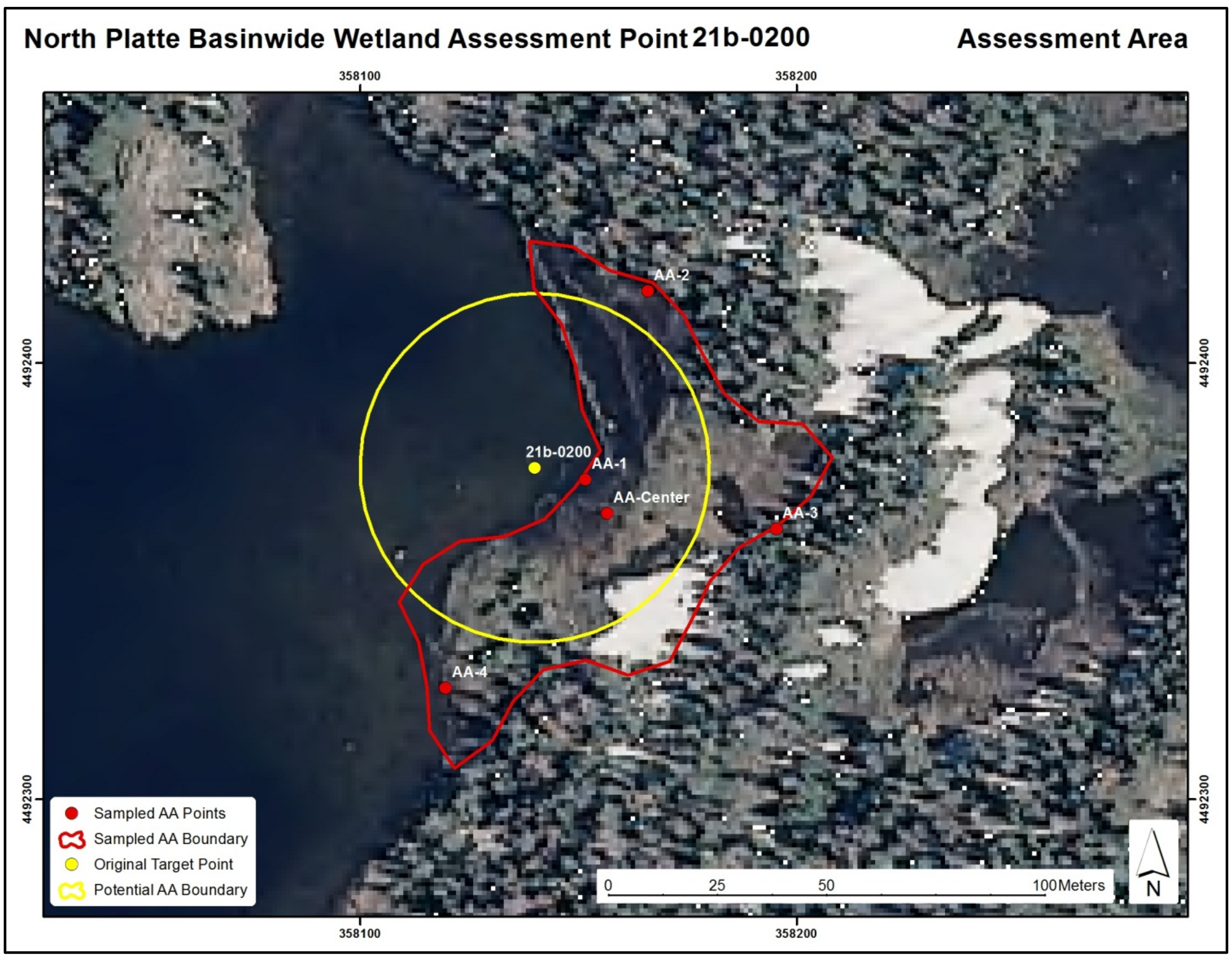

Figure 6. Example of a freeform AA delineated during field sampling. The yellow point and circle represent the original target point and potential AA, which included water too deep to sample. The red polygon represents the 5000 m^2 freeform AA delineated in the field and the red point is the center of the sampled AA.

Photos of the Assessment Area

The aim of AA photos is to represent the AA in photographs—as they say, a photo is worth 1000 words. There are various standard photos that must be taken in each AA, with the photo numbers recorded:

1) The four standard AA positions (record photo number on page 1),
2) Vegetation plots, if site is selected for Level 3 sampling (record photo number on page 4)
3) Soil pit photos (record photo number on soil pit page),
4) Unknown plant photos (record photo range on vegetation plot species table page),
5) Photos of anything notable. When possible, it is helpful to have photos looking down at the entire wetland. Photo numbers should always be recorded when photo is taken outside the AA. When there are questions on how to record data, take photos and record their numbers to represent the issue in question. Otherwise, not all photos within AAs must be labeled if they fall within the AA photo range and are not standard photo (record photo number, photo type, and range on 'Additional AA Photos and Comments,' page 1).

The **photo number** is visible on the camera's screen when it is placed in view or playback mode and when data about the photos are shown. *Remember that the photo number is NOT the sequential number based on the count of photos taken since the camera was last erased. The photo number often starts with a three digit number, a dash, and then a four or five digit number. Only the last four or five digit number is necessary to write down on the form. If sequential numbers are written on the field form, this data will be meaningless, as they are lost when uploading photos.*

A **photo placard** will be held in all four of the standard AA photos (Figure 7). Photo placards will be placed in the very corner of the photo, taking up only a small portion of the frame, with as little arm or body visible as possible. The camera should be tilted to represent as much of the AA as possible, and photos should be reviewed for clarity before moving on. In dense vegetation, one may want to hold the camera higher and move branches directly in front of the camera out of the way. The point code should be written on in full on the first line of the placard (e.g., 21i-191). The second line of the placard will contain the aspect that the photo is facing and the location of the photo (e.g., 140°/AA-4; 300°/AA-1; 90°/AA-1). Aspect should be rounded to the nearest 5 degrees in all photo points. *Make sure to set the declination of your compass.* Date should be written as month / day / 2013 (e.g., 7/7/2013; 6/24/2013). The standard photos can be taken while walking the perimeter of the AA, or after the AA perimeter is flagged. It is essential that two people participate in taking the placard photographs.

Figure 7. Example AA photos. Note placement of photo placard in corner and information written on placard.

2.3 Describing the Assessment Area (AA)

Location and General Information

The first page of the **2013 Colorado Ecological Integrity Assessment Field Form** contains general information about the site. This information can be filled out once the user determines that a target sample area is located at or near the sample point. The following guidance will assist in filling out this section of the form.

Point Code: The code of the original sample point. For CNHP projects, this code starts with a two to three digit code for the Level 4 Ecoregion. The second part of the point code is three-digit number for the point itself. As an example, a point code might be 25c-0032. This code could be anything project specific.

Site Name: This is a name given to the site by the field user. This name can be anything the user wants and should reflect the location of something memorable that happened or was observed during sampling. The name could be something like Spring Creek Shrubland or could be Dizzy Cloud Fen. It is helpful to include the Ecological System at the end of the name. Landowners may request copies of the data sheets so site names (and all notes) should be appropriately professional for landowner review.

Level 2 or Level 3: These check boxes indicate whether the site was sampled with Level 2 rapid protocols or Level 3 intensive protocols. Each site will be designated as Level 2 or Level 3. The primary differences between these two protocols in 2013 surveys is that for Level 3 surveys, vegetation plots are laid out and detailed species and structure data are taken in each plot, while for Level 2 surveys, there are no vegetation plots and the same data is taken at the AA scale.

Date: Date of sampling, written as month, day, year (e.g., July 12, 2013 or 7/12/2013).

Surveyors: The first initial and last name of field user members sampling the site (e.g., J. Lemly, L. Gilligan).

General Location: A brief phrase describing the general location of the site, usually a creek name or other landmark from the USGS topo map (e.g., Spring Creek, Mt Emmons, Beaver Meadows).

County: The county in which the wetland occurs.

General Ownership: A general description of the land ownership, using the following short abbreviations and others where applicable:

- USFS = U.S. Forest Service
- BLM = Bureau of Land Management
- NPS = National Park Service
- SLB = State Land Board
- Private = Privately owned lands

Specific Ownership: A more specific description of the land ownership, such as Rio Grande National Forest, Mt Zirkel Wilderness, Glacier National Park, or landowner name.

Directions to Point: Directions should specify a starting point, either "From Fort Collins" or "From Highway 14 heading N" or "From the 'x' trailhead in Kiowa." Include route taken, approximate mileage traveled on dirt roads, trails, and off trail navigation, and parking location used.

Access Comments: Can be blank, but record any information that would be helpful if one were to revisit the site. Indicate any access restrictions to visiting site such as parking limitations, keys needed, gate codes, or entry facilitation by agency person or landowner. Also indicate if permit is needed, or if challenging structures/vegetation require an indirect approach.

Dimensions of AA: Circle AAs are the 40-m radius standard AA. Rectangular AAs are rectangular. Other dimensions indicate a free-form AA, adjusted to the shape of the wetland/target area boundary.

Elevation: Record elevation at AA center in meters. For all GPS points, when >1 UTM Zone occurs in the study area, users should note the UTM Zone of all GPS points.

Slope: Record slope at AA center in degrees, averaging slope of wetland within AA between uphill and downhill. Depressional wetlands generally do not slope in one direction, so in those slope is N/A. If there are two general slopes (e.g., for a riparian area, the wetland might slope down to the river channel and might also slope with the general gradient and direction of the river), the larger slope outside of the AA can be noted in the comments. Slope is measured either with a clinometer or a compass.

Aspect: Visualize the direction that water would flow downhill, along a scale comparable to the AA size, and take a compass reading of that direction (degrees). Record N-facing aspects as zero, not as 360. If the aspect within the AA is obviously different than the azimuth across a larger land area, record a second aspect and note which one is which. In depressional wetlands, even when depression is larger than AA, aspect is generally N/A. *Make sure to set the declination on your compass.*

AA-Center: If AA is a standard 40-m radius circle, record the center waypoint number and UTMs. To record error, use averaging device on GPS until error appears to stabilize. Optimally, error is < 5m, but that is not always possible. In non-standard AAs, the center point is not needed.

AA-1 through AA-4: These are the reference waypoints, UTMs, and error recorded at four standard locations on the AA perimeter, along with associated photos. It does not matter which directions are labeled AA-1 through AA-4 or what sequence they are taken in. In standard AAs waypoints are recorded at the cardinal directions, facing the AA center. In rectangular AAs, waypoints are taken on the four corners, looking in towards center. In other non-standard AAs, these waypoints and photographs are better taken along the long and short midpoints of AA vertices, facing into the AA towards the center. In long linear or sinuous AAs, the two midpoints along the long vertices may not be directly across from each other, may instead may face the opposite bank, but the two midpoints along the short vertices should still face into the AA towards the center.

The user should make any notes necessary to describe how the AA was established and the reasoning behind the AA shape in the box for **AA Placement and Dimensions Comments**. This will address whether the AA boundary was not standard because the wetland was too small, or whether non-standard because target area was shaped in a way that could not be assessed by a circular AA (such as a linear feature).

Environmental Description and Classification of the Assessment Area

The top of the second page of the field form contains environmental descriptors and classification information. Guidance is given below. For any environmental descriptor or classification where there is doubt, ambiguity, or further explanation is necessary, use the comments sections below the data fields.

Non-target Inclusions: Estimate the percent of the AA occupied by non-target inclusions of water > 1 m deep and upland areas. Non-target inclusions should be limited to < 10% each.

Wetland Origin: Note whether the wetland is a) a natural feature with minimal disturbance, b) a natural feature altered or augmented by human modification that affects hydrology, or c) a non-natural feature created by human management action (creation can be intentional such as created wetland for mitigation, or an unintentially created wetland because of impoundment or irrigation seepage). Use topographic map and aerial photography to interpret possible natural sources of hydrology, such as ponded water from precipitation, old channels, or a high water table due to groundwater exposure at a break in slope. A high water table from irrigation ditch seepage above AA is not considered natural; however, some wetlands could have seeps or springs. When in doubt, use best professional judgment and note thought process.

Ecological System: Use the key provided in **Appendix A** and select the Ecological System targeted in the survey. Circle High, Med, or Low to denote how well classification fits key, and explain in the comments section below when confidence is medium or low.

Cowardin Classification: Record the appropriate Cowardin classification codes, using the definitions provided in **Appendix B**. The Cowardin classification should be applied to patches 0.1 ha (1000 m^2) or larger. The final total of percentages should equal 100% of the AA. Designate affinity to key as above.

HGM Class: Select the appropriate HGM Class using the key provided in **Appendix C.** Try to pick only one dominant HGM Class. Designate affinity to key as above. If it seems there is >1 dominant HGM, reconsider if AA spans over more than one Ecological System (AA should only have one Ecological System). *Note that additional classification and metrics apply to AAs in the Riverine HGM Class.*

Riverine Specific Classification of the Assessment Area

Specific classification is applied to AAs in the Riverine HGM class. Some Riverine Class AAs will include the channel or be located adjacent to a channel. Others may be in a floodplain, but not located near the channel. Answer all questions possible based on available evidence in and surrounding the AA. These questions should be answered based on best professional judgment and do not require exact measurements.

Confined vs. Unconfined Valley Setting: Streams in confined (Figure 8) and unconfined (Figure 9) settings behave very differently. Confinement can result from hard geomorphic barriers such as a rock wall that impedes flow, not to incised banks. Confined wetlands that meet the minimum width requirements for sampling are uncommon. There are two pieces of information necessary to determine whether a stream is in a confined or unconfined setting. This first is bankfull width, the second is valley width. It is not necessary to measure either one precisely in order to make a determination about confined or unconfined status of a stream. Estimate these widths as precisely as is necessary to determine whether the valley width is greater or less than 2x the bankfull width. **Bankfull width** is the width of a stream channel at the point where over-bank flow begins during a flood event. Bankfull indicators may include: the lower limit of perennial vegetation, stain lines, moss or lichen, a change in particle size, etc. **Valley width** is the width of the topographic floodplain, the extent of the area where water could easily flood. In confined valley setting, valley width is less than 2x bankfull width. In unconfined valley settings, valley width is greater than 2x bankfull width. See Figure 10 for a graphical illustration of these components.

Proximity to Channel: Note whether the AA includes the channel and both banks, is adjacent to the channel and includes one bank, or is far from the channel and the banks were not evaluated.

Wadable vs. Non-wadable stream: Note whether the AA is located on both sides of a wadable stream (< 1 m deep), on one side of a non-wadable stream, or is located on one side of a stream but not adjacent to the channel.

Figure 8. Example of a confined valley setting.

Figure 9. Example of an unconfined valley setting.

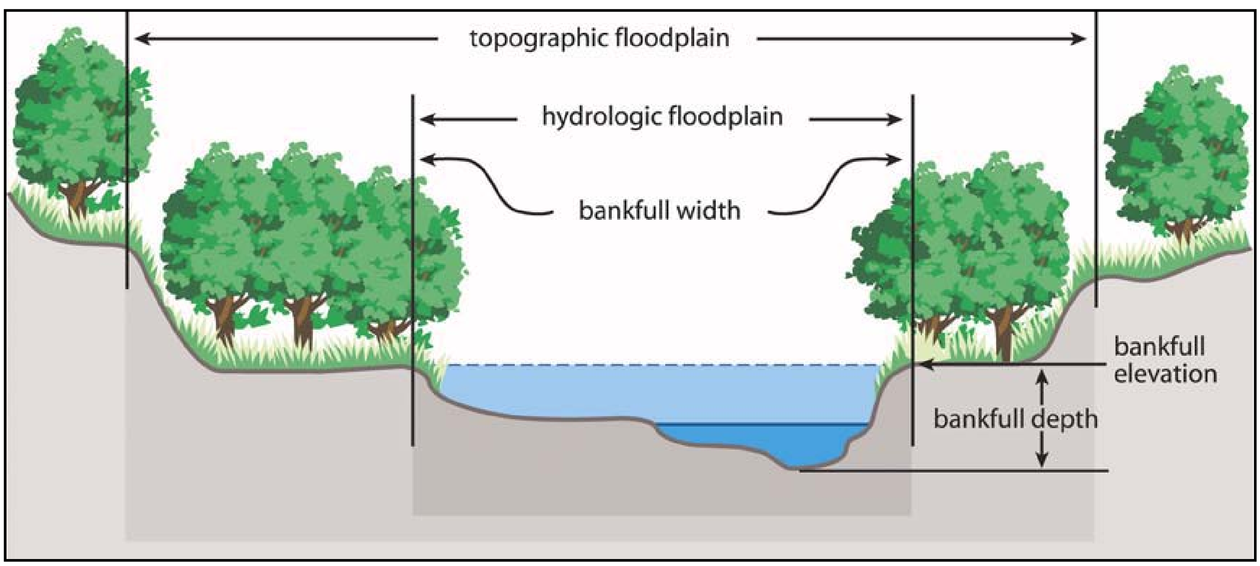

Figure 10. Graphical illustration of bankfull width and the topographic floodplain.

Major Zones within the Assessment Area

Identify and describe the major zones within the AA, which may be vegetation zone or may be physical patches such as open water or bare soil. Vegetation zones often consist of more than one plant species, but some zones can be mono-specific. A vegetation zone should be described if it meets the following rules:

1a. The plant zone is dominated by a physiognomic class distinctly different from other plant zones; OR
1b. The plant zone is dominated by the same physiognomic class as other plant zones, BUT each plant zone is dominated by different species AND the average height of the dominant species differs by > 1 m (e.g., *Typha latifolia* vs. *Juncus balticus*).
2. The plant zone makes up more than 5% of the AA (e.g., 250 m^2 for an AA of 0.5 ha).
3. Each individual patch of the plant zone is greater than 10 m^2.

For each zone identified, note the physiognomy of the dominant stratum, the dominant species (e.g., *Salix monticola/Calamagrostis canadensis*), and the percent of the AA that the zone occupies. Percentages of these zones should total 100% of the AA. Use the following major physiognomic classes:

- **Forest/Woodland** (trees or shrubs > 5 m tall occupy > 30% cover within a patch)
- **Shrubland** (shrubs < 5 m tall occupy > 30% cover within a patch)
- **Herbaceous** (graminoides, forbs, or ferns dominate)
- **Nonvascular** (bryophytes, cryptogrammic crusts dominate)
- **Submerged / Floating** (rooted or floating aquatics dominant, this does not include emergent veg)
- **Sparsely Vegetated** (vegetation cover < 5 %)
- **Open Water** (unvegetated)
- **Bare Ground / Rock** (unvegetated)

Assessment Area Drawing and Description

Provide a drawing of the assessment area illustrating the AA shape and boundary, including major vegetation zones, direction of drainage into and out of wetland, soil pit placement, and vegetation plot placement. Anthropogenic features like culverts, berms, or impoundments should also be included in the sketch. Also, indicate any major vegetation zones on the aerial photo of the AA. Include a north arrow. The AA drawing can be done once the AA is established or it can be done after all sampling is complete, if you have a better understanding of the site.

For the assessment area description and comments, describe the wetland type, dominant vegetation, soils, and hydrology. Also include abiotic zones, habitat features present, general location, and any notable feature about the wetland that may not have been captured in the classification or other information on the first two pages. Also note surrounding vegetation and land use. This is the best place to sum up the major characteristics of the site in paragraph form.

AA Representativeness: Note if AA is typical of surrounding wetland area, or not, and note if AA is the entire wetland.

Wildlife Species: I wildlife species are encountered, they can be listed at the bottom of this page (not required, something to consider if landowners have issues with wildlife observations). Photographs are useful for verification when possible.

2.4 Vegetation Sampling Protocols

Level 2 vs. Level 3 Vegetation Sampling

CNHP recommends one of two vegetation sampling protocols to address metrics in the vegetation condition category of the EIA.

For Level 2 Assessments, walk through the AA and identify as many plant species as possible within one hour. Attempt to identify all common species in the AA during this time, and scan the array of microhabitats in the AA for new plants (e.g., in shade vs. sun, depressional swales, above and below hummocks, away from water vs. in the water). Skip the vegetation plot set up and spend *no more* than 1 hour compiling the species list. Once the species list is compiled, use the first plot column on the form to estimate cover for the entire AA. In addition to the vegetation survey, ground cover estimates should also be made following the same guidance given below for the Level 3 protocol, except that the estimate should be for the entire AA. Data should be entered in the first plot column on the datasheet.

Level 3 Assessments, carry out the full vegetation plot as explained below. It is often advisable that the user lay out and sample the vegetation plot before filling out the EIA metrics. Many of the questions will be easier to answer once the vegetation plot has been carried out.

Determining Placement of the Vegetation Plot

Intensive assessments (Level 3) involve the collection of plant species cover and composition data. The vegetation plot recommended by CNHP is adapted from the EPA's National Wetlands Condition Assessment (NWCA) flexible-plot method (EPA 2011). Five 10 m x 10 m plots (100 m^2 = 0.01 ha) are placed along pre-set locations within the AA (Figure 11). Plot 1 is located 2 m south of the center point on the southern axis. Plot 2 is located 10 m beyond Plot 1, also on the southern axis. Plot 3 is located 15 m from the center point on the western axis. Plot 4 is located 15 m from the center point on the northern axis. Plot 5 is located 20 m from the center point on the eastern axis.

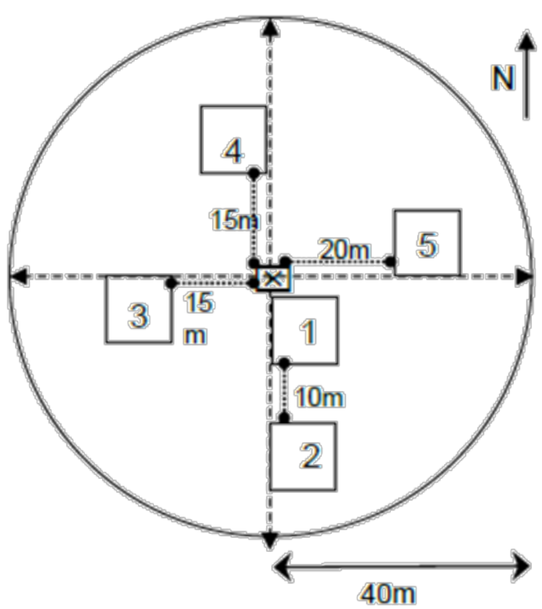

Figure 11. Standard Level 3 Veg Plot Layout. Vegetation Plots are located at specified distances from the AA center. Figure from EPA (2011).

When a non-standard AA layout is used, placement of vegetation plots follows the protocol below:

1a) AA is a 0.5 ha polygon .... Go to 2
1b) AA is <0.5 ha, but >0.1 ha, equaling the wetland boundary........ Wetland Boundary Veg Plot Layout (Fig. 12)

2a) AA width and length >30m .... Wide Polygon Veg Plot layout (Fig. 13)
2b) AA is ≤ 30m wide .... Narrow Polygon Veg Plot Layout (Fig. 14)

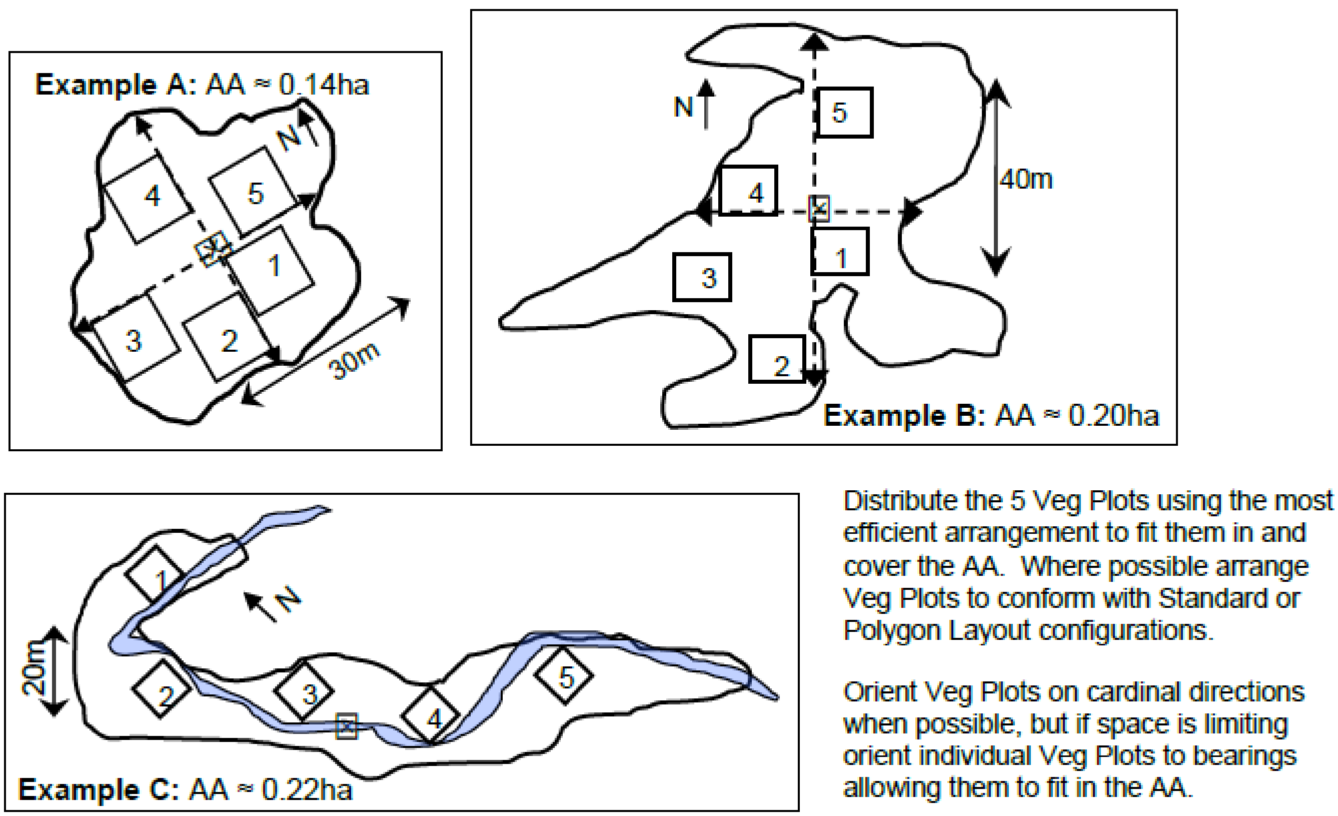

Figure 12. Examples of Wetland Boundary Veg Plot Layout. Plots are laid out as close to the standard layout as possible, but may be placed wherever they fit within small or unusually shaped AAs. Figures from EPA (2011).

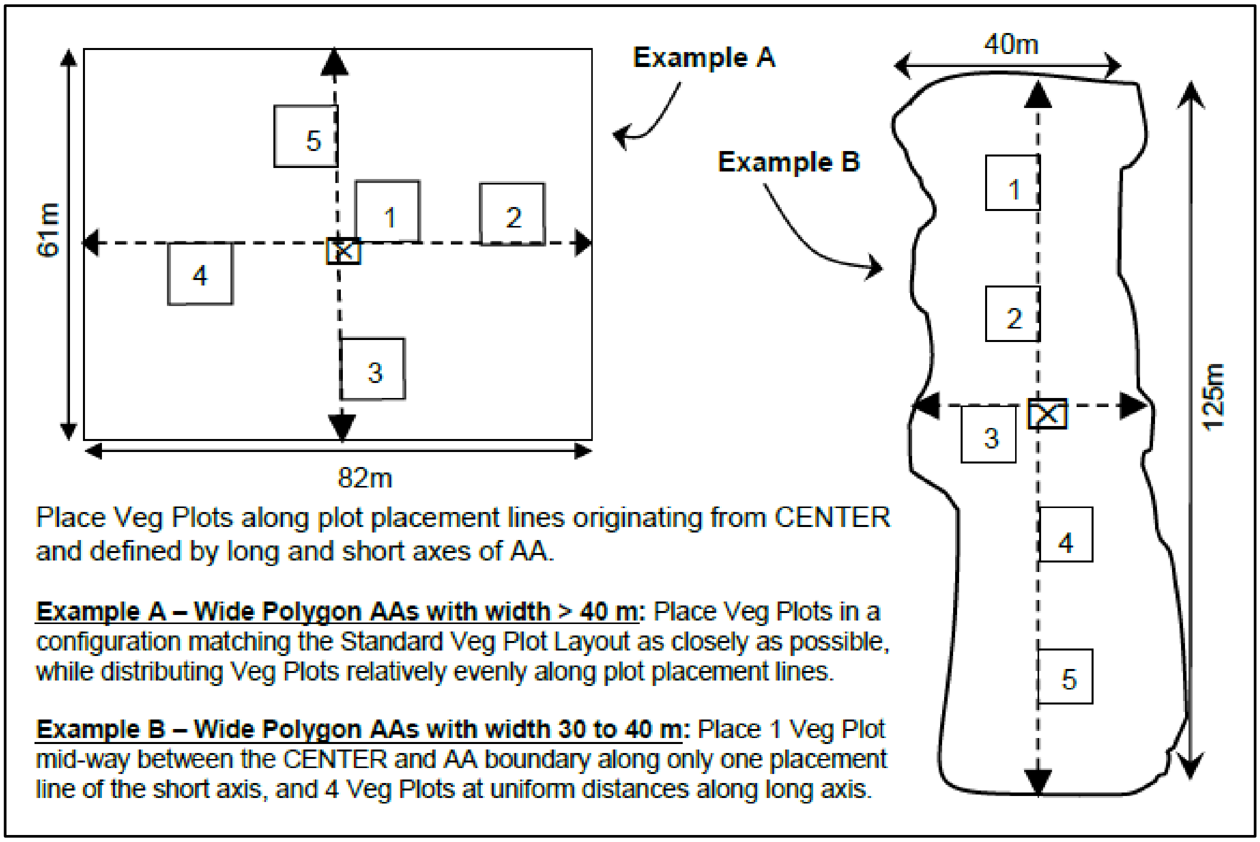

Figure 13. Examples of Wide Polygon Veg Plot Layouts. Veg plots are laid out along both axis as close to the standard layout as possible. Figures from EPA (2011).

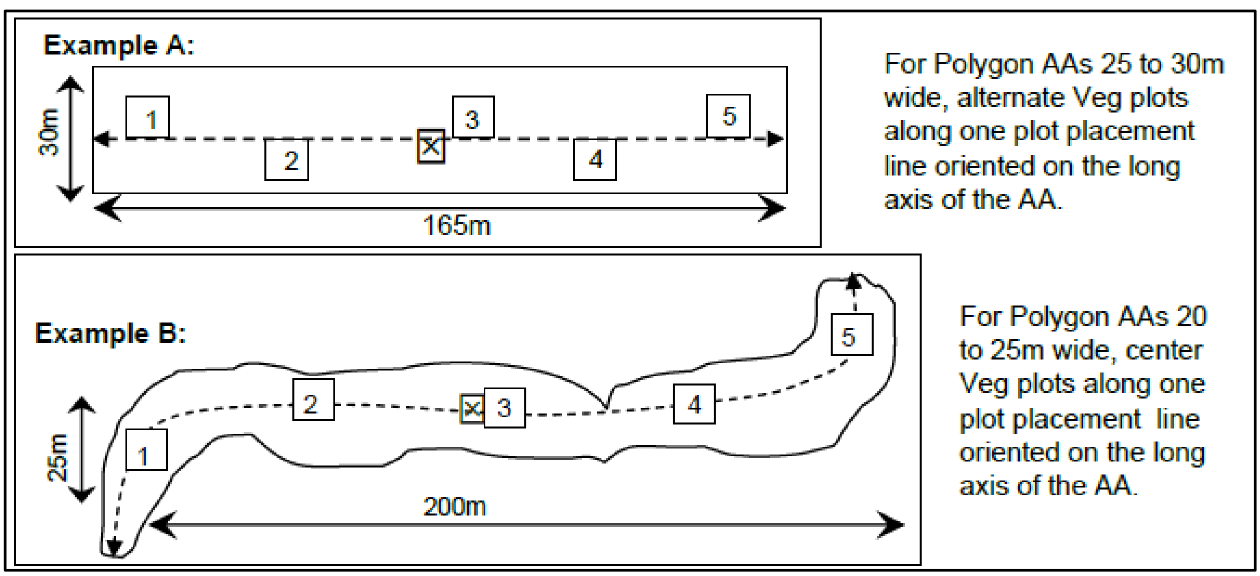

Figure 14. Examples of Narrow Polygon Veg Plot Layouts. Veg plots are laid out along one axis of the AA, spaced as evenly as possible. Figures from EPA (2011).

Laying Out and Documenting the Vegetation Plot

CNHP's Level 3 vegetation protocols are very similar to the NWCA, but are deviate slightly in the interest of sampling efficiency. We set up all five plots, as in the NWCA protocol, but only collect intensive vegetation data in four of the plots. The last plot is designated as a residual plot where only additional species not found in other plots are recorded. The residual plot should be the least noteworthy or unique of the five vegetation plots.

Once the AA corners along the tape are flagged, the 10-m rope will be used to mark out the plots. One crew member should hold the end of the 10-m rope at a plot corner along the tape while the other walks out perpendicular to the tape, so the plot is counterclockwise to the tape. The direction of this 10-m line should be checked by the crew member along the tape line with a compass. Pin flags or flagging tape should be used both along the center line and along the outside edge to mark the plots. After one side of the plot is laid out, the crew then walks back towards the beginning, laying out the second side of the plot. Veg plots are always on the counterclockwise side of each cardinal AA radius. A trick to remembering this is "plots are out in left field", so as you walk out away from the center, plots are to the left.

Before surveying vegetation plots, GPS waypoints and photos should be taken of each plot on their SW corner, facing NE. These photos and waypoints should be taken in a manner consistent with the AA photographs (see Figure 7).

Crew members should note any pertinent information about the plot layout on the form, including whether the vegetation plot layout was standard, or the specifics of the alternative configuration used can be described. Lastly, users should document in the comments if the vegetation plots were not representative of the vegetation within the AA.

Vegetation Plot Species Table

Floristic measurements including presence/absence and abundance (i.e., cover) of all vascular plant species will be made within four intensive veg plots. Sampling will begin in one 1-m^2 corner of the plot to focus the field user's search. Once all species in that corner have been identified, the user can move to a larger area, about 3 m^2. Then user continues throughout the entire plot and each species identified will receive a P to indicate it is present in the plot. Another significant different between CNHP's protocols and the NWCA protocol is that we do not establish the nested quadrats for data collection. We have found that we can identify as many species without the nested quadrats and eliminating them saves valuable field time.

Nomenclature for all plant species should follow the Weber and Wittmann 3rd edition (Weber and Wittmann 2001a, b). C-values from the FQA for Colorado wetlands were determined based on the nomenclature in these floras and data analysis tools reply on these names. When other floras are used to key a species, the key path and species name should be checked in Weber. All species will be recorded on the field form using the fully spelled out scientific name.

Any **unknown species** will be entered on the field form with a descriptive name. If the genus of the species is known, the descriptive name should include the genus name (e.g., Carex 1 sp. or Aster 2 sp). The descriptive name should also include some identifiable characteristics to distinguish multiple unknown species from the same genus (Carex sp. elongate back head or Carex sp. clustered brown head). If the genus is not known, the descriptive name should include any descriptors necessary (fuzzy round basal leaves or purple united corolla). All unknown species will be collected by the field user either when the species is encountered or at the end of the vegetation plot. If the species is not collected until the end of the plot, a marker or pin flag should be left to mark the spot of the unknown species for later collection. Even if the species appears to be unidentifiable, the user should default by collecting unless they are sure the species could not be discerned from other similar species by a botanist's gestault when aware of habitat and growing location. The user may find the same species further developed at a later site and can compare the further developed specimen with the earlier voucher. *The only species the user should not collect are those identified as or suspected to be **federally or state listed species.*** All users should be aware of the listed species in their State and should document occurrences with **multiple clear photographs** and document the photo numbers in the Photos column. It is also useful to photograph plants that the user expects will change substantially after collecting, such as very small or large plants (shrubs, tiny annuals), and aquatics.

All collected unknown species will receive a **collection number**, which will be a running sequential series of numbers that starts at every site. This collection number will be written on the field form in the column "Coll #". When users encounter species that look alike, their bases should be taped with masking tape, and the collection number can be written on the tape with a sharpie. All unknown species should be properly collected for later identification and should include portions of the roots, stems, leaves, flowers, and fruits to the full extent possible. The collector should note whether the plant is rhizomatous or cespitose. Users should always review field keys of unknown species to ensure they record pertinent information. Proper collection technique will be demonstrated in field training.

When all species within a plot have been identified, cover will be visually estimated for the plot using the following cover classes (Peet *et al*. 1998). The visual aid provided in Figures 15 and 16 for estimating cover can be helpful in the field.

1 =	trace (one or two individuals)	6 =	>10–25%
2 =	0–1%	7 =	>25–50%
3 =	>1–2%	8 =	>50–75%
4 =	>2–5%	9 =	>75–95%
5 =	>5–10%	10 =	>95%

Though noting presence in the first plot may seem redundant (every species on the list will be within the plot), this column will be increasingly important as the user moves on to the second, third, and forth plots. Starting with the second plot, the user will record each of the species from the first plot that they encounter in the second plot by placing a P in the "Presence" column. The user may also add to the species list if additional species are encountered in the second plot. This will also receive a "P" in the "Presence" column. Once the user feels confident that all species have been identified, the marks in this column will give the user a list to use when estimating cover for the plot.

Residual plot: After sampling each of the intensive plots, the last (i.e. residual) plot will be walked through to document presence of any species not recorded in the intensive plots. Percent cover of these species will be estimated over the entire AA. In a 5000-m^2 AA, 1% cover is approximately 7x7 m^2. It is ok to also note any observed species from in the AA not in the veg plots in the residual, as long as they are not in an upland inclusion. This is uncommon to do, and the user should not search for any additional species outside the vegetation plots. Rather, when the user notices a very common species in the AA that is not represented in the veg plots or residual, they can add it to the residual plot.

Vegetation Plot Ground Cover and Vertical Strata

Within each of the four intensive plots, in-depth information on the ground cover and vertical vegetation strata will be recorded. The residual plot (the least notable plot) is surveyed last, and only new species or new ground/vertical strata data are recorded when not observed in previous plots. This page comes before the species table within the field form, but is easier to fill out after the plot has been searched for species. The reason it is presented first is so the two pages of the species table are facing each other, which is much easier for use in the field. In each plot, document any attributes observed for the ground cover and vertical strata page. Guidance is provided below.

Cover of standing water of any depth, vegetated or not: This field is for any and all water within the plot, whether it is 0.5 cm or 70 cm deep. Using the cover classes provided at the top of the form, estimate total cover of water.

Minimum depth of standing water: Estimate the minimum depth of standing water that is at least 1 cm. Walk through the plot to make sure you identify the minimum depth.

Maximum depth of standing water: Estimate the maximum depth of standing water. It is likely that this will be < 1 m, since AAs are limited to areas with < 1 m of water. Walk through the plot to make sure you identify the maximum depth.

Predominant depth of standing water: Estimate the predominant depth of standing water. Walk through the plot to get a sense of the range of depths and estimate the most typical depth in the plot.

Cover of bare ground: Cover of bare ground will be estimated using cover classes for three separate categories of bare ground: 1) soil, sand, or sediment; 2) gravel or cobble ~2–250 mm in diameter; and 3) bedrock, rock, or boulders > 250 mm in diameter. Similarly to above, these particle sizes do not overlap, so choose the dominant size.

Cover of litter: Cover of litter will be estimated using cover classes. This includes litter that is hidden beneath vegetation or water. In cases where dense herbaceous vegetation covers the plot, this can be difficult to determine, as this year's herbaceous vegetation can intermix with litter from previous years. Litter can also include standing dead herbaceous vegetation, particularly annual vegetation or dead attached leaves from the previous year, which would become litter once it fell over.

Depth of litter: This is an average of the depth (in cm) of litter at the four plot corners. If those corners have no litter but there is litter in the plot, choose a depth representative of the average. The measured litter height should not be trampled, but should reflect the height at which it occurs naturally.

Predominant litter type: Select the predominant litter type (C = coniferous, E = broadleaf evergreen, D = deciduous, S = sod/thatch, F = forb). Sod/thatch is used for graminoid litter.

Cover of standing and downed woody debris: The cover of woody debris is estimated based on whether it is standing or downed, and the diameter either at breast height or the average diameter of the debris. To differentiate down debris from standing debris, use the 45° rule. If a tree is leaning more than 45° from upright, it is considered downed woody debris. If it is leaning less that 45° from upright, it is considered a standing dead tree or snag.

Cover of nonvascular species: The cover of non-vascular species (eg: moss, liverworts) will be estimated using the cover classes. For each species group, make sure to look underneath vegetation. The cover of these species groups is often underestimated because people do not look for them hiding among the leaves of graminoids or under shrubs.

Vertical vegetation strata: The overall cover and average height class of each vertical stratum will be estimated for the plot. Each vertical stratum has a corresponding height class noted on the data sheet.. Any given stratum can have up to 100% cover, but the overlapping species within the stratum are ignored. Note that the height classes are more specific in the vegetation plots than the height classes in the habitat data.

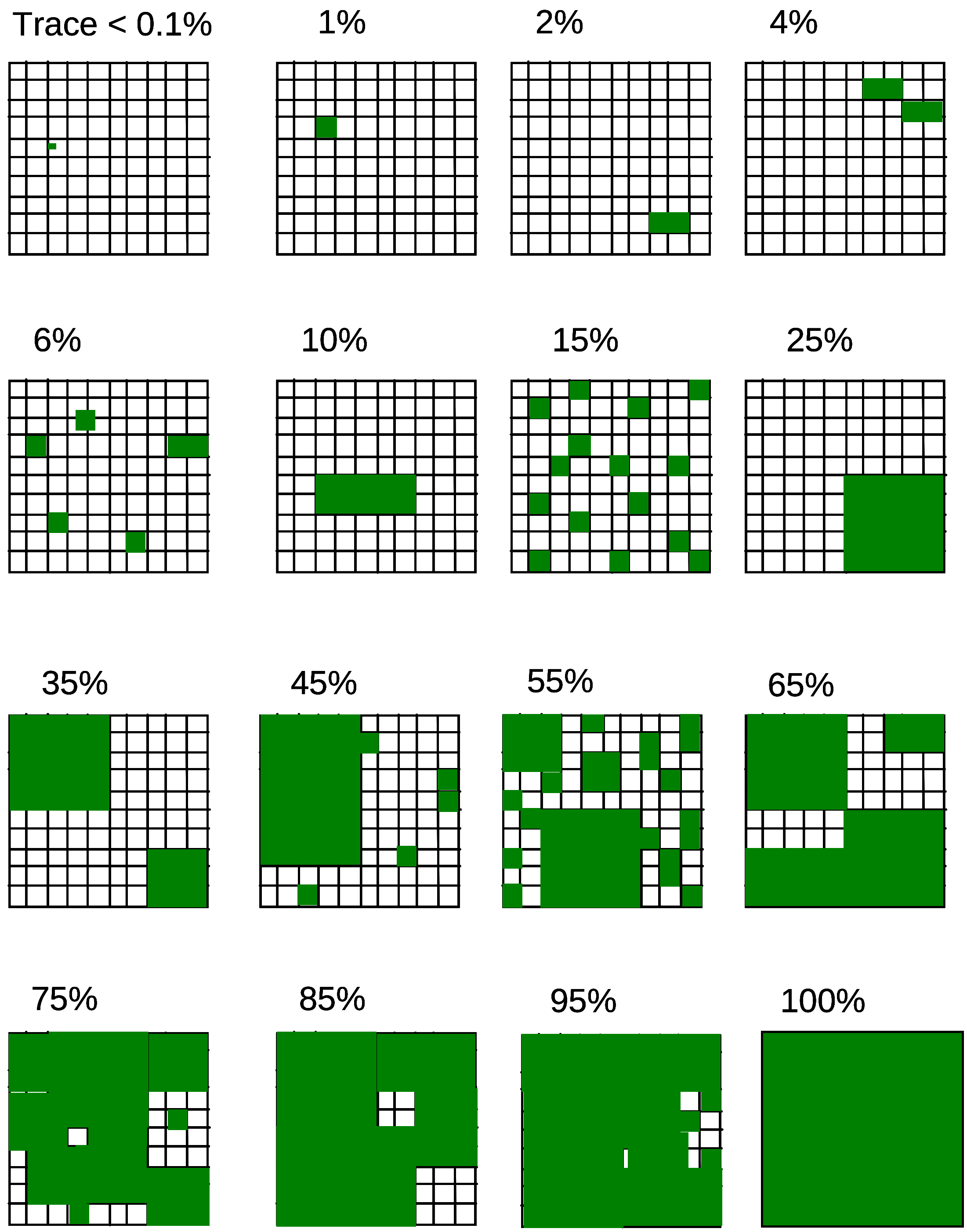

Chart 1. Examples of Percent Cover Estimates. Each large square = 100 m^2 module, grid squares = 1 m^2 (i.e., one grid square = 1% cover in a module), shaded areas represent cover of a vegetation stratum or of an individual species.

Figure 15. Examples of percent cover estimate.

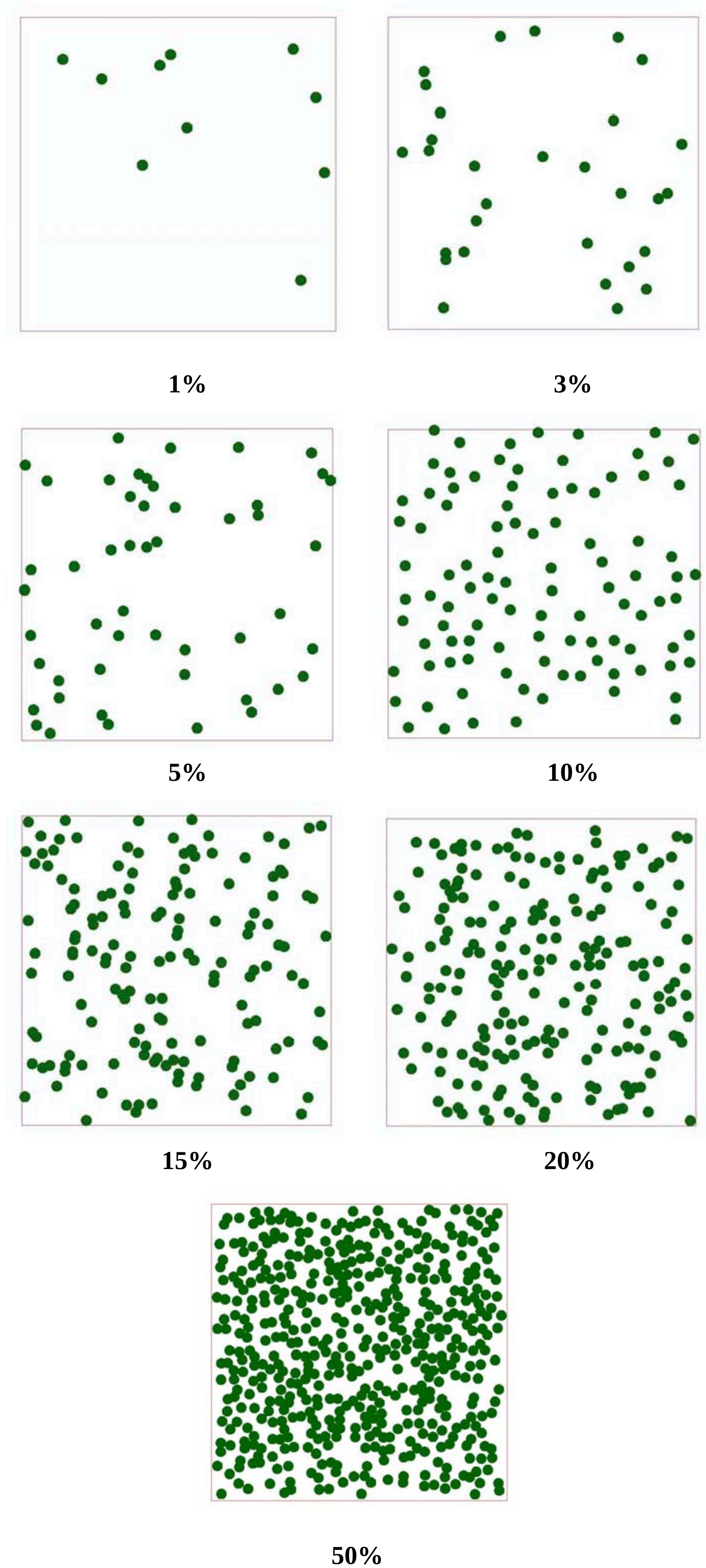

Figure 16. Examples of percent cover estimate.

2.5 Soil Profile Descriptions and Water Chemistry Sampling

Location of soil and water sampling will be determined while laying out the AA. Care should be made not to trample the vegetation plots or water sampling locations while laying out the AA. Shortly after plot layout is complete, water quality data should be taken to minimize mucking of water. In the same vein, vegetation plots should be laid out as soon as possible to flag areas that should not be trampled. When soil pits are dug next to vegetation plots, avoid trampling plots if the pits are dug before vegetation identification.

Soil: At least two soil pits will be dug within the AA. The pits can be dug before or after the vegetation plot is conducted depending on the flow of the sampling day. Pits should be placed in vegetation communities characteristic of the AA. If the vegetation and soil surface appears relatively homogenous, only two pits are necessary. If there is variability within the vegetation and soil, at least three and up to four soil pits should be dug to capture the range of variation within the site. When soil pits are variable, mark which pit best represents the AA. Because digging soil pits is difficult in standing water, it is advisable to pick a location on the edge of deep water, if possible. For all soil pits, take a GPS waypoint and record the waypoint number on the field form. Take photographs, if possible, of the pit and the soil profile one laid out. Mark all soil pits on the site drawing.

Soil pits should be dug with a 40-cm sharp shooter shovel. The pit should be only slightly larger than the width of the soil on all sides to minimize disturbance to the ground surface. Pits will be dug to at least one shovel length depth (35 to 40 cm) when possible. The core removed should be set down next to the pit, taking care to keep all horizons intact and in order. A bucket auger can be used to examine the soil deeper in the profile if needed to find hydric soil indicators. It is difficult to dig soil pits in areas with deep standing water. Concentrate on areas near the water's edge if standing water is a significant part of the AA.

Following guidance in the *ACOE Regional Supplement* and the National Resources Conservation Service (NRCS) Field Indicators of Hydric Soils in the United States (NRCS 2010), identify and describe each distinct layer in the soil pit. It is not necessary to name the layers with horizon designations unless you feel comfortable with soil taxonomy. Measure and record the depth of each distinct layer. For each layer, record the following information: 1) color (based on a Munsell Soil Color Chart) of the matrix and any redoximorphic concentrations (mottles and oxidized root channels) and depletions; 2) the soil texture (using Appendix D); and 3) any specifics about the concentration of roots, the presence of gravel or cobble, or any usual features to the soil. Based on the characteristics, identify which, if any, of the hydric soil indicators occur at the pit. See Appendix E for notes on hydric soil indicators commonly found in the Rocky Mountain region. If soil survey information is known for the assessment area, write down the soil survey unit name and note whether the pit matched the soil survey description.

Water Table: The water table will be measures in soil pits where groundwater is visible. Allow the pit to sit at least 15 minutes and up to one hour before measuring depth to saturation and depth to free water. Once the pit has equilibrated as much as possible, measure the distance to saturated soil and to free water. Saturated soil can be identified by a sheen on the soil surface or water seeping an oozing into the pit. Free water is an approximation of the groundwater table, but in some cases may not represent the true groundwater table because it can take many hours for the water table to equilibrate. If free water is not observed, note whether the pit is dry or if it appears to be slowly filling.

Water Chemistry: Basic field measurements of water chemistry (pH, EC and temperature) can be taken reading using a handheld meter in a variety of locations in the AA depending on the purpose. To characterize groundwater-fed system (fens, seeps or springs), it is best to take water chemistry measurements in soil pits where groundwater is evident. For monitoring water chemistry parameters for amphibians, it is best to take water chemistry measurements in surface water. For all water chemistry sampling, take a GPS waypoint and mark on the field form whether the sample was taken in 1) surface or groundwater, 2) standing or flowing water, 3) shallow or deep water, and 4) clear or turbid water. It is important to recognize that surface water parameters fluctuate widely during the day, throughout the season, and with varying water levels. A single measurement is only a snapshot. To make more rigorous conclusions about water chemistry and water quality, a more intensive sampling regime would be needed.

For the handheld meter, be sure to calibrate the meter daily, log each calibration, and keep the electrode clean at all times. A small squirt bottle is helpful to carry in the field to keep the electrode clean before and after using it.

SECTION 3: EIA METRIC DESCRIPTIONS AND RATINGS

3.1 Landscape Context Metrics

Landscape context metrics evaluate the condition of the landscape surrounding the wetland AA. Anthropogenic impacts to the surrounding watershed can have a significant impact on wetland processes. These metrics focus on 1) the degree of natural connectivity in the landscape, as measured by landscape fragmentation and, for riverine wetlands, by the continuity of the riparian corridor; and 2) the extent, width and condition of the wetland buffer.

Key Ecological Attribute: Landscape Connectivity

Landscape connectivity measures the degree to which the wetland AA is still connected to natural land covers and larger-scale natural process occurring within the surrounding landscape. For all wetlands, fragmentation within the entire surrounding landscape is evaluated. For riverine wetlands, special emphasis is given to the riparian corridor.

Metric 1a: Landscape Fragmentation

Definition and Background: This metric measures the percent of the landscape within 500 meters of the AA that is contiguous with the AA itself, meaning there is an unfragmented connection to the AA. The intensity of human activity in the landscape often has a proportionate impact on the ecological processes of natural systems. The percentage of natural land covers vs. altered land covers (i.e., development or agriculture) provides an estimate of connectivity among natural ecological systems. Fragmentation can dramatically impact natural processes such as seed dispersal, animal movement, and genetic diversity (Lindenmayer and Fischer 2006).

Metric Level: Level 1 (remote sensing) with Level 2 (rapid assessment) verification.

Metric Application: Use for all wetlands, regardless of classification.

Measurement Protocol: To assess this metric, examine land use patterns within a 500 m envelope of the AA. This is best done using the most recent aerial photography available. GIS layers of land use or land cover can also be used, but may not be as accurate as interpretation of aerial photography. When possible, walk through portions of the 500 m envelop to ground truth the photo. Identify the largest unfragmented block *that contains the AA* and estimate its percentage of the total area within the 500 m envelope (Figure 17). This percent of unfragmentated landscape can have small fragmentation inclusions (e.g., individual houses in a forested landscape, etc.) that are subtracted from the percent unfragmented area, but roads that bisect the landscape form a hard boundary on the unfragmented block. Well-traveled dirt roads and major canals count as fragmentation, but hiking trails, non-tilled hayfields, open fences, and small lateral ditches can be included in unfragmented blocks (Table 8). For larger roads, such as highways where road fill and trash borders the road, the zone of the road's influence should also be considered as fragmentation.

NOTE: If you define the AA as an entire wetland, the landscape with 500 m of the AA will be variable in size. The larger the wetland, the larger the landscape under consideration. If your study uses an area-based design with a fixed AA size (i.e., 01–0.5 ha), the landscape will be a more or less standard in size. In this case, the AA may be embedded within a larger wetland complex and some of the landscape under consideration may be continuous wetland area.

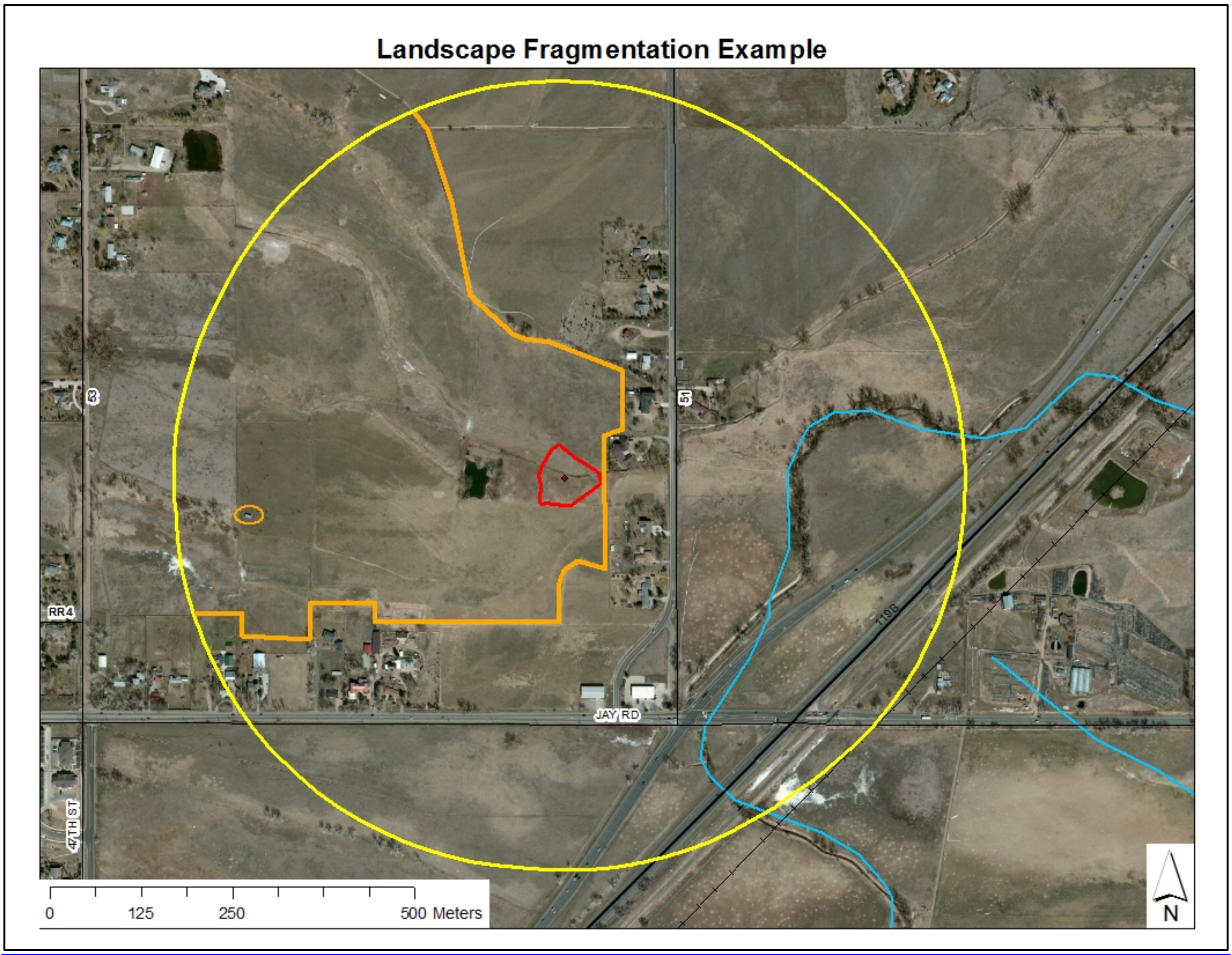

Figure 17. Orange lines follow the boundary of contiguous land cover in the 500m radius envelope surrounding the AA boundary. This AA is embedded in an unfragmented, natural landscape block in the 20–60% of the 500m envelope category. In this example, dirt roads, buildings, and urban areas/yards break the unfragmented block, but small shallow ditches do not.

Metric Rating: Assign the metric rating and associated score based on the thresholds in Table 7.

Table 7. Rating for Landscape Fragmentation

Rank	*Score*	*State*
Excellent (A)	5	Intact: AA embedded in >90–100% unfragmented, natural landscape.
Good (B)	4	Variegated: AA embedded in >60–90% unfragmented, natural landscape.
Fair (C)	3	Fragmented: AA embedded in >20–60% unfragmented, natural landscape.
Poor (D)	1	Relictual: AA embedded in ≤20% unfragmented, natural landscape.

Table 8. Land covers that are included and excluded from unfragmented blocks and wetland buffers.

Examples of Land Covers Included in Unfragmented Blocks or Buffers	*Examples of Land Covers Excluded from Unfragmented Blocks or Buffers*
o Additional wetland/riparian area o Natural upland habitats o Nature or wildland parks o Bike trails o Foot trails o Horse trails o Low or open fences o Small power lines o Open rangeland with light grazing o Swales and ditches with natural substrate o Open water o Vegetated levees o Non-tilled hay fields	o Commercial developments o Residential developments o Paved roads o Dirt roads o Railroads o Parking lots o Lawns/non-native landscaping o Golf courses o Sports fields o Urbanized parks with active recreation o Paved or heavily used pedestrian/bike trails (frequent traffic) o Sound walls or high, solid fences that interfere with wildlife movements o Major power transmission lines o Wind farms, oil and gas wells o Ditches with hard substrate (concrete) o Intensive agriculture (tilled row crops, orchards, vineyards) o Dryland farming o Intensive livestock areas (horse paddocks, animal feedlots, poultry ranches) o Rangeland with intensive grazing

Metric References: Metric concept and thresholds adapted from Rondeau (2001), Rocchio (2006), and Faber-Langendoen et al. (2008).

Metric 1b: Riparian Corridor Continuity

Definition and Background: This metric measures the degree to which the riverine corridor/floodplain above and below the AA exhibits connectivity with adjacent natural systems. For Riverine HGM Class wetlands, the continuity of the riparian corridor is a particularly important aspect of landscape connectivity. Of special concern is the ability of wildlife to enter the riparian area at any place within 500 m of the AA and to move easily through adequate cover along the riparian corridor from either upstream or downstream. Continuity of the floodplain also allows for overbank flow, which replenished floodplain aquifers and transports sediments and nutrients.

Metric Level: Level 1 (remote sensing) with Level 2 (rapid assessment) verification.

Metric Application: Use for all wetlands in the Riverine HGM class.

Measurement Protocol: To assess this metric, examine land cover within the riparian corridor 500 m upstream and 500 m downstream. Estimate the percent of anthropogenic, non-buffer patches within the corridor. The riparian corridor is defined as the width of the natural geomorphic floodplain, which may be extensive on the plains and mountain parks or may be narrow where the landscape or hydrology naturally limits floodplain development. In general, assume that the riparian corridor upstream and downstream is similar to what it is in the AA, unless it is obviously different to due geomorphology (i.e., the valley naturally widens or narrows). Anthropogenic patches include roads, bridges, urban/industrial development, tilled agriculture fields, etc. (land uses listed in Table 8). Look for patches that cross the corridor, enter it, or run along its length, but are obviously within the geomorphic floodplain and interrupting the continuity. For extensive, wide floodplains, it can be hard to tell if land use adjacent to the riparian corridor is in the historicalnatural floodplain or on its edge. The purpose of this metric is to assess linear movement up and down the riparian corridor. As a rule of thumb, if 1) it is difficult to tell if a land use patch is in the geomorphic floodplain, 2) the land use is at least 100 m from the channel, and 3) the floodplain is otherwise uninterrupted, then the land use can be ignored.

NOTE: If you are assessing a wetland AA on the floodplain of a very large, unwadable river, only consider the riparian corridor on the side of the channel where the wetland AA is located.

Metric Rating: Assign the metric rating and associated score based on the thresholds in Table 9.

Table 9. Rating for Riparian Corridor Continuity

Rank	***Score***	***State***
Excellent (A)	5	Intact: >95–100% natural habitat within the riparian corridor both upstream and downstream.
Good (B)	4	Variegated: >80–95% natural within the riparian corridor both upstream and downstream.
Fair (C)	3	Fragmented: >50–80% natural habitat within the riparian corridor both upstream and downstream.
Poor (D)	1	Relictual: ≤50% natural habitat within the riparian corridor both upstream and downstream.

Metric References: Metric and thresholds adapted from Rocchio (2006), Collins et al (2008; 2013), Faber-Langendoen et al. (2008), and Muldavin et al. (2011).

Key Ecological Attribute: Wetland Buffer

This attribute is evaluates the overall area and condition of the buffer immediately surrounding the AA using three measures: percent of buffer land cover surrounding the AA, average buffer width (up to 200m from the AA), and buffer condition. Wetland buffers are vegetated, natural (non-anthropogenic) areas that surround a wetland (see Table 8 for buffer land covers). These include forest, grasslands, shrublands, lakes, ponds, streams, or other wetlands. Some low impact land uses can be included in the buffer, such as light recreation and light grazing. Non-tilled, irrigated hay meadows can be counted as part of the buffer if they are not intensively managed or frequently harvested. Buffers serve to protect critical wetland functions, such as wildlife habitat and water quality, by limiting the invasion of non-native species, filtering nutrients and pollutants, and reducing erosion and sedimentation (ELI 2008).

NOTE: If you define the AA as an entire wetland, the buffer metrics will evaluate the actual buffer around the wetland edge. However, if your study uses an area-based design with a fixed AA size (i.e., 01–0.5 ha), the AA may be embedded within a larger wetland complex and some of the buffer under consideration may be continuous wetland area.

Metric 1c: Buffer Extent

Definition and Background: Wetland buffers that fully surround a wetland offer greater protection than those that cover only part of the wetland. Exposed wetland edges are at greater risk of invasion and pollutant loading.

Metric Level: Level 1 (remote sensing) with Level 2 (rapid assessment) verification.

Metric Application: Use for all wetlands, regardless of classification.

Measurement Protocol: This metric can be assessed first using the aerial photography, but must be verified with field observation. Visually estimate the total percentage of the AA perimeter with adjacent land covers that provide buffer functions (Table 8). To be considered as a buffer, a suitable land cover must be at least 5 m wide extending out from the AA edge and continue for at least 10 m in length around the AA perimeter.

Metric Rating: Assign the metric rating and associated score based on the thresholds in Table 10.

Table 10. Rating for Buffer Extent

Rank	*Score*	*State*
Excellent (A)	5	Buffer land covers surround 100% of the AA.
Very Good (A-)	4.5	Buffer land covers surround >75–99% of the AA.
Good (B)	4	Buffer land covers surround >50–75% of the AA.
Fair (C)	3	Buffer land covers surround >25–50% of the AA.
Poor (D)	1	Buffer land covers surround ≤25% of the AA.

Metric References: Metric and thresholds adapted from Collins et al (2008; 2013), Faber-Langendoen et al. (2008; 2012), and Muldavin et al. (2011).

Metric 1d: Buffer Width

Definition and Background: Like extent, the wider the buffer, the more effective it is at protecting wetland function. Through a synthesis of research on buffer, ELI (2008) report that buffers must be at least ~30 m (100 ft.) to effectively filter all three major water quality stressor of sediment, phosphorus and nitrogen. Wider buffers are even more effective for the removal of nitrogen. The effectiveness of buffer for wildlife habitat depends on the species, but should also be at least 30 m and likely up to 100 m or more to protect a range of native species.

Metric Level: Level 1 (remote sensing) with Level 2 (rapid assessment) verification.

Metric Application: Use for all wetlands, regardless of classification.

Measurement Protocol: This metric can be assessed first using aerial photography but must be verified with field observation. Use an aerial photo, either on a field map or in GIS, to draw eight lines radiating away from the edge of the AA along the cardinal and ordinal directions (N, NE, E, SE, S, SW, W, NW) , up to 200m from the AA perimeter. End each line when it encounters a non-buffer land cover, as they do in Figure 18 below at the railroad. (Note that the buffer lines do cross a minor canal, but they would end at the canal if it was cement lined or a more major conveyance structure. These calls must be verified in the field.) Visually estimate the average distance between the edge of the AA and the edge of the buffer for each of these lines. Enter the length of each line in the table on the field form, calculate the average, and select the narrative description that matches the average.

Metric Rating: Assign the metric rating and associated score based on the thresholds in Table 11.

Table 11. Rating for Buffer Width

Rank	***Score***	***State***
Excellent (A)	5	Average buffer width is >200 m.
Very Good (A-)	4.5	Average buffer width is >100–200 m.
Good (B)	4	Average buffer width is >50–100 m.
Fair (C)	3	Average buffer width is >25–50 m.
Poor (D)	1	Average buffer width is ≤25 m OR no buffer exists.

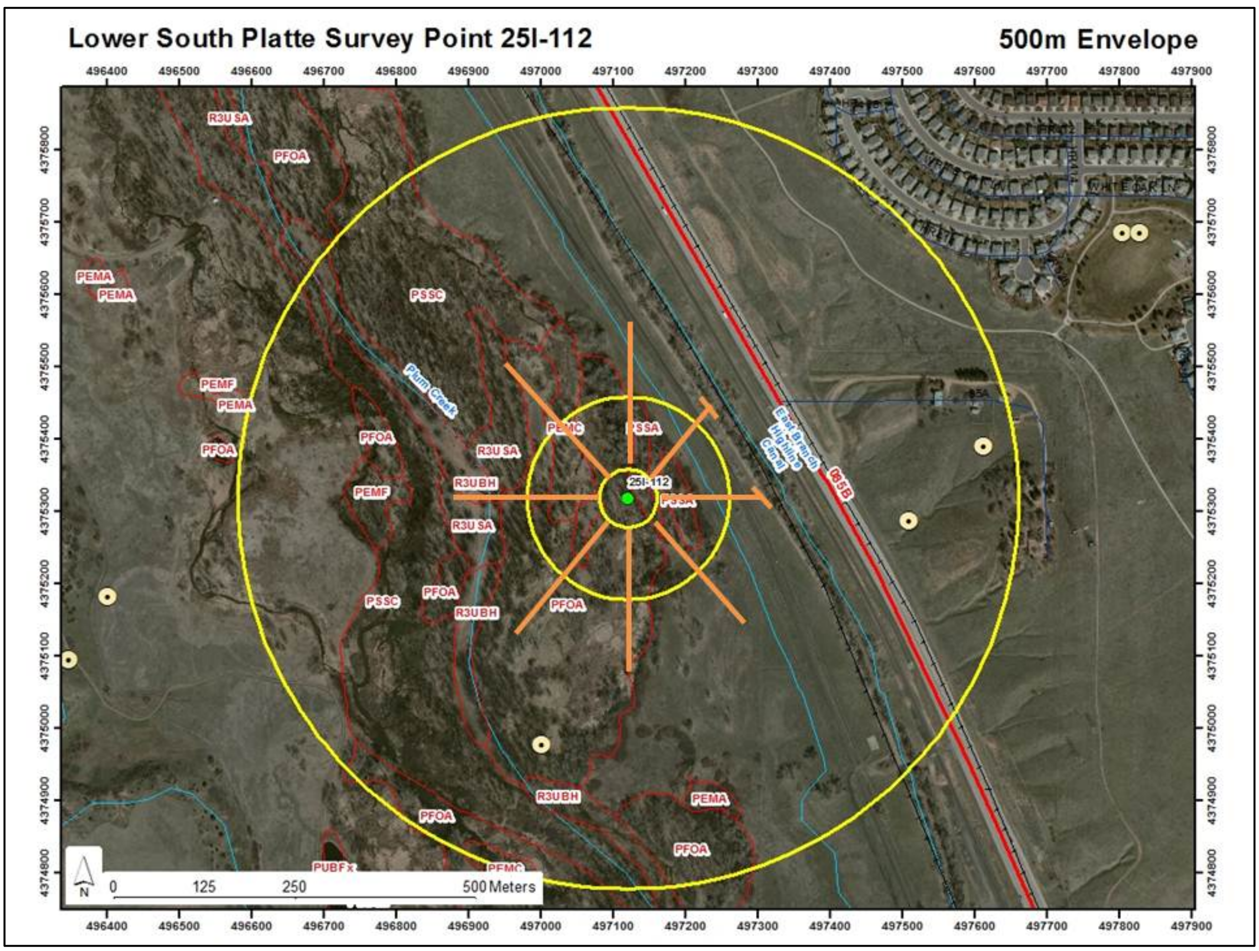

Figure 18. Orange buffer lines begin at the AA perimeter, continue up to 200m outside the AA, but stop upon reaching non-buffer land cover. The lines are used to determine average buffer width. This wetland has an average buffer width between 100-200m.

Metric References: Metric and thresholds adapted from Rocchio (2006), ELI (2008), Collins et al (2008; 2013), Faber-Langendeon et al. (2008; 2012), and Muldavin et al. (2011).

Metric 1e: Buffer Condition

Definition and Background: The condition of the buffer can also limit its effectiveness. A vegetated hay field (considered buffer) is better than parking lot (not considered buffer), but is far less effective at controlling nutrient loading and non-native species dispersal that a native prairie or shrubland. This metric evaluates two aspects of buffer separately, the vegetation and soil/substrate disturbance. These two aspects are then averaged for a final buffer condition score.

Metric Level: Level 2 (rapid assessment).

Metric Application: Use for all wetlands, regardless of classification.

Measurement Protocol: Walk through enough of the buffer to familiarize yourself with the dominant vegetation and any obvious signs of soil disturbance or dumping. Select one statement from *each* column on the form that best describes the buffer vegetation and buffer soils/substrate condition. Only consider *buffer areas* from 1c and 1d above. This metric is evaluating the condition of the *buffer itself,* not land covers determined to be non-buffer.

Metric Rating: Assign the metric ratings and associated scores based on the thresholds in Table 12.

Table 12. Rating for Buffer Condition

Rank	*Score*	*State – Vegetation*	*State – Soils/Substrate*
Excellent (A)	5	Abundant (≥95%) relative cover native vegetation and little or no (<5%) cover of non-native plants (remember to look for non-native hay grasses).	Intact soils, little or no trash or refuse, and no evidence of human visitation.
Good (B)	4	Substantial (≥75–95%) relative cover of native vegetation and low (5–25%) cover of non-native plants (remember to look for non-native hay grasses).	Intact or moderately disrupted soils, moderate or lesser amounts of trash, OR minor intensity of human visitation or recreation.
Fair (C)	3	Moderate (≥50–75%) relative cover of native vegetation (remember to look for non-native hay grasses).	Moderate or extensive soil disruption, moderate or greater amounts of trash, OR moderate intensity of human use.
Poor (D)	1	Low (<50%) relative cover of native vegetation (remember to look for non-native hay grasses) 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, OR no buffer exists.

Metric References: Metric and thresholds adapted from Collins et al (2008), Faber-Langendeon et al. (2008; 2013), and Muldavin et al. (2011).

Metric 1f: Natural Cover within a 100 m Envelope (Supplemental Metric)

Definition and Background: The complexity and composition of surrounding vegetation can help to buffer a wetland from potential impacts. Although this metric is not used to calculate EIA scores, knowing the structure and composition of surrounding land cover is important to understand the wetland's landscape context.

Metric Level: Level 2 (rapid assessment).

Metric Application: Use for all wetlands, regardless of classification.

Measurement Protocol: Using the table on the form (Table 13), estimate the total percent cover of non-natural land use within a 100 m envelope of the AA. The remaining cover represents the total cover of natural land use / natural cover. In this case, natural cover includes both *native and non-native vegetation*. From the total natural cover, separate natural wetland cover from natural upland cover. Then break total wetland cover and total upland cover by major cover types. Double check that: 1) for each row, upland + wetland cover = total % cover; 2) total upland cover (all rows) + total wetland cover (all rows) = total natural cover; and 3) total non-natural cover + total natural cover = 100%. Record dominant species for each cover type in the comments with the corresponding letter. If the surrounding landscape is not accessible (on a different landowner's property), guess to the best of your ability (e.g., native shortgrass prairie, or heavily grazed rangeland with kochia).

Table 13. Rating for Natural Cover

Natural Cover Type	*Total % Cover*	*Upland % Cover*	*Wetland % Cover*
Total non-natural cover (development, roads, row crops, feed lots, etc.).			
Total natural cover (breakdown by type below)			
A. Deciduous forest			
B. Coniferous forest			
C. Mixed forest type (neither deciduous nor coniferous trees dominate)			
D. Shrubland			
E. Perennial herbaceous (includes hay fields and CRP lands)			
F. Annual herbaceous or disturbed bare (generally weedy)			
G. Naturally bare (open water, rock, snow/ice)			

Metric Rating: There are no ratings assigned to this matric at this time.

Metric References: This metric is unique to the Colorado EIA method. We currently use it more for descriptive or explanatory purposes.

Landscape Stressors

Using the table on the field form (Table 14), estimate the scope of each land use within a 500 m envelope of the AA. Stressors can overlap and do not need to total 100% (e.g., light 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%.

Table 14. Landscape stressors

Landscape stressors/ Land use categories	*Scope*
Paved roads, parking lots, railroad tracks	
Unpaved roads (e.g., driveway, tractor trail, 4-wheel drive roads)	
Domestic or commercially developed buildings	
Intensively managed golf courses, sports fields, urban parks, expansive lawns	
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)	
Dam sites and flood disturbed shorelines around water storage reservoirs	
Agriculture – tilled crop production	
Agriculture – permanent crop (hay pasture, vineyard, orchard, tree plantation)	
Vegetation conversion (chaining, cabling, rotochopping, or clear-cutting of woody veg)	
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/browse by livestock or native ungulates	
Moderate grazing/browse by livestock or native ungulates	
Light grazing/browse 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 fallow lands dominated by *non-native* species (weeds or hay grasses)	
CRP lands (grasslands planted with a mix of *native* and *non-native* species)	
Haying of *native* grassland (*not* dominated by non-native hay grasses)	
Beetle-killed conifers	
Evidence of recent fire (<5 years old, still very apparent on vegetation, little regrowth)	
Other:	

3.2 Vegetation Condition Metrics

Vegetation condition is at the heart of the EIA method. Ecological and biotic condition-based methods view vegetation (and other biological taxa) as able to synthetically express the range and degree of stress faced by the wetland over many years. Vegetation condition metrics are divided between two key ecological attributes: vegetation composition (largely based on the site species list) and vegetation structure. We strongly encourage users of the EIA method to carry out a vegetation survey, either using Level 3 vegetation plot or a more rapid Level 2.5 plotless survey. The data collected from this exercise can greatly inform conclusions regarding overall wetland health.

Key Ecological Attribute: Vegetation Composition

Typically, these metrics are calculated in office from a species list with cover values. If the EIA is carried out as a purely Level 2 assessment with no species list generated, Metrics 2a-c can be visually estimated, Metric 2d can be excluded, and the weighting of other vegetation composition metrics would be increased. However, we have found that these estimates often overlook non-native species with low cover and even ones with high cover that are not immediately recognized. Spending at least an hour with a trained botanist on a Level 2.5 rapid vegetation survey can add highly valuable information about the site's species composition. If the metrics are calculated based on the species list, notes should still be are recorded in the field on noxious species and overall composition for comparison with any post-field species identification results.

Metric 2a: Percent Cover Native Species

Definition and Background: This metric measures the relative percent cover of native species in the AA. This metric measures the degree to which native plant communities have been altered by human disturbance. Wetlands with high ecological integrity are dominated by native species, while increasing human disturbance can allow non-native species to invade and even dominant wetlands. Non-native species (and aggressive native species) can displace native species, alter hydrology, alter structure, and affect food web dynamics by changing the quantity, type, and accessibility to food. Wetlands dominated by non-native species typically support fewer native animals (Zedler and Kercher 2004).

Metric Level: Level 2 (rapid assessment), Level 2.5 (rapid vegetation survey), or Level 3 (intensive vegetation survey).

Metric Application: Use for all wetlands, regardless of classification.

Measurement Protocol: This metric is calculated by dividing the total cover of native species by the total cover of all species. This is a relative cover measure, meaning that a non-native species with 5% cover of the AA could only represent 2% relative cover if there is extensive overlap of vegetation layer. With overlapping vegetation layer, the total over of all species can be >100%. Alternatively, a non-native species with 5% cover of the AA could represent 20% relative cover in a sparsely vegetated wetland like a playa. If a species list with cover values has been created, this measure can be easily calculated from the field data. Otherwise, make an ocular estimate of the relative percent cover. Unidentified species that are recorded on the plant list are not included in this calculation unless if their nativity is known.

Metric Rating: Assign the metric rating and associated score based on the thresholds in Table 15.

Table 15. Rating for Percent Cover Native Species

Rank	*Score*	*State*
Excellent (A)	5	>99% of vegetation cover within the AA is comprised of native species.
Good (B)	4	>95–99% of vegetation cover within the AA is comprised of native species.
Fair (C)	3	>80–95% of vegetation cover within the AA is comprised of native species.
Borderline (C-)	2	>50–80% of vegetation cover within the AA is comprised of native species.
Poor (D)	1	≤50% of vegetation cover within the AA is comprised of native species.

Metric References: Metric and thresholds adapted from Rocchio (2006) and Faber-Langendeon et al. (2008; 2013).

Metric 2b: Percent Cover Noxious Weeds

Definition and Background: Noxious weeds are non-native species that have been designated by state agricultural authorities as injurious to agriculture, horticulture, natural habitats, humans, or livestock. They can aggressively take over from native vegetation and should be eradicated or managed when found. For the purpose of the Colorado EIA, we define noxious weeds as all species on the Colorado Department of Agriculture Noxious Weed Lists A, B, and C (Appendix F).

Metric Level: Level 2 (rapid assessment), Level 2.5 (rapid vegetation survey), or Level 3 (intensive vegetation survey).

Metric Application: Use for all wetlands, regardless of classification.

Measurement Protocol: This metric is the absolute cover of noxious weeds encountered in the AA. This metric is *not* relative cover. The cover of noxious weeds is *not* divided by the total cover of all species. If a species list with cover values has been created, this measure can be easily calculated from the field data. Otherwise, make an ocular estimate of the absolute cover of noxious weeds.

Metric Rating: Assign the metric rating and associated score based on the thresholds in Table 16.

Table 16. Rating for Noxious Weeds

Rank	*Score*	*State*
Excellent (A)	5	Noxious weeds absent.
Good (B)	4	Noxious weeds present, but sporadic (<3% absolute cover).
Fair (C)	3	Noxious weeds common (3–10% cover).
Poor (D)	1	Noxious weed abundant (>10%) cover.

Metric References: Metric and thresholds adapted from Rocchio (2006), Faber-Langendeon et al. (2008; 2013), and Muldavin et al. (2011).

Metric 2c: Percent Cover Aggressive Native Species

Definition and Background: For some wetland types, particularly marshes and other depressional wetlands, aggressive native species can be more problematic than non-native species. For the purpose of this metric, aggressive natives include reed canarygrass (*Phalaroides arundinacea = Phalaris arundinacea*); giant reed (*Phragmites australis*); and cattails (*Typha* spp.), which can dominate sites with excess nutrients. There are both native and non-native ecotypes of reed canarygrass. The non-native, Eurasian ecotype is naturalized in the northern U.S. and can spread aggressively. It is thought that the Colorado populations are likely the Eurasian ecotype, but may also contain the native ecotype. Since the native status is uncertain and the ecotypes are difficult to distinguish in the field, for the purpose of this method, reed canarygrass is considered an aggressive native species. Likewise, there is debate over the origins of some cattail species (*Typha angustifolia* in particular) and the degree to which native and non-native populations have hybridized. For the purpose of this metric, all cattail species are considered aggressive natives.

Metric Level: Level 2 (rapid assessment), Level 2.5 (rapid vegetation survey), or Level 3 (intensive vegetation survey).

Metric Application: Use for all wetlands, regardless of classification.

Measurement Protocol: This metric is the absolute cover of aggressive native species encountered in the AA, specifically reed canarygrass (*Phalaroides arundinacea = Phalaris arundinacea*), giant reed (*Phragmites australis*), and cattails (*Typha* spp.). Additional species could be considered aggressive natives with reasonable explanation. This metric is *not* relative cover. The cover of noxious weeds is *not* divided by the total cover of all species. If a species list with cover values has been created, this measure can be easily calculated from the field data. Otherwise, make an ocular estimate of the absolute cover of noxious weeds.

Metric Rating: Assign the metric rating and associated score based on the thresholds in Table 17. The cover thresholds for reed canarygrass and giant reed are less than for cattails, due to the more aggressive nature of these two grass species. Assign the rank based on whichever species scores the lowest (i.e., 15% of cattails and 20% reed canarygrass would be rated with a C rank).

Table 17. Rating for Aggressive Natives

Rank	*Score*	*State*
Excellent (A)	5	Aggressive natives present, but sporadic (<10% absolute cover of cattails or <5% absolute cover of reed canarygrass or giant reed).
Good (B)	4	Aggressive natives common (10-25% absolute cover of cattails or 5-10% absolute cover of reed canarygrass or giant reed).
Fair (C)	3	Aggressive natives abundant (>25-50% absolute cover of cattails or 10-25% absolute cover of reed canarygrass or giant reed).
Poor (D)	1	Aggressive natives dominant (>50% absolute cover of cattails or >25% absolute cover of reed canary grass or giant reed grass).

Metric References: Metric and thresholds adapted from Rocchio (2006).

Metric 2d: Mean C

Definition and Background: Every wetland type has a specific range of species that can be expected to dominate under reference or minimally disturbed conditions. Those spices have naturally adapted to the environmental characteristics and disturbance regimes found within the wetland type. However, when disturbance (often human-induced) exceeds the natural range of variation, only those plants with wide tolerance to disturbance will survive. Conservative species (those with high fidelity to habitat integrity) will decline or disappear relative to the degree of disturbance (Wilhelm and Maters 1995). This predictable pattern is the basis behind the Floristic Quality Assessment (FQA; see Section 1.2 for more background). Mean C is the most basic measure of floristic quality that can be calculated using the FQA's coefficient of conservatism values (C-values). Mean C is the average of C-values for all species encountered within a site. It has been shown to be the single strongest measure of wetland condition within the EIA method (Lemly and Rocchio 2009a).

Metric Level: Level 2 (rapid assessment), Level 2.5 (rapid vegetation survey), or Level 3 (intensive vegetation survey).

Metric Application: Use for all wetlands, regardless of classification. Scoring thresholds differ by Ecological System.

Measurement Protocol: This metric is calculated by averaging C-values for all species encountered within the AA. C-values and an FQA Calculator can be found at CNHP's website. If a species list with cover values has been created, this measure can be easily calculated from the field data. Otherwise, this metric should be excluded and the weighting of other vegetation composition metrics should be increased.

Metric Rating: Assign the metric rating and associated score based on the thresholds in Table 18. Scoring thresholds differ by Ecological System. Thresholds for low elevation wetlands are still being evaluated and may change in the future. Any input on threshold values is appreciated.

Table 18. Rating for Mean C

Rank	***Score***	***States***		
		Riparian Areas and Fens	***Wet Meadows***	***Marshes, Playas and Saline Wetlands***
Excellent (A)	5	Mean C > 6.0	Mean C > 6.0	Mean C > 4.5
Good (B)	4	Mean C > 5.5–6.0	Mean C > 5.5–6.0	Mean C > 4.0–4.5
Fair (C)	3	Mean C >5.0–5.5	Mean C >4.0–5.5	Mean C >3.0–4.0
Border line (C-)	2	Mean C >4.5–5.0	Mean C >3.0–4.0	Mean C >2.0–3.0
Poor (D)	1	Mean C ≤ 4.0	Mean C ≤ 3.0	Mean C ≤ 2.0

Metric References: Metric and thresholds adapted from Rocchio (2006), Lemly and Rocchio (2009a; 2009b), Lemly et al. (2011), Lemly and Gilligan (2012).

Key Ecological Attribute: Vegetation Structure

Vegetation structure metrics evaluate structural components of wetland vegetation, both vertically through the regeneration of native woody species and horizontally through the interspersion of physical and vegetation patches. In addition, structure includes the accumulation and distribution of organic materials, both woody debris and litter. Structure is an important reflection of dynamic ecosystem processes, including hydrologic regime, regeneration, and nutrient cycling. More complex structure allows for many, small-scale habitat niches for both wildlife and plant species.

Metric 2e: Regeneration of Native Woody Species

Definition and Background: Intensive grazing by domestic livestock, heavy browse by native ungulates, and/or alteration of natural flow regimes can reduce to eliminate regeneration of native woody plants (Elmore and Kauffman 1994). Species such as willow (*Salix* spp.) and cottonwood (*Populus* spp.) need episodic flooding to create new bare surfaces suitable for germination of seedlings (Woods 2001). In addition, base flows following flooding need to be high enough to maintain soil water content in these areas at or above 15% through the late summer in order for these seedlings to survive long enough for to establish a deep root system. Lack of reproduction is indicative of altered ecological processes and has adverse impacts to the biotic integrity of the riparian area.

Metric Level: Level 2 (rapid assessment).

Metric Application: Use for all wetlands where woody cover would be expected. This includes most riparian Ecological Systems, though not every occurrence of them. For example, some instances of the Western Great Plains Riparian system naturally lack woody growth due to very limited hydrologic inputs. At the same time, some instances of riparian systems (i.e., some streams in South Park) are now completely devoid of woody vegetation where they likely once had abundant cover of willows. In addition, some Rocky Mountain Subalpine-Montane Fens have woody cover, but it is not expected in all fens. A degree of familiarity with wetland systems across Colorado is needed to recognize where woody species should occur. Looking at aerial photography to understand landscape-scale hydrologic processes can help discern whether woody vegetation should be expected.

Measurement Protocol: During the vegetation survey or while walking through the AA, pay special attention to the regeneration of native woody species. Select the statement on the form that best describes regeneration within the AA. Keep in mind that healthy, functioning woody systems should contain a mix of age classes, indicating natural disturbance regimes. Consider the effects of grazing and other stressors on potential regeneration. This metric is scored a N/A in naturally herbaceous wetlands.

Metric Rating: Assign the metric rating and associated score based on the thresholds in Table 19.

Table 19. Rating for Regeneration of Native Woody Species

Rank	*Score*	*State*
N/A	--	Woody species are naturally uncommon or absent.
Excellent (A)	5	All age classes of desirable (native) woody riparian species present.
Good (B)	4	Age classes restricted to mature individuals and young sprouts. Middle age groups absent.
Fair (C)	3	Stand comprised of mainly mature species OR mainly evenly aged young sprouts that choke out other vegetation.

Poor (D)	1	Woody species predominantly consist of decadent or dying individuals OR AA has >5% canopy cover of Russian Olive and/or Salt Cedar.

Metric References: Metric and thresholds adapted from Rocchio (2006), Faber-Langendeon et al. (2008; 2013), and Muldavin et al. (2011).

Metric 2f: Coarse and Fine Woody Debris

Definition and Background: Woody debris plays a critical role in riparian systems. There is extensive documentation of the importance of in stream wood for altering channel form and characteristics, enhancing aquatic and riparian habitat, retention of organic matter and nutrients (Wohl 2011). Though much research on woody debris has focused on the Pacific Northwest, research specific to Colorado's Rocky Mountains finds the same relationships hold true, even if the volume and size of woody debris is often smaller than found elsewhere (Richmond and Fausch 1995). Prior to European settlement, Colorado's streams likely had greater amounts of woody debris, but these volumes were reduced through widespread logging and trapping of beaver.

Metric Level: Level 2 (rapid assessment).

Metric Application: Use for all wetlands where woody debris would be expected. This includes most riparian Ecological Systems, though not every occurrence of them. For example, some instances of the Western Great Plains Riparian system naturally lack woody growth, and therefore woody debris, due to very limited hydrologic inputs. Low gradient systems in open areas and systems with few natural trees either within or surrounding will naturally have less woody debris. However, some woody debris can be found in all systems, even marshes and fens, if there are occasional large trees or tall shrubs. A degree of familiarity with wetland systems across Colorado is needed to recognize where woody debris should occur.

Measurement Protocol: During the vegetation survey or while walking through the AA, pay special attention to the amount of coarse and fine woody debris. Select the statement on the form that best describes the amount of woody debris within the AA. Riverine wetlands that have incised banks, no longer experience flooding, experience overgrazing, or are no longer at a dynamic equilibrium may lack. This metric is scored a N/A in naturally herbaceous wetlands.

Metric Rating: Assign the metric rating and associated score based on the thresholds in Table 20.

Table 20. Rating for Buffer Width

Rank	*Score*	*State*
N/A	--	There are no obvious inputs of woody debris.
Very Good (AB)	5	AA characterized by moderate amount of coarse and fine woody debris, relative to expected conditions. For riverine wetlands, debris is sufficient to trap sediment, but does not inhibit stream flow. For non-riverine wetlands, woody debris provides structural complexity, but does not overwhelm the site.
Fair (C)	3	AA characterized by small amounts of woody debris OR debris is somewhat excessive. For riverine wetlands, lack of debris may affect stream temperatures and reduce available habitat.

Poor (D)	1	AA lacks woody debris, even though inputs are available.

Metric References: Metric and thresholds adapted from Faber-Langendeon et al. (2008) with input from the literature.

Metric 2g: Herbaceous / Deciduous Litter Accumulation

Definition and Background: The accumulation of organic material and an intact litter layer are integral to a variety of wetland functions, such as surface water storage, percolation and recharge, nutrient cycling, and support of wetland plants. Intact litter layers provide areas for primary production and decomposition that are important to maintaining functioning food chains. They nurture fungi essential to the growth of rooted wetland plants. They support soil microbes and other detritivores that comprise the base of the food web in many wetlands. The abundance of organic debris and coarse litter on the substrate surface can significantly influence overall species diversity and food web structure. Fallen debris serves as cover for macroinvertebrates, amphibians, rodents, and even small birds. Litter is the precursor to detritus, which is a dominant source of energy for most wetland ecosystems.

Metric Level: Level 2 (rapid assessment).

Metric Application: Use for all wetlands, regardless of classification.

Measurement Protocol: During the vegetation survey or while walking through the AA, note the quantity and distribution of litter compared with a baseline that may be expected in the landscape. Playas are typically low in litter; densely vegetated wetlands can be high in litter. Overgrazing or woody vegetation removal can reduce and compact litter and aggressive plant colonization or artificially reduced water levels can result in excessive litter. Excessive litter can choke out new growth and inhibit animal movement. Select the statement on the form that best describes the litter. Litter is often detached from the live plant, but dead plant material at the base of plants that was growth from the prior year or before is also considered litter. Be sure the assessment of litter is not based on seasonality (i.e., when a wetland is surveyed early in the year, the prior years' desiccated vegetation can appear more dense than later in the season because most new growth has yet to occur).

Metric Rating: Assign the metric rating and associated score based on the thresholds in Table 21.

Table 21. Rating for Buffer Width.

Rank	*Score*	*State*
Very Good (AB)	5	AA characterized by moderate amount of herbaceous and/or deciduous leaf litter. New growth is more prevalent than previous years'. Litter and duff layers in pools and topographic lows are thin. Organic matter is neither lacking nor excessive.
Fair (C)	3	AA characterized by small amounts of litter with little plant recruitment OR litter is somewhat excessive.
Poor (D)	1	AA lacks litter OR litter is extensive and limiting new growth.

Metric References: Metric and thresholds adapted from Rocchio (2006) and Faber-Langendeon et al. (2008).

Metric 2h: Horizontal Interspersion / Complexity

Definition and Background: Ecological diversity of a site is often correlated with the complexity of abiotic and biotic patches. Increased complexity leads to increased habitat niches and can enhance ecological processes.

Metric Level: Level 2 (rapid assessment) or Level 3 (intensive vegetation survey).

Metric Application: Use for all wetlands, regardless of classification. Different wetland systems have differing ranges of expected patch types. Some systems are naturally more complex (e.g., riparian systems) than others (e.g., wet meadows and some fens), though the benefit of complexity are universal. Therefore, we are evaluating whether this metric should be weighted less for some systems than for others.

Measurement Protocol: Using observations gathered while walking the AA and examining aerial photography, create a sketch of both vegetation zones and physical patch types within the AA. These should be documented in the site sketch on Page 3 of the field form. Major vegetation zones should also be listed on Page 2 of the field form for descriptive purposes, following rules for defining vegetation zones in Section 2.3 of this manual. Along with vegetation zones, include physical patch types when evaluating interspersion. Table 22 provides a list of potential physical patch types to note. On the field form, refer to interspersion diagrams (Figure 19) and circle the letter that best describes the horizontal interspersion within the AA either for the riverine (linear) or non-riverine (oval) diagram.

Table 22. Descriptions of physical patch types potentially found within the AA.

Patch Type	Description
Open water - river / stream	Areas of flowing water associated with a sizeable channel.
Open water - tributary / secondary channels	Areas of flowing water entering the main channel from a secondary source.
Open water – swales on floodplain or along shoreline	Swales are broad, elongated, vegetated, shallow depressions that can sometimes help to convey flood flow to and from vegetated floodplains. They lack obvious banks, regularly spaced deeps and shallows, or other characteristics of channels. Swales can entrap water after flood flows recede. They can act as localized recharge zones and they can sometimes receive emergent groundwater.
Open water - oxbow / backwater channels	Areas that hold stagnant or slow moving water from that has been partially or completely disassociated from the primary river channel.
Open water - rivulets / streamlet	Areas of flowing water associated with a small, diffuse channel. Often occurring near the outlet of a wet meadow or fen or at the very headwaters of a stream.
Open water - pond or lake	Medium to large natural water body.
Open water - pools	Areas that hold stagnant or slow moving water from groundwater discharge but are not associated with a defined channel.
Open water - beaver pond	Areas that hold stagnant or slow moving water behind a beaver dam.
Active beaver dams	Debris damming a stream, clearly constructed by beaver (note gnawed ends of branches).
Beaver canals	Canals cut through emergent vegetation by beaver.
Debris jams / woody debris in channel	Aggregated woody debris in stream channel deposited by high flows.
Pool / riffle complex	Deep, slow-moving pools alternating with shallow, fast-moving riffles along the relatively straight course of a stream or river.
Point bars	A low ridge of sediment (sand or gravel) formed on the inner bank of a meandering stream.

Patch Type	Description
Interfluves on floodplain	The area between two adjacent streams or stream channels flowing in the same general direction.
Bank slumps or undercut banks in channel or along shoreline	A bank slope is the portion of a stream or other wetland bank that has broken free from the rest of the bank but has not eroded away. Undercuts are areas along the bank or shoreline of a wetland that have been excavated by waves or flowing water.
Adjacent or onsite seeps/springs	Localized point of emerging groundwater, often on or at the base of a sloping hillside.
Animal mounds or burrows	Many vertebrates make mounds or holes as a consequence of their forage, denning, predation, or other behaviors. The resulting disturbance helps to redistribute soil nutrients and influences plant species composition and abundance.
Mudflats	An accumulation of mud of the edge of shallow waters, such as a lake or pond. Often intermittently flooded and exposed.
Salt flats / alkali flats	Dry open areas of fine grained sediment and accumulated salts. Often wet in the winter months or with heavy precipitation.
Hummock / tussock	In fens, a mound composed of organic material (peat) either created by *Sphagnum,* other moss, or formed by sedges and grasses that have a tussock growth habit as they raise themselves on a pedestal of persistent rhizomes and roots.
Water tracks / hollows	In fens, a depression found between hummocks or mounds which remains permanently saturated or is inundated with slow moving surface water.
Floating mat	Mats of peat held together by roots and rhizomes of sedges. Floating mats are found along the edges of ponds and lakes and are slowing encroaching into open water. The mats are underlain by water and/or very loose peat.
Marl/Limonite beds	Marl is a calcium carbonate precipitate often found in calcareous fens. Limonite forms in iron fens when iron precipitates from the groundwater incorporating organic matter.

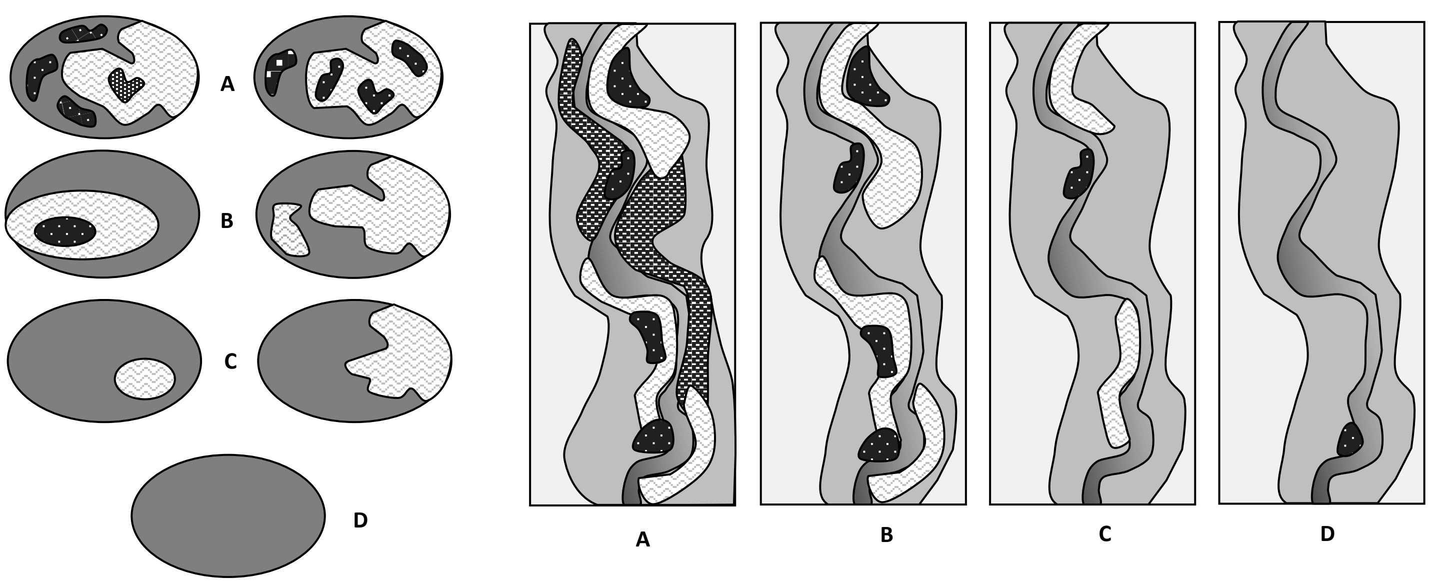

Figure 19. Potential states of Horizontal Interspersion.

Metric Rating: Assign the metric rating and associated score based on the thresholds in Table 23.

Table 23. Rating for Horizontal Interspersion.

Rank	*Score*	*State*
Excellent (A)	5	High degree of horizontal interspersion: AA characterized by a very complex array of nested or interspersed zones with no single dominant zone.
Good (B)	4	Moderate degree of horizontal interspersion: AA characterized by a moderate array of nested or interspersed zones with no single dominant zone.
Fair (C)	3	Low degree of horizontal interspersion: AA characterized by a simple array of nested or interspersed zones. One zone may dominate others.
Poor (D)	1	No horizontal interspersion: AA characterized by one dominant zone.

Metric References: Metric and thresholds adapted from Rocchio (2006), Collins et al (2008; 2013), Faber-Langendeon et al. (2008; 2012), and Muldavin et al. (2011).

Vegetation Stressors

Using the table on the field form (Table 24), estimate the scope of each vegetation stressor within the AA. Some of these stressors may have already been rated as occurring within the landscape (500 m envelope), but the stressors on this list should be occurring directly within the AA. Stressors can overlap and do not need to total 100% (e.g., light 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%.

Table 24. Vegetation stressors

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/browse by livestock or native ungulates	
Moderate grazing/browse by livestock or native ungulates	
Light grazing/browse 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 fallow lands dominated by *non-native* species (weeds or hay)	
Haying of *native* grassland (*not* dominated by non-native hay grasses)	
Beetle-killed conifers	
Evidence of recent fire (<5 years old)	
Other:	

3.3 Hydrologic Condition Metrics

Hydrology is the key driver and defining attribute for all wetlands. Without water, there would be no wetland. The EIA method assesses the condition of a wetland's hydrology through three inter-related metrics: water source, hydroperiod (the timing and duration of inundation or saturation), and hydrologic connectivity (the ability of water to move naturally through and beyond the wetland). Because the metrics are interconnected, where when one metric rates poorly, it is likely that others will too. However, this is not always the case, particularly in managed situations where some natural attributes of hydrology can be mimicked while others cannot. Wetland size and distance from hydrology stressors can also buffer the effects of alterations on hydrology. Examining the size and influence of hydrology stressors is also helpful. To fully understand stressors, it is necessary to look significantly bound the AA itself, particularly for riverine features that have been impacted by diversion, withdrawals and additions far upstream.

Key Ecological Attribute: Hydrology

Metric 3a: Water Source

Definition and Background: Water sources encompass the *forms* or *places* of *direct inputs of water* to the AA. Inputs of water, especially during the growing season, are important because they strongly influence structure and composition of wetland plant and animal communities. This metric compares the proportion of water that enters the wetland from natural vs. artificial sources. Natural water sources include precipitation, groundwater discharge, and flooding of the AA due to naturally high flows, seasonal runoff, etc. Examples of unnatural sources include storm drains that empty directly into the AA; pipes directly controlling water inputs (even if for wildlife habitat purposes); urban or agricultural runoff; and irrigated sources via direct irrigation application and sub-irrigated water from ditch seepage. Sub-irrigation water sources can appear natural (and some land managers view them as naturalized), but they are not considered natural in the EIA method because if the pipe or ditch was turned off, the source would be depleted. It is important to understand potential water sources in different topographic locations and wetland types. Is the wetland in a natural geomorphic floodplain where it could be tied into alluvial aquifer? Or is the wetland in an otherwise dry landscape position, but downslope from one or more ditches that cut across the slope. Plant and soil indicators of water source permanence and consistency are useful to consider. For instance, the presence of peat (>16 in organic soil) does confirm a natural groundwater source (at least in part), because the rate of peat accumulation (~8 in/1,000 yrs: Chimner and Cooper XXXX) is slow enough that true peat could not have formed since European settlement. It can be tempting to link this metric to concerns about water quality, but that is not the focus of this metric. The metric is solely focused on the natural vs. artificial sources and pathways of water delivery.

Metric Level: Level 2 (rapid assessment) with some Level 1 (remote sensing) background information.

Metric Application: Use for all wetlands, regardless of classification. Metric rating includes variants to consider based on HGM class or Ecological System.

Measurement Protocol: Review the aerial photo and topographic map for potential sources. It is important to look at the larger landscape, not just the immediate surroundings. Look for direct channels or saturated zones indicating flow paths. Then walk the AA and buffer to confirm the dominant source of water. Use the checklist on the field form (Table 25) to identify all major water sources influencing the AA and designate the dominant source with a star. Mark all inlets on the aerial photo and those within the AA on the site sketch. If there is an indication that inflow during the growing season is controlled by artificial water sources, explain in comments. Then select the statement on the form that best describes the water sources feeding the AA during the growing season.

In riverine systems, inputs and controls to the water source are examined up to ~2 km upstream from AA, but with greater emphasis on the most immediate water sources, and decreasing emphasis with distance from AA. In non-riverine systems, inputs are generally examined in closer proximity to the site. New development such as roads or oil and gas wells that occurred after the aerial photography was taken may disconnect a former flow path from reaching the wetland, in effect altering or removing the water source. This information should be verified in office with GIS, so comments about visible alterations in the field that are not on shown the aerial photo are particularly useful.

Table 25. Potential water source checklist. Natural sources are on the left; non-natural sources are on the right.

Potential Water Sources			
_____	Overbank flooding	_____	Irrigation via direct application
_____	Alluvial aquifer	_____	Irrigation via seepage
_____	Groundwater discharge	_____	Irrigation via tail water run-off
_____	Natural surface flow	_____	Urban run-off / culverts
_____	Precipitation	_____	Pipes (directly feeding wetland)
_____	Snowmelt	_____	Other:

Metric Rating: Assign the metric rating and associated score based on the thresholds in Table 26.

Table 26. Rating for Water Source.

Rank	*Score*	*State*
Excellent (A)	5	Water sources are precipitation, groundwater, natural runoff, or natural flow from an adjacent freshwater body. The system may naturally lack water at times,even in the growing season (e.g. playas). 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.
Good (B)	4	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.
Fair (C)	3	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 supported 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).

Borderline (C-)	2	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, or direct pumping.
Poor (D)	1	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.

Metric References: Metric and thresholds adapted from Collins et al (2008; 2013) and Faber-Langendoen et al. (2008; 2012).

Metric 3b: Hydroperiod

Definition and Background: This metric assesses the characteristic frequency, timing, extent, and duration of inundation or saturation of a wetland during a typical year, compared to an unaltered state. Depressional, lacustrine, and riverine wetlands may have daily variations in water height that are governed by diurnal increases in evapotranspiration, and seasonal cycles that are governed by wet season rainfall and runoff. Slope wetlands that depend on groundwater may have relatively slight seasonal variations in hydroperiod.

Regardless of wetland type, alterations to the water source can result in changes in to the hydroperiod, such as raising or lowering water levels or altering flow rates and timing. Alterations to the hydroperiod are best considered in light of the potential hydrologic modifications impacting the site and its contributing watershed (Table 29). Some alterations reduce the amount, frequency and timing of water on site (e.g., upstream dams and diversions, onsite ditches moving water out of the wetland, groundwater wells that can lower local groundwater tables), while other alterations actually contribute additional water to the wetland, either by adding greater volume of water to the system (trans-basin diversions or other diversions that add water) or by impounding water and altering the timing of drawdown. Pits in playa wetlands, berms to form stock ponds, or impoundments caused by road grades or inadequate culverts are examples of alterations that alter the timing of drawdown. For fens in the subalpine, even small scale ditching can dramatically change the hydroperiod and dry peat bodies, leading to decomposition and loss of plant diversity.

Hydroperiod can be closely connected to water source. In most cases, the water source rating can be viewed as limiting the hydroperiod rating. If the water source is either predominantly artificial or essentially eliminated, the hydroperiod may score a correspondingly low score. However, the two are not always rated the same. Some site may have completely natural water sources (e.g., riparian shrublands along mountain streams), but their hydroperiod may be significantly impacted by dams and diversions immediately upstream. On the other hand, some wetlands with entirely managed water sources may still mimic a natural hydroperiod, or at least approximate natural seasonality. For entirely artificial wetlands, consider the management purpose of the wetland and whether the hydroperiod mimics a natural analogue, such as a natural floodplain depression or a natural seeping slope. Best professional judgment will be needed to rate this metric for artificially controlled wetlands. Good notes on the rationale for metric rating will be essential in these cases.

Metric Level: Level 2 (rapid assessment) with some Level 1 (remote sensing) background information.

Metric Application: Use for all wetlands, regardless of classification. Metric rating includes variants to consider based on HGM class.

Measurement Protocol: Review aerial photography and topographic maps to identify hydrologic stressors and modifications. Remember to look upstream of the AA in riverine systems, as the largest hydrologic alterations may be well outside the AA. This may involve using large-scale maps, such as an atlas or gazetteer, while in the field. If it is possible to obtain and reference GIS layers of dams, local diversions, trans-basin diversions, and groundwater wells, they can help inform the degree of alteration. Compare the GIS-based information with observed effects of hydroperiod alterations in-field. If nearby upstream ditches are large, they likely have a gate that impacts the natural hydroperiod. New development such as roads or oil and gas wells that occurred after the aerial photography was taken may divert water and slow or increase flows, altering the hydroperiod. These recent changes should be noted on the field form for later reference. Once all available information is gathered, select the statement that best describes the alteration to the hydroperiod during the growing season.

Metric Rating: Assign the metric rating and associated score based on the thresholds in Table 27. Metric ratings at the low end of the spectrum are still under review.

Table 27. Rating for Hydroperiod.

Rank	*Score*	*State*
Excellent (A)	5	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.
Good (B)	4	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 impacted pitted or dissected. *If wetland 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).
Fair (C)	3	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 wetland 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.
Borderline (C-)	2	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 wetland 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.
Poor (D)	1	Hydroperiod is dramatically different from natural. Upstream diversions severely stress the wetland. Riverine wetlands may run dry during critical times. *If wetland is artificially controlled,* hydroperiod does not mimic natural seasonality. Site is actively managed for filling or drawing down without regard for natural wetland functioning.

Metric References: Metric and thresholds adapted from Rocchio (2006), Collins et al. (2008; 2013) and Faber-Langendoen et al. (2008; 2012).

Metric 3c: Hydrologic Connectivity

Definition and Background: This metric assesses the ability of water to flow across and out of the wetland laterally, or to accommodate rising flood waters without persistent changes in water level that can result in stress to wetland plants and animals. Assessment of this metric is based solely on field indicators and is different by HGM class. For riverine wetlands, an important aspect of hydrologic connectivity is the degree of channel entrenchment. Channel entrenchment itself is an optional riverine metric (see page XX). If it is possible to measure channel entrenchment, it will inform this rating. If not, it can be estimated from visual clues.

Metric Level: Level 2 (rapid assessment).

Metric Application: Use for all wetlands, regardless of classification. Metric rating includes variants to consider based on HGM class.

Measurement Protocol: Search the AA for hard obstacles that impound and constrain flood waters, such as retaining walls, road grades, or entrenched banks. Use best professional judgment to determine the overall condition of the hydrologic connectivity and *s*elect the statement that best describes the AA.

Metric Rating: Assign the metric rating and associated score based on the thresholds in Table 28.

Table 28. Rating for Hydrologic Connectivity.

Rank	*Score*	*State*
Excellent (A)	5	Rising water has unrestricted access to adjacent areas without levees or other obstructions to the lateral movement of flood waters. Channel, if present, is not entrenched and is still connected to the floodplain (see entrenchment ratio in optional riverine metrics).
Good (B)	4	Unnatural features such as levees or road grades limit the amount of adjacent transition zone or the lateral movement of floodwaters, relative to what is expected for the setting, but limitations exist 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. Channel, if present, is somewhat entrenched. If playa, surrounding vegetation does not interrupt surface flow.
Fair (C)	3	The amount of adjacent transition zone or the lateral movement of flood waters to and from the AA is limited, relative to what is expected for the setting, by unnatural features for 50–90% of the boundary of the AA. Features may include levees or road grades. Flood flows may exceed the obstructions, but drainage out of the AA is probably obstructed. Channel, if present, may be moderately entrenched and disconnected from the floodplain except in large floods. If playa, surrounding vegetation may interrupt surface flow.
Poor (D)	1	The amount of adjacent transition zone or the lateral movement of flood waters is limited, relative to what is expected for the setting, by unnatural features for >90% of the boundary of the AA. Channel, if present, is severely entrenched and entirely disconnected from the floodplain. If playa, surrounding vegetation may dramatically restrict surface flow.

Metric References: Metric and thresholds adapted from Rocchio (2006), Collins et al (2008; 2013), Faber-Langendeon et al. (2008; 2012), and Muldavin et al. (2011).

Hydrology Stressors

Using the table on the field form (Table 29), mark the presence of each hydrology stressor either within the AA, upstream of the AA, or downstream of the AA. For stressors within the AA, use the scope rating to indicate the amount of the AA that is affected: 1 = 1–10%, 2 = >10–25%, 3 = >25–50%, 4 = >50–75%, 5 = >75%. For stressors outside the AA, mark the stressors with a 'X' to acknowledge their presence.

Table 29. Hydrology stressors

Hydrology stressor categories	*Within AA*	*Upstream / Upslope*	*Downstream / Downslope*
Dam / reservoir			
Impoundment / stock pond			
Spring box diverting water from wetland			
Pumps, diversions, ditches that move water *out of* the wetland			
Pumps, diversions, ditches that move water *into* the wetland			
Berms, dikes, levees that hold water in the wetland			
Deeply dug pits for holding water			
Weir or drop structure that impounds water and controls energy of flow			
Observed or potential agricultural runoff			
Observed or potential urban runoff			
Flow obstructions into or out of wetland (roads without culverts)			
Dredged inlet or outlet channel			
Engineered inlet or outlet channel (e.g., riprap)			
Other:			

3.4 Physiochemical Condition Metrics

Physiochemical metrics assess water quality within the wetland, both in terms of turbidity and pollutants and in terms of algal growth, along with the integrity of the soil or predominant substrate.

Key Ecological Attribute: Water Quality

Improving water quality by filtering nutrients, sediment and other pollutants is one of the most valuable functions wetlands provide. Wetlands naturally have varying water quality states, including a range of natural pH and salinity. Their water quality can also differ dramatically over the course of the growing season as runoff increases or decreases and water levels rise and fall. The EIA method evaluates water quality with two metrics: surface water turbidity/pollutants and algal growth. To fully understand the water quality of any given site, more intensive data collection would be needed. CNHP is actively seeking funding opportunities to expand our understanding of the natural range of variation for water quality measurements. We hope that in the coming years, these metrics will become more precise and quantitative.

Metric 4a: Surface Water Turbidity/Pollutants

Definition and Background: Water quality is difficult to assess visually in the field. However, sometimes there are obviously water quality problems that can be documented, such as oil sheens or excess nutrient runoff. Seasonality and weather can play into the rating of this metric. Riverine wetland can be turbid if flood waters are high. Playas can also be naturally turbid when filled, due to their fine sediments. Other depressional wetlands should not be turbid, although recent weather events can affect turbidity. Even if the turbidity appears natural, it is still good to note its presence in the wetland to help document wetland types that tend to be turbid when the wetland is in good condition. Water color can be an indicator of pollutant issues such as a blue-green tint from cyanobacteria bloom or a red-orange tint from mine tailings. Knowledge of surrounding land uses can help inform if water discoloration is due to pollutant issues or natural occurrences such as tannins from decomposition or iron oxide in the soil substrate.

Metric Level: Level 2 (rapid assessment).

Metric Application: Use for all wetlands with standing water at the time of the survey.

Measurement Protocol: Use all available data sources—aerial photos, topographic maps, and other GIS data sources, as well as observations in the field—to record any potential impacts water quality in the physiochemical stressors table (Table 33). Keeping these stressors in mind, select the statement on the form that best describes the turbidity or pollutant load of surface waters within the AA. If the water looks turbid, but there are no obvious sources of pollutants, the wetland should still be rated with a 'B' to acknowledge the current conditions during sampling. Ratings of 'C' or 'D', however, should be reserved for sites with obvious sources of pollutants (excessive livestock dung, adjacent agricultural fields, urban runoff, feedlots, surface mining, etc.).

Metric Rating: Assign the metric rating and associated score based on the thresholds in Table 33.

Table 30. Rating for Surface Water Turbidity/Pollutants.

Rank	*Score*	*State*
N/A	--	No open water in AA
Excellent (A)	5	No visual evidence of degraded water quality. No visual evidence of turbidity or other pollutants.

Good (B)	4	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.
Fair (C)	3	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.*
Poor (D)	1	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.*

Metric References: Metric and thresholds adapted from Rocchio (2006) and Faber-Langendeon et al. (2008).

Metric 4b: Algal Growth

Definition and Background: Algae can be problematic in sites with excessive nutrient loading. Thick algal mats can block light from reaching the water profiles and can also reduce dissolved oxygen levels. However, some amount of algae can also be entirely natural. Like the surface water turbidity/pollutant metrics, it is best to rate this metric in terms of how you encounter the wetland during the survey, but to also keep in mind potential sources of nutrient enrichment in the surrounding landscape.

Metric Level: Level 2 (rapid assessment).

Metric Application: Use for all wetlands with standing water at the time of the survey *or* sites where water has been drawn down recently, but algae is still evident.

Measurement Protocol: Select the statement on the form that best describes algal growth within current or recent surface water in the AA. Algal growth often happens naturally with pond dry-down. Use best professional judgment to assess if the algal growth is a problem, as it will often be present in these dynamic ecosystems. Small patches of algae that appear natural should still be rated with a 'B' to acknowledge the current conditions during sampling. Ratings of 'C' or 'D', however, should be reserved for sites with more extensive algal growth that is likely related to water quality concerns.

Metric Rating: Assign the metric rating and associated score based on the thresholds in Table 31.

Table 31. Rating for Algal Gowth.

Rank	*Score*	*State*
N/A	--	No open water in AA or evidence of open water.
Excellent (A)	5	Water is clear with minimal algal growth.
Good (B)	4	Algal growth is limited to small and localized areas of the wetland. Water may have a greenish tint or cloudiness.
Fair (C)	3	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).

Poor (D)	1	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).

Metric References: Metric and thresholds adapted from Rocchio (2006) and Faber-Langendeon et al. (2008; 2012).

Key Ecological Attribute: Substrate / Soils

Soils play a key role in overall ecological integrity. Many of the biogeochemical processes integral to wetland functioning take place within the soil. Disturbance to the soil surface can disrupt these processes, hindering plant growth, slowing or increasing decomposition rates, and altering hydrologic flow paths.

Metric 4c: Substrate / Soil Disturbance

Definition and Background: This metric assess the degree to which human impacts have disturbed the natural soil or substrate. Common sources of disturbance include: fill or sediment dumping; human recreation, either foot traffic of motorized vehicles; and cows that can cause unnatural hummocks (pugging), which in turn can alter the wetland hydrology and disrupt soil process like organic accumulation. A lack of soil horizons can indicate the substrate was filled or tilled when it is not otherwise obvious. It is important to rate this metric according to wetland type. For example, bare patches may be a sign of unnatural disturbance in many wetlands. Playas, however, should have bare ground with compact soils. In playas, extra sediment on top of the naturally compacted soil can be an indicator of undesirable disturbance. Because it can be difficult to assess the degree of compaction in playas as they fill and close with water, best professional judgment will be needed.

Metric Level: Level 2 (rapid assessment).

Metric Application: Use for all wetlands, regardless of classification. Metric rating includes variants to consider based on HGM class.

Measurement Protocol: Select the statement on the form that best describes the substrate or soil disturbance within the AA, in the context of the wetland ecosystem.

Metric Rating: Assign the metric rating and associated score based on the thresholds in Table 32.

Table 32. Rating for Buffer Width

Rank	*Score*	*State*
Excellent (A)	5	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.
Good (B)	4	Minimal soil disturbance within AA. Some amount of bare soil, pugging, compaction, or sedimentation present due to human causes, but the extent and impact are minimal. The depth of disturbance is limited to only a few inches and does not show evidence of altering hydrology. Any disturbance is likely to recover within a few years after the disturbance is removed.

Fair (C)	3	Moderate soil disturbance within AA. Bare soil areas due to human causes are common and will be slow to recover. There may be pugging due to livestock resulting in several inches of soil disturbance. ORVs or other machinery may have left some shallow ruts. Sedimentation may be filling the wetland. Damage is obvious, but not excessive. The site could recover to potential with the removal of degrading human influences and moderate recovery times.
Poor (D)	1	Substantial soil disturbance within AA. Bare soil areas substantially degrade the site and have led to altered hydrology or other long-lasting impacts. Deep ruts from ORVs or machinery may be present, or livestock pugging and/or trails are widespread. Sedimentation may have severely impacted the hydrology. The site will not recover without active restoration and/or long recovery times.

Metric References: Metric and thresholds adapted from Rocchio (2006) and Faber-Langendeon et al. (2008; 2012).

Physiochemical Stressors

Using the table on the field form (Table 33), estimate the scope of each physiochemical stressor on the water quality or soil of AA. Stressors can occur within the AA or immediately adjacent to the AA's water source. Stressors can overlap and do not need to total 100% (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%.

Table 33. Physiochemical stressors

Physiochemical stressors	*Scope*
Erosion	
Sedimentation	
Current plowing or disking	
Historical 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 or native ungulates	
Compaction and soil disturbance by human use (trails, ORV use, camping)	
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:	

3.5 Size Metrics

Size metrics evaluate both the relative size of the wetland or AA (relative to presumed historicalsize) and the absolute size. Size itself is not a measure of condition, as many natural, high quality wetlands can be small. However, for conservation interests, size can be a useful metric to compare between wetlands. A larger high quality wetland may have more conservation value than a smaller one, based on the amount of habitat is provides or the level of other ecosystem services it can provide. Size metrics can be included or excluded for over roll-up score, depending on the focus of the assessment.

Key Ecological Attribute: Size

Metric 5a: Relative Size

Definition and Background: This metric is an indication of the degree to which human modification has altered the size of the original wetlands. In the traditional sense, we think of human alteration as limiting wetland size, either through ditching, draining, development, or fill other. Complicating this analysis is the fact that the size of many wetlands in the arid West have actually been increased my water and land management practices, either intentionally or unintentionally. In fact, there are many wetlands along the Front Range and in Colorado's agricultural landscapes that are created solely due to water management.

Metric Level: Level 1 (remote sensing) with Level 2 (rapid assessment) verification.

Metric Application: Use for all wetlands, regardless of classification.

Measurement Protocol: Use all available data sources—aerial photos, topographic maps, and other GIS data sources, as well as observations in the field—to estimate the presumed historical size of the wetland. The definition of historical generally refers to the size of the wetland prior to European settlement. If the wetland has been enlarged or created from management action and is located in an area that would otherwise be upland, this metric can be rated as 'A'. The impacts of those management actions should be reflected elsewhere on the form, if they alter the condition. This metric can be difficult to evaluate. Notes on rationale behind the conclusion are very important.

Metric Rating: Assign the metric rating and associated score based on the thresholds in Table 34.

Table 34. Rating for Relative Size.

Rank	*Score*	*State*
Excellent (A)	5	Wetland area ≈ onsite abiotic potential; <5% of wetland has been reduced.
Good (B)	4	Wetland area < abiotic potential; 5–25% of wetland has been reduced.
Fair (C)	3	Wetland area < abiotic potential; 25–50% of wetland has been reduced.
Poor (D)	1	Wetland area < abiotic potential; >50% of wetland has been reduced.

Metric References: Metric and thresholds adapted from Rocchio (2006), Faber-Langendeon et al. (2008; 2012), and Muldavin et al. (2011).

Metric 5b: Absolute Size

Definition and Background: This metric measures the absolute size of the wetland. While many high quality wetlands can be naturally small, size can be an important aspect of the overall value of the wetland from a functional and conversation perspective. The diversity of plants or animals may be higher in larger wetlands. Larger wetlands may be more resilient to hydrologic stressors and invasions by exotics, as they essentially buffer their own inner cores. Size should be evaluated in comparison to similar wetland types. Therefore, the ratings are based on Ecological Systems.

Metric Level: Level 1 (remote sensing) with Level 2 (rapid assessment) verification.

Metric Application: Use for all wetlands, regardless of classification.

Measurement Protocol: Use all available data sources—aerial photos, topographic maps, and other GIS data sources, as well as observations in the field—to estimate the absolute size of the wetland. If the assessment is based on a fixed area, absolute size should reflect the entire wetland that they AA is part of. If the wetland occurs in a mosaic of different wetland types, use the rules in the Ecological System key to delineate distinct occurrences of each Ecological System (i.e., a few cattails within a wet meadow is not a separate wetland, but a major expanse of cattails at the far end of a wet meadow may mean a change in system and therefore should not be included in the size calculation). If there is a major change in land use in the wetlands, such that the condition rating of other metrics would be affected, use that as a break in the size as well. This metric will be combined with the others and will be used to assess the size of the wetland in more or less the same condition.

Metric Rating: Assign the metric rating and associated score based on the thresholds in Table 35.

Table 35. Rating for Absolute Size by Ecological System.

Rank	*Score*	*State*			
		Wet Meadows	*Marshes*	*Fens*	*Playas*
Excellent (A)	5	>30 hectares	>20 hectares	>10 hectares	>5 hectares
Good (B)	4	10–30 hectares	10–20 hectares	2–10 hectares	2–5 hectares
Fair (C)	3	1–10 hectares	1-10 hectares	0.5–2 hectares	0.5–2 hectares
Poor (D)	1	<1 hectare	<1 hectare	<0.5 hectares	<0.5 hectares

Rank	*Score*	*State (must be >10 m throughout the extent)*	
		Riparian Woodlands	*Subalpine Riparian Shrublands*
Excellent (A)	5	>8 linear km	>2.5 linear km
Good (B)	4	5–8 linear km	1.5–2.5 linear km
Fair (C)	3	1.5–5 linear km	0.5–1.5 linear km
Poor (D)	1	<1.5 linear km	<0.5 linear km

Metric References: Metric and thresholds adapted from Rondeau (2001), Rocchio (2006), Faber-Langendeon et al. (2008; 2012), and Muldavin et al. (2011).

3.6 Optional Riverine Hydrology Metrics

There are many specific properties of streams that affect the riverine wetlands they support. Numerous protocols have been developed for assessing stream health that focus on physical properties of streams more than the biotic properties of surrounding wetlands. For riverine wetlands that are adjacent to streams, it can be useful to consider two additional metrics regarding the physical integrity of the stream itself: channel/bank stability and entrenchment ratio. These metrics can be integrated with the hydrology metrics for riverine wetlands.

Metric 6a: Channel/Bank Stability

Definition and Background: Channel stability is assessed as the degree of channel aggradation (net accumulation of sediment on the channel bed such that it is rising over time) or degradation (net loss of sediment from the bed such that it is being lowered over time). This metric can be filled out for AAs in riverine wetlands that include a channel or are adjacent to a channel. The stream does not have to be waded to assess many of the variables in this metric. If the channel is not within or adjacent to the AA, this metric can be left blank.

Every stable riverine channel tends to have a particular form in cross section, profile, and plan view that is in **dynamic equilibrium** with the inputs of water and sediment. If these supplies change enough, the channel will tend to adjust toward a new equilibrium. An increase in the supply of sediment, relative to the supply of water, can cause a channel to aggrade (i.e., the elevation of the channel bed increases), which might cause simple increases in the duration of inundation for existing wetlands, or complex changes in channel location and morphology through braiding, avulsion, burial of wetlands, creation of new wetlands, spray and fan development, etc. An increase in water relative to sediment might cause a channel to incise (i.e., the bed elevation decreases), leading to bank erosion, headward erosion of the channel bed, floodplain abandonment, and dewatering of riparian habitats. For most riverine systems, chronic incision (i.e., bed degradation) is generally regarded as more deleterious than aggradation because it is more likely to cause significant decreases in the extent of riverine wetland and riparian habitats.

Metric Level: Level 2.5 (quantitative measurement of channel properties).

Metric Application: Optional metric for riverine wetlands where the channel is in close proximity to the AA.

Measurement Protocol: There are many well-known field indicators of equilibrium conditions, or deviations from equilibrium, that can be used to assess the existing mode of behavior of a channel and hence the degree to which its hydroperiod can sustain wetland and riparian habitats. To evaluate this metric, visually survey the AA for field indicators of aggradation or degradation given on the form (Table 36). Check “Y” for all those observed and “N” for those not observed.

Metric Rating: Review the indicators checked and determine which statement in Table37 best describes the overall channel/bank stability.

Metric References: Metric and thresholds adapted from Rocchio (2006), Collins et al (2008; 2013), Faber-Langendeon et al. (2008; 2012), and Muldavin et al. (2011).

Table 36. Field indicators of channel equilibrium, aggradation or degradation.

Condition	Y	N	Field Indicators
Indicators of Channel Equilibrium / Natural Dynamism	☐	☐	The channel (or multiple channels in braided systems) has a well-defined usual high water line or bankfull stage that is clearly indicated by an obvious floodplain, topographic bench that represents an abrupt change in the cross-sectional profile of the channel throughout *most* of the site.
	☐	☐	The usual high water line or bank full stage corresponds to the lower limit of riparian vascular vegetation.
	☐	☐	Leaf litter, thatch, wrack, and/or mosses exist in most pools.
	☐	☐	The channel contains embedded woody debris of the size and amount consistent with what is available in the riparian area.
	☐	☐	Active undercutting of banks or burial of riparian vegetation is limited to localized areas and not throughout site.
	☐	☐	There is little evidence of recent deposition of cobble or very coarse gravel on the floodplain, although recent sandy deposits may be evident.
	☐	☐	There are no densely vegetated mid-channel bars and/or point bars, indicating flooding at regular intervals.
	☐	☐	The spacing between pools in the channel tends to be 5-7 channel widths, if appropriate.
	☐	☐	The larger bed material supports abundant periphyton.
Indicators of Active Aggradation / Excessive Sediment	☐	☐	The channel through the site lacks a well-defined usual high water line.
	☐	☐	There is an active floodplain with fresh splays of sediment covering older soils or recent vegetation.
	☐	☐	There are partially buried tree trunks or shrubs.
	☐	☐	Cobbles and/or coarse gravels have recently been deposited on the floodplain.
	☐	☐	There is a lack of in-channel pools, their spacing is greater than 5-7 channel widths, or many pools seem to be filling with sediment.
	☐	☐	There are partially buried, or sediment-choked, culverts.
	☐	☐	Transitional or upland vegetation is encroaching into the channel throughout most of the site.
	☐	☐	The bed material is loose and mostly devoid of periphyton.
Indicators of Active Degradation / Excessive Erosion	☐	☐	The channel through the site is characterized by deeply undercut banks with exposed living roots of trees or shrubs.
	☐	☐	There are abundant bank slides or slumps, or the banks are uniformly scoured and unvegetated.
	☐	☐	Riparian vegetation declining in stature or vigor, and/or riparian trees and shrubs may be falling into channel.
	☐	☐	Abundant organic debris has accumulated on what seems to be the historical floodplain, indicating that flows no longer reach the floodplain.
	☐	☐	The channel bed appears scoured to bedrock or dense clay.
	☐	☐	The channel bed lacks fine-grained sediment.
	☐	☐	Recently active flow pathways appear to have coalesced into one channel (i.e. a previously braided system is no longer braided).
	☐	☐	There are one or more nick points along the channel, indicating headward erosion of the channel bed.

Table 37. Rating for Channel/Bank Stability.

Rank	*Score*	*State*
Excellent (A)	5	Most of the channel within or near the AA is characterized by naturally dynamic equilibrium conditions, with little evidence of excessive aggradation or degradation. Streambanks typically dominated (>90% cover) by stabilizing plant species, including trees, shrubs, herbs.
Good (B)	4	Most of the channel within or near the AA is characterized by some aggradation or degradation, none of which is severe, and the channel seems to be approaching an equilibrium form. Streambanks may have 70–90% cover of stabilizing plant species, but some bare areas occur.
Fair (C)	3	There is evidence of severe aggradation or degradation of most of the channel within or near the AA or the channel is artificially hardened through less than half of the AA. Streambanks may have 50–70% cover of stabilizing plant species within several bare areas.
Poor (D)	1	The channel is concrete or otherwise artificially hardened through most of the AA. Streambanks have <50% cover of stabilizing plant species.

Metric 6b: Entrenchment Ratio

Definition and Background: Entrenchment is a field measurement calculated as the flood-prone width divided by the bankfull width. Bankfull width is the channel width at the height of bankfull flow. The flood-prone channel width is measured at the elevation of twice the maximum bankfull depth. Entrenchment is a quantitative measure of how deeply the channel has been downcut.

Metric Level: Level 2.5 (quantitative measurement of channel properties).

Metric Application: Optional metric for riverine wetlands where the channel is in close proximity to the AA *and* is wadable.

Measurement Protocol: The process for estimating entrenchment is outlined in Table 38 below and illustrated in Figure 20. Once estimated, use best professional judgment to determine if entrenchment is affecting hydrologic connectivity. Use the calculations as a guide, but sometimes it is clear a channel is entrenched even when the math does not indicate this, and sometimes a channel is not entrenched despite the math. Long term changes to river levels can cause entrenchment. Criteria are different for confined and unconfined streams.

Table 38. Steps for estimating entrenchment ratio.

1. Estimate bankfull width.	This is a critical step requiring experience. If the stream is entrenched, the height of bankfull flow is identified as a scour line, narrow bench, or the top of active point bars well below the top of apparent channel banks. If the stream is not entrenched, bankfull stage can correspond to the elevation of a broader floodplain with indicative riparian vegetation. Estimate or measure the distance between the right and left bankfull contours.
2. Estimate max bankfull depth.	Imagine a line between right and left bankfull contours. Estimate or measure the height of the line above the thalweg (the deepest part of the channel).

3. Estimate flood prone height.	Double the estimate of maximum bankfull depth from Step 2.
4. Estimate flood prone width.	Imagine a level line having a height equal to the flood prone depth from Step 3. Note the location of the new height on the channel bank. Estimate the width of the channel at the flood prone height.
5. Calculate entrenchment.	Divide the flood prone width (Step 4) by the max bankfull width (Step 1).

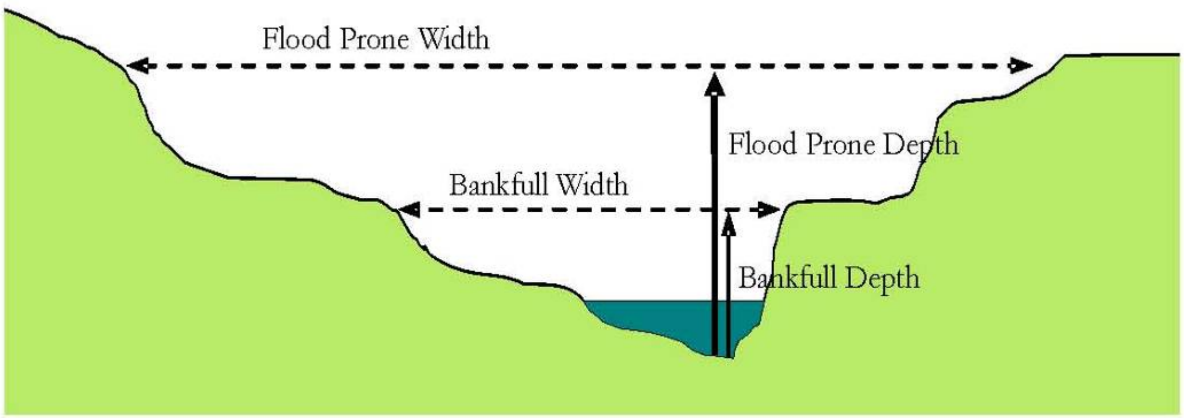

Figure 20. Elements of calculating entrenchment ration. Illustration from Collins *et al.* 2008. California Rapid Assessment Method for Wetlands v 5.0.2

Metric Rating: Assign the metric rating and associated score based on the thresholds in Table XX. Criteria are different for confined and unconfined streams. These thresholds are from Collins et al. (2006; 2013) and are still being tested in Colorado.

Table 39. Rating for Entrenchment Ratio.

Rank	***Score***	***State – Confined Valleys***	***State – Unconfined Valleys***
Excellent (A)	5	Entrenchment ratio >2.0.	Entrenchment ratio >2.2.
Good (B)	4	Entrenchment ratio 1.6–2.0.	Entrenchment ratio 1.9–2.2.
Fair (C)	3	Entrenchment ratio 1.2–1.5.	Entrenchment ratio 1.5–1.8.
Poor (D)	1	Entrenchment ratio <1.2.	Entrenchment ratio <1.5.

Metric References: Metric and thresholds adapted from Rocchio (2006), Collins et al (2008; 2013), Faber-Langendeon et al. (2008; 2012), and Muldavin et al. (2011).

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APPENDICES

APPENDIX A: **Field Key to Wetland and Riparian Ecological Systems of Colorado**

APPENDIX B: **National Wetland Inventory Classification Modified from Cowardin *et al.* 1979**

APPENDIX C: **Field Key to the Hydrogeomorphic (HGM) Classes of Wetlands in the Rocky Mountains**

APPENDIX D: **Soil Texture Flowchart**

APPENDIX E: **Notes on Hydric Soil Indicators for the Mountain West**

APPENDIX F: **Colorado Noxious Weed List**

APPENDIX A: Field Key to Wetland and Riparian Ecological Systems of Colorado

Last Updated February 1, 2013

1b. Wetlands and riparian areas of Colorado's Great Plains, including all areas below ~6,000 ft. from the Front Range east to the Kansas boarder. Within Colorado, this area is referred to as the Eastern Plains, but from a national perspective, these are the Western Great Plains or the High 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 (San Luis Valley, South Park, North Park, etc.). *[If the site does not match any of the descriptions within Key B, try Key C as well. Not all wetlands and riparian areas of the inter-mountain basis will fit within this key.]* ....**KEY B: WETLANDS AND RIPARIAN AREAS OF THE INTER-MOUNTAIN BASINS**

2b. Wetlands and riparian areas of the Rocky Mountains, including the foothills of the Front Range and all of the West Slope. Localized "hanging garden" wetlands of the Colorado Plateau are also keyed here, as they are the only system specific to that region. ....**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 cana*, and *Artemisia tridentata.* Vegetation may be sparse and soils may be saline. Sites may be located on flats or in washes, but typically not 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 >10% total vegetation cover, located on flats or in temporarily or intermittently flooded drainages, and 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 < 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*, *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. **9**

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 floodplain expression of this system is located on the floodplain, but may be disconnected from flooding regimes. 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 highest canopy cover. Species composition may be dominated by non-native hay grasses. 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)**

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. (*Populus angustifolia*, *P. deltoides,* or the hybrid *P. acuminata*). Common native shrub species include *Salix* spp., *Alnus incana*, *Betula occidentalis, Cornus sericea*, and *Crataegus* spp. Exotic shrub species include *Tamarix spp.* and *Elaeagnus angustifolia.* 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 Colorado's Western Great Plains. Dominant native species include *Populus deltoides*, *Salix fragilis, Salix amygdaloides, Salix exigua, Acer negundo, Fraxinus* spp., and *Ulmus* spp. Dominant non-native species include *Tamarix* spp., *Elaeagnus angustifolia,* and other introduced woody species **7**

7a. Woodlands, shrublands, and meadows of draws and ravines associated with steep north-facing slopes or canyon bottoms that do not experience prolonged flooding. Common tree species include *Acer negundo, Populus tremuloides*, *Fraxinus* spp., and *Ulmus* spp. Important shrub species include *Crataegus* spp., *Prunus virginiana*, *Rhus* spp., *Rosa woodsii*, *Symphoricarpos occidentalis*, and *Shepherdia argentea. [It is uncertain how common this type is in Colorado. This type is more common on the plains to the north and east of Colorado (Wyoming, Nebraska, and South Dakota), where there is more relief to the landscape.]* .... **Western Great Plains Wooded Draw and Ravine**

7b. Woodlands, shrublands, and meadows of small to large streams and rivers of the Western Great Plains. Overall vegetation is lusher than above and includes more wetland indicator species. **8**

8a. 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 (streams close to the Rocky Mountain front), groundwater (prairie streams), and summer rainfall. Dominant species include *Populus deltoides, Salix* spp., *Fraxinus pennsylvanica, Artemisia cana* ssp. *cana, Pascopyrum smithii, Panicum virgatum, Panicum obtusum, Sporobolus cryptandrus,* and *Schizachyrium scoparium. Carex* spp., *Tamarix* spp., *Elaeagnus angustifolia,* and less desirable grasses and forbs can invade degraded examples. Groundwater depletion, lack of fire, heavy grazing, and/or agriculture have resulted in species and hydroperiod changes. .... **Western Great Plains Riparian**

8b. Woodlands, shrublands, and meadows along large rivers with extensive floodplain development and periodic flooding that is more associated with snowmelt and seasonal dynamics in the mountains than with local precipitation events. 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 virgatum*, *Andropogon gerardii*, and *Carex* spp. *Tamarix* spp., *Elaeagnus angustifolia,* and non-native grasses have invaded degraded areas within the floodplains, which are subjected to heavy grazing and/or agriculture. Groundwater depletion and lack of fire have created additional alterations in species composition and hydroperiod. In most cases, the majority of the native wet meadow and prairie communities may be extremely degraded or extirpated from examples of this system. .... **Western Great Plains Floodplain**

9a. 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 and lacks a groundwater connection. 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. *[On Colorado's Eastern Plains, 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.]* **10**

9b. 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. **11**

10a. 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, Buchloe dactyloides, Eleocharis* spp., *Oenothera canescens, Ratibida tagetes, Plantago* spp., *Polygonum* spp., and *Phyla cuneifolia.* Non-native species are very common in these sites, including *Salsola australis, Bassia sieversiana, Verbena bracteata,* and *Conyza canadensis.* Sites have often been disturbed by agriculture and heavy grazing. Many have been dug out or "pitted" to increase water retention and to tap shallow groundwater. *[Most of the playas on Colorado's Eastern Plains will likely fit within this ecological system.]*......... **Western Great Plains Closed Depression Wetland**

10b. Shallow depressional herbaceous wetlands with saline soils. Salt encrustations can occur on the surface. Species are typically salt-tolerant, including *Distichlis spicata*, *Puccinellia* spp., *Salicornia* spp., *Schoenoplectus maritimus. Sporobolus airoides,* and *Hordeum jubatum.* Other commonly occurring taxa include *Puccinellia nuttalliana, Salicornia rubra, Schoenoplectus maritimus, Schoenoplectus americanus, Suaeda calceoliformis, Spartina* spp., *Triglochin maritima,* and occasional shrubs such as *Sarcobatus vermiculatus* and *Krascheninnikovia lanata. [It is not clear how common this system is in Colorado. This* *system occurs more commonly in surrounding states where plains soils are more saline. Note: Low stature shrub-dominant wetlands key in the flats and wash systems above.]* .... **Western Great Plains Saline Depression Wetland**

11a. 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**

11b. 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 highest canopy cover. Species composition may be dominated by non-native hay grasses. 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 Sand Dunes National Park and Preserve, North Sand Hills Recreation Area in North Park). .... **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**

6b. 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 semipermanently flooded, usually retaining water into the growing season and drying completely only in drought years. Many are associated with hot and cold springs, located in basins with internal drainage. Seasonal drying exposes mudflats colonized by annual wetland vegetation. Vegetation cover is generally >10% and species are typically salt-tolerant such as *Distichlis spicata*, *Puccinellia* spp., *Leymus* sp., *Poa secunda*, *Schoenoplectus maritimus, Schoenoplectus americanus, Triglochin maritima,* and *Salicornia* spp. This system can occur in alkaline basins and swales and along the drawdown zones of lakes and ponds..
....**Inter-Mountain Basins Alkaline Closed Depression**

3b. Barren and sparsely vegetated playas (generally <10% plant cover). Salt crusts are common throughout, with small saltgrass beds in depressions and sparse shrubs around the margins. These systems are intermittently flooded. The water is prevented from percolating through the soil by an impermeable soil subhorizon 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 or in temporarily or intermittently flooded drainages. Vegetation 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**

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. Herbaceous wetlands ("hanging gardens") associated with seeps and springs within canyons of the Colorado Plateau region, typically along drainages of the major rivers of the region and their tributaries. Vegetation is supported by perennial water sources (seeps) that form pocketed wetlands and draping vegetation across wet cliff faces. Typical plant species include southern maidenhair fern (*Adiantum capillus-veneris*), northern maidenhair fern (*Adiantum pedatum*), Eastwood's monkeyflower (*Mimulus eastwoodiae*), common large monkeyflower (*Mimulus guttatus*), Hapeman's coolwort (*Sullivantia hapemanii*), Rydberg's thistle (*Cirsium rydbergii*), and several species of columbine, including Mancos columbine (*Aquilegia micrantha*). .... **Colorado Plateau Hanging Garden**

1b. Wetlands not as above. Not associated with seeps and springs within canyons of the Colorado Plateau. **2**

2a. 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 hectares (0.25 acres). If the wetland occurs as an isolated patch surrounded by upland, then there is no minimum size criteria. ... . **Rocky Mountain Subalpine-Montane Fen**

2b. 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 ... **3**

3a. Total woody canopy cover generally 25% or more within the overall wetland/riparian area. Any purely herbaceous patches are less than 0.5 hectares and occur within a matrix of woody vegetation. *[Note: Relictual woody vegetation such as standing dead trees and shrubs are included here.]* **4**

3b. Total woody canopy cover generally less than 25% within the overall wetland/riparian area. Any woody vegetation patches are less than 0.5 hectares and occur within a matrix of herbaceous wetland vegetation **6**

4a. Riparian woodlands and shrublands of the foothill and lower montane zones on both the east and west slopes of Colorado's Rocky Mountains. Woodlands are dominated by *Populus* spp. (*Populus angustifolia*, *P. deltoides,* or the hybrid *P. acuminata*). Common native shrub species include *Salix* spp., *Alnus incana*, *Betula occidentalis, Cornus sericea*, and *Crataegus* spp. Exotic shrub species include *Tamarix spp.* and *Elaeagnus angustifolia.* 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**

4b. Riparian woodlands and shrublands of the montane or subalpine zone **5**

5a. 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*, *Pseudotsuga menziesii*, and *Populus tremuloides* .... **Rocky Mountain Subalpine-Montane Riparian Woodland**

5b. 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 *or* as a wide, extensive shrub stand on alluvial terraces in low-gradient valley bottoms (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*. .... **Rocky Mountain Subalpine-Montane Riparian Shrubland**

6a. Herbaceous wetlands with a permanent water source 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 species including species of *Scirpus*, *Schoenoplectus*, *Typha*, *Juncus*, *Carex*, *Potamogeton*, *Polygonum*, and *Nuphar*. .... **Western North American Emergent Marsh**

6b. Herbaceous wetlands that typically lacks 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**

7a. 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 and may be subjected to high disturbance events such as flooding (Riverine HGM Class). 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**

7b. 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. Species composition may be dominated by non-native hay grasses. .... **Irrigated Wet Meadow (not an official Ecological System)**

APPENDIX B National Wetland Inventory Classification

Modified from Cowardin et al. 1979

Cowardin System:

Upland (UPL): Non-wetland areas on land.

Open Water (OW): Deep water > 2 m deep.

Palustrine (P): All wetlands sampled within the REMAP project will fall under the Palustrine Cowardin System because they are vegetated. This system includes all wetlands dominated by trees, shrubs, and emergent, herbaceous vegetation. Wetlands lacking vegetation are also included in this system if they are less than 8 hectares (20 acres) and have a depth less than 2 meters (6.6 feet) in the deepest portion of the wetland.

Cowardin Classes:

Aquatic Bed (AB): Wetlands with vegetation that grows on or below the water surface for most of the growing season.

Emergent (EM): Wetlands with erect, rooted herbaceous vegetation present during most of the growing season.

Scrub-Shrub (SS): Wetlands dominated by woody vegetation that is less than 6 meters (20 feet) tall. Woody vegetation includes tree saplings and trees that are stunted due to environmental conditions.

Forested (FO): Wetland is dominated by woody vegetation that is greater than 6 meters (20 feet) tall.

Unconsolidated Bottom (UB): Wetlands that have a muddy or silty substrate with at least 25% cover.

Unconsolidated Shore (US): Wetlands with less than 75% areal cover of stones, boulders, or bedrock AND with less than 30% vegetative cover AND are irregularly exposed due to seasonal or irregular flooding and subsequent drying.

Cowardin Water Regime Modifiers (in order from driest to wettest):

Intermittently Flooded (J): The substrate is usually exposed, but surface water is present for variable periods without detectable seasonal periodicity. Weeks, months, or even years may intervene between periods of inundation.

Temporarily Flooded (A): Surface water is present for brief periods during the growing season, but the water table usually lies well below the soil surface for most of the season. Plants that grow both in uplands and wetlands are characteristic of the temporarily flooded regime.

Saturated (B): The substrate is saturated to the surface for extended periods during the growing season, but surface water is seldom present. This modifier is applied to fen like areas with stable water tables regardless of their connectivity.

Seasonally Flooded (C): Surface water is present for extended periods especially early in the growing season, but is absent by the end of the season in most years. When surface water is absent, the water table is often near the land surface.

Semi-permanently Flooded (F): Surface water persists throughout the growing season in most years. When surface water is absent, the water table is usually at or very near the land surface.

Intermittently Exposed (G): Surface water is present throughout the year except in years of extreme drought. This is applied to large ponds and shallow lakes where the water does not appear likely to dry up.

Permanently Flooded (H): Water covers the land surface throughout the year in all years. Vegetation is composed of obligate hydrophytes. Mostly applied to deepwater habitats such as lakes where there is no chance drying.

Cowardin Special Modifiers

Beaver (b): This modifier describes wetlands that are formed within and adjacent to streams by beaver activity.

Excavated (x): This modifier describes wetlands that were created through the excavation of soils.

Partially ditched/drained (d): This modifier describes manmade alterations to wetlands including ditches.

Diked/impounded (h): This modifier describes manmade alterations to wetlands where impoundments or dikes have been added.

Farmed (f): This modifier describes wetlands that have been altered due to farming practices.

Examples of Palustrine System:

To classify Palustrine wetlands, we combine the codes for the system, class, and water regime. The following are examples of types of wetlands and how they would be coded for wetland mapping purposes.

1. Cattail marsh that has standing water for most of the year: **PEMF**
2. A prairie pothole dominated by grasses and sedges that is only wet at the beginning of the growing season: **PEMA**
3. A fen in the subalpine zone: **PEMB**
4. A small shallow pond that has lily pads and other floating vegetation and holds water throughout the growing season: **PABF**
5. A small shallow pond with less than 30% vegetation and a muddy substrate that holds water for most of the year: **PUBF**
6. A wetland dominated by willows adjacent to a stream that is only periodically flooded: **PSSA**

APPENDIX C: Field Key to the Hydrogeomorphic (HGM) Classes of Wetlands in the Rocky Mountains

1a. Entire wetland unit is flat and precipitation is the primary source (>90%) of water. Groundwater and surface water runoff are not significant sources of water to the unit ....**Flats HGM Class**

1b. Wetland does not meet the above criteria; primary water sources include groundwater and/or surface water **2**

2a. Entire wetland unit meets ***all*** of the following criteria: a) the vegetated portion of the wetland is on the shores of a permanent open water body at least 8 ha (20 acres) in size; b) at least 30% of the open water area is deeper than 2 m (6.6 ft); c) vegetation in the wetland experiences bidirectional flow as the result of vertical fluctuations of water levels due to rising and falling lake levels. ....**Lacustrine Fringe HGM Class**

2b. Wetland does not meet the above criteria; wetland is not found on the shore of a water body, water body is either smaller or shallower, OR vegetation is not effected by lake water levels.. **3**

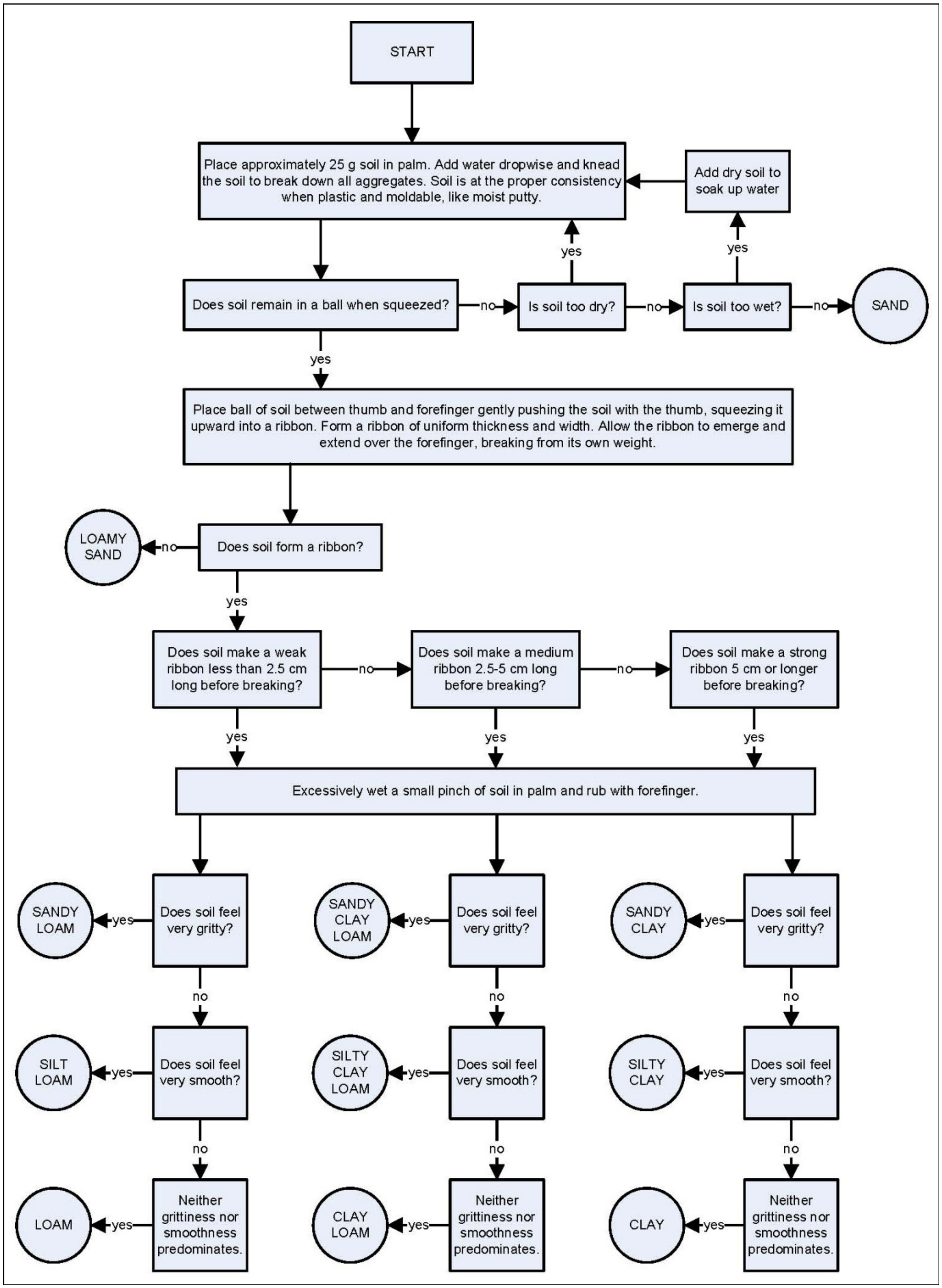
3a. Entire wetland unit meets ***all*** of the following criteria: a) wetland unit is in a valley, floodplain, or along a stream channel where it is inundated by overbank flooding from that stream or river; b) overbank flooding occurs at least once every two years; and c) wetland does not receive significant inputs from groundwater. **NOTE:** *Riverine wetlands can contain depressions that are filled with water when the river is not flooding such as oxbows and beaver ponds*... **Riverine HGM Class**

3b. Wetland does not meet the above criteria; if the wetland is located within a valley, floodplain, or along a stream channel, it is outside of the influence of overbank flooding or receives significant hydrologic inputs from groundwater. **4**

4a. Entire wetland unit meets ***all*** of the following criteria: a) wetland is on a slope (slope can be very gradual or nearly flat); b) groundwater is the primary hydrologic input; c) water, if present, flows through the wetland in one direction and usually comes from seeps or springs; and d) water leaves the wetland without being impounded. **NOTE:** *Small channels can form within slope wetlands, but are not subject to overbank flooding. Surface water does not pond in these types of wetlands, except occasionally in very small and shallow depressions or behind hummocks (depressions are usually < 3ft diameter and less than 1 foot deep).* .... **Slope HGM Class**

4b. Wetland does not meet all of the above criteria. Entire wetland unit is located in a topographic depression in which water ponds or is saturated to the surface at some time during the year. **NOTE:** *Any outlet, if present, is higher than the interior of the wetland.* ....**Depressional HGM Class**

APPENDIX E: Soil Texture Flowchart



APPENDIX F: Notes on Hydric Soil Indicators for the Mountain West

All Soil Types

A1. Histosol: Organic soil material **≥ 40 cm** think within the top **80 cm**.

A2. Histic Epipedon: Organic soil material **≥ 20 cm** thick above a mineral soil layer. Aquic conditions or artificial drainage *required,* but can be assumed if hydrophytic vegetation and wetland hydrology are present.

A3. Black Histic: Very dark organic soil material **≥ 20 cm** thick that starts **within 15 cm** of soil surface. Color: hue = 10YR or yellower; value ≤ 3; chroma ≤ 1. Aquic conditions or artificial drainage *not required. Rare in our region.*

A4. Hydrogen Sulfide: Rotten egg odor within **30 cm** of the soil surface due to the reduction of sulfur. Most commonly found in areas that are permanently saturated or inundated; almost never at the wetland boundary.

A11. Depleted Below Dark Surface: Depleted (colorless) layer **≥ 15 cm** that starts **within 30 cm** of the soil surface. Color: chroma ≤ 2. Redox features required if color = 4/1, 4/2, 5/2. Layers above must be dark. See Table 1 for specifics.

A12. Thick Dark Surface. Depleted (colorless) layer **≥ 15** cm that starts **below 30 cm** of the soil surface. Color: chroma ≤ 2. Redox features required if color = 4/1, 4/2, 5/2. Layers above must be dark. See Table 1 for specifics. *Not common in our region.*

For the remaining indicators, unless otherwise indicated, all mineral layers above the indicators must have a dominant chroma of ≤ 2 or the layers with dominant chroma of > 2 must be < 15 cm thick.

Sandy Soil Types Sandy soil indicators are generally shallower and thinner than loamy/clayey soil indicators.

S1. Sandy Mucky Mineral: A layer of mucky modified sandy soil material **≥ 5 cm** starting **within 15 cm** of the soil surface. *Limited in our region,* but found in swales associated with sand dunes.

S4. Sandy Gleyed Matrix: Gleyed matrix that occupies **≥ 60%** of a layer starting **within 15 cm** of the soil surface. No minimum thickness required. Gley colors are not synonymous with grey colors. They are found on the Gley page. *Rare in our region;* only found where sandy soils are almost continuously saturated.

S5. Sandy Redox: Redox features in a depleted (colorless) layer **≥ 10 cm** that starts **within 15 cm** of the soil surface. Color: chroma ≤ 2. See Table 1 for specifics. *Most common indicator in our region of the wetland boundary for sandy soils.*

S6. Stripped Matrix: A layer starting **within 15 cm** of the surface in which iron/manganese oxides and/or organic matter has been stripped and the base color of the soil material is exposed. Evident by faint, diffuse splotchy patterns of two or more colors. Stripped zones are ≥ 10% and ~1–3 cm in diameter.

Loamy / Clayey Soil Types Loamy/clayey soil indicators are generally deeper and thicker than sandy soil indicators.

F1. Loamy Mucky Mineral: A layer of mucky modified loamy or clayey soil material **≥ 10 cm** starting within 15 cm of the soil surface. Difficult to tell without testing.

F2. Loamy Gleyed Matrix: Gleyed matrix that occupies **≥ 60%** of a layer starting **within 30 cm** of the soil surface. No minimum thickness required. Gley colors are not synonymous with grey colors. They are found on the Gley page.

F3. Depleted Matrix: Depleted (colorless) layer **≥ 5 cm** thick **within 15 cm** *or* **≥ 15 cm** thick w**ithin 30 cm** of the soil surface. Color: chroma ≤ 2. Redox features required if color = 4/1, 4/2, 5/2. See Table 1 for specifics. *Most common indicator at wetland boundaries.*

F6. Redox Dark Surface: A dark surface layer with **redox features.** Depth and location: **≥ 10 cm** thick entirely **within 30 cm of** the mineral soil. Matrix color and redox features: matrix value ≤ 3 and chroma ≤ 1 with ≥ 2% distinct, prominent redox concentrations OR matrix value ≤ 3 and chroma ≤ 2 with ≥ 5% distinct, prominent redox concentrations. The chroma can be higher with more redox features. *Very common indicator to delineate wetlands,* though difficult to see in soils with high organic matter.

F7. Depleted Dark Surface: A dark surface layer with **redox depletions.** Depth and location: **≥ 10 cm** thick entirely **within 30 cm of** the mineral soil. Matrix color and redox depletions: matrix value ≤ 3 and chroma ≤ 1 with ≥ 10% redox depletions OR matrix value ≤ 3 and chroma ≤ 2 with ≥ 20% redox depletions. The chroma can be higher with more redox depletions. Redox depletions themselves should have value ≥ 5 and chroma ≤ 2. *Rare in our region.*

F8. Redox Depressions: A layer **≥ 5 cm** thick entirely **within 15 cm** of soil surface with ≥ 5% distinct or prominent redox concentrations in closed depressions subject to ponding. *No color requirement for the matrix soil, but only applies to depressions in otherwise flat landscapes.*

Table 1. Comparison of indicators with depleted matrices and redox features.

	A11	***A12***	***F3***	***S5***
Depleted matrix extent	≥ 60%	≥ 60%	≥ 60%	≥ 60%
Depleted matrix color	chroma ≤ 2	chroma ≤ 2	chroma ≤ 2	chroma ≤ 2
Redox requirements	≥ 2% distinct or prominent redox concentrations ***if matrix color is*** 4/1, 4/2, 5/2	≥ 2% distinct or prominent redox concentrations ***if matrix color is*** 4/1, 4/2, 5/2	≥ 2% distinct or prominent redox concentrations ***if matrix color is*** 4/1, 4/2, 5/2	≥ 2% distinct or prominent redox concentrations
Starting within	< 30 cm	≥ 30 cm	see below	> 15 cm
Min thickness	15 cm or 5 cm if fragmental soil material	15 cm	**5 cm** within 15 cm of soil surface OR **15 cm** within 25 cm of soil surface	10 cm
Color of layers above	***loamy/clayey*** value ≤ 3 chroma ≤ 2 ***sandy material*** value ≤ 3 chroma ≤ 1 70% coated with organic material	***all types to 30cm*** value ≤ 2.5 chroma ≤ 1 ***all types below 30 cm and above depleted matrix*** value ≤ 3 chroma ≤ 1 ***all sandy material*** 70% coated with organic material	no requirements	no requirements

APPENDIX D: Colorado Noxious Weed List

Source: Colorado Department of Agriculture Noxious Weed Program.

List A species in Colorado that are designated by the Commissioner for eradication:

- African rue *(Peganum harmala)*
- Camelthorn *(Alhagi pseudalhagi)*
- Common crupina *(Crupina vulgaris)*
- Cypress spurge *(Euphorbia cyparissias)*
- Dyer's woad *(Isatis tinctoria)*
- Giant salvinia *(Salvinia molesta)*
- Hydrilla *(Hydrilla verticillata)*
- Meadow knapweed *(Centaurea pratensis)*
- Mediterranean sage *(Salvia aethiopis)*
- Medusahead *(Taeniatherum caput-medusae)*
- Myrtle spurge *(Euphorbia myrsinites)*
- Orange hawkweed *(Hieracium aurantiacum)*
- Purple loosestrife *(Lythrum salicaria)*
- Rush skeletonweed *(Chondrilla juncea)*
- Sericea lespedeza *(Lespedeza cuneata)*
- Squarrose knapweed *(Centaurea virgata)*
- Tansy ragwort *(Senecio jacobaea)*
- Yellow starthistle *(Centaurea solstitialis)*

List B weed species are species for which the Commissioner, in consultation with the state noxious weed advisory committee, local governments, and other interested parties, develops and implements state noxious weed management plans designed to stop the continued spread of these species:

- Absinth wormwood *(Artemisia absinthium)*
- Black henbane *(Hyoscyamus niger)*
- Bouncingbet *(Saponaria officinalis)*
- Bull thistle *(Cirsium vulgare)*
- Canada thistle *(Cirsium arvense)*
- Chinese clematis *(Clematis orientalis)*
- Common tansy *(Tanacetum vulgare)*
- Common teasel *(Dipsacus fullonum)*
- Corn chamomile *(Anthemis arvensis)*
- Cutleaf teasel *(Dipsacus laciniatus)*
- Dalmatian toadflax, broad-leaved *(Linaria dalmatica)*
- Dalmatian toadflax, narrow-leaved *(Linaria genistifolia)*
- Dame's rocket *(Hesperis matronalis)*
- Diffuse knapweed *(Centaurea diffusa)*
- Eurasian watermilfoil *(Myriophyllum spicatum)*
- Hoary cress *(Cardaria draba)*
- Houndstongue *(Cynoglossum officinale)*
- Leafy spurge *(Euphorbia esula)*

- Mayweed chamomile *(Anthemis cotula)*
- Moth mullein *(Verbascum blattaria)*
- Musk thistle *(Carduus nutans)*
- Oxeye daisy *(Chrysanthemum leucanthemum)*
- Perennial pepperweed *(Lepidium latifolium)*
- Plumeless thistle *(Carduus acanthoides)*
- Quackgrass *(Elytrigia repens)*
- Redstem filaree *(Erodium cicutarium)*
- Russian knapweed *(Acroptilon repens)*
- Russian-olive *(Elaeagnus angustifolia)*
- Salt cedar *(Tamarix chinensis, T.parviflora, and T. ramosissima)*
- Scentless chamomile *(Matricaria perforata)*
- Scotch thistle *(Onopordum acanthium)*
- Scotch thistle *(Onopordum tauricum)*
- Spotted knapweed *(Centaurea maculosa)*
- Spurred anoda *(Anoda cristata)*
- Sulfur cinquefoil *(Potentilla recta)*
- Venice mallow *(Hibiscus trionum)*
- Wild caraway *(Carum carvi)*
- Yellow nutsedge *(Cyperus esculentus)*
- Yellow toadflax *(Linaria vulgaris)*

List C weed species are species for which the Commissioner, in consultation with the state noxious weed advisory committee, local governments, and other interested parties, will develop and implement state noxious weed management plans designed to support the efforts of local governing bodies to facilitate more effective integrated weed management on private and public lands. The goal of such plans will not be to stop the continued spread of these species but to provide additional education, research, and biological control resources to jurisdictions that choose to require management of List C species.

- Chicory *(Cichorium intybus)*
- Common burdock *(Arctium minus)*
- Common mullein *(Verbascum thapsus)*
- Common St. Johnswort *(Hypericum perforatum)*
- Downy brome *(Bromus tectorum)*
- Field bindweed *(Convolvulus arvensis)*
- Halogeton *(Halogeton glomeratus)*
- Johnsongrass *(Sorghum halepense)*
- Jointed goatgrass *(Aegilops cylindrica)*
- Perennial sowthistle *(Sonchus arvensis)*
- Poison hemlock *(Conium maculatum)*
- Puncturevine *(Tribulus terrestris)*
- Velvetleaf *(Abutilon theophrasti)*
- Wild proso millet *(Panicum miliaceum)*

Appendix B

USA-RAM Protocol

USA RAM MANUAL

Version 11
January 2011

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Table of Contents

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Basic Guidance

Purposes of USA-RAM

The primary purpose of USA-RAM is to assess the overall condition and stress for the nation's wetlands as part of the USEPA 2011 National Wetland Condition Assessment (NWCA). Secondary purposes include exploring relationships between stress and condition as mediated by buffers, and providing a RAM to US States and Tribes that they can further develop for their own purposes.

Assumptions of USA-RAM

- The overall condition of a wetland is its capacity or potential to provide its full suite of functions and services, relative to reference sites.
- The overall condition of a wetland can be assessed in terms of the complexity of its visible form and structure, relative to reference sites.
- The overall stress on a wetland is the sum total and extent of human-caused processes and events that are likely to degrade wetland form and structure.
- The overall stress on a wetland can be assessed as the number of evident stressors and their cumulative extent. As the number and extent of stressors accumulates, wetland overall condition declines, regardless of wetland type or vegetation community composition.
- Indicators are visible representations of wetland form, structure, or stress. Suitable indicators can be identified using conceptual models that relate wetland form and structure to wetland processes, functions, and stress.
- For any wetland type or class, larger wetlands with more intact structure and less stress tend to have greater levels of characteristic functions and services. This can be represented by Condition Profiles and Stress Profiles.

Structure of USA-RAM

USA-RAM is designed to assess overall condition and stress for a 0.5-ha Assessment Area (AA) and its buffer (defined here as the area within 100m distance from the perimeter of the AA). Each AA is assessed in terms of Attributes of condition and stress, based on Metrics of the Attributes and Field Indicators of the Metrics (Table 1).

USA-RAM recognizes four Attributes of condition and stress: Buffer, Hydrology, Physical Structure, and Biological Structure. However, for the following reasons, the Hydrology Attribute is only assessed in terms of its stressors.

- All aspects of wetland condition are affected by hydrology. Physical structure, biological structure, and buffer condition tend to be correlated to hydrology. The importance of the Hydrology Attribute is therefore adequately reflected by the assessment of these other Attributes of condition, without having to assess hydrological conditions per se. An assessment of hydrological stressors is necessary, however, to understand the results for of the condition assessment.

- The hydrological conditions that account for the conditions of the other Attributes is not always evident during the assessment. The observed conditions might be affected by the hydrology of a previous season or year. In general, efforts to reconstruct previous hydrological conditions tend to incur substantial uncertainty.
- Hydrology varies more that the other Attributes of condition, both within and among wetland classes. Different metrics of hydrological condition are needed to assess different types of wetlands. Wetland hydrology is therefore not well assessed by a single set of hydrological metrics, as required for USA RAM.

Table 1: USA RAM Attributes and Metrics of wetland condition and stress.

Attributes	Condition Metrics	Stress Metrics
Buffer	Percent of AA Having Buffer	Stress to the Buffer Zone
	Buffer Width	
Hydrology	None	Alterations to Hydroperiod
		Stress to Water Quality
Physical Structure	Topographic Complexity	Habitat/Substrate Alterations
	Patch Mosaic Complexity	
Biological Structure	Vertical Complexity	Percent Cover of Invasive Plants
	Plant Community Complexity	Vegetation Disturbance

Joint Sampling for USA-RAM and the Field Operations Manual

During data collection for the NWCAA, field crews will be organized to simultaneously collect all data necessary to complete both the USA-RAM and the Field Operations Manual (FOM; USEPA 2010). The Vegetation Team and the AB Team will be tasked with completing different sections of USA-RAM. The AB Team will verify and collect data for the USA-RAM Buffer Metrics (Metrics 1 - 3), while the Vegetation Team will collect data for the Stressor and Condition Metrics (Metrics 4 - 12). This will streamline data collection efforts, making time spent in the field more efficient, while matching the Metrics to the different expertise of the Teams. Each Team will receive the appropriate Field Data Forms for its particular set of USA-RAM Metrics.

How to Use USA-RAM Version 11

- Learn USA-RAM in it entirety before applying it in the field. Many of the Metrics can be addressed more-or-less concurrently when all the Metrics are understood in detail. The time required to apply USA-RAM decreases as experience in its use is gained.
- Begin each application by inspecting the entire AA and its buffer zone. Many of the Metrics can be provisionally assessed during this initial inspection.

- Record all data on the appropriate Field Data Forms using the protocols described in the FOM.
- Use USA-RAM faithfully. Finalize all the Metrics while in the field at the AA. Do not alter any Metric. However, recommendations to improve the method should be recorded and provided to the USEPA NWCA team.

Scoring Plan

USA-RAM will provide separate scores for stress and condition for each AA and its associated buffer zone. Each AA score and each buffer zone score will be the sum of their respective Attribute scores. The Attribute scores will be sums of their respective Metric scores. The Metric scores will be derived from standardized "scoring tables." The scoring tables will be used to assign each Metric result to one of four categories of condition or stress. The categories will have unique numerical values that are scaled to help distinguish between similar AAs.

Separate scoring tables will be developed for each wetland class and NWCA region. This will help assure that the USA-RAM results reflect the natural variation in form and structure between wetland classes and regions, and that similar scores for like wetlands in different regions indicate similar condition or stress (i.e., scores for like wetlands will be comparable across the country).

A regional cumulative frequency distribution (regional CFD) will be calculated for the AA scores of each wetland class. It is likely that each AA score will be assigned to one of four categories of overall condition that correspond to the quartiles of the affiliated regional CFD. This will support regional and national reports on the distribution of wetlands among different categories of condition and stress.

A final stage in the analysis of USA-RAM results will be quantification of the effect of buffer condition on the correlation between AA condition and AA stress. The intent of this analysis is to explore how buffers might be used to mitigate stress.

Establishing the Assessment Area (AA) and Buffer Area

The rules for establishing an AA and its buffer zone are the same for USA-RAM and the NWCA Field Operations Manual (FOM; USEPA 2010). Highlights of the rules are described below. For a full description of the rules see Chapters 3 and 4 of the FOM

The FOM provides strict guidelines for establishing an AA. Once the sampling POINT has been identified, the AA can be been planned. After the plan has been verified in the field (see FOM Section 3.1.2), the AA can be established (see FOM Section 3.2). The guidelines for establishing an AA are summarized below.

- The "Standard Circular AA" is a 40m-radius circle centered on the POINT.
- The "Standard Circular AA–Shifted" is used when the center of the AA has to be shifted away from the POINT to fit within the wetland area that can be assessed.

- The “Polygon AA” is used for sites that are large enough for a full-sized (0.5 ha) AA, if the AA is not a circle. In this situation a 0.5 ha polygon is established with the center of the AA situated as close to the POINT as possible.
- The “Wetland Boundary AA” is used when the total area of the site is less than 0.5 ha but at least 0.1 ha. In this case, the AA boundary coincides with the wetland boundary.

The buffer zone for an AA will be established as follows (see Chapter 4 of the FOM for full details).

- For a Circular AA, the buffer zone is the area that lies within a 100m distance of the AA perimeter or 140m from the AA center. To mark the edge of the buffer zone, four (4) 140m transects are established in the four cardinal directions from the AA center, whether or not the center is the POINT (Figure 1A on page 7 below). The buffer zone is defined by the distance greater than 40m from the AA center.
- For a Polygon AA, the buffer zone is the area that lies within a 100m distance from the polygon boundary (Figure 1B on page 7 below).
- For a Wetland Boundary AA, the buffer extends 100m from the wetland boundary.

Integration of USA-RAM with the NWCA Site Evaluation Guidelines

Before fieldwork begins, a desktop evaluation of each sampling POINT will be done as described in the NWCA Site Evaluation Guidelines (USEPA 2010). The primary purpose of this evaluation is to determine if the selected POINT is, or likely will be, in the target population. Sources of information that will be used in the desktop evaluation include, but are not limited to, aerial photos, topographic maps, NWI data, NAIP imagery, and state, county or tribal wetland resource data.

As part of the data collection for the NWCA, several of the USA-RAM Metrics will be assessed using the NWCA imagery of the POINTS as described in the NWCA Site Evaluation Guidelines (USEPA 2010). The Metrics for which data will be derived in this way are:

Metric 1: Percent of the AA Having Buffer

Metric 2: Buffer Width

Metric 6: Patch Mosaic Complexity

The measurements needed for these Metrics will be determined by the Field Crews before the AA is assessed (i.e., during the desktop evaluation) using the site packet that contains information about site location and site access (e.g., maps and aerial images).

Section A: Assessment of the Buffer

The following three Metrics are designed to evaluate the form and condition of the buffer zone and the kind of stressors and amount of stress to which it is subject. Here we define the buffer as land adjacent to the AA that is comprised of natural vegetation and lacks evidence of intrusive human activity. As described above, the buffer has a maximum width of 100m. It is assumed that the buffer helps protect the AA by mitigating stress, including the deleterious effects of human land uses that adjoin the buffer zone.

Metrics 1 and 2 will be completed in two steps. Metric 1 consists of a desktop evaluation at the time of AA planning (USEPA 2010, Chapter 3, FOM) to determine the land use surrounding each sample POINT. Once the AA is established, the land area within 100m of the AA boundary will comprise the buffer zone (i.e., the area that has the potential to serve as buffer, depending on its land use). Examples of the buffer configuration to be used for the Standard Circular AA and the Polygon AA are shown in Figure 1. The second step for metric 1 is a field verification of the data derived from the aerial imagery.

Integrated Sampling of the Buffer

In order to streamline data collection for the NWCA, the AB Team will collect data for the Buffer Metrics that are included in USA-RAM, as well as complete the field protocol for sampling the buffer zone as described in the FOM. This will allow for efficient sampling of the buffer and enable field crews to use the information provided on aerial imagery to gather data and then perform a rigorous field verification of these data.

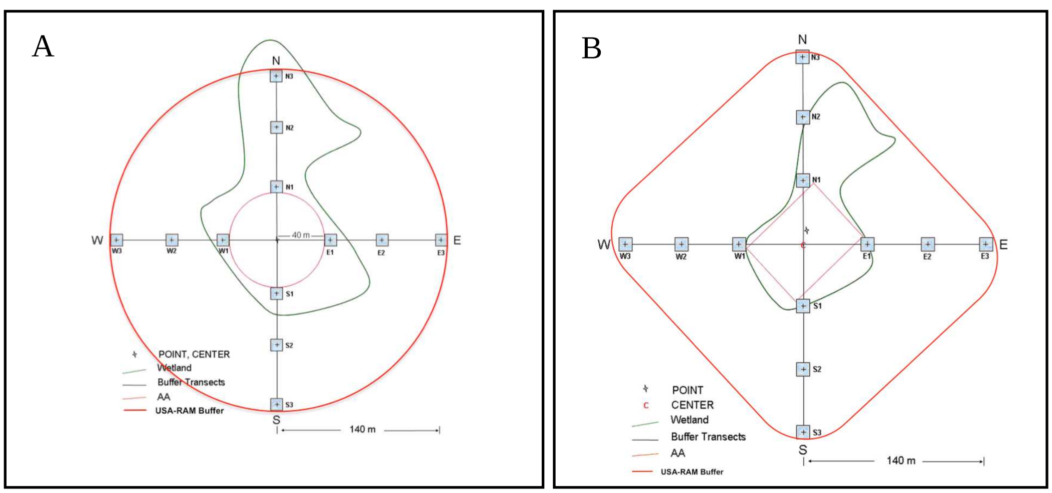


Figure 1. Establishment of the 100m buffer zone, defined as the 100m distance from the AA perimeter for a Circular AA (A) or the Polygon AA (B). Note the four transects laid out in the cardinal directions (North, South, East, West), along which are located the plots for assessing the buffer according to the FOM (original figure modified from the FOM; USEPA 2010). USA-RAM Buffer Metrics 1 and 2 will be verified when walking the four cardinal-direction transects.

Metric 1: Percent of AA having Buffer.

Land only counts as buffer if it consists of a land cover type that is capable of "buffering" the AA by protecting it from multiple kinds of stressors originating in the surrounding landscape outside. This Metric is based on the percent of the AA perimeter that adjoins a general type of "buffer land cover" as defined in Table 2. For the NWCA, land covers that might provide limited buffering under special circumstances, such as pasture land managed for ecological functions are not considered to be buffers because adequate knowledge of such localized circumstances cannot be assured throughout the survey.

General approach – The NWCA sample point imagery will be used to score this Metric, followed by ground verification of the imagery during the fieldwork. Site imagery plus field reconnaissance will be used to examine the entire perimeter of the AA and to estimate the percent of the perimeter that adjoins any type of Buffer Land Cover, based on Tables 2 and 3 below. Make estimates in increments of 5% of the distance of the perimeter of the AA. The AB Team) will implement USA-RAM protocol described here as well as the buffer sampling protocol described in the Field Operations Manual.

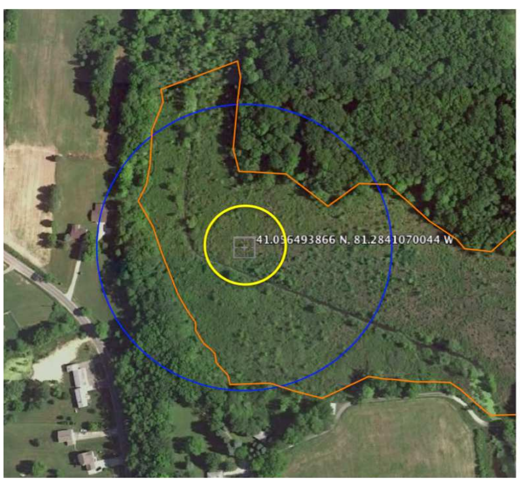
Table 2: Buffer Land Cover Criteria. To qualify as buffer, a land cover must meet all four of the listed criteria.

Buffer Land Cover Criteria
1. Is on the list of "buffer land covers" in Table 2
2. Is at least 5m wide
3. Extends at least 10m along the AA boundary as a contiguous cover **patch**
4. Is not separated from the AA by a non-buffer cover or open water that is ≥ 5m wide

Table 3: List of Buffer Land Covers based on the Anderson Land Cover Class system.

Buffer Land Covers	Non-buffer Land Covers
▪ Open water (surfaces of lakes, bays, ponds, rivers, etc. with <5% plant cover) ▪ Wetlands ▪ Permanent ice or snow (year round snow or ice surfaces with <5% plant cover) ▪ Natural, non-vegetated earth surfaces (natural rock outcrops, sand, gravel, etc. with <5% plant cover) ▪ Natural vegetation (areas with ≥ 5% cover of mostly non-impacted vegetation, including herbaceous, forest, or old fields undergoing succession; excludes lawns, playing fields, agricultural crops of any kind, recent **clear-cuts** or otherwise impacted forest lands, or recently burned lands) ▪ Trails (foot trails, equestrian trails, single-track bicycle trails, etc.)	▪ Built structures (houses, factories, schools, etc.) ▪ Artificial, non-vegetated land surfaces (parking lots, solar farms, feed lots, etc. that support <5% plant cover) ▪ Active mining areas (quarries, strip mines, gravel pits, etc.) ▪ Any active agriculture (orchards, vineyards, row crops, hay or grain fields, sod farms, feedlots, recently **clear-cut** or otherwise severely impacted forest lands, etc. Includes fallow agricultural fields) ▪ Any recently burned lands ▪ Urban and recreational lawns, sports fields, etc.) ▪ Any roadway dangerous to wildlife (railroads, busy streets, highways, etc.) ▪ ATV trails

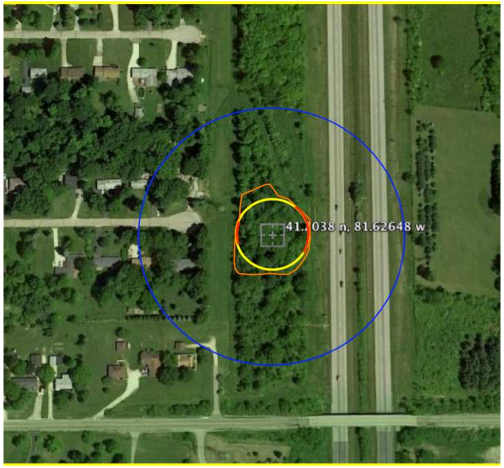
Figure 2. Two examples of Buffer Metric 1, percent of AA perimeter having buffer.



Example 2A Worksheet

Percent of AA Perimeter Adjoining Buffer	
Land Use	**% of Perimeter**
Buffer	100
Non-buffer	0
Total % AA Perimeter with Buffer	**100**

Figure 2a: Example of buffer extent for a Standard Circular AA. Yellow indicates portions of the AA perimeter that adjoin a buffer land cover. In this case the buffer extent is 100% of the AA perimeter *(image from Google Earth)*.



Example 2B Worksheet

Percent of AA Perimeter Adjoining Buffer	
Land Use	**% of Perimeter**
Buffer	75
Non-buffer	25
Total % AA Perimeter with Buffer	**75**

Figure 2b. Example of buffer extent for a Standard Circular AA. Yellow indicates portions of the AA perimeter that adjoin a buffer land cover. In this case, about 75% of the AA perimeter is buffered *(image from Google Earth)*.

Table 4: Metric 1 data table.

Choose 1	Percent of AA Perimeter adjoining buffer
O	< 25 %
O	26 – 50%
O	51 – 75%
O	> 75%

Metric 2: Buffer Width.

The ability of an area to buffer a wetland from external stressors depends on the width of the buffer area. Minimum effective buffer widths can vary among stressors. However, it is assumed that buffers do not usually need to be wider than 100m. A width of 100m has become a commonly used definition of what constitutes a buffer for the sake of assessment in many programs, and land use in the 100m buffer has been found to be correlated with wetland condition.

For the NWCA, the AB Team will implement the USA-RAM protocol described here as well as the buffer sampling protocol described in the Field Operations Manual.

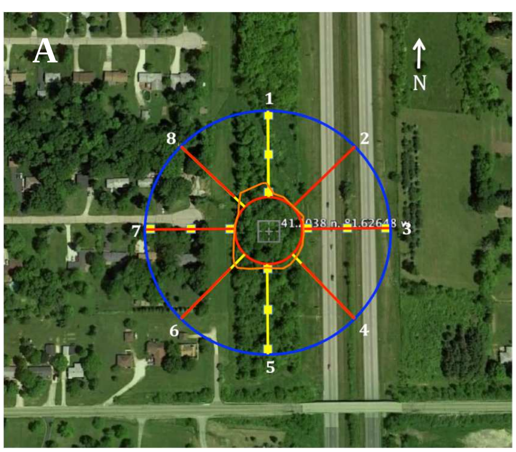
General approach - Four lines, each 100m long, are drawn from the AA perimeter on the site imagery in the cardinal directions (N, S, E, W); these are the transect lines along which the sampling plots for the FOM buffer protocol will be located. Another four lines are drawn in the ordinal directions (NE, SE, SW, NW), outward from the AA perimeter (see Figure 3 below). Lines are numbered clockwise with North as "1" as shown. Starting at the AA perimeter, the following procedure is followed.

- On each of the eight (8) transect lines, estimate the distance (meters) between the AA perimeter and the point at which the line first intercepts any type of non-buffer land cover (see Table 3 above). This distance equals the buffer width for each transect line.
- Make estimates of buffer width in increments of 5m.
- Ignore any non-buffer areas that do not cover at least 5m of a line.
- Enter the buffer width for each line in the Metric 2 Worksheet.
- See Tables 2 and 3 above for examples of buffer and non-buffer land covers.

There is potential that landuse changes may have occurred since the aerial imagery used in this Metric was developed. To ensure the best possible estimate of buffer width, the AB Team will need to ground-check the accuracy of the aerial imagery in the field. If there has been substantial change to the landscape in the 100m buffer zone, the data to indicate buffer width that are based on the imagery will have to be corrected, based on the following procedure.

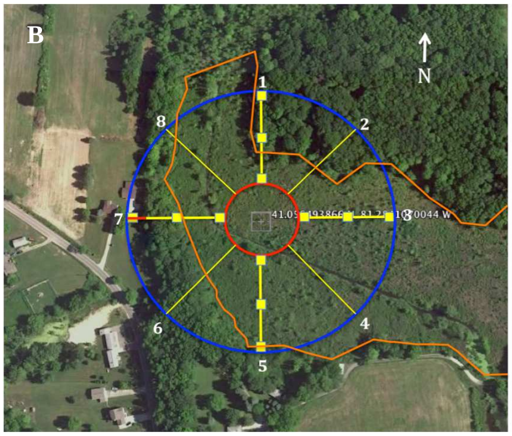
- As the AB Team walks the cardinal-direction transects to assess the buffer according to the FOM, it will also assess the usability of the aerial imagery.
- The buffer zone may also be observed from a nearby high vantage point.
- Any needed corrections should be noted by drawing on the aerial imagery.
- If the AB Team estimates that more than 10% of the buffer zone has changed (e.g., from forest to subdivision, or grassland to row crops) then the buffer width estimates along the eight transect lines must be corrected, based on the revised imagery, and the new estimates recorded on the Metric 2 Worksheet.

Figure 3. Example calculations of Metric 2: buffer width.



Example 3A Worksheet

Line	Buffer Width (m)
1	100
2	100
3	100
4	100
5	100
6	100
7	90
8	100
Average Width	**99**



Example 3B Worksheet

E

Line	Buffer Width (m)
1	100
2	0
3	0
4	10
5	100
6	20
7	0
8	15
Average Width	**31**

Figure 3A (top) and 3B (bottom). Example of buffer width calculation for Standard Circular AAs, showing AA perimeter (red), 100m area around AA (blue), and wetland boundary (orange). The eight transect lines are shown including the four cardinal-direction lines (yellow) with the buffer plots (yellow boxes) according to the FOM. Red portions of transect lines indicate non-buffer land use. The example worksheets show the buffer width along each line, and the average buffer width that is the Metric result.

Table 5: Metric 2 data Table.

Transect Line	Buffer Width (m)
1	
2	
3	
4	
5	
6	
7	
8	
Average Width	

Metric 3: Stress to the Buffer Zone.

Buffer areas can provide some protection to wetlands from human activities and the stressors they can generate. This metric is designed to tabulate and characterize the types and severity of stressors that can act to reduce the effectiveness of the buffer in protecting the AA from activity in the surrounding landscape.

For the sake of this Metric, the buffer zone is considered to be the entire 100m area around the AA, regardless of land use. Stressors that occur in land use covers, whether or not they count as buffers (see Table 3), have the potential to directly impact the AA. Therefore, stressors that occur in any land use within 100m of the AA will be tallied using the provided checklist.

General approach - Buffer stress will be assessed by the AB Team as it walks the four cardinal-direction transects (N, S, E, W) established in the buffer zone to assess the buffer according to the FOM. The AB Team will thoroughly examine the buffer zone along these transects and the visible adjoining buffer zone for evidence of stressors. It is particularly important to investigate any evidence of stressors noted in the buffer zone on the aerial imagery or maps, even if such evidence occurs away from the four cardinal-direct transect lines.

Observations will be made using site imagery, direct field observations, maps, and any other useful sources of information. Only stressors that are observed at the time of the field assessment should be counted. Indicators of past disturbance tend be less reliable and should not be considered.

This Metric is assessed based on the number of stressors that are evident (i.e., their presence – absence), as well as their severity. The severity of a stressor is characterized based on the portion of the entire buffer zone that the stressor apparently influences, using the guidelines shown in Table 6. The field indicators of stress are provided in Table 5, and are organized by Stressor Category (i.e., Hydrology, Habitat/Vegetation, Residential/Urban/Commercial Land Use, and Agriculture). All stressor indicators that are observed in the buffer zone should be checked, and the severity of that stressor must be indicated. After the checklist has been completed for a Stressor category, the overall severity of stress for the Categories is estimated on the field form.

Table 6: Guidelines for assessing stressor severity.

Portion of Buffer Zone Influenced by Stressor	Severity Code
less than one-third	1
between one-third and two-thirds	2
at least two-thirds	3

Table 7: Indicators of stress in the buffer zone. Rank each observed indicator based on Table 6 above. Rank the overall severity of stress for any Stressor Category with observed stress indicators. **Do not include these overall rankings for Stressor Categories in the final tally of stressors.**

If stressor is present, mark its severity			Field Indicators by Stressor Category
1	*2*	*3*	**Hydrological Stressors**
1	**2**	**3**	**Ditches**/ drains/ channelization
1	**2**	**3**	**Dikes**/dams/**levees**/ railroad or road beds
1	**2**	**3**	Culverts, pipes (point source discharge except stormwater) in buffer zone
1	**2**	**3**	Water level control structure
1	**2**	**3**	Obvious spills, discharges or odors; unusual water color or foam
1	**2**	**3**	Moderate to heavy formation of filamentous algae
1	**2**	**3**	Excavation, dredging
1	**2**	**3**	Fill / spoil banks
1	**2**	**3**	Wall/riprap
1	**2**	**3**	Inlets and outlets
1	**2**	**3**	Input from impervious surfaces (stormwater culvert)
1	*2*	*3*	**Habitat/Vegetation Stressors**
1	**2**	**3**	**Soil subsidence**, scour or surface erosion (root exposure)
1	**2**	**3**	Substrate disturbance (ATVs off-road vehicles, mountain biking)
1	**2**	**3**	Sediment input (construction, erosion, agricultural runoff)
1	**2**	**3**	Forest **- selective cut**
1	**2**	**3**	Forest **-** clear cut
1	**2**	**3**	Removal of **large woody debris**
1	**2**	**3**	Tree plantation present
1	**2**	**3**	Heavily grazed grasses, excessive grazing
1	**2**	**3**	**Tree** canopy herbivory
1	**2**	**3**	**Shrub** layer browsed
1	**2**	**3**	**Fire lines** (fire breaks)
1	**2**	**3**	Recently burned forest canopy
1	**2**	**3**	Recently burned grassland
1	**2**	**3**	Mowing/shrub cutting (brush hogging)
1	**2**	**3**	Other mechanical plant removal
1	**2**	**3**	Chemical vegetation control (herbicide application)
1	**2**	**3**	Cover of non-native or **invasive species**
1	**2**	**3**	Presence of power lines or utility corridors (continual maintenance)
1	**2**	**3**	Oil/gas wells
1	**2**	**3**	Logging roads
1	**2**	**3**	Trails
1	*2*	*3*	**Residential/Urban/Commercial Stressors**
1	**2**	**3**	Suburban residential land use
1	**2**	**3**	Urban multifamily land use
1	**2**	**3**	Urban/commercial buildings

Table 7 (continued).

1	**2**	**3**	Road – gravel
1	**2**	**3**	Road – 1 or 2 lane paved
1	**2**	**3**	Road- 4 lane
1	**2**	**3**	Parking lot/ pavement
1	**2**	**3**	Lawn/ park
1	**2**	**3**	Golf course
1	**2**	**3**	Landfill
1	**2**	**3**	Gravel pit/mining
1	**2**	**3**	Surface mine
1	**2**	**3**	Military land
1	**2**	**3**	Trash/ dumping
1	***2***	***3***	**Agricultural Stressors**
1	**2**	**3**	Pasture / rangeland
1	**2**	**3**	Row crops
1	**2**	**3**	Small grains
1	**2**	**3**	Nursery
1	**2**	**3**	Orchard
1	**2**	**3**	Dairy
1	**2**	**3**	Confined animal feeding operations
1	**2**	**3**	Irrigation (irrigated land)
1	**2**	**3**	Fallow field – recent
1	**2**	**3**	Fallow field – old
1	**2**	**3**	Rural residential
			A. Note the total number of marks in each column (not including marks for Stressor Category)
1 x __	***2 x*** __	***3 x*** __	**B. Multiply "A" above by its corresponding severity score**
			C. Add together the numbers from "B" above.

Section B: Assessment of Wetland Form and Structure

Physical Structure Attribute

Metric 4: Topographic Complexity.

Natural wetlands develop topographic relief due to variations in sediment production or deposition, erosion or oxidation of sediments, variations in hydroperiod, wildlife activities, etc. The resulting relief can be evident at multiple spatial scales. Increases in **micro-relief** represent increases in the surface area of a wetland and therefore can lead to increased bio- and geo-chemical processes at the sediment-water or sediment-air interface. It can also represent an increase in habitat quantity and diversity for diminutive forms of plants and animals, including plant propagules, insects, and amphibian larvae. Increases in **macro-relief** can lead to increases in the diversity of larger species or larger colonies of diminutive species, and plant community zonation.

General approach – the number of standard indicators of macro- and micro-topographic relief evident in the AA is used to assess its overall topographic complexity. To aid in the assessment, the likely influence of the indicators on the topographic cross-section of AA should be considered (Figure 4).

Macro-relief refers to the overall shape of the profile, including major changes in its steepness and the locations and sizes of persistent topographic features such as **benches**, plains, **berms,** furrows, **channels,** etc. **Micro-relief** refers to less persistent relief that occurs as details or elements of the macro-relief, such as animal burrows, **soil cracks**, surface objects (e.g., woody debris, cobbles or boulders), etc.

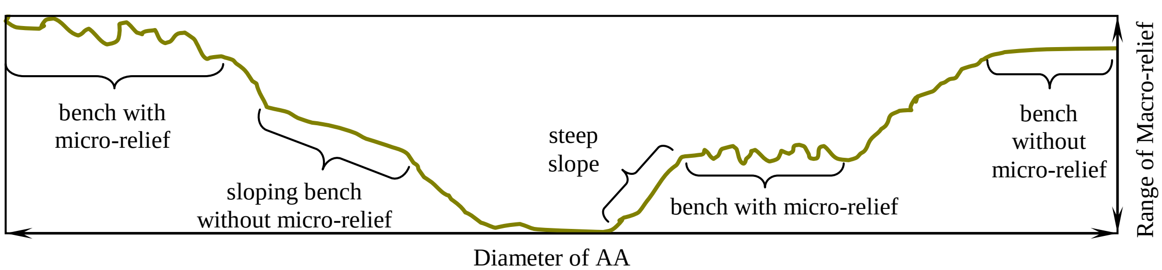


Figure 4: Example topographic cross-section of an AA showing the effect of macro- and micro-relief on overall topographic complexity. In this example, there are two **benches** and intervening slopes that account for the **macro-relief** of each half of the AA. Some of the **benches** and slopes have **micro-relief**, which might result from **woody debris**, **tussocks**, cobbles, animal burrows, etc. The vertical scale, which spans the total range of **macro-relief**, is exaggerated relative to the horizontal scale, which spans the AA.

Table 8: Checklist of field indicators of topographic complexity observed in the AA. Bold terms are in the glossary. An indicator should not be checked unless it covers at least $2m^2$ of the AA. For example, animal burrows should not be checked unless, *in aggregate*, they cover at least $2m^2$ of the AA.

Indicators	**Check if observed**
Multiple horizontal plains, **benches**, t**erraces**, or **flats** at different elevations	
Multiple slopes of varying steepness	
Natural or artificial **levee** or **berm**	
Bank slumps or undercut banks	
Undercut banks	
Multiple high water marks etched in substrate	
Potholes, sink holes or similar depressions not caused by animals	
Natural or artificial **channels**	
Natural or artificial **swales**	
Animal burrows or spoil piles from burrows (including ant or termite mounds)	
Animal tracks deep enough to hold water (e.g., cattle or elk tracks)	
Wallows, pig damage, or similar scale excavations by animals	
Inorganic **sediment mounds** not made by animals	
Natural or artificial debris or **wrack** along high water lines	
Natural or artificial debris in topographic low areas	
Natural or artificial debris dispersed across AA (**tree** limbs, lumber, etc)	
Plant hummocks or **tussocks**	
Soil cracks or fissures	
Cobbles or boulders	
Bare ground	
Total Number of Indicators Observed	

Metric 5: Patch Mosaic Complexity.

This metric addresses the structural complexity of the AA in plan-view (i.e., as viewed from above), based on the number of structural **patches** and their zonation or interspersion. When viewed from above, most wetlands are **mosaics** of different **patches** of substrate or plant cover. The complexity of the **mosaic** has two basic aspects: the diversity of the component **patches** and the degree to which they are interspersed (i.e., the amount of interface between multiple p**atches**). Within a given wetland class, the diversity and levels of ecological function of a wetland **mosaic** are expected to increase with its overall complexity. The basic assumption is that more **patches** and more interface between them translates into more kinds of habitat and broader ranges in habitat condition, as well as more kinds and higher levels of material and energy transformation per unit area of the **mosaic**.

General approach – This metric is assessed based on visual comparisons between the AA, as viewed in NAIP imagery or imagined in plan-view, and schematic diagrams of the full range of possible **patch mosaic** complexity. The scale at which the AA is viewed must be standardized. The AA should be viewed or envisioned in its entirety. The 1m-pixel NAIP imagery supports this view. However, expert field personnel can also imagine a detailed orthogonal view of the entire AA based on their on-the-ground reconnaissance.

Table 9: Suggested **patch** types. The following surfaces or land covers should be considered possible **patches,** if they are *obviously visibly distinct* when the entire AA is viewed or envisioned from above. Each **patch** must cover a contiguous area of at least $10m^2$ to be considered for this metric. Inert constructed covers, such as pavement, roofs, etc., are ignored.

Mono-specific **patches**, including **patches** of one **tree** or **shrub** species, etc.
Visibly distinct assemblages of plant species; p**atches** may have species in common.
Surface water visible in lakes, lagoons, **channels**, wetlands, etc.
Bare substrate (i.e., < 5% plant cover), such as bedrock outcrops, river bars, etc.
Natural organic debris, including tree fall, flood deposits, etc.

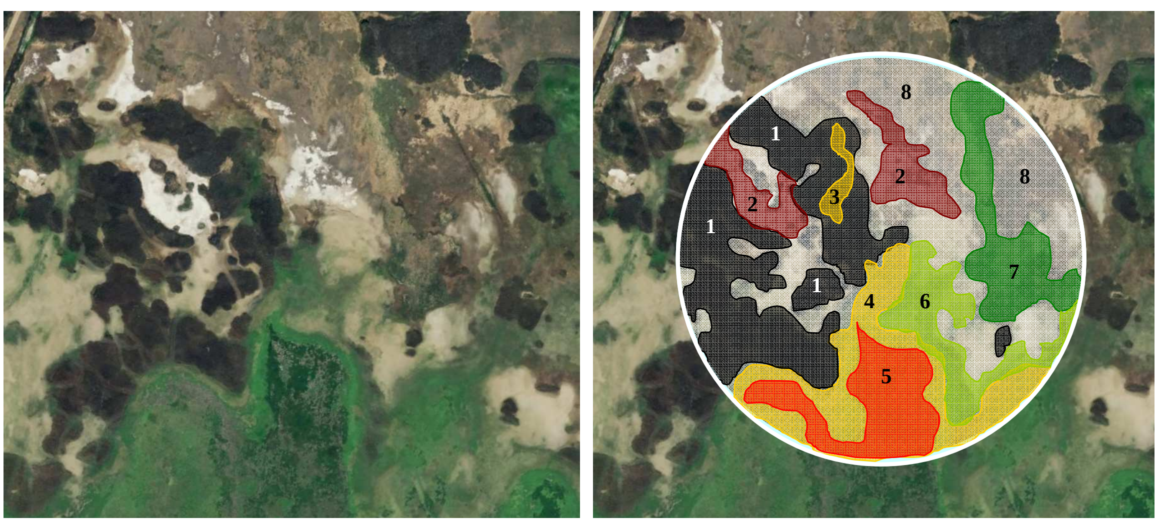
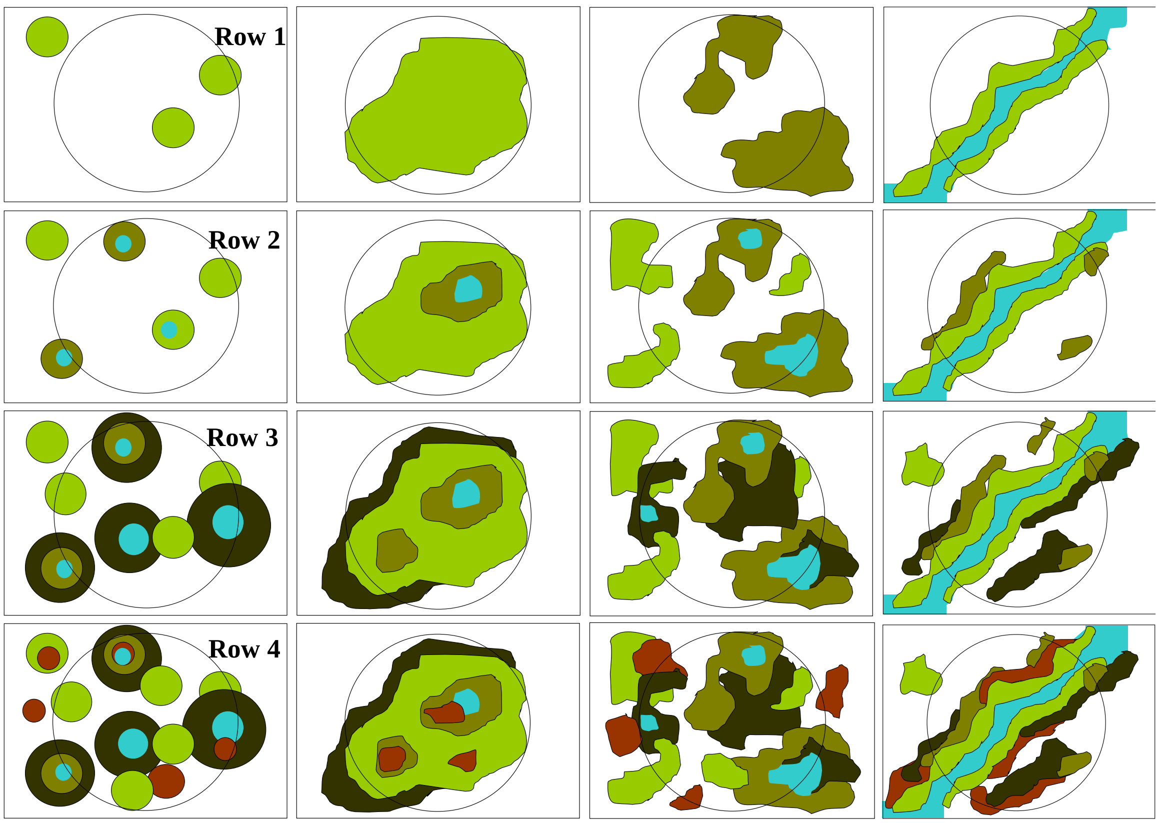


Figure 5: Example sketch of a **patch mosaic** (right-side image) based on NAIP imagery (left-side image). The white area in the **mosaic** is the matrix or background **patch** type. The other colors represent **patches** of different plant species, distinct assemblages of plant species, or bare ground. This **mosaic** has eight **patch** types, including the matrix.

Figure 6: Schematic diagrams of alternative **patch mosaics**. Each column of sketches represents a different **patch** pattern or template, ranging from separate circular **patches** (far left column) to parallel linear **patches** (far right column). For each column, **mosaic** complexity increases from Row 1 to Row 4. The large circle in each case represents the AA. The non-colored (white) area represents the matrix of the AA, or its background **patch** type. It could be upland. Blue represents standing water. Other colors represent **patch** types based on Table 9 above.



Select the diagram that most closely resembles the actual AA. The **mosaic** within the AA might appear to consist of replications of one of these diagrams. Any AA with a simpler **mosaic** than indicated in Row 1 should be assumed to belong to Row 1. Any AA with a more complex **mosaic** than indicated in Row 4 should be assumed to belong to Row 4.

Table 10: Metric 5 data table.

Selected the Row Number of the Mosaic That Most Resembles the AA
1
2
3
4

Biological Structure Attribute

Metric 6: Vertical Complexity.

This metric addresses the vertical structure of the plant community in terms of its component number of **plant strata**. Different strata provide different physical and ecological services. Tall vegetation tends to be more efficient at intercepting and holding rainwater, providing shade, serving as sources of allochthonous inputs, and moderating air temperature. Low-growing vegetation can shield soils from intense rainfall while serving as forage for herbivorous game. Transpiration by wetland plants can cause diel fluctuations in groundwater height or surface water depth. Perennial wetland plants tend to produce abundant below-ground biomass that influences substrate elevation and chemistry. Animal species tend to partition themselves vertically among wetland and riparian **plant strata**. The basic assumption is that more strata translates into more kinds of habitat and broader ranges in habitat condition, as well as more kinds and higher levels of material and energy transformation for the wetland as a whole.

General approach –The following worksheet is used to identify the dominant **plant strata** of the AA. USA-RAM recognizes seven (7) strata: **Submerged Plants, Floating** or **Floating-Leaved Plants, Tall Emergent Plants, Short Emergent Plants, Short Woody Plants, Tall Woody Plants,** and **Vines.** The absolute percent cover of each plant stratum is estimated in increments of 10%, based on a reconnaissance of the AA and site imagery. Each stratum is then assigned to one of five cover classes based on Table11 below. Dominant strata cover at least 10% of the AA. Cover estimates should include vegetation covering the AA but rooted outside the AA. Data can include standing stock from previous seasons, but all data must represent observed conditions rather that hindcasts or forecasts.

Table 11: Absolute cover of **plant strata**. Mark the category of absolute percent coverage of the AA that best fits each plant stratum. Since strata can overlap, their combined coverage can exceed 100%. See Glossary for definitions.

Plant Strata (see glossary)	**Percent Coverage**				
	< 10%	**10-15%**	**16-25%**	**26-50%**	**>50%**
Submerged Plants (any depth)					
Floating or Floating-leaved Plants					
Short Emergent Plants (< 0.5 m)					
Tall Emergent Plants (≥ 0.5 m)					
Short Woody Plants (shrubs and trees <5.0m)					
Vines					
Tall Woody Plants (shrubs and trees ≥ 5.0m)					
Total Number of Plant Strata Covering at Least 10% of the AA					

Metric 7: Plant Community Complexity.

Metric 7 addresses the diversity of plant species that dominate the **plant strata**. Since different species tend to have different growth patterns and morphometry, an increase in species diversity within a stratum tends to increase its internal architectural complexity. Different species are hosts to different parasites and diseases, may support and depend on different pollinators, can serve as cover or forage for different animal species, and may play very different roles in pollutant uptake and nutrient cycling. Within a wetland class, the diversity and levels of ecological function of a wetland are expected to increase with the number and abundance of different plant species. The basic assumption is that within a wetland class, greater diversity of co-dominant species translates into more kinds and higher levels of wetland functions.

General approach – In Table 12 below, mark the dominant plant strata (those that cover at least 10% of the AA), based on Table 11 of Metric 6. For each of these dominant strata, list the plant species that comprises at least 10% relative cover. Estimates of relative cover should be made in 10% increments. The listed species are the co-dominant species for each dominant stratum. The invasive status of each co-dominant species should also be determined. Users of this method may refer to local invasive plant species lists or resource agencies to determine which species are to be considered invasive. For a list of targeted species defined for the NWCA, consult the **NWCA FOM Appendix B - Targeted Invasive Alien Plant** Species. This information will be useful in the assessment of stress due to invasive species in Metric 11.

Table 12: The invasive status and relative percent cover of co-dominant plant species of the dominant plant strata. Disregard strata with less than 10% absolute cover of AA (see Metric 6). Information about invasive status is used in Metric 11.

Plant Strata disregard strata with less than 10%cover (see Metric 6)	**For each Plant Stratum List All Plant Species Comprising at least 10% Relative Cover**					
	Species Name	**mark if Invasive**	**% Cover**	**Species Name**	**mark if Invasive**	**% Cover**
Submerged (any depth)						
	Total Percent Coverage for All Invasive Species in Stratum					
Floating or Floating-leaved						
	Total Percent Coverage for All Invasive Species in Stratum					
Short Emergent (herbaceous, < 0.5m)						
	Total Percent Coverage for All Invasive Species in Stratum					
Tall Emergent (herbaceous, ≥ 0.5 m)						
	Total Percent Coverage for All Invasive Species in Stratum					
Short Woody (shrubs, trees <5.0m)						
	Total Percent Coverage for All Invasive Species in Stratum					

Table 12 (continued).

Vines (any present)						
	Total Percent Coverage for All Invasive Species in Stratum					
Tall Woody (shrubs, trees ≥ 5.0m)						
	Total Percent Coverage for All Invasive Species in Stratum					
Total number of listed species for all plant strata combined (Do not count any species more than once).						

Section C: Assessment of Stressors in the AA

The following Metrics are used to assess stressors within the AA. Stress to the buffer is considered in the preceding Section A.

The primary purpose of the Stressor Metrics is to assess the distribution and severity of stressors within and among regions of the US. Information on stressors is valuable for diagnosing the causes of impairment and for determining what remediation or rehabilitation measures are warranted. A secondary purpose is to gain insight into possible causes for low condition scores. To meet this purpose, each Stressor Metric is designed to provide information relevant to one or both Metrics of an Attribute of condition. As explained in Section B, the Hydrology Attribute is assessed only in terms of its stressors.

The effects of stressors on wetland condition tend to increase with the number of different kinds of stressors and their severity, regardless of wetland type or vegetation community. The severity of a stressor depends on its duration, intensity, frequency, and proximity. The field indicators of stress tend to integrate across these parameters, such that they are not assessed independently.

However, by observing whether the stressor indicators are obvious and pervasive, subtle and highly restricted, or characterized as more moderate, the users should be able to judge whether each stressor has a high, medium, or low degree of severity. Additional evidence of stressors that is provided by maps, aerial imagery, and local reports can also be used. Each observed indicator will be ranked according to Table 13 below.

Table 13: Descriptions of stressor severity ranks.

Severity	Rank
Not severe - the stressor is present, but does not appear to negatively impact any Attribute of condition in the AA.	**1**
Moderately severe - the stressor is present and appears to have moderately negative impacts on one or more Attributes of condition in the AA.	**2**
Severe - the stressor is present and appears to have major negative impacts on one or more Attributes of condition in the AA.	**3**

The stressors in the following Metrics will be assessed based on these integrated rankings of stressor duration, intensity and frequency, and not based on aerial extent as was done for Metric 3. Walking the AA to make observations will be necessary, but care must be taken not to damage or trample the vegetation or other habitat features within the AA.

Hydrology Attribute

Metric 8: Stress to Water Quality.

Hydrology has been called the "master variable" that determines the structure, function and ecosystem services provided by wetlands. It includes measures of both water quality (Metric 8) and quantity (Metric 9). Human activities that degrade water quality include discharge from **point sources**, watershed activities that result in high sediment loads, nutrient runoff, mine drainage, or excess salts. As stressors accumulate at a site, services such as biodiversity support and biogeochemical cycling are compromised and downstream aquatic systems become altered. Water quality impacts can reduce vegetation diversity and lead to the establishment of **invasive species**. The water quality purification function of a wetland is typically reduced as water contaminants accumulate.

General approach – This Metric accounts for activities that affect or degrade water quality in the AA. It is assessed based on a checklist of field indicators of water quality stressors (Table 14 below). The indicators are listed in Stressor Categories.

All indicators of water quality stressors that are observed in the AA should be noted, and the severity of the indicated stressors should be ranked based on Table 13 above. After completing the checklist for a Stressor Category, the overall severity of stress for the Stressor Category as a whole should be estimated, unless none of the indicators in the category were observed. To complete the assessment for this Metric, the noted severity ranks should be tallied (added together) and recorded on the field form. Ranks for the Stressor Categories are not included in the tally of the indicator ranks.

Table 14: Indicators of water quality stress observed in the AA. Each observed indicator is ranked as (1) not severe; (2) moderately severe; or (3) severe, based on Table 13. Each indicator can have only one severity rank. Tally all the marked ranks to complete the metric, excluding the ranks for the Stressor Categories. Bold terms are in the glossary.

If stressor is present, mark its severity			**Field Indicators by Stressor Category**
1	***2***	***3***	**Point Sources**
1	**2**	**3**	**Point source** inputs (discharge from wastewater plants, factories, etc)
1	**2**	**3**	Stormwater inputs (discharge pipes, culverts, sewer outfalls)
1	*2*	*3*	**Sedimentation/Pollutants**
1	**2**	**3**	Debris lines on plants, **trees** or silt-laden vegetation
1	**2**	**3**	Sedimentation (e.g., the presence of sediment fans, deposits or plumes)
1	**2**	**3**	Industrial or domestic spills or discharges (odors; foam, oil sheen*)
1	**2**	**3**	**Turbidity** in the water column

Table 14 (continued).

1	*2*	*3*	**Eutrophication**
1	**2**	**3**	Direct discharges from feedlot manure pits, etc.
1	**2**	**3**	Direct discharges from septic or sewage systems
1	**2**	**3**	Direct application of fertilizer
1	**2**	**3**	Agricultural runoff (drain tiles, etc. discharging to site)
1	**2**	**3**	Formation of heavy algal or *Lemna* sp. surface mats or heavy benthic algal growth
1	*2*	*3*	**Mining Impacts**
1	**2**	**3**	**Acid mine drainage** discharge (excessively clear water (low pH) or presence/accumulation of "yellow-boy" orange precipitate)
1	*2*	*3*	**Salinity**
1	**2**	**3**	Obvious increases in the concentration of dissolved salts (dead or stressed plants; salt encrustations, etc)
Tally of all Ranks (excluding ranks for Stressor Categories)			

* Oil sheen should not be confused with surface iron films (normal in many wetlands); iron films can be broken while oil films cannot.

Metric 9: Alterations to Hydroperiod.

The hydroperiod (pattern of water level change over time) affects wetland vegetation community composition and productivity, the provision of spawning and nursery grounds for fish and amphibians, migratory waterfowl habitat, and biogeochemical processes. Functions such as floodwater storage and flood peak reduction are reflected in the hydroperiods of wetlands.

General approach - This Metric is assessed using a checklist of field indicators of hydroperiod alterations in the AA (Table 15 below). While many hydroperiod alterations will occur outside of the AA, only those that occur within the AA are considered in the Metric. Hydrologic alterations that are outside of the AA are assessed in Metric 3 or using other assessment methods.

The occurrence of any stressor indicator in the AA should be noted in the checklist, and its severity should be estimated, based on Table 13 above. To assess this Metric, the severity ranks (1, 2, and 3) noted for each observed indicator should be tallied (added together) and the sum should be recorded on the field form.

Table 15: Indicators of altered hydroperiod observed in AA. Each observed indicator is ranked as (1) not severe; (2) moderately severe; or (3) severe based on Table 13. Each indicator can have only one severity rank. Tally all the marked ranks to complete the Metric. Bold terms are in the glossary.

If stressor is present, mark its severity			**Field Indicators**
1	**2**	**3**	**Ditches**/channelization within AA
1	**2**	**3**	**Dikes**/dams/**levees**/**berms** at AA margin or within AA or roadbed or railroad (acting as block to water flows into or through AA)
1	**2**	**3**	**Channels** have deeply undercut banks and/or bank slumps or slides
1	**2**	**3**	**Culverts**, pipes (**point sources**) into AA *(change in water quantity)*
1	**2**	**3**	Water level control structure that impound water in all or part of the AA
1	**2**	**3**	Upland plant species encroaching into AA (due to drying of wetland)
1	**2**	**3**	**Die-off** of trees within AA due to increased ponding (exempting beaver impounded sites)
1	**2**	**3**	**Tidal restriction** in tidal wetlands (restricts flows to and from AA)
1	**2**	**3**	Presence of agricultural tiles or culverts at AA margin or within AA
1	**2**	**3**	Siphons, pumps moving water in or out of AA
1	**2**	**3**	Stormwater inputs from impervious surfaces/**flashy flows** into AA
			Tally of all Ranks

<u>Physical Structure Attribute</u>

Metric 10: Habitat /Substrate Alterations.

There is a range of anthropogenic events and activities that alter wetland habitats by disturbing their substrates. Off-site events and activities are usually hydrological. For example, floods caused by excessive runoff or major releases of water from dams can cause scouring of substrates or large deposits of sediment and debris. Onsite events and activities that alter substrates include grading, mining, off-road vehicle use, and vegetation control. Some urban wetlands are severely impacted by dumping of yard debris and other trash. Substrate alterations can cause changes in drainage and soil productivity that subsequently alter wetland plant communities. Severe alterations of wetland substrates often lead to plant invasions.

General approach - This Metric is assessed using a checklist of field indicators of stressors that affect or degrade the substrate observed in the AA (Table 16).

Table 16. Indicators of altered substrate observed in AA. Each observed indicator is ranked as (1) not severe, (2) moderately severe, or (3) severe based on Table 13. Each indicator can have only one severity rank. Tally all the marked ranks to complete the metric. Bold terms are in the glossary.

If stressor is present, mark its severity			Field Indicators
1	2	3	**Soil subsidence**, scour or surface erosion (root exposure, etc)
1	2	3	Off-road vehicles, mountain biking, trails cut, etc.
1	2	3	Inorganic sedimentation inflow (sediment accumulation around vegetation, deep **sediment splay**s, recent vegetation burial, etc)
1	2	3	**Dredging** or other prominent excavation at AA margin or in AA
1	2	3	Grazing by domesticated or feral animals in AA (includes trampling, digging, wallowing, etc)
1	2	3	Grazing by native ungulates.
1	2	3	Recent farming activity (plowing, **disking**, etc.)
1	2	3	Soil compaction by human activity (parking by cars, heavy machinery, etc)
1	2	3	Filling, grading, or other prominent deposition of sediment
1	2	3	Dumping of garbage or other debris
1	2	3	Mechanical plant removal that disturbs substrate (rutting, grubbing by heavy machinery, etc.)
1	2	3	**Fire lines** (fire breaks) dug in AA or at AA margin
			Tally of all Ranks

Biological Structure Attribute

Metric 11: Percent Cover of Invasive Plant Species.

Wetland plants are particularly useful as indicators because they are an easily observed, universal component of wetland ecosystems. Plant community composition, including the occurrence of invasive species, provides clear and robust signals of human disturbance.

This Metric is assessed based on field observations of the percent cover of **invasive species** in each of the **plant strata** within the AA. The observations made to assess Metric 7 will be useful, although in this metric the presence of any invasive species (i.e., any cover) is tallied using four broad cover classes (<5%, 5–25%, 26-75%, >75%). Users of this method may refer to local invasive plant species lists or resource agencies to determine which species are to be considered invasive. For a list of targeted species defined for the NWCA, consult the **NWCA FOM Appendix B – Targeted Invasive Alien Plant Species**. Some common invasive species are listed below (Table 17). This is not an exhaustive list.

Table 17: List of invasive plant species common to wetlands in many regions of the US. This is not an exhaustive list.

Invasive Plant Species That Commonly Invade Wetlands	
European milfoil (*Myriophyllum spicatum*)	Purple loosestrife (*Lythrum salicaria*)
Garlic mustard (*Alliaria petiolata*)	Reed canarygrass (*Phalaris arundinacea*)
Giant reed (*Phragmites australis)*	Russian olive (*Elaeagnus angustifolia)*
Giant salvinia *(Salvinia molesta)*	Salt cedar (*Tamarix spp*)
Poison hemlock (*Conium maculatum*)	Water hyacinth (*Eichhornia crassipes*).

General approach – A visual survey of the AA and its plant species composition will be used to note the percent cover of invasive species in each of the plant strata listed below. The information gathered to complete Metric 7 will be useful for this metric but will not be enough to complete it. For this Metric, all invasive species will be noted and recorded in one of the four cover classes, regardless of their cover. Strata that have no cover (zero) of any invasive species should be assigned a rank of "0".

Table 18: Metric 11 data table. Numbers indicate the rank score for each cover class in each strata. Circle one choice for each plant layer and tally all ranks for the final score.

Plant Strata (see glossary)	**Percent Cover of Invasive Species**				
	None	< 5%	5-25%	26-75%	>75%
Submerged (any depth)	**0**	**1**	**2**	**3**	**4**
Floating or Floating-leaved	**0**	**1**	**2**	**3**	**4**
Short Emergent (herbaceous, < 0.5m)	**0**	**1**	**2**	**3**	**4**
Tall Emergent (herbaceous, ≥ 0.5m)	**0**	**1**	**2**	**3**	**4**
Short Woody Plants (shrubs and trees < 5m)	**0**	**1**	**2**	**3**	**4**
Vines (any present)	**0**	**1**	**2**	**3**	**4**
Tall Woody Plants (shrubs and trees ≤ 5m)	**0**	**1**	**2**	**3**	**4**
Tally of all Ranks					

Metric 12: Vegetation Disturbance.

This metric accounts for human activities that directly alter the plant community in the AA. Vegetation is an easily observed component of wetlands that responds predictably to disturbance. As vegetation communities shift in response to stress, important wetland services, such as biodiversity support and water quality improvement, may be affected.

General approach - This Metric is assessed based on a checklist of field indicators of anthropogenic disturbance to the plant community (Table 19 below). The indicators are listed in Stressor Categories. All stressors observed in the AA are noted, and the severity of the indicated stressors is ranked based on Table 13. Only on-going or recent disturbances that are clearly impacting the vegetation are considered. After completing the checklist for a Stressor Category, the overall severity of stress for the category as a whole should be estimated, unless none of the indicators in the category were observed. To complete this Metric, the noted severity ranks should be tallied (added together) and recorded on the field form. Exclude the ranks for the Stressor Categories from the tally.

Table 19. Indicators of vegetation disturbance observed in AA. Each observed indicator is ranked as (1) not severe, (2) moderately severe, or (3) severe based on Table 13. Each indicator can have only one severity rank. Bold terms are in the glossary.

If stressor is present, rank its severity			**Field Indicators by Stressor Category**
1	***2***	***3***	**Human Use and/or Management**
1	**2**	**3**	Mowing within AA (or at AA margin)
1	**2**	**3**	Forest **- selective cut**
1	**2**	**3**	Forest **- clear cut**
1	**2**	**3**	Prominent removal of **large woody debris**
1	**2**	**3**	Mechanical plant removal besides **tree** cutting or woody debris removal
1	**2**	**3**	Evidence of planting of non-native vegetation
1	**2**	**3**	Chemical vegetation control (herbicide application, defoliant use)
1	**2**	**3**	Farming (recent plowing, **disking**, etc)
1	***2***	***3***	**Excessive Grazing or Herbivory**
1	**2**	**3**	Grazing by domestic or feral animals (cows, sheep, pigs, etc)
1	**2**	**3**	Excessive wildlife herbivory (deer, muskrat, geese, carp, beaver, etc.)
1	**2**	**3**	Excessive insect herbivory of **tree** canopy, **shrub** stratum
1	***2***	***3***	**Fire**
1	**2**	**3**	Evidence of intentional burning at AA margin or in AA
1	**2**	**3**	**Fire lines** (fire breaks)
Tally of all Ranks (excluding ranks for Stressor Categories)			

USA RAM
Glossary

Acid mine drainage – acidic water typically with high metal concentrations that results from water flowing over sulfur bearing materials. Acid mine drainage often results from the process of mining, particularly coal mining.

Bank slumps – sediment or soil collapse from the face of a riverbank.

Bench - A flat, horizontal area of land that is longer than wide, with the long axis general parallel to a nearby shoreline or bank, one long side bounded by land sloping steeply upward, and the other side bounded by land sloping steeply downward.

Berm - A narrow bench of land typically along the top or bottom of a slope that separates two areas, also termed “ledge” and “shelf” (see “bench”).

Channel - A landscape feature with well-defined bed and banks that has been formed by water and which under normal circumstances is maintained by the flow of water, or that is purposefully constructed and maintained to convey water.

Clear cut – a logging practice in which most or all of the trees in an area of forest are cut and removed.

Die-off - The relatively sudden, severe, and cotemporaneous deaths of most of the plants and/or animals of a kind in one area or habitat type, such as a lake or wetland.

Dike – An embankment or wall, typically of earth and stone, built to prevent flooding.

Disking – in farming, turning and loosening the soil with a series of discs (as in plowing)

Ditch – A small channel dug for the purposes of moving water, often used to speed drainage of an area.

Emergent (herbaceous) – Plants rooted in the soil with basal portions often in the water and whose leaves, stems, and reproductive structures are aerial. Examples include cattails (*Typha* spp.) and reed canary grass (*Phalaris arundinacea*).

Fire line – A gap in vegetation cut by fire crews in advance of a wildfire to stop its spread buy depriving the fire of fuel. Also known as fire breaks.

Flashy flows – Stream flows characterized by rapid rises and falls in water levels in response to rainfall. This includes higher peak flows (discharge) and lower base flows and is the result of impervious surfaces in the watershed. High water flows can lead to bank erosion and associated water quality issues.

Flat - A non-vegetated, horizontal area of land of any shape with at least one side bounded by water.

Invasive species - Plant species that are 1) non-native (alien) to the AA, and 2) whose introduction is likely to cause economic or environmental harm.

Large woody debris – Trees or portions of trees (limbs, rootwads, etc) typically with a diameter of 10 cm or more that have fallen into aquatic sites. These provide substantial habitat benefits.

Levee – An embankment that runs along the bank of a river or channel. It can be natural (due to flooding and sediment deposition) or human-made.

Macro-relief – Variations in ground surface elevation due to such factors as ground subsidence, erosion by waves, differential weathering rates of geologic strata, land slides, etc.

Micro-relief – Small scale variations in ground surface elevation due to such factors as animal burrowing, spatial differences in sediment accumulation, buried debris, etc.

Mosaic - An arrangement or array of patches of a landscape (see "patch").

Patch - An area assigned to a single land cover type or class that differs from its surroundings.

Pig damage - A wallow caused by wild or feral pigs digging into the ground (see "wallows").

Plant hummock or tussock – a compact tuft especially of grass or sedge, or an area of raised solid ground that is bound by roots of low-growing vegetation.

Plant Stratum (strata) – A class of plant height. Plants are classified based on their maximum height above the substrate, including aquatic plants rooted in benthic substrates and floating plants.

Point Source - any discernible confined and discrete conveyance including a pipe, ditch, channel, or conduit from which pollutants may be discharged.

Pothole - Any depression or hole in the land surface that is caused by physical processes other than subterranean erosion by groundwater, and that has a maximum width less than 3m.

Sediment mound - Any mound of sediment of any shape having a maximum height less that 2m and a maximum width or diameter less than 5m.

Sediment splay - A small fan of sediment deposited at the margin of a sudden and temporary inundation of the land surface by flood waters. Sediment splays are common on active riverine floodplains and interfluves.

Selective cut – Forestry practice in which certain desirable trees are cut and the remainder is left standing.

Shrub – Shrubs are woody species that have a relatively low height (typically 1.5 m or less). This group includes true shrubs (woody species that lack a single trunk), and young or stunted trees. Common examples include blackberries (*Rubus* spp.).

Soil cracks - Cracks less than 1m deep in the permeable ground surface caused by its shrinking and swelling, or by freezing and thawing.

Soil subsidence – The downward movement of a soil surface. In wetlands this is often due to dewatering and peat oxidation or to sediment starvation when floodplains are cut off from the river and sediment deposition is reduced.

Submerged – Plants that spend their entire life cycle below the surface of the water except for flowers, which are typically borne about the water. Most are rooted although there are rootless species that float free in the water column.

Floating-leaved, and floating plants – Plants having leaves that float on the water surface. Floating-leaved species are rooted and included members of the water lily family, and some pondweeds (*Potamogeton sp.).* Floating plants are not rooted and so float on the water surface. They include some of the most troublesome invasive species such as water hyacinth (*Eichhornia crassipes*).

Swale - A channel with gently sloping banks that is as wide or wider than the channel bed (see “channel”).

Terrace - A terrace is a former floodplain that is no longer inundated frequently enough to be termed active (ser “riverine floodplain” and “lacustrine floodplain”).

Tidal restriction – Restrictions of tidal flows caused by water control structures such as floodgates that prevent the free movement of tidal inflows and outflows.

Tree - Woody plants that dominate the canopy of forested wetlands with a height greater than 6m. Young and small stature individuals can also be seen in the sub canopy, typically ranging from 1.5 to 5m in height. Common species include *Melaleuca* sp.

Turbidity – A measure of substances in the water column that interfere with the passage of light, such as suspended sediments, algae.

Vine – Weak-stemmed, climbing plants that gain support by growing on other, more robust plant species or substrates. Common species include grapevines (*Vitis* spp.)

Wallow - Any depression in the land surface that is wider than deep and is caused by animals sitting, lying, or rolling on the ground surface or digging into it.

Woody debris – tree limbs, branches, lumber, and other large pieces of wood**.**

Wrack - Debris, including plant material and trash that is transported and deposited on the land surface by water.

Appendix C

USA-RAM scoring thresholds

Table C-1. General calculations and scoring thresholds used to score USA-RAM data. Metric number refers to metric numbers listed in USA-RAM protocol (see Appendix B).

Metric Number	General Calculation	12 points	9 points	6 points	3 points
1	Percent AA with buffer	>75%	51-75%	26-50%	<25%
2	Mean buffer width (m)	75-100	51-74	26-50	0-25
3	$\sum sev_i$, where *sev* is the severity value[1] for each stressor, *i,* found in buffer	<3	3-4	5-7	>7
4	Number of indicators present	>9	6-8	3-5	<3
5	Row corresponding to interspersion diagram	4	3	2	1
6	Number of plant strata covering ≥10% of AA	>5	4-5	2-3	1
7	Number of co-dominant plant species	>10	7-10	3-6	<3
8	$\sum sev_i$, where *sev* is the severity value for each stressor, *i,* found in AA	<2	2-4	5-6	>6
9	$\sum sev_i$, where *sev* is the severity value for each stressor, *i,* found in AA	<2	2-3	4-5	>5
10	$\sum sev_i$, where *sev* is the severity value for each stressor, *i,* found in AA	<2	2-3	4-5	>5
11	$strata_{(n<5)}$ + 2*$strata_{(5\leq n<25)}$, + 3*$strata_{(26\leq n<75)}$ + 4 *$strata_{(n\geq 75)}$, where *strata* equals the number of plant strata with the total percent cover value, *n,* within the indicated range	<2	2-4	5-7	>7
12	$\sum sev_i$, where *sev* is the severity value for each stressor, *i,* found in AA	<2	2-3	4-5	>5

[1]The term severity for this metric refers to a spatial extent rather than a degree of severity of the stressors.

Appendix D

UWAM Protocol

UTAH WETLANDS AMBIENT ASSESSMENT METHOD VERSION 1.2

Heidi M. Hoven [1]
and
Don S. Paul [2]

[1] The Institute for Watershed Sciences
1937 Mirror Lake Hwy
Kamas, Utah, 84036

[2] AvianWest, Inc.
5928 River View Circle
Mountain Green, Utah, 84050

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Utah Wetlands Ambient Assessment Method (UWAAM) Version 1.2

1. Background

Utah regulating agencies, public and private landowners alike lack a universally accepted rapid assessment method of wetlands even though there is a strong need for such a method. Wetland rapid assessment methods have been developed for various areas of the United States all with a unique set of wetland classes and associated hydrology, making it difficult to apply methods developed for other regions of the country to wetlands of the Great Basin.

The Utah Wetlands Ambient Assessment Method (UWAAM) is modeled closely after California and Ohio's rapid assessment methods (CRAM, Collins *et al*. 2007 and ORAM, Mack 2001, respectively) and has a unique habitat metric that addresses wildlife use specific to Utah's Great Basin wetlands. Since 75% of Utah's wetlands are associated with Great Salt Lake, there has been considerable adaptation of CRAM and ORAM metrics to suit those wetlands; however, UWAAM is also applicable for other wetlands of the Great Basin.

UWAAM uses the habitat categories of the United States Fish and Wildlife Service (USFWS) Status and Trends program (Dahl and Bergeson 2009) that are applicable to Utah's Great Basin wetlands. These habitat categories are adapted from Cowardin *et al*. (1979) and provide a basis for a classification system that will be compatible for the United Sates Environmental Protection Agency (U.S. E.P.A.) national ambient wetland survey scheduled to begin in 2011. Status and Trends does not include riverine or lacustrine systems as defined as deepwater habitat, however, we do include both riverine and lacustrine systems in the habitat classification that possess photic or littoral zones where hydrophytic vegetation has established. That is, in systems that include nonpersistent emergent vegetation and / or aquatic beds, or are intermittently flooded basins that are larger than 20 acres (8 ha), e.g. playa lakes, wetlands are considered part of those systems and can be assessed using UWAAM.

An additional wetland type that has been applied to the Great Salt Lake and surrounding Great Basin wetland classification system is impounded wetlands that were artificially created for wildlife habitat. These impounded wetlands do not occur naturally in the landscape, yet have been created by diking existing topographical depressions. Because they are commonly used around Great Salt Lake and other areas of the Great Basin, and due to their major contribution to wildlife habitat, impounded wetlands are included in the classification system presented here.

Although UWAAM addresses habitat as an ecological service provided by wetlands, it doesn't use real-time surveys of wildlife use. In certain circumstances, however, such information could be useful additional information for evaluation of wetland habitat function and a habitat suitability index was developed as a supplemental measurement of the capability of a wetland to provide suitable wildlife habitat (Appendix C). The supplemental avian habitat suitability index is unique to UWAAM and was developed with the intent of assisting Utah Department of Environmental Quality, Division of Water Quality (DWQ) users of UWAAM in Clean Water Act §305b assessments as well as providing habitat assessment applications for other agencies and state government. Developed specifically for wetlands associated with Great Salt Lake that provide habitat for millions of migratory and nesting shorebirds and other waterbirds; their quality and uniqueness are the principle attributes that agencies and NGO's desire to conserve and protect. The avian habitat suitability index evaluates habitat function of wetlands associated with Great Salt Lake through use of the wetlands by shorebirds and other waterbirds.

STRUCTURE OF UWAAM

Wetland rapid assessments have been developed for a variety of reasons including evaluation of ecological condition for the purpose of determining level of degradation, providing predictive indications of ecological stressors or degradation, to document the results of management actions, and to track successes or failures of wetland management, restoration, and mitigation measures associated with regulatory programs (Fennessy et al. 2007). There are a number of underlying assumptions in developing a wetland rapid assessment. First and perhaps foremost is the assumption that physical form and structure are closely aligned with ecological condition (or integrity) such that ecological condition of a wetland "can be described as the sum of its hydrology, structure of its physical components and biological communities, and … [setting in the] landscape" using visible field indicators (Sutula et al. 2006). UWAAM has five metrics for evaluating condition of Utah's Great Basin wetlands. They are buffer, hydrology, structural integrity, plant community, and habitat. All of the metrics are sensitive to seasonal variations and thus the time-frame of the assessment window is an important consideration for repeatability and comparison across years. Because the California Rapid Assessment Method v. 5.01 (CRAM, after which UWAAM was largely modeled) assumes that the condition of a wetland improves as structural complexity and size of wetland increase (Sutula et al. 2006), it is critical to compare assessment areas of equivalent sizes when comparing a suite of wetlands within the same class or type for the same objectives.

UWAAM Scoring

The UWAAM scoring system is based on a 100 point score with each metric having a total possible number of points (subtotal points vary by metric, Table 1.1). A running score is tracked on each page as one works through the various submetrics. Upon reaching the final page, a total (single) score is obtained.

Although it would be rare for a wetland to score within one condition rating across all metrics, the sums provided in Table 1.1 indicate where each rating falls along a 100 point spectrum.

Table 1.1 Maximum points assigned to each condition rating of best, good, fair and poor.

Metric and submetrics	**Condition Ratings**			
1 Buffer	**Best**	**Good**	**Fair**	**Poor**
1a- % buffer	7	5	3	1
1b- buffer width	6	4	3	1
1c - intactness	6	5	3	1
Buffer Subtotal	***19***	***14***	***9***	***3***
2 Hydrology				
2a- water source	7	5	3	1
2b- hydroperiod/stability	5	4	3	1
2c- upstream connectivity	6	6		2
2d- downstream connectivity	6	5	3	1
2e- landscape connectivity	5	4	3	1
Hydrology Subtotal	***29***	***24***	***12***	***6***
3 Structural Integrity				
3a- horizontal interspersion	6	5	3	1
3b- vertical biotic structure	6	5	3	1
3c- structural patch	6	5	3	1
3d- physical alteration	6	5	3	1
Structural Subtotal	***24***	***20***	***12***	***4***
4 Plant Community				
4a- vegetative condition	7	5	3	1
4b- plant layers/ sp. richness	7	2	2	2
Plant Subtotal	*14*	*7*	*5*	*3*
5 Habitat				
5a- water presence	7	5	3	1
5b- ecological services	7	5	3	0
5c- threats (-2 per threat)				
Habitat Subtotal	***14***	***10***	***6***	***1***
TOTAL Maximum Points	**100**	**75**	**44**	**17**

Once a final score is determined, a wetland categorical rating is assigned. Utah Department of Transportation uses a rapid assessment method for their linear projects (UDOT Functional Assessment Method, Johnson et al. 2006) that closely follows a rapid assessment method developed for Montana (PBS&J 2008). Both methods assign a wetland category to assessment areas after they have been rated – Category I being the best and Category IV being the worst. To provide an initial comparison of results between wetlands assessed using the UDOT Functional Assessment Method and UWAAM, UWAAM scores are divided into ranges that apply to the four wetland categories. The four categories are defined as follows (after PBS&J 2008, and Johnson et al. 2006):

Category I wetlands are high quality and rare in occurrence. They may provide: primary habitat for federally listed or proposed threatened or endangered species; represent a high quality example of a rare wetland type; provide irreplaceable ecological function; exhibit exceptionally high flood attenuation capability: or score high for all of the metrics assessed.

Category II wetlands are more common than Category I wetlands, and can provide habitat for sensitive plants or animals, provide a high level of ecological services for wildlife habitat, are unique to a given region, or score high in many of the metrics assessed.

Category III wetlands are more common and generally less diverse than Category I and II wetlands. They can provide many ecological services, but do not score as high in as many metrics as Category I and II wetlands.

Category IV wetlands lack vegetative diversity, provide little ecological services to wildlife and are often directly or indirectly disturbed.

The UWAAM score ranges for wetland category determination are subdivided by setting the lower end of the range 10 points below the maximum of each condition rating (e.g., total of all second choice scores as 75 - 10, are the category level maximum for Category II, Table 1.2). The upper end of the ranges is set at one below the next best category. The total points scored are assigned a categorical rating based on which of the four ranges it falls within.

Table 1.2 Wetland category determination.

	Category I	Category II	Category III	Category IV
UWAAM Score Range	90 - 100	65 - 89	34 - 64	< 34

During the next development phase, it will be necessary to identify the appropriateness of each metric and to filter out apparent redundancies that may exist among submetrics through a validation process perhaps similar to that conducted by (Stein et al. 2009). Through reviews by the Utah Wetlands Assessment Group (UWAG) and the EPA, UWAAM will become more refined and evolve as it goes through various stages of metrics development, refinement and calibration.

Getting Started

UWAAM requires the evaluator to gather background information on the assessment area prior to going to the field. There are a number of geographic information system based exercises that can be conducted prior to conducting the field assessment as well.

In preparing for the site visit, information can be obtained from the literature *and* by submitting a Data Services Request to the Utah Natural Heritage Program of Utah Department of Natural Resources, Division of Wildlife Resources located at 1594 West North Temple, Suite 2110, Box 146301, Salt Lake City, UT 84114-6301. Contact Utah Natural Heritage Program Information Manager - Sarah Lindsey (801) 538-4759; sarahlindsey@utah.gov or the following for information: Utah Natural Heritage Program Database Zoologist - Ben Sutter (801) 537-3439; bensutter@utah.gov, Utah Natural Heritage Program Research Zoologist - George Oliver (801) 538-4820; georgeoliver@utah.gov, and Utah Natural Heritage Program Botanist - Ben Franklin (801) 538-4763; benfranklin@utah.gov. Additional information is available at the Utah Conservation Data Center (UCDC) http://dwrcdc.nr.utah.gov/ucdc/ and DWR's State Wildlife Action Plan.

Note: "Critical habitat" is legally defined in the Endangered Species Act and is the geographic area containing physical or biological features essential to the conservation of a listed species or as an area that may require special management considerations or protection. The evaluator should contact the USFWS Utah Field Office for updates as to whether critical habitat has been designated for other federally listed threatened or endangered species. "Documented" means the wetland is listed in the appropriate State of Utah database. Additionally, free Landsat data and aerial or satellite imagery of the assessment area is likely available at the USGS web site and Google earth, respectively.

Utah Wetlands Ambient Assessment Method (UWAAM)
Version 1.2

Step 1: Background Information

Evaluators Names:
Address:
Lead Evaluator's phone #:
Lead Evaluator's email address:
Date (mm/dd/yyyy):
Assessment Area (AA) Name and § 404 Permit # (if applicable):
Purpose of Assessment (check all that apply): □ **Restoration** □ **Enhancement** □ **Creation** □ **Monitoring** □ **Mitigation** □ **Pre-construction** □ **Post-construction** □ **§305(b)** □ **Other (describe):**
Wetland System: □ **Palustrine** □ **Lacustrine** □ **Riverine**
Wetland Class and Types (refer to definitions on pages 6 – 9, check all that are present in the AA and circle dominant class)**:** □ **Non-Confined (Riverine)** □ **Confined (Riverine)** □ **Unconsolidated Bottom** □ **Aquatic Bed** □ **Unconsolidated Shore** □ **Emergent Wetland** □ **Shrub Wetland; Wetland Type(s)** ____
Hydrologic state of the wetland at the time of the assessment: □ **Ponded/inundated** □ **Saturated soil, but no surface water** □ **Dry**
Apparent hydrologic regime of the wetland: □ **> 9 mo (5 out of 10 yrs)** □ **4 – 9 mo** □ **2 wks – 4 mo**
Is the AA connected with the floodplain of a nearby stream or lake? □ **Yes** □ **No**
Is the topographic basin of the wetland □ distinct **or** □ indistinct**?**
Is the AA within a documented critical habitat (list area):
List specie(s) associated with critical habitat or need for special management considerations:
Lat/Long or UTM coordinates and Datum:
USGS Quad Name:
County:
Township, Range:
Section and Subsection:
Hydrologic Unit Code:
FINAL SCORE: **WETLAND CATEGORY:**

Great Salt Lake / Eastern Great Basin Wetland Systems (after Cowardin 1979)

Riverine Deepwater habitats contained within a channel. A channel is either naturally formed (nonconfined) or artificially constructed (confined), which periodically or continuously contains moving water; or which forms a connection between two bodies of standing water.

Classes: Rock Bottom, Unconsolidated Bottom, Aquatic Bed, Streambed, Rocky Shore, Unconsolidated Shore, and Emergent Wetland (nonpersistent)

Palustrine Freshwater systems that include wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens, farmed wetlands, and have water at the deepest part of the basin less than 2 meters.

Classes: Rock Bottom, Unconsolidated Bottom, Aquatic Bed, Unconsolidated Shore, Moss-Lichen Wetland, Emergent Wetland (persistent), and Scrub Wetland

Lacustrine Wetlands and deepwater habitats that are characterized by all of the following: situated in a topographic depression or a dammed river channel; lacking trees, shrubs, persistent emergents, emergent mosses or lichens with greater then 30 percent cover; and total area exceeds 20 acres (8ha). This system includes permanently flooded lakes and reservoirs, and intermittent lakes (e.g. playa lakes). Islands of Palustrine wetlands may lie within the boundaries of the Lacustrine System.

Classes: Rock Bottom, Unconsolidated Bottom, Aquatic Bed, Rocky Shore, Unconsolidated Shore, and Emergent Wetland (nonpersistent)

Selected Wetland Classes and Types Defined (please refer to Cowardin *et al.* (1979) for additional definitions of other classes)

Riverine – Nonconfined Type

"In non-confined riverine systems, the width of the valley across which the system can migrate without encountering a hillside, terrace, or other feature that is likely to prevent further migration is at least twice the average bankfull width of the channel. Non-confined riverine systems typically occur on alluvial fans, deltas in lakes, and along broad valleys" (Collins et al., 2007).

Examples of vegetation in this wetland type are *Schoenoplectus spp*. (various rushes), *Sium suave* (hemlock waterparsnip), *Ranunculis spp*. (buttercup), *Veronica americana* (American brookline), *Stuckenia spp*. (pondweed), *Potomogeton spp*. (pondweed), *Zannichellia palustris* (horned pondweed), *Ruppia cirrhosa* (spiral ditchgrass),..

Riverine – Confined Type

"In confined riverine systems, the width of the valley across which the system can migrate without encountering a hillside, terrace, man-made levee, or urban development is less than twice the average bankfull width of the channel. A channel can be confined by artificial levees and urban development if the average distance across the channel at bankfull is more than half the distance between the levees or more than half the width of the unurbanized lands that border the stream course. This assumes that the channel would not be allowed to migrate past the levees or into the urban development. Confinement is unrelated to the channel entrenchment. Entrenched channels can be confined or non-confined" (Collins et al., 2007).

Examples of vegetation in this wetland type are *Schoenoplectus spp*. (various rushes), *Sium suave* (hemlock waterparsnip), *Ranunculis spp*. (buttercup), *Veronica americana* (American brookline), *Stuckenia spp*. (pondweed), *Potomogeton spp*. (pondweed), *Zannichellia palustris* (horned pondweed), *Ruppia cirrhosa* (spiral ditchgrass).

Unconsolidated Bottom "Unconsolidated bottom includes all wetlands with at least 25 percent cover of particles smaller than stones, and a vegetative cover less than 30 percent" (as adapted from Cowardin *et al*. 1979 by Dahl and Bergeson 2009). Examples of unconsolidated bottom are: cobble – gravel, sand, mud, and organic material. A list of example types of ponds that fall under Palustrine Unconsolidated Bottom wetland class is presented below (Dahl and Bergeson 2009). The term impounded was added to the Cowardin *et al.* classification (1979) as a modifier in the National Wetlands Inventory program by the USFWS. Impounded wetlands are a prominent around the northern, eastern and southern shores of Great Salt Lake and are typically managed for waterfowl and shorebird habitat and thus are treated here as an example wetland type.

Natural ponds - inundated (intermittently exposed to permanently flooded) depressions, e.g., ponds including beaver ponds

Industrial ponds - mine pits or drainage ponds, highway borrow pits, sewage lagoons, industrial holding ponds

Urban use ponds - aesthetic or recreational ponds, golf course ponds, residential lakes, ornamental ponds, water retention ponds

Agricultural pond - ponds in proximity to agricultural, farming or silviculture operations such as farm ponds, dug outs for livestock, agricultural waste ponds, irrigation or drainage water retention ponds

Aquaculture pond - ponds singly or in series used for aquaculture including fish rearing

Impounded wetland - Impounded wetlands are those that are enclosed by dikes, earthen or otherwise, and have water control structures to allow for managed hydrology. Impounded wetlands do not occur naturally in the landscape although the landscape may have contained other, natural wetland classes before the hydrology was altered.

Aquatic Bed Aquatic beds are wetlands that are "dominated by plants that grow principally on or below the surface of the water for most of the growing season in most years" (Cowardin *et al*. 1979). Examples of aquatic bed and floating vegetation found in this subclass are *Stuckenia spp.* (pondweed), *Potomogeton spp*. (pondweed), *Zannichellia palustris* (horned pondweed), *Ceratophyllum demersum* (coontail), *Ruppia cirrhosa*, (spiral ditchgrass) and *Lemna minor* (duckweed). *Typha latifolia* (cattail) and *Phragmites australis* (common reed) are common invasive plants.

Unconsolidated Shore "Unconsolidated shore includes all wetland habitats having two characteristics: (1) unconsolidated substrates with less than 75 percent areal cover of stones, boulders or bedrock and; (2) less than 30 percent vegetation other than pioneering plants" (as adapted from Cowardin *et al*. 1979 by Dahl and Bergeson 2009).

Palustrine – Emergent Wetland "Emergent wetlands are characterized by erect, rooted, herbaceous hydrophytes, excluding mosses and lichens. This vegetation is present for most of the growing season in most years. These wetlands are usually dominated by perennial plants" (Cowardin *et al*. 1979). Examples of emergent wetland types that fall under this class are described below:

Fen A fen is a carbon accumulating (peat, muck) wetland that is saturated during most of the year, primarily by a discharge of free flowing, mineral rich, ground water with a circumneutral ph (5.5 - 9.0). It is often vegetated with grass or grass-like species such as *Distichlis spicata* (inland saltgrass), *Juncus spp*. (rushes), *Carex spp*. and other sedges but may be dominated by invasive species.

Spring "Springs occur on hillsides or at the bases of dunes, hills, alluvial fans, etc. Springs are indicated by groundwater emerging and flowing across the ground surface or through indistinct or very small rivulets, runnels, and other fluvial features that are too small to be called a creek or riverine system. They often lack the features of riverine channels, such as a thalweg or floodplain" (Collins *et al.*, 2007). Examples of vegetation in this wetland type are *Distichis spicata* (inland saltgrass), *Juncus spp*. and *Schoenoplectus spp*. (various rushes), *Juncus articus ssp. littoralis* (mounain rush), *Eleocharis palustris* (spikerush), *Carex spp*. (sedges), Salicornia utahensis (Utah samphire), and *Cordylanthus maritimus* (alkali birdsbeak). *Typha latifolia* (cattail) and *Phragmites australis* (common reed) may be present and potentially invasive.

Seep Seeps are similar to springs but lack a single-dominant origin of surface flow. Most of the flow is confined to the root zone and is not evident on the ground surface (Collins *et al.*, 2007). Examples of vegetation in this wetland type are *Juncus articus ssp. littoralis* (mounain rush), *Eleocharis palustris* (spikerush), *Carex spp,* Salicornia utahensis (Utah samphire), and *Cordylanthus maritimus* (alkali birdsbeak).

Vegetated Depression also referred to as a wet meadow or salt meadow is characterized as rooted herbaceous vegetation that is inundated by shallow water during part of its growing season but is dry during the rest of the year. Hydrophytic plants and hydric soils are present and soil salinity varies depending on its setting in the landscape. The plant community responds to the salinity regime and is reflected by individual tolerance or non-tolerance to salt. Examples of vegetation found in this wetland type are *Schoenoplectus* maritimus (alkali bulrush), S. americanus (chairmaker's bulrush / Olney's threesquare), *Triglochin maritima* (seaside arrowgrass), *Cordylanthus maritimus* (alkali birdsbeak), *Juncus articus ssp. littoralis* (mounain rush), *Eleocharis palustris* (common spikerush), *Carex spp*. (sedges), *Distichlis spicata* (inland saltgrass), *Hordeum pusillum* (little foxtail barley), and *Hordeum jubatum* (foxtail barley). *Phragmites australis* (common reed) may be present and potentially invasive.

Palustrine – Shrub Wetland Shrub wetlands include areas dominated by woody vegetation less than 20 feet (6 meters) tall. The species include true shrubs, young trees, and trees or shrubs that are small or stunted because of environmental conditions (Dahl and Bergeson 2009). Examples of vegetation in this wetland type are *Salix spp*. (willow), *Alnus incana* (gray alder), *Populus fremontii*., (Fremont cottonwood); *Elaeagnus angustifolia (*Russian olive), and *Tamarix ramosissima* (salt cedar) are common invasive plants.

Lacustrine The following are example lacustrine wetland types typically found around Great Salt Lake and the surrounding Great Basin:

Playa, Alkaline Flat, Mineral Flat - are shallow depressions of unconsolidated bottom (if inundated) and unconsolidated shore (if exposed) and typically are composed of fine-grained clays and silts (mud) that vary in soil salinity or alkalinity. They may be less than 2m deep and may be vegetated with salt or alkaline tolerant vegetation or remain barren. The dominant water source is precipitation and runoff. Examples of vegetation found in this wetland type are *Salicornia spp*. (pickleweed / samphire) and *Suaeda calceoliformis* (Pursh seepweed) with occasional *Allenrolfea occidentalis* (iodinebush) and *Sarcobatus spp*. (greasewood) within the basin; iodinebush, greasewood, *Atriplex spp*., *Distichlis spicata* (inland saltgrass), *Sporobolus aeroides* (alkali sacaton), *Hordeum pussillum* (little foxtail barley) and other grasses or forbes around the edge. If salts of surface soils within the basin have been leached away, grasses and weedy forbs may encroach.

Impounded wetland - Impounded wetlands are those that are enclosed by dikes, earthen or otherwise, and have water control structures to allow for managed hydrology. Impounded wetlands do not occur naturally in the landscape although the landscape may have contained other, natural wetland classes before the hydrology was altered. Impounded wetlands are a prominent wetland type around the northern, eastern and southern shores of Great Salt Lake and are typically managed for waterfowl and shorebird habitat.

Step 2: Establish the Assessment Area (AA)
Use the following tables to define your AA (after Collins et al., 2007).

Table 2.1: The following examples are features that should be used to determine AA boundaries. Note: If AA is being assessed for a highway project, include only the portion of delineated jurisdictional wetland that is within the proposed project zone, right of way, construction easement, permit area, known detour area, etc. Within this context, wetlands bisected by roads are considered as a single AA. Assessments for reasons other than highway projects use the guidelines from Tables 2.1 and 2.2 to determine AA boundary:

Flow-Through Wetlands	Non Flow-Though Wetlands	Artificial Impoundments
Riverine aquatic bed and emergent wetlands, Seeps, Springs	**Unconsolidated bottom and shore, Natural ponds, Aquatic beds, all other Palustrine emergent wetlands, Lacustrine emergent wetlands, Shrub wetlands, Playas, Alkaline Flats, and Mineral Flats**	**Industrial, urban use, agricultural, and aquaculture ponds, impounded wetlands**
• above-grade roads and fills • diversion ditches • end-of-pipe large discharges • grade control or water height control structures • major changes in riverine entrenchment confinement, degradation, aggradation, slope, or bed form • major channel confluences • water falls, spillways • open water areas more than 50 m wide on average or broader than the wetland • transitions between wetland types • backshores or sloughs and uplands at least 10 m wide • weirs, culverts, dams, levees, and other flow control structures	• above-grade roads and fills • berms and levees • jetties and wave deflectors • major point sources or outflows of water • open water areas more than 50 m wide on average or broader than the wetland • backshores or sloughs and uplands at least 10 m wide • weirs and other flow control structures	• above-grade roads and fills • major point sources of water inflows or outflows • weirs, berms, levees and other flow control structures

Table 2.2: The following are examples of features that should not be used to determine any AA.

• at-grade, unpaved, single-lane, infrequently used roadways or crossings • bike paths and jogging trails at grade • bare ground within what would otherwise be the AA boundary • equestrian trails • fences (unless designed to obstruct the movement of wildlife) • property boundaries • riffle (or rapid) – glide – pool transitions in a riverine wetland • spatial changes in land cover or land use along the wetland border • state and federal jurisdictional boundaries

Recommended maximum and minimum AA sizes for each wetland class / type. Note: Wetlands smaller than the recommended AA sizes can be assessed in their entirety. Additionally, some wetland complexes are composed of a combination of subclasses. In these cases, circle the dominant subclass and list other subclasses that are present. Base the UWAAM on the dominant wetland subclass within the AA. Refer to Appendix A for visual size estimate conversions.

Riverine – Confined and Nonconfined

- Recommended length is 10x average bankfull channel width
- Maximum length is 200 m
- Minimum length is 100 m
- Minimum width is 2 m
- AA should extend laterally (landward) from the bankfull contour to encompass all the vegetation (trees, shrubs vines, etc.) that probably provide woody debris, leaves, insects, etc. to the channel and its floodplain

Unconsolidated Bottom

- Maximum size is 2.25 ha (about 150 m x 150 m, but shape can vary)
- Minimum size is 0.5 ha (about 75 m x 75 m)

Unconsolidated Shore

- Maximum size is 2.25 ha (about 150 m x 150 m, but shape can vary)
- Minimum size is 0.1 ha (about 30 m x 30 m)

Palustrine Emergent Wetland or Aquatic Bed

- Maximum size is 2.25 ha (about 150 m x 150 m, but shape can vary)
- Minimum size is 0.1 ha (about 30 m x 30 m)

Fen, Spring or Seep

- Maximum size is 2.25 ha (about 150 m x 150 m, but shape can vary)
- there is no minimum size

Shub Wetland

- Maximum size is 1 ha (about 100 m x 100 m, but shape can vary)
- Minimum size is 0.1 ha (about 30 m x 30 m)

Lacustrine Emergent Wetland or Aquatic Bed

- Maximum size is 2.25 ha (about 150 m x 150 m, but shape can vary)
- Minimum size is 0.1 ha (about 30 m x 30 m)

Playa, Alkaline Flat, Mineral Flat

- Maximum size is 2.25 ha (about 150 m x 150 m, but shape can vary)
- Minimum size is 0.5 ha (about 75 m x 75 m)

Step 3: Describe wetland area being assessed in the box below. Sketch the shape and dimensions of the AA showing approximate proportions of wetland classes if appropriate. Show direction of flow or areas of standing water if appropriate. Show adjacent land uses and any unnatural structures or features if appropriate.

Step 4: QUANTITATIVE RATING

Metric 1: BUFFER

Definition: A wetland buffer is composed of primarily undisturbed land cover, reduces adverse impacts to wetland functions and values from adjacent land uses, and provides a variety of ecological services depending on its characteristics and adjacent land uses. For example, wetland buffers may provide habitat for species during all or part of there life history; may protect wildlife from indirect disturbances related to human activity; may prevent degradation of a wetland from physical disturbance such as, trampling (human, livestock), dumping, cut or burned vegetation, bicycle / OHV use, or unauthorized recreation; and may attenuate hydrologic disturbance related to storm events and improve water quality of in-flowing water.

1a. % of AA perimeter with buffer > 10 m and ≤ 250 m. Land cover that meets the buffer definition must fall immediately adjacent to the AA and be at least 10 m wide by 10 m long to be considered as buffer and provide at least some buffer function.

Use the following table (after CRAM) to identify wetland buffers associated with your AA:

Examples of Land Covers Included in Buffers	**Examples of Land Covers Excluded from Buffers** Note: buffers do not cross these land covers; areas of open water adjacent to the AA are not included in the assessment of the AA or its buffer.
• bike trails (intermittent use) • dry-land farming areas • foot trails • horse trails • links or target golf courses • natural upland habitats • nature or wildland parks • open range land • railroads (excluding multi-rail or train yards) • low traffic dirt roads • single lane paved road • swales and ditches • vegetated levees	• commercial developments • fences that interfere with the movements of wildlife • intensive agriculture (row crops, orchards and vineyards lacking ground cover and other BMPs) • paved roads (two lanes plus a turning lane or larger) • lawns • parking lots • horse paddocks, feedlots, turkey ranches, etc. • residential areas • sound walls • sports fields • traditional golf courses • urbanized parks with active recreation • pedestrian/bike trails (i.e., nearly constant traffic)

Score the percent of AA with buffer with the assigned points in the score column below:

Points	Percent of AA with Buffer (not including open water areas adjacent to AA)	Score
7	75 – 100 %	
5	50 – 74 %	
3	25 – 49 %	
1	0 – 24 %	

1b. Average buffer width. Although the appropriate buffer width for specific functions varies, buffer effectiveness generally improves with increased width. The average buffer width of the AA is estimated by drawing eight straight lines at regular intervals in the N, NE, E, SE, S, SW, W, and NW directions out to 250 m or to the nearest non-buffer land cover (which ever comes first) using GIS or by hand (see Figure 1). If assessing a riverine wetland, draw eight evenly spaced, perpendicular lines from direction of flow measuring from the bank out to 250 m or to the nearest non-buffer land cover on both sides of the channel, rendering eight lines on each side. If the stream is non-wadable, draw eight lines on the side that is being assessed. Lines are drawn only where there is adequate buffer. Any land of similar cover as the buffer but less than 10 m in width is considered too small to provide buffer functions.

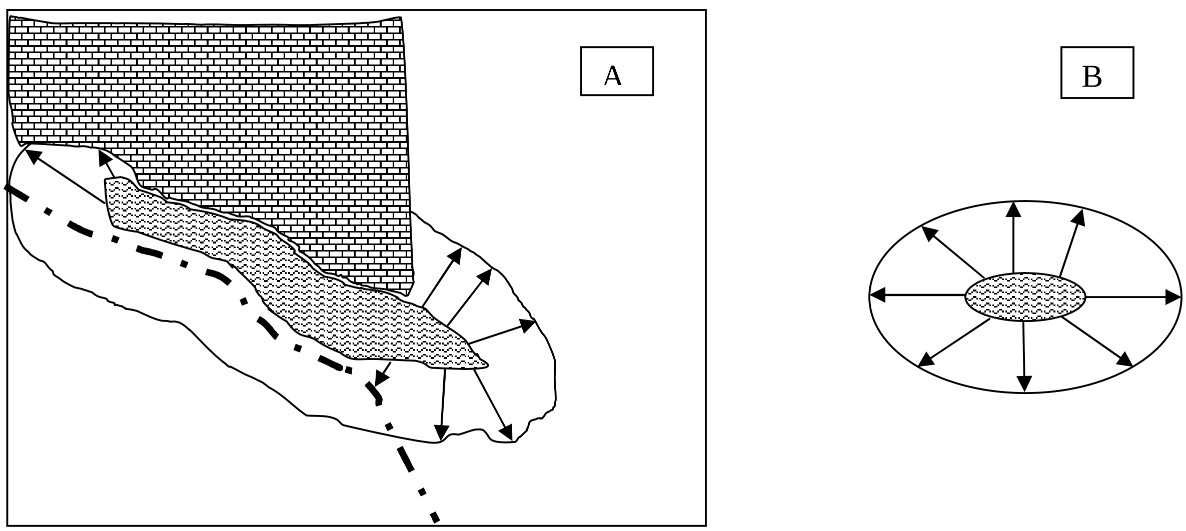

Figure 1. Average buffer width determination of AA (aquatic pattern). Eight evenly spaced lengths (up to 250 m) are drawn through areas with buffer (arrows). Non-buffer areas are shown in example A (brick pattern designates developed area, dashed line designates 4-lane above grade paved highway). Example B shows an AA that is surrounded by wetland buffer on all sides.

Subtotal

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Fill in the following table with buffer widths and determine the average:

Line	Buffer Width (m) 1st side Riverine or all other wetlands	Buffer Width (m) 2nd side of Riverine
N or 1		
NE or 2		
E or 3		
SE or 4		
S or 5		
SW or 6		
W or 7		
NW or 8		
Average Buffer Width	(Sum of non-wadable Riverine or other wetland buffer widths) / 8	(Sum Riverine side 1 and side 2 buffer widths) / 16

Select the range that includes the average buffer width of the AA and apply the assigned points in the score column below:

Points	Average Buffer Width	Score
6	100 – 250 m	
4	35 – 99 m	
3	15 – 34 m	
1	0 – 14 m	

1c. Intactness of buffer. The evaluator is asked to rate how well a buffer provides its various functions by assessing the condition of certain physical attributes that support the ability of a buffer to carry out its functions.

Points	Condition of Physical Attributes	Score
6	Buffer for AA is dominated by native vegetation, has undisturbed soils, and is subject to little or no human visitation	
5	Buffer for AA has an intermediate level of non-native vegetation, mostly undisturbed soils and subject to little or no human visitation	
3	Buffer for AA has substantial levels of non-native and / or invasive vegetation, a moderate degree of soil disturbance or compaction, and / or there is evidence of moderate intensity of human visitation	
1	Buffer for AA is barren ground and / or has highly compacted or otherwise disturbed soils, and / or there is evidence of very intense human visitation, or there is no buffer.	

Subtotal

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Metric 2: HYDROLOGY

Definition: This metric evaluates several aspects of a wetlands water budget (e.g., source, duration and frequency of inundation), connectivity to other water sources, and the observed degree of hydrologic alteration or water quality degradation within the AA.

2a. Water source. The evaluator is asked to assess the source and its degree of hydrological alteration and/ or water quality degradation.

Select the scenario that best characterizes your AA and apply the assigned points in the score column below:

Points	Quality of Water Source	Score
7	• Water source is from surface waters from natural runoff and precipitation or groundwater, and is not comprised of point source discharges (unless treated to the tertiary level or better) • There are no hydrologic alterations affecting flow (except in systems managed for wildlife habitat objectives)	
5	• Water source is > 50 % natural runoff, precipitation or groundwater, but also includes non-point source inputs from agricultural activities, a few small storm drains, and / or rural homes with septic systems • There are small effects of altered hydrology in the immediate vicinity – either in the AA or adjacent to it (dirt roads, levees, small check dams, weirs, or other control structures, etc.)	
3	• Water source is < 50 % natural runoff, precipitation or groundwater and is comprised primarily of point source discharges and / or is resultant of regulated releases from a dam, or direct irrigation • There are moderate effects of altered hydrology in the immediate vicinity (2-lane above grade paved road, exurban development, light industry, diversion / retention ditches, major control structures, etc.)	
1	• Natural water source has been completely diverted (except direct precipitation), and / or comprised of industrial, urban and / or road runoff • There are major effects of altered hydrology in the immediate vicinity (4-lane above grade paved highway, concrete lined ditches or canals, commercial with paved parking lot, industrial complex, urban development, feed lot, etc.)	

2b. Hydroperiod and Channel Stability (if Riverine). Hydroperiod is the frequency and duration of inundation or saturation of a wetland during a one-year time frame. The hydroperiod is closely linked with precipitation events and the subsequent rise and fall of the water table throughout the year. Channel stability is closely linked with hydroperiod in that duration and frequency of flow can compromise the integrity and the natural course of meandering channel. (If wetland is not riverine, base your score on the first bullet point that addresses hydroperiod).

Subtotal

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Points	Hydroperiod and Channel Stability	Score
5	• AA is subjected to natural hydroperiod where inundation and drying or drawdown is not affected by altered hydrology (except in systems managed for wildlife habitat objectives) • If Riverine, point bars present and bank slope varies with occasional undercuts and bank slumps within 200m up and downstream from AA	
4	• AA is subjected to a hydroperiod with magnified inundation but has natural drying or drawdown • If Riverine, banks are undercut or slumped for 20 - 40 % and channel is entrenched for < 50 % of 200 m course up and downstream from AA	
3	• AA is subjected to a hydroperiod with natural inundation but endures a rapid drawdown, or has a lower inundation with a natural drawdown • If Riverine, AA is subjected to a magnified inundation but allowed to dry or drawdown naturally, banks are undercut or slumped for > 41 %, and / or channel is entrenched 50 – 84 % of 200 m course up and downstream from AA	
1	• Both inundation and drawdown deviate from natural hydroperiod • If Riverine, channel is entrenched for ≥ 85 % of 200 m course up and downstream from AA and flow is unable to exceed banks unless during extraordinary flood	

2c. Upstream hydrologic connectivity. The evaluator is asked to assess the AA with respect to its hydrological connection in the localized landscape. Does the AA provide flood attenuation, intercept particulates and / or pollutants, and connectivity between natural upland or riparian areas?

Select the most appropriate description and write the assigned points in the score column below:

Points	Upstream Hydrologic Connectivity	Score
6	AA is within a 100 year floodplain or within level land next to a stream or river channel that is periodically submerged by flood waters	
6	AA is in physical proximity to, or part of other wetland, riparian or upland natural area	
2	AA is situated between a surface water body and a different adjacent land use, such that runoff from the adjacent land use (e.g. agricultural, residential, commercial, industrial, mining, etc.) could flow through the wetland before it discharges into the surface water	

Subtotal

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2d. Downstream hydrologic connectivity. The evaluator is asked to assess the hydrologic connection with lands or water bodies situated lower in the landscape. Are there artificial obstructions along the perimeter of the AA that prevent hydrologic flow or connectivity with adjacent lands or water bodies?

Points	Downstream Hydrologic Connectivity	Score
6	AA has unrestricted outflow to adjacent lands / water bodies	
5	< 50 % of AA boundary has restricted outflow to adjacent lands / water bodies	
3	50 – 90 % of AA boundary has restricted outflow to adjacent lands / water bodies	
1	> 90 % of AA boundary has restricted outflow to adjacent lands / water bodies	
6	AA is managed for wildlife habitat objectives	

2e. Landscape connectivity. The evaluator is asked to consider the spatial setting of an AA within the landscape in relation to other aquatic features. Examples are other wetlands, streams, lakes, ponds, etc. Using GIS or by hand, draw eight straight 500 m rays from AA boundary in the cardinal compass directions. See Figure 2 for example.

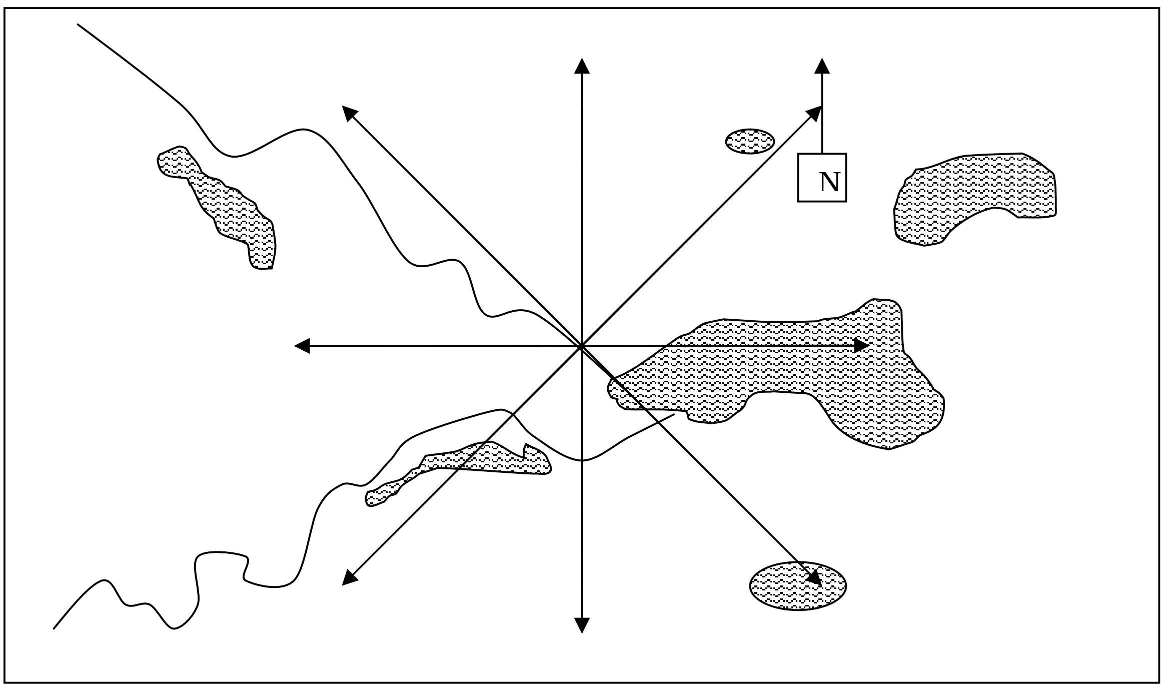

Figure 2. Landscape-level hydrological connectivity. Rays represent 500 m lengths from the AA in the cardinal compass directions and intersect a total of seven aquatic features (three stream channel segments and four wetlands represented by narrow meandering lines and an aquatic pattern, respectively).

Subtotal

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Estimate the percentage of aquatic features that are encountered along each line in the table below:

Segment Length (m) (or percent estimate)		Percentage of Line with Aquatic Features (Segment Length / 500) * 100	
N :	NE :	N :	NE :
E :	SE :	E :	SE :
S :	SW :	S :	SW :
W :	NW :	W :	NW :

Select the description below that best characterizes your AA and apply the assigned points in the score below:

Points	Percentage of Aquatic Features	Score
5	At least 50 % of 2 or more lines have aquatic features, or at least 30 % of 3 lines have aquatic features	
4	At least 30 % of 2 lines have aquatic features	
3	At least 10 % of 2 or more lines have aquatic features	
1	There is only 10 % or less of aquatic features on 1 line, or AA is isolated and does not support migratory or breeding bird populations, or does not support breeding habitat for amphibians and macroinvertebrates	
5	AA is isolated and supports migratory or breeding bird populations, or supports breeding habitat for amphibians and macroinvertebrates	

Metric 3: STRUCTURAL INTEGRITY

Definition: Structural integrity is the presence of physical plant surfaces or plant community features that allow an AA to provide habitat and water improvement functions. Habitat functions may be related to protective cover, breeding, and / or forage, for aquatic, wetland, riparian or upland species. All species, including macroinvertebrates, insects, and arthropods that are important to the aquatic life food chain, are to be considered. Water improvement functions may be related to filtration of particulates, absorption and adsorption of nutrients and other pollutants, and nutrient cycling.

Subtotal

3a. Horizontal (plan view) interspersion. This submetric asks the evaluator to assess the degree of interspersion among the various plant zones thereby providing a level of diverse habitat across the AA for species that are dependant upon them (see Figure 3.1).

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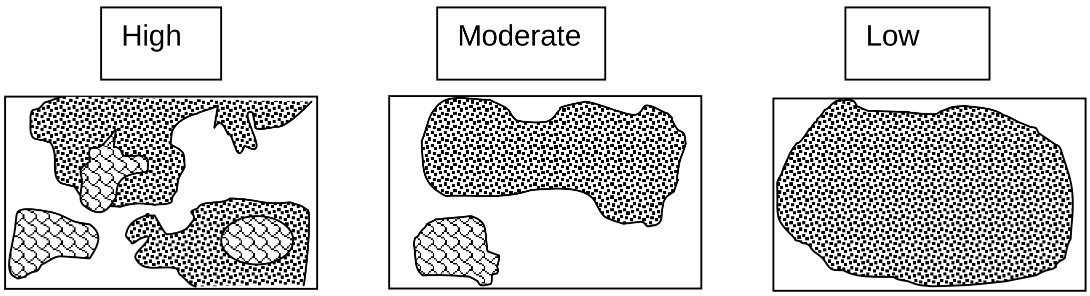
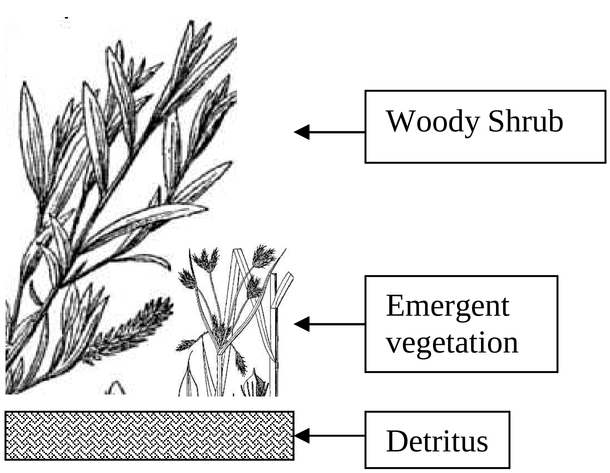


Figure 3.1 Example degrees of interspersion of plant zones (assume white background is a cover type).

Select level of interspersion of plant zones (excluding playas, alkaline / mineral flats) that best characterizes the AA and apply the assigned points in the score column below:

Points	Horizontal (Plan View) Interspersion	Score
6	High degree of interspersion	
5	Moderate degree of interspersion	
3	Low degree of interspersion	
1	No interspersion	
6	Playas, alkaline / mineral flats	

3b. Vertical biotic structure. (Excluding playas, alkaline / mineral flats), the evaluator is asked to assess the degree of overlap of vegetative layers (live, dead standing stock and detritus). See Figure 3.2 for example.



Subtotal

Figure 3.2. Example vertical overlap of three vegetative layers.

Select the description below that best characterizes your AA and apply the assigned points in the score column below:

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Points	Vertical Biotic Structure	Score
6	> 50 % of the vegetated area of the AA supports three or more overlapping plant layers	
5	> 50 % of the vegetated area of the AA supports at least two overlapping plant layers	
3	25 – 50 % of the vegetated area of the AA supports at least two overlapping plant layers, **or** three plant layers are well represented in the AA but there is little or no overlap	
1	< 25 % of the vegetated area supports at least two overlapping plant layers, **or** two layers are well represented with little or no overlap, **or** AA is sparsely vegetated.	
6	Playas, alkaline / mineral flats	

Subtotal

3c. Structural patch richness. This submetric asks the evaluator to assess the richness of patches within the AA. See Appendix B for definitions of typical patch types that provide structural integrity to an AA.

Circle patch types that are present in your AA in the table below. Put total number of observed patch types (# of points circled) under appropriate wetland subclass or type, and determine percent of total possible points. If AA contains a wetland type specific to a class, assign points to the column with the wetland type rather than the class (e.g., circle points under seep and not palustrine emergent marsh).

STRUCTURAL PATCH	Riverine (non-confined)	Riverine (confined)	Palustrine Unconsolidated Bottom	Unconsolidated Shore	Aquatic Bed	Palustrine Emergent Marsh	Fen	Seep or Spring	Vegetated Depression	Shrub Wetland	Lacustrine Emergent Marsh	Playa, Alkaline / Mineral Flat
Minimum Patch Size (m^2)	**3**	**3**	**3**	**3**	**3**	**3**	**1**	**1**	**3**	**3**	**3**	**3**
2˚ channels on floodplain or along shorelines	1	0	1	1	0	1	0	0	0	1	1	1
Swales on floodplain or along shoreline	1	0	1	0	0	1	0	0	1	1	1	1
Pannes or pools on floodplain or along shoreline	1	0	1	1	0	1	0	1	0	1	1	1
Vegetated islands (when above high water)	1	0	1	0	1	1	1	1	1	1	0	1
Pools or depressions in wet or dry channels	1	1	0	0	0	0	0	0	0	0	0	0
Riffles/rapids (wet channel) Planar bed (dry channel)	1	1	0	0	0	0	0	0	0	0	0	0

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STRUCTURAL PATCH	Riverine (non-confined)	Riverine (confined)	Palustrine Unconsolidated Bottom	Unconsolidated Shore	Aquatic Bed	Palustrine Emergent Marsh	Fen	Seep or Spring	Vegetated Depression	Shrub Wetland	Lacustrine Emergent Marsh	Playa, Alkaline / Mineral Flat
Point bars and in-channel bars	1	1	0	0	0	0	0	0	0	0	0	0
Debris jams	1	1	0	0	0	0	0	1	0	1	1	0
Wrackline or organic debris	1	1	0	1	0	1	1	1	1	1	1	0
Plant hummocks or sediment mounds	1	1	1	1	1	1	1	1	1	1	1	1
Bank slumps or undercut banks	1	1	0	0	0	0	0	0	0	1	1	0
Variegated, convoluted, or crenulated foreshore (instead of broadly arcuate or mostly straight)	1	1	0	0	1	1	0	1	1	1	1	0
Animal, macroinvertebrate, or insect mounds and burrows	1	1	1	1	1	1	1	0	1	1	1	1
Standing snags (at least 3 m tall)	1	1	0	1	0	1	1	1	1	1	1	0
Filamentous macroalgae or algal mats	1	1	1	1	1	1	0	1	1	0	1	1
Concentric or parallel high water marks	0	0	1	1	0	1	0	1	1	1	1	1

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STRUCTURAL PATCH	Riverine (non-confined)	Riverine (confined)	Palustrine Unconsolidated Bottom	Unconsolidated Shore	Aquatic Bed	Palustrine Emergent Marsh	Fen	Seep or Spring	Vegetated Depression	Shrub Wetland	Lacustrine Emergent Marsh	Playa, Alkaline / Mineral Flat
Soil cracks	0	0	1	1	1	1	0	0	1	0	1	1
Cobble and / or boulders	1	1	0	0	1	1	0	0	0	0	1	0
Submerged vegetation	1	0	1	0	1	1	0	1	1	0	1	0
TOTAL POSSIBLE POINTS	**17**	**12**	**10**	**9**	**8**	**14**	**5**	**10**	**11**	**12**	**15**	**9**
# Observed Patch Types												
% of Total Possible Points (# observed / total possible) * 100												

Select rating category that captures the average % of total possible points of your AA below and apply assigned points in the score column below:

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Points	Rating of Structural Patch Richness	Score
6	≥ 80 % of total possible points	
5	60 – 79 % of total possible points	
3	25 – 59 % of total possible points	
1	< 25 % of total possible points	

3d. Physical alteration. The evaluator is asked to assess the physical intactness of the AA. The evaluator may use all available information (field visits, aerial photos, satellite imagery, etc.) to identify indicators of physical alteration to the AA.

Check all that applies and determine the degree of impact the alteration(s) has/have on the physical structure of the AA. You may select one or several stressors and still determine that the area is intact.

	Mowing		Channeled
	Grazing (cattle, sheep, pigs, etc.)		Herbaceous layer / aquatic bed removal
	Clearcutting		Sedimentation
	Selective cutting		Dredging
	Woody debris removal		Toxic pollutants
	Shrub / sapling removal		Nutrient enrichment, e.g. nuisance algae
	Farming		Dumping
	Soil or substrate disturbance		Other:
	Tile drained		Other:

Subtotal

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Are any stressors that were checked (above) more than trivial? Select the most appropriate characterization and apply appropriate score in the table below.

Points	Characterization of Level of Impact	Score
6	None or none apparent: there are no alterations or none that are apparent to the evaluator.	
5	Recovered: The wetland appears to have recovered from past alterations but alterations are still evident.	
3	Recovering: The wetland appears to be in the process of recovering from past alterations.	
1	Recent alteration or no recovery: the alterations have occurred recently, and/or the wetland has not recovered from past alterations, and/or the alterations are ongoing.	

Metric 4: PLANT COMMUNITY

4a. Vegetative Community Condition The evaluator is asked to assess the condition of the vegetative community based on ocular determination of aerial percent cover of native, non-invasive species one would expect to occur versus naturalized, introduced and/or invasive species. Comparison with reference wetland data of the same subclass or type (if available) in the reference wetland network database should be made (see Hoven 2010 for guidance).

Use the following worksheet to determine the total percent cover of cover types present in the AA and Daubenmire cover classes and mid-point range from Table 4.1. You may use any traditional botanical method or best professional judgment unless specific methods are required and necessary for your particular assessment. If the AA is variable in cover types and/or a complex of differing wetland types, you may need to determine percent cover for 4 to 5 small subsets of similar size and report the average. Otherwise, be sure to record what reflects the entire AA and not just one small portion of it. Note: upland species are not specifically addressed but may occur in some wetland subclasses in varying degrees such that the total percent cover for wetland cover types and/or bare ground may not add up to 100 percent.

Table 4.1 Daubenmire cover classes (Daubenmire 1959).

Cover Class	Range of Coverage	Midpoint of Range
1	< 5%	2.5%
2	5 - 25%	15.0%
3	25 - 50%	37.5%
4	50 - 75%	62.5%
5	75 - 95%	85.0%
6	95 - 100%	97.5%

Subtotal

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Cover Type	Co-dominant Species & Percent Cover (please list co-dominants and other species per subplot) N	E	S	W	Average Percent Cover	Daubenmire Cover Class & Mid-point of Range
Native, non-invasive						
Naturalized or introduced						
Invasive (native or non-native)						
Bare ground						

Check the following modifier definitions that apply and select the appropriate vegetative condition category (in the following table) of the AA based on the average percent cover for each cover type.

Modifier Definitions					
Native (% of total vegetation)			**Introduced and / or invasive (% of total vegetation)**		
High	95 - 100 % of expected *		High	> 60%	
Good	76 - 94%		Moderate	21 - 60 %	
Some	50 - 75 %		Some	6 - 20 %	
Low	< 50 %		Low	≤ 5 %	

* allows for as much as 5 % non-invasive introduced species; if saltgrass (*Distichlis spicata*) is present and expected, qualify it as native rather than invasive

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Points	**Vegetative Condition Categories** (refer to modifier definitions above and see note below)	Score
7	Excellent: No invasive non-natives, high representation / percentage cover of native specie(s) you expect to occur	
5	Good: Good representation / percentage cover of native specie(s) you expect to occur, some / low percentage of introduced species, and/or low percentage invasive native or non-native species	
3	Fair: Some representation / percentage cover of native specie(s) you expect to occur, some or moderate percentage of introduced species, moderate percentage of invasive native or non-native species	
1	Poor: Low representation / percentage cover of native specie(s) you expect to occur, moderate or high percentage of introduced species, moderate or high percentage of invasive native or non-native species	

Note: if site meets a definition for invasive species, the site defaults to the highest condition category that includes that invasive definition. Example: If high percentage of expected vegetation occurs with low (≤ 5 %) invasive, site condition qualifies as "Good" rather than “Excellent”.

4b. Plant Layers and Species Richness The evaluator is asked to assess the number of plant layers for the co-dominant species in the AA and then determine species richness within the AA (either from the entire AA or from subplots used to determine percent cover estimates). Plant layers are broken down by canopy height breaks (modified from Collins et al. 2007 to represent Utah wetland flora) and all living vegetative species that comprise at least 10% relative cover within the layer are considered to be co-dominant. Only living vegetation in growth position is considered in this metric. Dead or senescent vegetation is disregarded so it is advised that the evaluation occurs during the mid – to – late growth season. It is possible for one species to dominate more than one layer. Such plants provide a different set of habitats for wildlife, different amounts of shading and rainfall interception, and have other functional differences between layers. The occurrence of one species among multiple layers adds to the overall complexity of the AA.

Use the following table to identify the number of plant layers by canopy height breaks of co-dominant species in the entire AA (upper diagonal). Fill in the total number of species observed in the lower diagonal for each plant layer present in the subplots.

Subtotal

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Wetland Class / Type	Plant Layers				
	Submerged/ Floating veg	Short	Medium	Tall	Very Tall
Riverine, Palustrine and Lacustrine emergent marsh	present	< 0.5 m	0.5 – 1.5 m	1.5 – 3.0 m	> 3.0 m
Unconsolidated bottom	present	< 0.5 m	0.5 – 1.5 m	1.5 – 3.0 m	> 3.0 m
Impounded wetland	present	< 0.5 m	0.5 – 1.5 m	1.5 – 3.0 m	> 3.0 m
Vegetated depression	n/a	< 0.3 m	0.3 – 0.75	0.75 – 3.0 m	> 3.0 m
Fen	n/a	< 0.3 m	0.3 – 0.75	0.75 – 3.0 m	> 3.0 m
Seep, Spring	present	< 0.3 m	0.3 – 0.75	0.75 – 3.0 m	> 3.0 m
Playa, Alkaline flat, Mineral flat	n/a	< 0.3 m	0.3 – 0.75	0.75 – 3.0 m	> 3.0 m

Determine whether the number of plant layers and number species (from table above) fall within the range for the wetland class / type of the AA. If the number of plant layers OR species falls outside of the range, subtract 2 from the assigned points and apply the appropriate points in the score column below. If the number of plant layers and species both fall within the listed range, apply the designated points in the score column.

Points	**Wetland Class / Type**	**Number of Plant Layers Present**	**Species Richness**	**Score** (Subtract 5 if AA falls outside either range)
7	Riverine, Palustrine or Lacustrine emergent wetland	4 – 5	1 – 7 (saline) 10 – 21 (freshwater)	
7	Unconsolidated bottom	2 – 4	1 – 7	
7	Impounded Wetland	2 – 4	1 – 7	
7	Vegetated depression	3 – 4	5 – 7 (saline) 4 – 12 (freshwater)	
7	Fen	3 – 5	10 – 21	
7	Seep, Spring	4 – 5	5 – 7 (saline / alkaline) 10 – 21 (freshwater)	
7	Shrub Wetland	3 – 5	4 – 12	
7	Playa, Alkaline flat, Mineral flat	0 – 2	1 - 5	

Subtotal

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Metric 5. HABITAT

Wetlands provide a diversity of habitats for numerous invertebrate and vertebrate species. Wetland function both influences and is influenced by these organisms. Each wetland class or type provides a unique set of conditions that provide habitat for their associated organisms. This metric was originally organized to address upper food chain wildlife species with emphases on resident and migratory birds known to use Great Salt Lake wetlands but has now been expanded to assess the needs of Conservation Agreement Species known to occur in the ground-water fed wetlands of the West Desert.

Wetlands provide ecological services that fulfill the needs of particular species during different elements of their life cycle. For example, within the Intermountain West wetlands play a major role for breeding species and birds during migration, yet the condition of wetland classes or types will determine the use or extent of use by wildlife. Some important condition considerations for evaluation are; water quantity, quality, and seasonal availability, vegetation type, condition, pattern and seral stage. Also important is extent, contiguity and connectivity of the wetland complex within the landscape. Another factor sometimes tied to condition is disturbance to the wetland (e.g., off-road vehicular use, drainage, dumping, etc.). While various components have already been addressed in previous submetrics (e.g., water quality, vegetation community condition and structure, connectivity, physical disturbance) certain aspects that are specific to wildlife have not yet been assessed.

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5a. Presence of Water. Water must be present to provide for specific life cycle needs of aquatic birds, fish, and aquatic amphibians and macroinvertebrates. Standing or flowing surface water in sufficient quantity and quality is required for the successful breeding of all aquatic species, as well as the occurrence of migratory birds. The following table is used to assess present water values in the AA to species and suites of species. The evaluator should frame their assessment around the appropriate season to conduct a meaningful assessment or supplement with documented monitoring data. The evaluator is asked to select all conditions met and then determine (qualitatively) the percentage of the AA that meets these conditions. A series of percentage ranges with assigned point values are given below.

Water Condition	Seasonal need	Species/ Suites	Check if Condition Met
Dry/ wet mudflats	May-August	Breeding Snowy Plovers	
Wet mudflats	June-September	Migrant small shorebirds	
Shallow water depth (0-5 cm)	June-September	Migrant small-medium shorebirds (Western Sandpipers/ Yellow legs)	
Moderate water depth (5-20 cm)	June-September	Breeding-migrant large shorebirds (Avocets/ Stilts/ Godwits)	
Water under emergent vegetation	April-July or August	Breeding waders/ secretive species (Ibis, rails, egrets, herons) least chub	
Dry and wet mudflats Shallowly flooded unvegetated to sparsely vegetated mudflats Water under emergent vegetation (fresh to brackish)	Year round, allowing for receding water levels due to evaporation	Macroinvertebrates	
Shallow water fishery	Year round	Fish eating species (pelicans, grebes, terns, herons)	
Permanent water source with a variety of emergent, floating and submergent vegetation	Year round	Amphibians (Columbia spotted frog, northern leopard frog), and fish (least chub)	
Deep pools	Winter and summer	Amphibians (Columbia spotted frog, northern leopard frog), and fish (least chub)	
Shallowly flooded unvegetated or sparsely vegetated shelves on the NW side of shore	Spring and summer	Amphibians (Columbia spotted frog, leopard frog)	
Shallowly flooded with sparse vegetation	Spring and early summer	least chub	
Other			

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Score the percent of AA with any one of or a combination of water habitat characteristics present from previous table using the assigned points:

Points	Percent of AA with water habitat conditions in place and functioning during seasonal needs by species or suite of species	Score
7	75 – 100 %	
5	50 – 74 %	
3	25 – 49 %	
1	0 – 24 %	

5b. Ecological services. Having water present during the correct seasonal need is important for wildlife use. However, presence of water does not necessarily imply that certain ecological services are provided and supporting wildlife habitat requirements. The following table identifies habitat type found within wetlands that are known to provide important ecological services. The evaluator is asked to mark ecological services observed or known to exist and qualify the services by noting what was observed or what available data demonstrate acknowledgement. Points are then determined by the number of ecological services provided within the AA.

Subtotal

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Check all ecological services likely met within the AA. Note implications of services met (e.g., macroinvertebrate castings, shorebird/waterbird footprints, documented egg masses, etc.).

Wildlife Habitat Type(s) or Key Resource	Example Ecological Services (one or more may align with listed habitat types or resource)	Check if Services Met	Notes on implications
Shoreline / mud flat (Unconsolidated shore) Fresh to brackish water under emergent vegetation Aquatic bed Salicornia flat	Macroinvertebrate breeding, Shorebird, waterfowl, and fish macroinvertebrate foraging		
Alkali/ Olney's bulrush stand, cattail/ hardstem bulrush stand, Hemi Marsh (50% water, 50% emergent vegetation)	Waterfowl foraging, Waterbird nesting		
Aquatic bed	Waterbird nesting substrate; Waterfowl and waterbird foraging; fish foraging; increased oxygen supply and protection for eggs (least chub)		
Deep pools Shallowly flooded shelves	Thermal refuge for fish and amphibians		
NW shore with shallowly flooded shelves	Thermal refuge for amphibian egg masses (Columbia spotted frog, northern leopard frog)		
Wet meadow	Foraging and nesting (Greater Sandhill Cranes and Wilson's Phalaropes)		
Fen	Foraging and nesting (Yellowlegs and rails), Foraging (dowitchers)		
Shrub wetland / Riparian complex	Waterbird foraging and nesting		
Wetland associated natural uplands	Shorebird and waterfowl nesting		
Water rights associated with the AA	Site longevity		
Other			

Subtotal from Previous Page

Determine score from previous table based on the number of ecological services provided within the AA.

Points	Number of Ecological Services within AA	Score
7	≥ 5, (≥ 4 if Playa or mineral/alkaline flat)	
5	3 – 4	
3	1 – 2	
0	0	

5c. Threats to wildlife associated with wetland habitat. Success of any species that requires wetland habitat for part or all of its life history depends on the natural hydrologic regime and biota associated with the regime are in an ecological state of balance. Some of the biggest threats to wildlife associated with wetland habitat are related to habitat loss and degradation due to urbanization or other land use change, groundwater withdrawal or other water development, oil and gas exploration, and livestock grazing. Introduced species are also a threat to native wildlife due to competition for food and other resources and predation. While physical degradation and invasive plant species has been addressed in previous metrics, the evaluator is now asked to assess the presence of biological threats. Subtract 2 points for each threat that is present. You may supplement with available / existing monitoring databases such as that provided by the Utah Conservation Data Center.

Threat	Effect	Check	Score
American bullfrog	Competition and predation		
Largemouth bass	Competition and predation		
Common carp	Competition and predation, habitat destruction		
Western mosquitofish	Competition and predation		
Chytrid fungus	Mortality / decreased population size		
Red-rim melania	Displacement of native mollusks		
Water development +/or oil and gas exploration	Habitat loss +/or reduced water quality		

Grand Total

Step 6: UWAAM SCORE WORKSHEET Fill in the worksheet below using the scoring ranges for wetland category determination on following page.

		Circle One or Insert Score	Result
Narrative Rating	**Critical Habitat.**	YES NO	If Yes, Category I
	Threatened or Endangered Species, and State Listed S-1 Species.	YES NO	If Yes, Category I
	Suspected use by Federally Listed or Proposed Threatened or Endangered Species or State Listed S-1 Species.	YES NO	If Yes, evaluate for Category I, may also be a II
	Documented High Quality Wetland.	YES NO	If Yes, Category I
	Significant Breeding or Bird Concentration Area.	YES NO	If Yes, evaluate for Category I, may also be a II
Quantitative Rating	**Metric 1. Buffer**	Subtotal Score	
	Metric 2. Hydrology	Subtotal Score	
	Metric 3. Structural Integrity	Subtotal Score	
	Metric 4. Plant Community	Subtotal Score	
	Metric 5. Habitat	Subtotal Score	
	TOTAL SCORE		
	CATEGORY LEVEL (based on scoring ranges below)		

Utah Department of Transportation uses a rapid assessment method for their linear projects (UDOT Functional Assessment Method, Johnson et al. 2006) that closely follows a rapid assessment method developed for Montana (PBS&J 2008). Both methods assign a wetland category to assessment areas after they have been rated – Category I being the best and Category IV being the worst. To provide a comparison of results between wetlands assessed using the UDOT Functional Assessment Method and UWAAM, UWAAM scores are divided into ranges that apply to the four wetland categories. The four categories are defined as follows (after PBS&J 2008, and Johnson et al. 2006):

Category I wetlands are high quality and rare in occurrence. They may provide: primary habitat for federally listed or proposed threatened or endangered species; represent a high quality example of a rare wetland type; provide irreplaceable ecological function; exhibit exceptionally high flood attenuation capability: or score high for all of the metrics assessed.

Category II wetlands are more common than Category I wetlands, and can provide habitat for sensitive plants or animals, provide a high level of ecological services for wildlife habitat, are unique to a given region, or score high in many of the metrics assessed.

Category III wetlands are more common and generally less diverse than Category I and II wetlands. They can provide many ecological services, but do not score as high in as many metrics as Category I and II wetlands.

Category IV wetlands lack vegetative diversity, provide little ecological services to wildlife and are often directly or indirectly disturbed.

Category Level Determination (to be calibrated in subsequent version)

The following ranges were determined by setting the lower end of the range 10 points below the maximum of each condition rating (e.g., total of all second choice scores as 75 - 10, are the category level maximum for Category II, Table 1.1). The upper end of the ranges is set at one below the next best category. The total points scored are assigned a categorical rating based on which of the four ranges it falls within:

	Category I	**Category II**	**Category III**	**Category IV**
UWAAM Score Range	90 - 100	65 - 89	35 - 64	< 34

If the total score of the wetland (metrics 1 – 5) is located within the scoring range for a particular category, the wetland should be assigned to that category. In all instances however, a written justification can be used to clarify or change a categorization particularly if the Narrative Rating suggests the wetland category should differ. Detailed Level III biological and/or functional assessments and / or the reference wetlands network database may be used to support a categorization change.

Step 7. Apply final score and wetland category to Background Sheet (page 7).

End of UWAAM.

Appendix A. Conversion Table

Metric to English conversion table with visual estimation sizes (from ORAM v.5)							
acres	**ft^2**	**yd^2**	**ft on side**	**yd on side**	**ha**	**m^2**	**m on side**
50	2,177,983	241,998	1476	492	20.2	202,000	449
25	1,088,992	120,999	1044	348	10.1	101,000	318
10	435,596	48,340	660	220	4.1	41,000	203
3	130,679	14,520	362	121	1.2	12,000	110
0.3	13,067	1,452	114	38	0.12	1,200	35
0.1	4,356	484	66	22	0.04	400	20

Appendix B. Patch Type Definitions (after CRAM version 5.0):

Animal mounds and burrows. Many vertebrates make mounds or holes as a consequence of their foraging, denning, predation, or other behaviors. The resulting soil disturbance helps to redistributes soil nutrients and influences plant species composition and abundance. To beconsidered a patch type there should be evidence that a population of burrowing animals has occupied the Assessment Area. A single burrow or mound does not constitute a patch.

Bank slumps or undercut banks in channels or along shorelines. A bank slump is a portion of a depressional, estuarine, or lacustrine bank that has broken free from the rest of the bank but has not eroded away. Undercuts are areas along the bank or shoreline of a wetland that have been excavated by waves or flowing water.

Cobble and boulders. Cobble and boulders are rocks of different size categories. The long axis of cobble ranges from about 6 cm to about 25 cm. A boulder is any rock having a long axis greater than 25 cm. Submerged cobbles and boulders provide abundant habitat for aquatic macroinvertebrates and small fish. Exposed cobbles and boulders provide roosting habitat for birds and shelter for amphibians. They contribute to patterns of shade and light and air movement near the ground surface that affect local soil moisture gradients, deposition of seeds and debris, and overall substrate complexity.

Concentric or parallel high water marks. Repeated variation in water level in a wetland can cause concentric zones in soil moisture, topographic slope, and chemistry that translate into visible zones of different vegetation types, greatly increasing overall ecological diversity. The variation in water level might be natural (e.g., seasonal) or anthropogenic.

Debris jams. A debris jam is an accumulation of drift wood and other flotage across a channel that partially or completely obstructs surface water flow.

Hummocks or sediment mounds. Hummocks are mounds created by plants in slope wetlands, depressions, and along the banks and floodplains of fluvial and tidal systems. Hummocks are typically less than 1m high. Sediment mounds are similar to hummocks but lack plant cover.

Islands (exposed at high-water stage). An island is an area of land above the usual high water level and, at least at times, surrounded by water in a riverine, lacustrine, estuarine, or playa system. Islands differ from hummocks and other mounds by being large enough to support trees or large shrubs.

Macroalgae and algal mats. Macroalgae occurs on benthic sediments and on the water surface of all types of wetlands. Macroalgae are important primary producers, representing the base of the food web in some wetlands. Algal mats can provide abundant habitat for macro-invertebrates, amphibians, and small fishes.

Non-vegetated flats (sandflats, mudflats, gravel flats, etc.). A flat is a non-vegetated area of silt, clay, sand, shell hash, gravel, or cobble at least 10 m wide and at least 30 m long that adjoins the wetland foreshore and is a potential resting and feeding area for fishes, shorebirds, wading birds, and other waterbirds. Flats can be similar to large bars (see definitions of point bars and inchannel bars below), except that they lack the convex profile of bars and their compositional material is not as obviously sorted by size or texture.

Pannes or pools on floodplain. A panne is a shallow topographic basin lacking vegetation but existing on a well-vegetated wetland plain. Pannes fill with water at least seasonally due to overland flow. They commonly serve as foraging sites for waterbirds and as breeding sites for amphibians.

Point bars and in-channel bars. Bars are sedimentary features within intertidal and fluvial channels. They are patches of transient bedload sediment that form along the inside of meander bends or in the middle of straight channel reaches. They sometimes support vegetation. They are convex in profile and their surface material varies in size from small on top to larger along their lower margins. They can consist of any mixture of silt, sand, gravel, cobble, and boulders.

Pools in channels. Pools are areas along tidal and fluvial channels that are much deeper than the average depths of their channels and that tend to retain water longer than other areas of the channel during periods of low or no surface flow.

Riffles or rapids. Riffles and rapids are areas of relatively rapid flow and standing waves in tidal or fluvial channels. Riffles and rapids add oxygen to flowing water and provide habitat for many fish and aquatic invertebrates.

Secondary channels on floodplains or along shorelines. Channels confine riverine flow. A channel consists of a bed and its opposing banks, plus its floodplain. Riverine wetlands can have a primary channel that conveys most flow, and one or more secondary channels of varying sizes that convey flood flows. The systems of diverging and converging channels that characterize braided and anastomosing fluvial systems usually consist of one or more main channels plus secondary channels. Tributary channels that originate in the wetland and that only convey flow between the wetland and the primary channel are also regarded as secondary channels. For example, short tributaries that are entirely contained within the UWAAM Assessment Area (AA) are regarded as secondary channels.

Soil cracks. Repeated wetting and drying of fine grain soil that typifies some wetlands can cause the soil to crack and form deep fissures that increase the mobility of heavy metals, promote oxidation and subsidence, while also providing habitat for amphibians and macroinvertebrates. Cracks must be a minimum of 1 inch deep to qualify.

Standing snags. Tall, woody vegetation, such as trees and tall shrubs, can take many years to fall to the ground after dying. These standing “snags” provide habitat for many species of birds and small mammals. Any standing, dead woody vegetation that is at least 3 m tall is considered a snag.

Submerged aquatic vegetation. Submerged aquatic vegetation (SAV) consists of aquatic macrophytes such as *Stuckenia filiformis* (Sego pondweed), and *Ruppia cirhosa* (widgeon grass) that are rooted in the sub-aqueous substrate and may or may not grow high enough in the overlying water column to intercept the water surface. Submerged aquatic vegetation can strongly influence nutrient cycling while providing food and shelter for fish and other organisms.

Swales on floodplain or along shoreline. Swales are broad, elongated, vegetated, shallow depressions that can sometimes help to convey flood flows to and from lacustrine fringe wetlands or wetlands within a floodplain. But, they lack obvious banks, regularly spaced deeps and shallows, or other characteristics of channels. Swales can entrap water after flood flows recede. They can act as localized recharge zones and they can sometimes receive emergent groundwater.

Variegated or crenulated foreshore. As viewed from above, the foreshore of a wetland can be mostly straight, broadly curving (i.e., arcuate), or variegated (e.g., meandering). In plan view, a variegated shoreline resembles a meandering pathway. Variegated shorelines provide greater contact between water and land.

Wrackline or organic debris. Wrack is an accumulation of natural or unnatural floating debris along the high water line of a wetland.

Appendix C. Supplemental Habitat Suitability Index based on Wildlife Species Presence

Depending on the nature of the assessment, it may be necessary to document species presence to develop a habitat suitability index for the AA. During AA assessment record species present by direct observation or through evidence of current use. Provide the appropriate data presence and activity data to the following table. The quality of the data may be influenced by several factors including the season, weather condition, or time of day of the AA visit. It is important to fill in the conditional data that precedes the table and to conduct surveys during appropriate index windows (see seasonal needs in Metric 5a).

Date: ____________________ Start time: ______________ End time: ______________

Weather: ____

Wildlife ID skill: Novice ______ Average ______ Skilled ______

Wildlife observations	**Number Species**	**Number individuals**	*** Activity Observed**
Marsh Passerines (wrens, blackbirds…)			
Waders (herons, egrets, ibis, …)			
Gulls and terns			
Grebes and coots			
Pelicans and cormorants			
Large shorebirds (avocets, stilts, curlews…)			
Small shorebirds (peeps, plovers…)			
Secretive marsh birds (rails, bitterns…)			
Ducks, geese, swans			
Raptors (eagles, hawks, falcons, owls)			
Marsh mammals			
Marsh predators			
Colonial nest sites			

*** Activities**: Feeding (F), Loafing (L), Courting (C), Nesting (N), Brooding (B)

Supplemental Habitat Suitability Index Calculations:

Calculate the following data from the table and sum for a total wildlife presence score:

1. Species Richness: number of species divided by the number of hectares in AA
e.g., 28 species/ 10 ha = 2.8 species per ha: ____________________

2. Observations per effort: number of birds divided by period of observation (hour to nearest half) e.g., 500/ 2 hours = 250 counted per hour: ____________________

3. Effort: number of birds counted per hour divided by number of ha:
e.g., (500/2) / 10 ha = 25 counts/hr/ha: _____________________

4. Nesting: any colonial nesting with greater than 30 nests present: (check if meets criterion) ________

Supplemental Habitat Suitability Index Score*

Right the score that matches the range for each variable in the score column and sum for a total score. Highest score (12 total possible) comprises the best suitability of the habitat being assessed

	1	**2**	**3**	**4**	**SCORE**
Species Richness	< 1.0	1.1 – 2.0	2.1 – 3.0	> 3.0	
Effort **	< 5	6 - 20	21 - 45	> 46	
Nesting	None	< 30	n/a	> 30	
				TOTAL SCORE	

<u> Score ranges subject to habitat service. Some species will not aggregate in large concentrations, therefore adjust ranges that are acceptable for each bird group.</u>**

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Appendix E

Summary of major changes between tested protocols and Utah field methods

We tested wetland condition metrics from three protocols in order to determine appropriateness of use in Utah and to serve as a starting point for state-specific protocol development. Utah Wetlands Ambient Assessment Method (UWAAM) was recently developed for the state through adaptation primarily of methods used by California and Ohio (Hoven & Paul, 2010). The EPA developed a rapid assessment protocol (USA-RAM) used in conjunction with more detailed surveys carried out as part of the 2011 National Wetland Condition Assessment (see: www.epa.gov/wetlands/survey). Colorado Natural Heritage Program (CNHP) developed a rapid condition assessment protocol (CNHP-EIA) (Lemly & Gilligan, 2013) based on the Ecological Integrity Assessment developed by NatureServe (Faber-Langendoen et al., 2008). Metrics from these three protocols were combined into a single field form arranged by metric type, and metrics and overall field protocols were modified for clarity or to facilitate field efficiency. Wetland condition surveys were conducted at sites near Great Salt Lake and in Snake Valley, Utah using the modified protocol. In this Appendix, we outline some of the most important changes that we made to the original protocols so that our data can be understood in the context of what actually was measured rather than the intention of the original protocols. Full documentation of each metric will be developed for those metrics that are included in the final Utah Rapid Assessment Protocol (URAP).

E.1 Assessment Area and Buffer Distance

CNHP-EIA and USA-RAM use circular fixed-area assessment areas (AAs) of 40-m radius (~0.5 ha) whenever possible and rectangular or freeform assessment units of equal or smaller area if necessary due to the shape or size of the wetland being evaluated. UWAAM is designed to assess entire wetlands, up to a maximum wetland area of 2.25 ha. We used fixed-area AAs for all assessments. This choice of scale affected the degree to which we were able to evaluate UWAAM metrics and required some modification of UWAAM metrics. Fixed-area AAs are easier to compare to one another because many metrics, such as the complexity of topographic features or vegetation communities present, are scale dependent. Fixed-area AAs are also easier to evaluate in the field, both because they lessen the need to delineate exact wetland boundaries and because it can be difficult to walk throughout and remember the details of large whole-wetland AAs. Evaluations of entire wetlands, on the other hand, are useful because whole wetlands are often the unit at which mitigation, conservation, restoration, and management decisions are made. Condition metrics related to landscape immediately surrounding a wetland (buffer metrics) are more easily interpretable for whole-wetland AAs because they describe the interface between wetland and the surrounding landscape. Fixed-area AAs can be placed entirely within a wetland and thus their "buffer" can end up being wetland connected to the area under evaluation. Both methods, when used with metrics appropriate to the scale, can be used to extrapolate data to unsampled sites. Condition of fixed-area AAs can be extrapolated to describe the amount of wetland area in different condition classes, whereas whole-wetland AAs can be extrapolated to other whole wetlands in the region, potentially with wetland size and/or shape used as an explanatory covariate. The latter extrapolation is difficult to undertake if wetland boundaries have not been adequately mapped in an area.

A second issue of scale presented by this work is that each protocol has a different distance within which the buffer is evaluated. UWAAM evaluates buffer to 250 m, CNHP-EIA to 200 m, and USA-RAM to 100 m. A quick look at other well-known rapid wetland condition methods shows similar variability: 50 m for Ohio Rapid Assessment Method, 100 m for NatureServe's Ecological Integrity Assessments, and 250 m for California Rapid Assessment Method. Effective buffer distances for wetlands vary depending on the surrounding slope, the soil and vegetation composition of the buffer, and the particular function of interest. A review of wetland buffers by Castelle and others (1994) found that, depending on the study and site-specific conditions, widths between 3 and 200 m were necessary to protect wetland condition. For example, protection from adjacent feedlots was achieved with 90 m buffers when the slope was only 0.5% and 260 m with slopes of 4%. A more recent review undertaken for Minnehaha Creek Watershed District recommended buffers of between 15 to 91 m for sediment, phosphorus, pesticide, and nitrogen reduction as well as protection of wildlife habitat and associated corridors (Emmons & Olivier Resources, 2001). A meta-analysis of buffer widths found that, under low-slope conditions, buffers of 30 m in width could remove 85% of sediment, pesticides, nitrogen, and phosphorus (Zhang, Liu, Zhang, Dahlgren, & Eitzel, 2010). Land use had the largest effect on plant species community metrics in Canadian wetlands at distances between 250 to 400 m (Houlahan, Keddy, Makkay, & Findlay, 2006). We selected a buffer distance of 200 m for our initial protocol development and will work on further refinement of an appropriate distance during the development of URAP. We did score the buffer width metric according to the original protocol so that, for example, buffers with mean width >75 m were scored as the highest possible grade for USA-RAM.

E.2 Definition of Buffering Landscape

All three protocols define buffer land as natural or semi-natural land cover that is capable of playing a role in mitigating impacts to the AA from external stressors (Table E-1). However, protocols differed in the specific land cover classes considered to be buffer as well as to which land cover types were specifically mentioned (Table E-2). We therefore had to make some assumptions about what would/would not be included as buffer land cover for each protocol. We also decided to merge the EIA and USA-RAM definitions of buffers for ease of use in the field, but allowed gaps of <5 m to be ignored for USA-RAM, as specified by that protocol. Following is a list of the major change we made to buffer definitions as well as our rationale for doing so:

- We considered open water adjacent to an AA to be included as buffer for all three protocols, though UWAAM specifically declares this water not to be buffer. UWAAM's buffer definition regarding open water is taken directly from the California Rapid Assessment Protocol (CRAM, [California Wetlands Monitoring Workgroup, 2013]), which states that open water at least 30 m wide directly adjoining the AA is not considered buffer because the open water can be a source of either positive or negative influence on the wetland. It is difficult to determine whether a particular body of open water is a source of negative of positive influence, and counting open water as buffer can inflate buffer estimates. We included open water as buffer to facilitate buffer definitions in the field, though we will consider the ramifications of this as we further develop URAP.
- Recently burned land was not considered buffer by USA-RAM and not mentioned in the other protocols. However, we observed several areas that had been burned during the survey year for management reasons that had substantial return of vegetation and did not seem considerably disturbed. We considered these areas to be buffer; further refinement of when burned land should be excluded as buffer will occur as we encounter a greater variety of burned land in the field.

Table E-1. Land cover considered buffer by UGS for all three tested protocols.

Examples of buffer land covers	Examples of non-buffer land covers
• Vegetated natural and semi-natural areas including forests, grasslands, shrublands, wetlands, and old fields undergoing succession • Areas of light recreation including bike, foot, and horse trails • natural unvegetated areas including permanent snow or ice cover and natural rock outcrops or sandy and gravel areas. • Rangeland and pastures with predominantly native vegetation • Burned areas with recovering vegetation • Low or open fences, small power lines	• Lawns, sports fields, traditional golf courses • Busy streets and highway • Commercial and residential areas, developments, parking lots • High-use recreation areas, including paved and/or heavily used pedestrian or bike trials[1] • Intensive agricultural including row crops, orchards, vineyards, horse paddocks, clear-cuts • Animal feedlots, poultry ranches • Multi-rail railroads and train yards • Wind farms, oil and gas wells, mined areas

[1]Though many wetlands around Great Salt Lake are heavily used during hunting season, we did not exclude these areas as buffer unless they were associated with a land cover disturbance such as a parking area.

Table E-2. Summary of major differences in what was considered buffer by UGS based on interpretation of tested protocols. Differences are based on original protocols but often land cover types were only specifically mentioned in one of the three protocols so assumptions had to be made about what the other protocols would consider that cover type. Some cover types mentioned by the protocols are not listed if they were never encountered in the field.

Land Cover Type	**CNHP-EIA**	**USA-RAM**	**UWAAM**
Low use dirt roads	NO	NO[1]	YES
Single lane paved roads	NO	NO[1]	YES
Swales and ditches	YES if natural (not concrete) substrate	Same as CNHP-EIA[1]	YES
Links or target golf courses	NO	NO	YES[2]
Railroads (excluding multi-rail or train yards)	NO	NO	YES
Dry-land farming areas	NO	NO	YES

[1]Excluded from analysis if less than 5 m in width; otherwise followed CNHP-EIA guidelines.
[2]Links golf courses are courses in areas of coastal sand dunes or open parkland

- CNHP-EIA specifically declares pastures and rangeland with intensive grazing to be non-buffer land in their protocol. However, after further conversation with CNHP employees, it became clear that pasture areas with mostly native plant species and other areas with substantial grazing are generally considered buffer by CNHP-EIA, as are small fences that do not prevent large amount of wildlife movement. We therefore decided to consider pastures and other heavily grazed areas as buffer unless grazing left the area completely denuded of vegetation.
- CNHP-EIA specifically lists low-use dirt roads as non-buffer land. We encountered several different driven-on surfaces that we had to distinguish between, including ATV tracks, truck tracks through vegetation, frequently used dirt roads, and vegetated levees with differing amounts of driving

pressure. We generally considered a driven-on surface to be a road (and thus not buffer) if it was predominantly unvegetated and/or clearly used with some regularity. Surfaces without exposed bare ground or where bare ground was predominantly limited to tire tracks were considered buffer.

E.3 Definition of Zones within AA

At each site, we listed all of the zones within the AA and recorded ground cover and habitat data (e.g., cover of litter, bare ground, water at different depths, etc.) within each zone. Zone data were also used to evaluate the degree of interspersion within the AA, a metric present in all three tested protocols. We required each zone to be composed of individual patches ≥10 m², following the requirements of CNHP-EIA and USA-RAM, and that each zone cover at least 5% of the AA, as specified by CNHP-EIA. UWAAM did not have any listed size or area specifications for zones evaluated for the interspersion metric, though the specifications we used are similar to those found in CRAM, from which UWAAM was largely developed. Features that can be considered a unique zone included:

- Forest/Woodland (trees or shrubs >5 m tall occupying >30% cover within a patch)
- Shrubland (shrubs <5 m tall occupying >30% cover within a patch)
- Herbaceous (graminoids, forbs, or ferns dominate)
- Nonvascular (bryophytes, cryptogamic crusts dominate)
- Submerged / Floating (rooted or floating aquatics dominant, not including emergent plants)
- Sparsely Vegetated (vegetation cover <5 %)
- Open Water (unvegetated)
- Bare Ground / Rock (unvegetated)
- Natural organic debris including tree falls, flood deposits, etc.

Two areas with the same feature type (e.g., herbaceous) can be considered separate zones if each zone is dominated by a different plant species and the average height of dominant species differs between patches by >0.5 m. We had originally specified that height difference between dominants had to be 1 m, as specified by CNHP-EIA, but field work quickly indicated that important zonal distinctions occurred with smaller differences in height.

We evaluated both the number of zones present as well as the degree to which they were interspersed in order to determine interspersion at sites. Sites were also considered to have higher levels of interspersion if they had numerous physical patches present, including those patches listed in Table 22 of *Ecological Integrity Assessment for Colorado Wetlands Field Manual* (Lemly & Gilligan, 2013).

E.4 Protocol-Specific Changes

Below we detail changes between the original details of the three tested protocols and the actual field methods carried out by Utah Geological Survey (UGS). We use the unique identifiers found within each protocol to reference the metrics (e.g., UWAAM 3a refers to UWAAM's horizontal interspersion). Metrics for CNHP-EIA and UWAAM are composed of usually four statements describing potential states of the AA. We use the point value (call score by CNHP-EIA) to refer to individual statements within a metric (e.g., UWAAM 3a 6-point statement refers to “High degree of interspersion”).

E.4.1 CNHP-EIA

Many of our basic field procedures were adopted directly from CNHP-EIA. Major differences between CNHP-EIA’s field procedure and what was done by UGS include only doing vegetation sampling defined as Level 3 (entire AA) instead of Level 2 (plot-based) and only digging a single soil pit at sites instead of the minimum of two required by CNHP-EIA. Additionally, we removed language related to riparian wetlands and metrics specific only to riparian wetlands because we did not sample such wetlands.

Specific changes to the CNHP-EIA protocol are listed below.

- All checklists of stressors and adjacent land use were combined with checklists from USA-RAM. Both the extent (called the scope by CNHP-EIA) and severity of each stressor were recorded in the field. Descriptions of stressors were sometimes edited for clarity from the original wording of CNHP-EIA.
- The classifications of which land cover types that are considered buffer changed from the original protocol and are detailed in E.2 Definition of Buffering Landscape, above.
- **Metric 1e:** We changed the wording of the 5-point buffer soil condition statement from “no evidence of human visitation” to "little to no evidence of human visitation" to account for sites with very little evidence of disturbance (e.g., a hunting blind with no associated visible trails or other disturbance).
- **Metric 2b:** We considered any species listed as a noxious weed in any of the states that share a border with Utah to be a noxious weed for the sake of this metric. This includes species listed by the states of Arizona, Colorado, Idaho, Nevada, and Wyoming as well as Utah. We thought that including a broader list of species would allow us to more accurately capture species that are of concern in our region, even if those species have not been brought through the political process required to receive official designation in the state of Utah.
- **Metric 2c:** CNHP-EIA includes *Phalaris arundinacea*, *Phragmites australis*, and all *Typha* species as aggressive native species. In our data, we differentiated between *Phragmites australis* ssp. *australis*, the European genotype, from the native *Phragmites australis* ssp. *americanus.* Samples brought back from Snake Valley, Utah, were identified as the native genotype, and *Phragmites* ssp. encountered around Great Salt Lake was assumed to be non-native. Additionally, we are uncertain of the provenance of *Typha* species encountered in the field. Most is probably native, but it is possible that some is of hybrid origin or even non-native. Disregarding their nativity, we considered *Phalaris arundinacea*, *Phragmites australis* ssp. *australis*, and all *Typha* for this metric.
- **Metric 2d:** Utah has not developed state-specific coefficient of conservatism values (C-values) for plants in the state. We assigned C-values to species by taking the mean of values from three proximal states with developed values, Colorado, Montana, and Washington (which are also being used by Idaho). We then ensured that all non-native species received a C-value of 0 and that no native species were given a C-value of 0. Further development of C-values for the state of Utah will be conducted when more state wetland plant data has been collected.

- **Metric 2e:** The 1-point statement for this metric was accidently left off the datasheet. However, woody species were naturally uncommon or absent from all sites, and no site had more than 2% cover of the targeted species listed in the statement, so the omission did not affect the final data.
- **Metric 2g:** The 3-point and 1-point statements for this metric were each split into two statements, and the four resultant statements were arranged in ascending order from most litter to least litter. This allowed us to record specific information on the state of the site (i.e., is there too much or too little litter) rather than just the site condition. Each component of the split statements received the same score as the original statement would have.
- **Metric 2h:** See E.3 Definition of Zones within AA, above, for a description of how we determined which features constituted zones for the sake of interspersion.
- **Metric 3a:** We only evaluated water source for those sites where >75% of their water did not come from managed ditches. This metric focuses on the method of water conveyance, not water quality, and all water that comes from a managed ditch is entirely from an anthropogenic source. Upon further discussion with personnel at CNHP-EAI, we realized that they take into account additional factors, such as whether a site is connected to its natural water source, even if that water source is now conveyed by a non-natural means. A site that receives water from a managed ditch that in turn receives water from the Bear River should therefore score higher than a site that receives water from urban run-off or agricultural return flows in an area that historically would not have received any water. In the office, we assigned all sites a score of 3 if we did not record data for the site in the field, with the assumption that these sites received over 75 percent of their water from managed canals that were connected to their original water source. This scoring is obviously imperfect; more detailed scoring will occur when sites are rescored as part of URAP development.
- **Metric 3b:** We split the hydroperiod metric into two separate metrics on the field form, one each for natural and managed systems. This led to quicker evaluation in the field, though final scoring combined the descriptors back into their original scoring categories.
- **Metric 3c:** We evaluated the degree of connectivity between each AA and the surrounding area 200 m from the site. Upon further conversation with CNHP-EIA, we realized that connectivity actually refers only to the direct edge of the AA. We believe there is a need for looking at both the immediate and larger-scale connectivity and this metric will be further developed for URAP.
- **Metric 5a:** We added a new statement to the ratings for relative size: "Wetland created in area where similar wetland most likely did not previously exist" in order to address constructed wetlands. We did not assign a point value for this statement. We generally had a lack of confidence in our ability to rate this metric. Because this metric is not used in the final CNHP-EIA scoring algorithm, we did not make an effort to calibrate or further develop this metric.
- **Metric 5b:** We sometimes made notes in the field for this metric, but did not conduct an office-based spatial analysis to determine absolute wetland size. This metric is not used in the CNHP-EIA scoring algorithm.

E.4.2 USA-RAM

Specific changes to the USA-RAM protocol are listed below.

- All metrics that consisted of checklists of stressors were combined with checklists from CNHP-EIA and often divided into new list categories. Both the extent (area covered by impact) and severity (degree of impact) of each stressor were recorded in the field (note that in USA-RAM, severity can indicate either area covered or degree of impact, depending on the metric, but we used the terms extent and severity in a consistent manner to avoid confusion). Descriptions of stressors were sometimes edited for clarity from the original wording. We only used those stressors listed by USA-RAM or modified from the original USA-RAM when tabulating USA-RAM scores. We used CNHP-EIA extent classes instead of the aerial cover classes used by USA-RAM. Extents of 1 or 2 (≤25%) were considered a USA-RAM extent of 1 (<33), extents of 3 or 4 (>25-≤75) were considered a USA-RAM extent of 2 (≥33-<67%) and an extent of 5 (>75%) was considered a USA-RAM extent of 3 (≥67%).
- The definition of land cover types that are considered buffer and the buffer width evaluated changed from the original protocol and are detailed in E.1 Assessment Area and Buffer Distance and E.2 Definition of Buffering Landscape, above.
- **Metric 3.** We evaluated buffer stressors predominantly through examination of aerial imagery in the field instead of walking on transects established in the four cardinal directions. We marked unidentifiable or uncertain features on the map and examined them at closer detail before making final assessments.
- **Metric 4:** The list of topographic features was rearranged to correspond more closely with UWAAM's list of topographic features, including in some cases splitting features into two separate categories. We also determined whether features occupied at least one, two, or three square meters of area and specified that plant hummocks or tussocks had to be natural in origin. For final USA-RAM scoring, we included only those features listed in USA-RAM covering at least 2 m^2, being certain not to count any split feature twice.
- **Metric 5:** See E.3 Definition of Zones within AA, above, for a description of how we determined which features constituted zones for the sake of interspersion.
- **Metric 6:** We recorded data on species height and cover in the field. In the office, we assigned each recorded species as belonging to one of the following strata: submerged, floating, emergent, woody, or vines, based on designations in the USDA Plants Database (http://plants.usda.gov) or observations obtained in the field. We considered all forb and graminoid species to be emergent. Emergent and woody species at each site were then classified as either tall or short using species height data recorded in the field. Woody species >5 m in height and emergent species >0.5 m in height were considered tall.
- **Metric 7:** We did not have exact cover estimates for each plant species in the AA; instead, we recorded cover class values. We used the mid-point of each cover class to determine which species had at least 10% relative cover within their strata.
- **Metric 11:** We included any species listed in *Appendix B: Target Invasive Alien Plant Species* of the National Wetlands Condition Assessment Field Operations Manual (http://water.epa.gov/type/wetlands/assessment/survey) as a species included in the calculation of

this metric. However, we differentiated between the introduced *Phragmites australis* ssp. *australis* and the native *Phragmites australis* ssp. *americanus* and only included the former in the calculation.

E.4.3 UWAAM

Many UWAAM metrics needed to be modified to reflect the fact that we evaluated fixed-area instead of whole-wetland AAs. Metrics could have either been calibrated for the usually smaller AAs or redefined to encompass some of the surrounding landscape; we used the second approach. Many UWAAM metrics assigned playas, mineral and alkaline flats, and wetlands managed for wildlife habitat the highest possible score despite deviation from the expected condition. We instead scored sites based on the condition noted in the field. We decided it would be better to either not evaluate or to recalibrate some metrics for certain types of wetlands rather than artificially inflate wetland scores for entire classes of wetlands. Specific changes to the UWAAM protocol are listed below.

- The definition of land cover types that are considered buffer and the buffer width evaluated changed from the original protocol and are detailed in E.1 Assessment Area and Buffer Distance and E.2 Definition of Buffering Landscape, above.
- **Metric 1c:** We evaluated buffer soil and vegetation condition separately in the field using only CNHP-EIA's buffer condition metric. Each statement in UWAAM's buffer condition metric was composed of a vegetation component and a soil and human visitation component that were similar to the respective components of CNHP-EIA's buffer condition soil and vegetation metrics. We assigned the statement associated with each component of CNHP-EIA's buffer condition metric a number based on its rank so, for example, the 5-point statement was assigned a one and the 1-point statement was assigned a four. We then calculated the mean overall rank based on the values assigned to the soil and vegetation components. Mean ranks were then used to assign point values for UWAAM's buffer condition. Cut-offs in mean ranks between 6 and 5 points, 5 and 3 points, and 3 and 1 points were, respectively, 1, 2, and 3. For example, a site that scored an A for buffer soil and a B for buffer vegetation would receive an overall condition score for UWAAM of B, weighing the importance of the lower score somewhat more highly.
- **Metric 2a:** We divided the water source metric into two separate metrics in the field, one related specifically to water quality and the other to the presence of hydrologic modifications. Since water quality is difficult to determine in the field, we added language to the metric that indicators of poor water quality, such as large amounts of filamentous algae, can also be used to make a judgment regarding water quality. We also removed the language in the metric that allows a site to be scored as the highest category despite hydrologic alterations if the site is managed for wildlife habitat objectives. We scored each component using the scoring established by UWAAM, and then used the mean score as the final site score for this metric.
- **Metric 2b:** The 3-point statement in this metric was split into two components, with each component still receiving a score of 3 points. We also changed the language of the statement for clarity, adopting language from a similar metric in CRAM. We removed language from this metric that allowed sites managed for wildlife objectives to receive the top score.
- **Metric 2c:** This metric was removed from analysis. The metric is difficult to score because statements are not mutually exclusive. Furthermore, the metric is based on a similar metric in

ORAM that was intended to quantify ecological services rather than evaluate condition and allowed for selection of multiple statements.

- **Metric 2d:** We only used the CNHP-EIA metric to collect data on connectivity, though descriptions were similar between protocols. We removed language from this metric's evaluation allowing sites managed for wildlife habitat objectives to automatically receive the highest possible score. We also evaluated connectivity in a buffer 200-m from sites instead of immediately adjacent to sites' edges. We believe there is a need for looking at both immediate and larger-scale connectivity, and this metric will be further developed for URAP.
- **Metric 3a:** See E.3 Definition of Zones within AA, above, for a description of how we determined which features constituted zones for the sake of interspersion. In addition, we removed language allowing playas and alkaline or mineral flats to receive the highest score (though we did not sample any of these wetland types).
- **Metric 3b:** UWAAM documentation lacked any clear explanation of what is supposed to be considered a vegetation layer for this metric. We used a definition similar to that found in CRAM, where each layer must occupy 5% of suitable habitat and height differences between layers are specified. Layers we used included submerged/floating, short (<0.5 m), medium (0.5-0.75 m), tall (0.75-1.5 m), and very tall (>1.5 m). These thresholds were adapted from CRAM's thresholds for depressional and slope wetlands. In addition, we only included entrained litter capable of being used by wildlife as a layer for this metric and excluded dead standing stock and other detritus.
- **Metric 3c:** The list of topographic features was rearranged to correspond more closely with USA-RAM's list of topographic features, including in some cases splitting features into two separate categories. We also determined whether features occupied at least one, two, or three square meters of area and specified that plant hummocks or tussocks had to be natural in origin. UWAAM specified a minimum patch size for each feature; we changed the metric by requiring patches to instead cover that minimum amount of area across the entire AA. This made it easier to consider certain features, such as burrows, that are never individually 3 m^2 in size. UWAAM scores topographic complexity differently for different wetland types. To determine wetland type, we first assigned all sites with HGM slope as seep or spring wetland. Of the remaining sites, those with an Ecological System of Western North American Emergent Marsh were considered Palustrine Emergent Marsh and the remaining were all classified as Vegetated Depression. We then scored all sites based on the required topographic features and patch sizes in the UWAM protocol for the given wetland types, being certain not to count any split feature twice.
- **Metric 3d:** We added additional wording to this metric to allow sites to score relatively well despite the presence of current alterations. As an example, a phrase was added to the 5-point statement that said, "…and/or current stressors are on-going and noticeable but overall impact is low."
- **Metric 4a:** We added percent cover values in parenthesis following the words high, good, some, and low in the metric statements in accordance with how these terms are defined by UWAAM.
- **Metric 4b:** See *4.3.1 Metric 4b: Plant Layers and Richness*, below, for an in-depth discussion of how scores for this metric were calculated.
- **Metric 5a:** Data on the presence of water is evaluated within the AA for UWAAM; however, UWAAM uses whole-wetland instead of fixed-area AAs. We scored this metric in an area outside the

AA in order to more accurately reflect UWAAM's original intention. We first consolidated the list of water features so that features (e.g., wet mudflats) were not counted more than once. We then calculated cover of water features separately for the AA and for the area encompassed by the AA plus 200-m. For the AA plus buffer calculation, we summed the percent cover (as the mid-point of each cover class) for mudflats, shallow water, moderate water, water under emergent vegetation, deep pools, and shallowly flooded shelves on NW shore. This essentially includes everything on UWAAM's list of features except for "shallow water fishery," which was not recorded, and "permanent water source with a variety of emergent, floating, and submergent vegetation," which is too vague to specifically tabulate. We multiplied the resultant value by two to reflect the fact that these scores were originally intended only for the entire wetland area and not necessarily everything in a 200 m buffer around a site. For the AA-only calculation, we summed the percent cover of extremely shallow and shallow water, water under emergent vegetation, and open water because these were the only relevant water features recorded at this scale. We then scored sites based on the maximum value of the AA plus buffer and AA only calculations.

- **Metric 5b:** Data on most ecological services listed in the UWAAM protocol were collected as part of our data collection for features indicating presence of water. We used this data, collected within the AA and surrounding 200 m buffer, to determine the presence of each key ecological service. For the ecological service category of alkali, Olney's, or hardstem bulrush; cattail; or hemi-marsh, we determined if listed species were present on our list of species found in the AA. We did not collect data on the presence of hemi-marsh and thus did not evaluate this component of the service. We also did not evaluate the ecological service of water rights associated with sites. Because we removed a service from the list of services, we subtracted one from the number of services required to obtain each score (e.g.; sites received 7 points if they had at least four services instead of five).
- **Metric 5c:** We separately recorded whether threats were located in the AA or in the 500 m buffer surrounding the AA and included either threat type in scoring. Threats associated with water development and/or oil and gas exploration were not tabulated. UWAAM does not assign threats to A, B, C, and D categories but does specify that two points will be subtracted from the final score for each threat present. In order to present summary data in the report, we assigned sites with no threats to A, one threat to B, and two threats to C. No site had more than two threats listed.

4.3.1 Metric 4b: Plant Layers and Richness

The exact definition of a plant layer for the Plant Layers and Species Richness metric was somewhat unclear in the UWAAM documentation. Plant layers are defined by height classes, but there is no explanation as to how much of the assessment area a layer has to cover to be considered a layer, nor is there a definition for layers beyond the height thresholds. This metric is primarily adapted from CRAM, which states that each plant layer has to cover "at least 5% of the portion of the AA *that is suitable for the layer.*" Unfortunately, while we have data on both the presence of different plant layers and on individual plant species cover and height, we do not have data making it clear in which plant layer(s) individual species were found. For example, a short plant may be found intermixed in a tall vegetation layer or may be a component of a short plant layer. Furthermore, the height thresholds used to define plant layers differ from the height data we collected for each plant and both differ from the heights used in UWAAM to define plant layers. Another issue with this metric is that UWAAM intended data collection to occur over an entire wetland rather than within a fixed area. The calculation for this metric is therefore quite inexact, because of both our data limitations and the lack of clarity in the metric description in the UWAAM documentation.

We compared three methods for determining the number of layers present at a site: counting the number of layers checked in the field, counting the number of layers recorded in the species data, and counting only those layers with at least 2.5% species cover. We compared two methods for determining the species richness of co-dominant species: counting the number of species with at least 10% relative cover in the layer they were found in across all layers, and counting the number of species with at least 10% relative cover for only those species in layers with at least 2.5% cover in the AA. Looking at only those plant layers checked in the field only changed the status of one site and was not further considered. Fourteen sites met plant layer and richness conditions regardless of whether there was a cut-off for the percent cover of a particular layer, three additional sites met the conditions if a threshold was established, and five additional sites met the conditions if there was no threshold. We decided to use the threshold of 2.5% cover because of the assumed greater similarity to the CRAM protocol that we believe this metric was adapted from.

Sites must be coded as saline or fresh for the sake of this metric. We called sites freshwater if they had a salinity ≤7.5 dS electroconductivity (EC), based on thresholds suggested by Keate (2005). We were not able to collect EC data at sites when the readings were out of range for the water quality meters; we assumed these sites were saline as well. The remaining sites did not have any water quality data because no water was accessible at the sites at the time of sampling. One of these sites was at Snake Valley; for this site, we declared it fresh because all of the other sites in Snake Valley were fresh. For the remaining sites around Great Salt Lake (n=16), we determined their likely status based on their position in their landscape and comparison with known sites. Freshwater versus saline designation never appeared to be the deciding factor preventing sites from meeting plant community composition values for those sites where the designation was uncertain.

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Appendix F

Utah field forms and reference cards

Reviewed (initials):	*Review Date:*	*Data entry initials:*	*Entry Date:*

URAP_2013TEST	*version 2.2*

GENERAL INFORMATION: *THIS FORM SHOULD BE FILLED OUT WHETHER THE SITE IS RETAINED IN THE SAMPLE OR NOT*

Original Site ID:		**Date (*mm/dd/yyyy*):**	
Site Name:			
Crew Lead:		**Additional Crew:**	

SITE LOCATION AND DIRECTIONS

General Location:		**County:**	
General Ownership:		**Specific Ownership:**	
Contact Information and Directions:			

Need Return Visit ? Y N **Return Visit Comments:**	**General Site Notes:**

Mark unclear features on the aerial imagery with a unique identifier (A, B, C, etc.) and describe below.

Checklist of items to do before leaving site

☐ Remove flagging

☐ Double check that you have all field equipment

☐ Collect all unknown plant species

☐ Collect water quality data:

☐ Other: ____

☐ Other: ____

☐ Other:____

GPS Coordinates of Target Point and Assessment Area (NAD 83 UTM Zone12)

Dimensions of AA: **____40m Radius Circle** **____Rectangle, width_____, length_____** **____Freeform, describe and collect GPS track of edge**	**Elevation (m):** **Slope (deg): _____________ OR Flat** **Aspect (deg): _____________ OR Flat**

Circle Only: AA-Center WP#:_______ UTM E:___ ___ ___ ___ ___ ___ UTM N: ___ ___ ___ ___ ___ ___ ___ Error (+/-)__________

Rectangle:

AA-1 WP#:_______ UTM E:___ ___ ___ ___ ___ ___ UTM N: ___ ___ ___ ___ ___ ___ ___ Error (+/-)__________

AA-2 WP#:_______ UTM E:___ ___ ___ ___ ___ ___ UTM N: ___ ___ ___ ___ ___ ___ ___ Error (+/-)__________

AA-3 WP#:_______ UTM E:___ ___ ___ ___ ___ ___ UTM N: ___ ___ ___ ___ ___ ___ ___ Error (+/-)__________

AA-4 WP#:_______ UTM E:___ ___ ___ ___ ___ ___ UTM N: ___ ___ ___ ___ ___ ___ ___ Error (+/-)__________

Freeform:

AA-Track Track Name:________________________________ Area:_________________________________

AA Placement and Dimension Comments:

Photos of Assessment Area (same as waypoints for circular AAs)

WP #:_________ Aspect:_________ AA-1 Photo #: ______ UTM E:___ ___ ___ ___ ___ ___ UTM N: ___ ___ ___ ___ ___ ___ ___ Error (+/-)____

WP #:_________ Aspect:_________ AA-1 Photo #: ______ UTM E:___ ___ ___ ___ ___ ___ UTM N: ___ ___ ___ ___ ___ ___ ___ Error (+/-)____

WP #:_________ Aspect:_________ AA-1 Photo #: ______ UTM E:___ ___ ___ ___ ___ ___ UTM N: ___ ___ ___ ___ ___ ___ ___ Error (+/-)____

WP #:_________ Aspect:_________ AA-1 Photo #: ______ UTM E:___ ___ ___ ___ ___ ___ UTM N: ___ ___ ___ ___ ___ ___ ___ Error (+/-)____

Additional Photos and Photo Comments (Include overview photo if possible):

Photo #____________ Description:____ WP#______________ Aspect:____________

Photo #____________ Description:____ WP#______________ Aspect:____________

Photo #____________ Description:____ WP#______________ Aspect:____________

Photo #____________ Description:____ WP#______________ Aspect:____________

Photo #____________ Description:____ WP#______________ Aspect:____________

ENVIRONMENTAL DESCRIPTION AND CLASSIFICATION OF ASSESSMENT AREA

Non-target Inclusions % AA with > 1m standing water: ______________ % AA with upland inclusions: _________________	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

Cowardin Classification(pick *one each*) Fidelity: High Med Low System and Class: Water Regime: Modifier (optional): ____ PEM ____ PAB ____ A ____ F ____ b ____ h ____ PSS ____ PUB ____ B ____ G ____ x ____ f ____ PFO ____ PUS ____ C ____H ____ d	HGM Class (pick *only one*) Fidelity: High Med Low ____Riverine* ____Lacustrine Fringe ____Depressional ____ Slope ____ Flats ____ Novel (Irrigation-Fed) **Specific classification and metrics apply to the Riverine HGM Class*

ENVIRONMENTAL AND CLASSIFICATION COMMENTS

Classification Issues (important for sites with low fidelity to one or more classification systems):

AA REPRESENTATIVENESS
Is AA the entire wetland? ___ Yes ___ No If no, is AA representative of larger wetland? ___ Yes ___ No Provide comments:
Optional Note wildlife species observed

MAJOR ZONES WITHIN THE ASSESSMENT AREA (See manual for rules and definitions. Mark each zone on the site sketch.)
Individual patches must be ≥10 m² (approximately 3.2 m x 3.2 m) in size and each patch type must cover at least 5% of the AA (e.g. 250 m² for an AA of 0.5 ha). Plants in same physiognomic class must differ in mean height by at least 0.5 m

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: ______

A. Landscape and Buffer Evaluation

A1. Estimate % of AA surrounded by buffer	EIA-1c	USARAM-1	UWAAM-1a
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.			
FLAG	Comments:		

A2 & A3. Estimate buffer width (m) up to 200 m and percent of 500 m area surrounded by aquatic features using 8 transect lines

Transect	A2. EIA -1d (width- m)	A2. USARAM-2 (width- m)	A2. UWAAM-1b (width- m)	A3. UWAAM-2e (%) 500 m
N				
NE				
E				
SE				
S				
SW				
W				
NW				
FLAG	Comments:			

A4. Record the extent of the following stressors if present in a 200-m area (buffer and non-buffer) around AA.
EIA extent classes: 0= 0%, 1 = 1–10%, 2 = >10–25%, 3 = >25–50%, 4 = >50–75%, 5 =>75%. Severity 1: Not severe 2: Moderate 3: Severe

Stressor	Extent	Severity
Hydrologic Stressors		
Dikes/dams/levees/ railroad or road beds	0 or _____________	
Point source inputs (discharge from wastewater plants, factories, etc.)	0 or _____________	
Water level control structure	0 or _____________	
Obvious spills, discharges or odors; unusual water color or foam	0 or _____________	
Moderate to heavy formation of filamentous algae	0 or _____________	
Excavation, dredging	0 or _____________	
Fill / spoil banks	0 or _____________	
Wall/riprap	0 or _____________	
Inlets and outlets	0 or _____________	
Direct input from impervious surface (not through pipes, culverts)	0 or _____________	
EIA extent classes: 0= 0%, 1 = 1–10%, 2 = >10–25%, 3 = >25–50%, 4 = >50–75%, 5 =>75%. Severity 1: Not severe 2: Moderate 3: Severe		

	Extent	Severity
Stormwater inputs via discharge pipes, culverts, sewer outfalls)	0 or _____________	
Direct discharges from feedlot manure pits, etc.	0 or _____________	
Direct discharges from septic or sewage systems	0 or _____________	
Direct application of fertilizer	0 or _____________	
Agricultural runoff (drain tiles, etc. discharging to site)	0 or _____________	
Habitat/Vegetation Stressors		
Soil subsidence, scour or surface erosion (root exposure)	0 or _____________	
Substrate disturbance (ATVs off-road vehicles, mountain biking)	0 or _____________	
Sediment input (construction, erosion, agricultural runoff)	0 or _____________	
Forest - selective cut	0 or _____________	
Forest - clear cut	0 or _____________	
Removal of large woody debris	0 or _____________	
Tree plantation present	0 or _____________	
Heavily grazed grasses, excessive grazing	0 or _____________	
Trampling, pugging, soil disturbance from grazing	0 or _____________	
Tree canopy herbivory	0 or _____________	
Shrub layer browsed	0 or _____________	
Fire lines (fire breaks)	0 or _____________	
Recently burned forest canopy	0 or _____________	
Recently burned grassland	0 or _____________	
Shrub cutting (brush hogging)	0 or _____________	
Mowing	0 or _____________	
Other mechanical plant removal	0 or _____________	
Chemical vegetation control (herbicide application)	0 or _____________	
Cover of non-native or invasive species	0 or _____________	
Presence of power lines or utility corridors (continual maintenance)	0 or _____________	
Oil/gas wells	0 or _____________	
Logging roads	0 or _____________	
Trails	0 or _____________	
Residential/Urban/Commercial Stressors		
Suburban residential land use	0 or _____________	
Urban multifamily land use	0 or _____________	
Urban/commercial buildings	0 or _____________	
Abandoned dwelling	0 or _____________	
Road – gravel	0 or _____________	
Road – 1 or 2 lane paved	0 or _____________	
Road- 4 lane	0 or _____________	
Parking lot/ pavement	0 or _____________	
Lawn/ park	0 or _____________	
Golf course	0 or _____________	
Landfill	0 or _____________	
Gravel pit/mining	0 or _____________	
Surface mine	0 or _____________	
Military land	0 or _____________	
Trash/ dumping	0 or _____________	
Agricultural Stressors		
Pasture / rangeland	0 or _____________	
Row crops	0 or _____________	
Small grains	0 or _____________	
Nursery	0 or _____________	
Orchard	0 or _____________	
Dairy	0 or _____________	
Confined animal feeding operations	0 or _____________	
Irrigation (irrigated land)	0 or _____________	
Fallow field – recent	0 or _____________	
Fallow field – old	0 or _____________	
Rural residential	0 or _____________	

FLAG	Comments:

A5. Presence of habitat features. List extent of the following features in AA *and* 200 m buffer around AA Extent classes: 0= 0%, 1 = 1–10%, 2 = >10–25%, 3 = >25–50%, 4 = >50–75%, 5 = >75%.	
Feature	**Extent**
Mudflat	
Shallow water < 5 cm	
Moderate water 5- 20 cm	
Open water < 1 m with potential for open sunlight	
Deep pools >1 m	
Water under emergent vegetation	
Shallowly flooded shelves under which fish and amphibians can take thermal refuge	
Shallowly flooded shelves **on the NW shore** under which fish and amphibians can take thermal refuge	
Aquatic bed	
Salicornia flat	
Wet meadow	
Marsh	
Fen	
Shrub wetland/riparian complex	
Natural uplands near wetlands	
Other:	
Other:	
FLAG	Comments:

A6. Buffer Condition: Select one statement from each of the following columns that indicates the condition of the 200 m buffer. Only evaluate those lands actually considered buffer if buffer is present. If no buffer land is present, evaluate for non-buffer land.

Evaluated for: ☐ Buffer land ☐ Non-buffer land (only should be done when no buffer land exists)

EIA- Vegetation		**EIA- Soil**	
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 little to no evidence of human visitation.	
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, 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, 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, OR no buffer exists.	
FLAG	Comments:		

A7. Estimate the extent of different land uses within a 500 m envelope around the AA primarily using imagery. Extent classes: 0= 0%, 1 = 1–10%, 2 = >10–25%, 3 = >25–50%, 4 = >50–75%, 5 = >75%.	
Landscape Stressors/Land use categories	**Extent**
Paved roads, parking lots, railroad tracks	0 or ______
Unpaved roads (e.g., driveway, tractor trail, 4-wheel drive roads)	0 or ______
Domestic or commercially developed buildings	0 or ______
Intensively managed golf courses, sports fields, urban parks, expansive lawns	0 or ______
Gravel pit operation, open pit mining, strip mining	0 or ______
Mining (other than gravel, open pit, and strip mining), abandoned mines	0 or ______
Resource extraction (oil and gas wells and surrounding footprint)	0 or ______
Dam sites and flood disturbed shorelines around water storage reservoirs	0 or ______
Agriculture – tilled crop production	0 or ______
Agriculture – permanent crop (hay pasture, vineyard, orchard, tree plantation)	0 or ______
Vegetation conversion (chaining, cabling, rotochopping, or clear-cutting of vegetation)	0 or ______
Logging or tree removal with 50-75% of trees >50 cm dbh removed	0 or ______
Selective logging or tree removal with <50% of trees >50 cm dbh removed	0 or ______
Heavy grazing/browse by livestock or native ungulates	0 or ______

Extent classes: 0= 0%, 1 = 1–10%, 2 = >10–25%, 3 = >25–50%, 4 = >50–75%, 5 = >75%.	
Moderate grazing/browse by livestock or native ungulates	0 or ______
Light grazing/browse by livestock or native ungulates	0 or ______
Intense recreation or human visitation (ATV use / camping / popular fishing spot, etc.)	0 or ______
Moderate recreation or human visitation (high-use trail)	0 or ______
Light recreation or human visitation (low-use trail)	0 or ______
Recent old fields and other fallow lands dominated by non-native species (weeds or hay grasses)	0 or ______
CRP lands (grasslands planted with a mix of native and non-native species)	0 or ______
Haying of native grassland (not dominated by non-native hay grasses)	0 or ______
Beetle-killed conifers	0 or ______
Evidence of recent fire (<5 years old, still very apparent on vegetation, little regrowth)	0 or ______
Other:	0 or ______
Other:	0 or ______
FLAG	Comments:

A8. Fragmentation: Estimate largest unfragmented area in 500 m buffer around AA	EIA-1a
Unfragmented area composed of: ☐ buffer land only ☐ non-buffer land that may still allow for wildlife connectivity (e.g. heavily grazed rangeland)	
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.	
FLAG	Comments:

B. Plant Community Evaluation

B1. Litter Accumulation: Select the most appropriate statement for the AA.	
AA characterized by moderate amount of herbaceous and/or deciduous leaf litter. New growth is more prevalent than previous years'. Litter and duff layers in pools and topographic lows are thin. Organic matter is neither lacking nor excessive.	
Litter is extensive and limiting new growth.	
AA is characterized by somewhat excessive litter	
AA characterized by small amounts of litter with little plant recruitment	
AA lacks litter	
FLAG	Comments:

B2. Plant Layers: Check of all vegetation layers occupying at least 5% of available area within AA.

	Submerged/ Floating	Short	Medium	Tall	Very Tall
CRAM def.	Presence	<0.5 m	0.5- 0.75 m	0.75- 1.5 m	> 1.5 m
Check if present					
FLAG	Comments:				

B3. Vertical Biotic Structure: Assess overlap between layers, including all layers listed above as well as entrained litter.	
> 50 % of the vegetated area of the AA supports three or more overlapping plant layers	
> 50 % of the vegetated area of the AA supports at least two overlapping plant layers	
25 – 50 % of the vegetated area of the AA supports at least two overlapping plant layers, **or** three plant layers are well represented in the AA but there is little or no overlap.	
<25 % of the vegetated area supports at least two overlapping plant layers, **or** two layers are well represented with little or no overlap, **or** AA is sparsely vegetated..	
FLAG	Comments:

B7. Plant Community Condition: Use species list to select one of the statement below, looking at relative plant cover in AA.	
Excellent: No invasive non-natives, high (≥95%) representation / percentage cover of native specie(s) you expect to occur	
Good: Good (76-94%) representation / percentage cover of native specie(s) you expect to occur, some (6-20%) or low (≤5%) percentage of introduced species, and/or low (≤5%) percentage invasive native or non-native species	
Fair: Some (50- 75%) representation / percentage cover of native specie(s) you expect to occur, some or moderate (21-60 %) percentage of introduced species, low or moderate (6-60 %) percentage of invasive native or non-native species.	
Poor: Low (<50%) representation / percentage cover of native specie(s) you expect to occur, moderate (21-60%) or high (>60%) percentage of introduced species, moderate (21-60%) or high (>60%) percentage of invasive native or non-native species	
FLAG	Comments:

C. Stressors and Physical Habitat Evaluation

C1. Evaluate the following stressors to ***vegetation*** in the AA. **Severity : 1= Not Severe, 2= Moderately severe or 3 = Severe. Extent: 1 = 1–10%, 2 = >10–25%, 3 = >25–50%, 4 = >50–75%, 5 = >75%**

Stressor	**Severity**	**Extent**
Human Use and/or Management	0 1 2 3	
Mowing within AA (or at AA margin)	0 1 2 3	
Forest - selective cut	0 1 2 3	
Forest - clear cut	0 1 2 3	
Prominent removal of large woody debris	0 1 2 3	
Mechanical plant removal besides tree cutting or woody debris removal	0 1 2 3	
Haying	0 1 2 3	
Evidence of planting of non-native vegetation	0 1 2 3	
Chemical vegetation control (herbicide application, defoliant use)	0 1 2 3	
Farming (recent plowing, disking, etc.)	0 1 2 3	
Haying of native grassland (not dominated by non-native hay grasses)	0 1 2 3	
Unpaved Roads (e.g., driveway, tractor trail, 4-wheel drive roads)	0 1 2 3	
Recreation/human visitation	0 1 2 3	
Excessive Grazing or Herbivory	0 1 2 3	
Grazing by domestic or feral animals (cows, sheep, pigs, etc.)	0 1 2 3	
Excessive wildlife herbivory (deer, muskrat, geese, carp, beaver, etc.)	0 1 2 3	
Excessive insect herbivory of tree canopy, shrub stratum	0 1 2 3	
Fire	0 1 2 3	
Evidence of intentional burning at AA margin or in AA	0 1 2 3	
Evidence of recent fire (<5 years old), not known to be intentional	0 1 2 3	
Fire lines (fire breaks)	0 1 2 3	

FLAG	Comments:

C2. Evaluate the following stressors to ***physical habitat*** within the AA.

Soil subsidence, scour or surface erosion (root exposure, etc.)	0 1 2 3	
Erosion	0 1 2 3	
Off-road vehicles, mountain biking, trails cut, etc.	0 1 2 3	
Inorganic sedimentation inflow (sediment accumulation around vegetation, deep sediment splays, recent vegetation burial, etc.)	0 1 2 3	
Dredging or other prominent excavation at AA margin or in AA	0 1 2 3	
Grazing by domesticated/ feral animals in AA (e.g. trampling, digging, wallowing)	0 1 2 3	
Grazing by native ungulates (compaction, soil disturbance)	0 1 2 3	
Recent farming activity (plowing, disking, etc.)	0 1 2 3	
Historical plowing/disking (evident by abrupt A horizon boundary at plow depth)	0 1 2 3	
Soil compaction by human activity (parking by cars, heavy machinery, etc.)	0 1 2 3	
Filling, grading, or other prominent deposition of sediment	0 1 2 3	
Dumping of garbage or other debris	0 1 2 3	
Mechanical plant removal that disturbs substrate (rutting, grubbing by heavy machinery, etc.)	0 1 2 3	
Fire lines (fire breaks) dug in AA or at AA margin	0 1 2 3	

FLAG	Comments

C3. Soil disturbance: Use stressor checklists from above to help in evaluation of soil disturbance in AA	
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.	
Minimal soil disturbance within AA. Some amount of bare soil, pugging, compaction, or sedimentation present due to human causes, but extent and impact are minimal. The depth of disturbance is limited to only a few inches and does not show evidence of altering hydrology. Any disturbance is likely to recover within a few years after disturbance is removed.	
Moderate soil disturbance within AA. Bare soil areas due to human causes are common and will be slow to recover. There may be pugging due to livestock resulting in several inches of soil disturbance. ORVs or other machinery may have left some shallow ruts. Sedimentation may be filling the wetland. Damage is obvious, but not excessive. The site could recover to potential with the removal of degrading human influences and moderate recovery times.	
Substantial soil disturbance within AA. Bare soil areas substantially degrade the site and have led to altered hydrology or other long lasting impacts. Deep ruts from ORVs or machinery may be present, or livestock pugging and/or trails are widespread. Sedimentation may have severely impacted the hydrology. The site will not recover without active restoration and/or long recovery times.	
FLAG	Comments:

C4. Physical/Vegetation Alteration: Select statement that describes degree of physical intactness of AA based on stressors noted above. You may select the highest category even if stressors are present if severity is low.	
None or none apparent: there are no alterations or none that are apparent to the evaluator, current alterations are so minor that no impact is noted.	
Recovered: Wetland appears to have recovered from past alterations but alterations are still evident, and/or current stressors are on-going and noticeable, but overall impact is low	
Recovering: The wetland appears to be in the process of recovering from past alterations , and/or current disturbance is on-going and noticeable with a moderate impact	
Recent alteration or no recovery: The wetland has not recovered from past alterations, and/or the alterations are recent or on-going with noticeable high impact.	
FLAG	Comments:

C5. Interspersion: Patches for USARAM and EIA are the same and include both physical and vegetation patches; only consider vegetation patches for UWAAM. Individual patches must be ≥10 m² (approximately 3.2 m x 3.2 m) in size and each patch type must cover at least 5% of the AA (e.g. 250 m² for an AA of 0.5 ha). See Interspersion Reference Cards 1 and 2.			
UWAAM		**EIA/USARAM**	
high degree of interspersion		High degree of horizontal interspersion: AA characterized by a very complex array of nested or interspersed zones with no single dominant zone. (Row 4)	
moderate degree of interspersion		Moderate degree of horizontal interspersion: AA characterized by a moderate array of nested or interspersed zones with no single dominant zone. (Row 3)	
low degree of interspersion		Low degree of horizontal interspersion: AA characterized by a simple array of nested or interspersed zones. One zone may dominate others. (Row 2)	
No interspersion		No horizontal interspersion: AA characterized by one dominant zone. (Row 1)	
FLAG	Comments:		

C6. Topographic Complexity- Indicate the maximum area covered by each patch type within the Assessment Area or check None if not present in AA					
Patch Type	**source**	**None**	**1m²**	**2 m²**	**3 m²**
Pannes or pools on floodplain or along shoreline- pools lacking or with limited vegetation that fill with water seasonally and exist on well-vegetated wetland plain[A]	both				
Potholes (< 3 m wide), sink holes or similar depressions not caused by animals and not as above[A]	USARAM				
Animal tracks deep enough to hold water (e.g., cattle or elk tracks)	USARAM				
Natural or artificial debris or wrack along high water lines[B]	both				
Natural or artificial debris in topographic low areas[B]	both				
Natural or artificial debris dispersed across AA (tree limbs, lumber, etc.)	USARAM				
Bare ground	USARAM				
Plant hummocks or tussocks- must be naturally created[C]	both				
Inorganic sediment mounds not made by animals (must be < 2 m tall and <5 m wide) [C]	both				
Animal burrows or spoil piles from burrows (e.g. ant/ termite mounds)	both				
Variegated, convoluted, or crenulated foreshore (instead of broadly arcuate or mostly straight)	UWAAM				
Multiple high water marks etched in substrate	both				
Filamentous macroalgae or algal mats	UWAAM				
Submerged vegetation	UWAAM				
Soil cracks or fissures (>2.5 cm and <1m deep)	both				
Wallows, pig damage, or similar scale excavations by animals	USARAM				
Natural or artificial swales- broad, elongated, vegetated depressions that lack obvious banks and other characteristics of channels, though they may help to convey flood flows in wetlands	both				
Multiple horizontal plains, benches, terraces, or flats at different elevations	USARAM				
Multiple slopes of varying steepness	USARAM				
Natural or artificial levee or berm	USARAM				
Standing snags (at least 3 m tall)	UWAAM				
Cobble (6 - 25 cm long) and/or boulders (>25 cm long)	both				
Vegetated islands (when above high water)- large enough to support trees or shrubs	UWAAM				
Other:					
Other:					
Only in systems with channels					
Bank slumps or undercut banks	both				
Natural or artificial channels- primary channels[D]	USARAM				
2° channels on floodplain or along shorelines[D]	both				
Pools or depressions in wet or dry channels	UWAAM				
Riffles/rapids (wet channel) Planar Bed (dry channel)	UWAAM				
Point bars and in-channel bars	UWAAM				
Debris jams	USARAM				
[A] Only count once in office for USARAM [B] Only count once in office for UWAAM [C] Only count once in office for UWAAM [D] Only count once in office for USARAM					

FLAG	Comments:

D. Hydrologic Evaluation

D1. Evaluate the following stressors to *water quality* within the AA. Severity : 1= Not Severe, 2= Moderately severe or 3 = Severe. Extent: 1 = 1–10%, 2 = >10–25%, 3 = >25–50%, 4 = >50–75%, 5 = >75%. For extent, include stressors present immediately adjacent to the AA's water source.

Stressor	**Severity**	**Extent**
Debris lines on plants, trees or silt-laden vegetation	0 1 2 3	
Sedimentation (e.g., the presence of sediment fans, deposits or plumes)	0 1 2 3	
Industrial or domestic spills or discharges (odors; foam, oil sheen*)	0 1 2 3	
Turbidity in the water column	0 1 2 3	
Formation of heavy algal or Lemna sp. surface mats or heavy benthic algal growth	0 1 2 3	
Acid mine drainage discharge (excessively clear water (low pH) or presence/accumulation of "yellow-boy" orange precipitate)	0 1 2 3	
Obvious increases in concentration of dissolved salts (e.g. dead or stressed plants; salt encrustation)	0 1 2 3	

FLAG	Comments:

D2. Surface Turbidity and Pollutants: If the water looks turbid, but there are no obvious sources of pollutants, the wetland should still be rated with "some negative water quality indicators" to acknowledge current conditions. The lowest two ratings should be reserved for sites with obvious sources of pollutants (excessive livestock dung, adjacent agricultural fields, urban runoff, feedlots, mining, etc.)

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).	
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). *	

FLAG	Comments, including evidence of water quality degradation:

*Oil sheen should not be confused with surface iron films (natural bacterial process in many wetlands); iron films can be broken when you run your finger through it while oil films cannot

D3. Algal Growth: Small patches of algae that appear natural should still be rated with "limited growth" to acknowledge the current conditions during sampling. The lowest two ratings, however, should be reserved for sites with more extensive algal growth that is likely related to water quality concerns.

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).	

FLAG	Comments: 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.

D4. Evaluate the following stressors to hydroperiod within the AA. Severity : 1= Not Severe, 2= Moderately severe or 3 = Severe. Extent: 1 = 1–10%, 2 = >10–25%, 3 = >25–50%, 4 = >50–75%, 5 = >75%. Also mark if stressors are present within 500 m of AA.			
Stressor Description	**Severity**	**Extent- AA**	**Present in 500m?**
Ditches/channelization	0 1 2 3		Y N
Dam/reservoir	0 1 2 3		Y N
Berms, dikes, levees that block flow into or through AA	0 1 2 3		Y N
Berms, dikes, levees that hold water in the wetland	0 1 2 3		Y N
Passive flow obstructions into or out of wetland (roads without culverts)	0 1 2 3		Y N
Channels have deeply undercut banks and/or bank slumps or slides	0 1 2 3		Y N
Dredged inlet or outlet channel	0 1 2 3		Y N
Engineered inlet or outlet channel (e.g., riprap)	0 1 2 3		Y N
Culverts, pipes (point sources) into AA (change in water quantity)	0 1 2 3		Y N
Water level control structure that impound water in all or part of AA	0 1 2 3		Y N
Impoundment / stock pond	0 1 2 3		Y N
Spring box diverting water from wetland	0 1 2 3		Y N
Deeply dug pits for holding water	0 1 2 3		Y N
Weir or drop structure that impounds water & controls energy of flow	0 1 2 3		Y N
Upland plant species encroaching into AA (due to drying of wetland)	0 1 2 3		Y N
Die-off of trees within AA due to increased ponding (exempting beaver impounded sites)	0 1 2 3		Y N
Presence of agricultural tiles or culverts at AA margin or within AA	0 1 2 3		Y N
Siphons, pumps moving water ***out*** of AA	0 1 2 3		Y N
Siphons, pumps moving water ***into*** AA			Y N
Stormwater inputs from impervious surfaces/flashy flows into AA	0 1 2 3		Y N
FLAG	Comments:		

D5. Overall Hydrologic Connectivity- Evaluate in 200 m buffer around site.	
Rising water has unrestricted access to adjacent areas without levees or other obstructions to the lateral movement of flood waters. Channel, if present, is not entrenched and is still connected to the floodplain (see entrenchment ratio in optional riverine metrics).	
Unnatural features such as levees or road grades limit the amount of adjacent transition zone or the lateral movement of floodwaters, relative to what is expected for the setting, but limitations exist 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. Channel, if present, is somewhat entrenched. If playa, surrounding vegetation does not interrupt surface flow.	
The amount of adjacent transition zone or the lateral movement of flood waters to and from the AA is limited, relative to what is expected for the setting, by unnatural features for 50–90% of the boundary of the AA. Features may include levees or road grades. Flood flows may exceed the obstructions, but drainage out of the AA is probably obstructed. Channel, if present, may be moderately entrenched and disconnected from the floodplain except in large floods. If playa, surrounding vegetation may interrupt surface flow.	
The amount of adjacent transition zone or the lateral movement of flood waters is limited, relative to what is expected for the setting, by unnatural features for >90% of the boundary of the AA. Channel, if present, is severely entrenched and entirely disconnected from the floodplain. If playa, surrounding vegetation may dramatically restrict surface flow.	
FLAG	Comments

D6. Water Source: Mark all water sources influencing the AA in the list below, marking with a star if a source appears to be dominant. Then select one statement from each column that best describes the AA's water source. Consider an area 500 m from the AA the "immediate vicinity" and/or "local watershed"

Natural Sources

___ overbank flooding
___ alluvial aquifer
___ groundwater discharge
___ natural surface flow
___ precipitation
___ snowmelt

Unnatural Sources

___ irrigation via direct application
___ irrigation via seepage
___ irrigation via tail water run-off
___ urban run-off/culverts
___ pipes (directly feeding wetlands)
___ managed ditch
___ other: ________________________

Direct Water Source- Evaluate *where* water comes from for sites that do not get the majority (>75%) of their water from managed ditches		**Alterations to Hydrology**		**Water Source- Evaluate *quality* of water based on source**	
Water sources are precipitation, groundwater, natural runoff, or natural flow from an adjacent freshwater body. The system may naturally lack water at times, even in the growing season (e.g. playas). **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.		There are no hydrologic alterations affecting flow		Water source is from surface waters from natural runoff and precipitation or groundwater, and is not comprised of point source discharges (unless treated to the tertiary level or better). There are no indicators of poor water quality in the vicinity, such as large filamentous algal blooms	
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.		There are small effects of altered hydrology in the immediate vicinity – either in the AA or adjacent to it (dirt roads, levees, small check dams, weirs, or other control structures, etc.)		Water source is > 50 % natural runoff, precipitation or groundwater, but also includes non-point source inputs from agricultural activities, a few small storm drains, and / or rural homes with septic systems. Some indicator species of poor water quality may be present in the vicinity, but they do not form extensive mats	
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 supported 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).		There are moderate effects of altered hydrology in the immediate vicinity (2-lane above grade paved road, exurban development, light industry, diversion / retention ditches, major control structures, etc.)		Water source is < 50 % natural runoff, precipitation or groundwater and is comprised primarily of point source discharges, direct irrigation, or other non-natural sources. Filamentous algae and other indicators of poor water quality may be extensive in the vicinity.	
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/ 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 b/c of direct irrigation, irrigation seepage or return flows, urban storm water runoff, direct pumping.		There are major effects of altered hydrology in the immediate vicinity (4-lane above grade paved highway, concrete lined ditches or canals, commercial with paved parking lot, industrial complex, urban development, feed lot, etc.)		Natural water source has been completely diverted (except direct precipitation), and / or comprised entirely of unnatural sources. such as industrial, urban and / or road runoff. Filamentous algae and other indicators of poor water quality may be extensive in the vicinity.	
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.					

Flag	Comments:

D7. Hydroperiod: Select statement that best describes the degree of alteration to the AA's hydroperiod, using the stressor checklist as a guide.	
Indicators of Reduced Extent and Duration of Inundation or Saturation ____ Upstream spring boxes ____ Dams ____ Pumps, diversions blocking flow into wetland ____ Pumps, diversions, ditching that move water out of the wetland ____ Evidence of aquatic wildlife mortality ____ Encroachment of terrestrial vegetation ____ Stress or mortality of hydrophytes ____ Compressed or reduced plant zonation	**Indicators of Increased Extent and Duration of Inundation or Saturation** ____ Berms ____ Dikes ____ Pumps, diversions, ditching that move water into the wetland ____ Late-season vitality of annual vegetation ____ Recently drowned riparian vegetation ____ Extensive fine-grain deposits

UWAAM-2bDescription		EIA-3b Description- Natural Systems		EIA-3b description- Managed systems	
AA is subjected to natural hydroperiod where inundation and drying or drawdown is not affected by altered hydrology.		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.		The management regime closely mimics a natural analogue (it is very unusual for a purely artificial wetland to be rated in this category).	
AA is subjected to a hydroperiod with magnified inundation but has natural drying or drawdown		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 impacted pitted or dissected.		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 of the AA is characterized by natural patterns of filling or inundation, but thereafter, is subject to more rapid or extreme drawdown or drying, as compared to more natural wetlands.		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.		The site is actively managed and not connected to any natural season fluctuations, but the hydroperiod supports natural functioning of the wetland.	
The filling or inundation patterns in the AA are of substantially lower magnitude or duration than would be expected under natural conditions, but thereafter, the AA is subject to natural drawdown or drying.		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.		Hydroperiod does not mimic natural seasonality. Site is actively managed for filling or drawing down without regard for natural wetland functioning.	
Both inundation and drawdown deviate from natural hydroperiod.		Hydroperiod is dramatically different from natural. Upstream diversions severely stress the wetland.			

FLAG	Comments:

E. Wetland Size

E1. Relative Size: Estimate the % of potential wetland size that remains, using maps and site assessment.

Wetland created in area where similar wetland most likely did not previously exist	
Wetland area ≈ onsite abiotic potential; <5% of wetland has been reduced.	
Wetland area < abiotic potential; 5–25% of wetland has been reduced.	
Wetland area < abiotic potential; 25–50% of wetland has been reduced.	
Wetland area < abiotic potential; >50% of wetland has been reduced.	

FLAG	Notes and Justification:

E2. Absolute Size: Describe any boundaries in the targeted Ecological System not evident from aerial imagery or alterations that have occurred since imagery was taken to aid in GIS analysis

FLAG	Comments:

F. Habitat Evaluation

F1. Threats to Wildlife: Check any threats seen in AA or surrounding 500 m buffer.

Threat	Notes (list species of mammal if present and type of evidence seen (i.e. the animal itself, scat, footprint, etc.)	Photo #	AA	Buffer
American bullfrog				
Largemouth bass				
Common carp				
Western mosquitofish				
Chytrid fungus				
Red-rim melania				
Mammalian predators				
Other:_______________				
Other:_______________				

Site ID:	Surveyors:	Date:

B5. Plant Species Table: List all plant species found in AA and estimate height, cover class and dominant phenology

Height class (H): A: <0.5 m **B**: 0.5–1 m **C**: 1-2 m **D**: 2–5 m **E**: 5- 10 m **F:** >10 m **50 m² = 1% of standard circular AA**

Cover class (C):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%

Phenology (P): V: Vegetative , **Fl:** Flowering **Fr:** Fruiting **SD:** standing dead (from current year, not previous years)

Scientific Name/Pseudonym	Coll #	Photos	H	C	P

All measurements in cm	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	AA
Litter depth (four untrampled locations)						
Average depth water < 5 cm						
Average depth water 5-20 cm						
Average depth water >20 cm						

B4. Ground Cover and Vertical Strata **Cover class (C):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%						
Ground Cover Type **Zones**	**1**	2	3	4	**5**	**AA**
Actual cover of water (any depth, vegetated or not, standing or flowing)						
Actual cover of extremely shallow water (< 5 cm)						
Actual cover of shallow water > 5- 20 cm / average depth shallow water (cm)						
Actual cover of deep water >20 cm / average depth deep water (cm)						
Actual cover of open water with no vegetation						
Actual cover of water with submergent or floating aquatic vegetation*						
Actual cover of water with emergent vegetation						
Potential cover of water at ordinary high water						
Potential average depth at ordinary high water						
Cover of exposed bare ground* *– soil / sand / sediment (including mudflats and salt encrustations)						
Cover of exposed bare ground* *– gravel / cobble (~2–250 mm)						
Cover of exposed bare ground **– bedrock / rock / boulder (>250 mm)						
Cover of entrained litter open enough for wildlife						
Cover of remaining litter						
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)						
*Can overlap with other water cover, such as emergent vegetation **Bare ground has no vegetation/litter/water cover, but may have algae cover. The three categories are mutually exclusive and should total ≤100%.						
FLAG	Comments:					

B5. Regeneration of Woody Species: Select the most appropriate statement for the AA.	
Woody species are naturally uncommon or absent.	
All age classes of desirable (native) woody riparian species present.	
Age classes restricted to mature individuals and young sprouts. Middle age groups absent	
Stand comprised of mainly mature species OR mainly evenly aged young sprouts that choke out other vegetation.	

B6. Woody Debris: Select the most appropriate statement for the AA.	
There are no obvious inputs of woody debris.	
AA characterized by moderate amount of coarse and fine woody debris, relative to expected conditions. For riverine wetlands, debris is sufficient to trap sediment, but does not inhibit stream flow. For non-riverine wetlands, woody debris provides structural complexity, but does not overwhelm the site.	
AA characterized by small amounts of woody debris OR debris is somewhat excessive. For riverine wetlands, lack of debris may affect stream temperatures and reduce available habitat.	
AA lacks woody debris, even though inputs are available.	

Site ID:	Surveyors:	Date:
Site Sketch: Define scale for grid, add north arrow. Mark inlets and outlet if present in or adjacent to AA.		

Site ID:______________________ **Surveyors:**________________________________ **Date:**_________________________

SOIL PROFILE DESCRIPTION – SOIL PIT 1 **Pit Depth (cm)** ________________ **Photo #s** ___________________ **GPS Waypoint** _______________________

Settling Time (mins): __________ Depth to saturated soil* (cm): ___________Depth to free water* (cm): ____________ ☐ Not observed, if so: ☐Pit is filling slowly OR ☐Pit appears dry

Settling Time Begin (Time):________________ Settling Time End (Time):________________

*depths below the soil surface are recorded as positive values and depths above the soil surface are recorded as negative

Horizon (optional)	Depth (cm)	Matrix Color (moist)	Dominant Redox Features Feature Type	Dominant Redox Features Color (moist)	Dominant Redox Features %	Secondary Redox Features Feature Type	Secondary Redox Features Color (moist)	Secondary Redox Features %	Texture	% Coarse	% Roots
________	_______	______________	________________	___________	_______	________________	___________	_______	_____________	______	______
________	_______	______________	________________	___________	_______	________________	___________	_______	_____________	______	______
________	_______	______________	________________	___________	_______	________________	___________	_______	_____________	______	______
________	_______	______________	________________	___________	_______	________________	___________	_______	_____________	______	______
________	_______	______________	________________	___________	_______	________________	___________	_______	_____________	______	______

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

____Surface Salts (B11)
____Histosol (A1)
____Histic Epipedon (A2/A3)
____Mucky Mineral (S1/F1)
___/_____ Hydrogen Sulfide Odor (A4) /depth (cm)
____Gleyed Matrix (S4/F2)
____Depleted Matrix (A11/A12/F3)
____Redox Concentrations (S5/F6/F8)
____Redox Depletions (S6/F7)

Comments:

WATER CHEMISTRY - PH, EC, AND TEMPERATE MEASUREMENTS

Take one water chemistry sample in the soil pit and an optional water chemistry sample at an area with surface water

	GPS WP#	Location	Water Depth (cm)	Surface OR Ground	Standing OR Flowing	Clear OR Turbid	pH	EC/TDS Out of Range	EC	TDS	Temp
Site 1 low				Surface / Ground	Standing / Flowing	Clear / Turbid		☐			
Site 1 high								☐			
Site 2 low				Surface / Ground	Standing / Flowing	Clear / Turbid		☐			
Site 2 high								☐			

Buffer Reference Card

Examples of buffer land covers	Examples of non-buffer land covers

Examples of buffer land covers

- Vegetated natural and semi-natural areas including forests, grasslands, shrublands, wetlands, and old fields undergoing succession
- Areas of light recreation including bike, foot, and horse trails
- natural unvegetated areas including permanent snow or ice cover and natural rock outcrops or sandy and gravel areas.
- open range land with light grazing

Examples of non-buffer land covers

- lawns, sports fields, traditional golf courses
- busy streets and highway
- commercial and residential areas, developments, parking lots
- mined areas
- high use recreation areas, including paved and/or heavily used pedestrian or bike trials
- intensive agricultural including row crops, orchards, vineyards, horse paddocks, clear-cuts
- animal feedlots, poultry ranches
- multi-rail railroads and train yards
- wind farms, oil and gas wells
- rangeland with intensive grazing

Differences between protocols in definitions of buffer land (YES), non-buffer (NO), not indicated (NA)

	EIA	**USARAM**	**UWAAM**
Low use dirt roads	NO	*	YES
Single lane paved roads	NO	*	YES
Open water in ponds, lakes, rivers	YES	YES	**
Swales and ditches	if natural substrate (not concrete)	*	YES
Vegetated levees	YES	*	YES
Low or open fences, small power lines	YES	*	*NA*
Non-tilled hay fields	YES	YES	*NA*
Links or target golf courses	NO	NO	YES
Railroads (excluding multi-rail or train yards)	NO	NO	YES
Dry-land farming areas	NO	NO	YES
Sound walls, High solid fences that interfere with wildlife	NO	*	*NA*
Recently burned land	NO	NO	*NA*
Fallow fields	NO	NO	*NA*
Pastures, fenced or unfenced	NO	NO	*NA*
Major transmission lines	NO	*	*NA*

*Excluded from analysis if less than 5 m in width; otherwise will follow EIA guidelines.

**Ignored if at least 30 m wide and immediately adjacent to AA; otherwise included

Dimensions/Gaps	EIA	USARAM	UWAAM
Minimum width	5 m	5 m	10 m
Minimum perimeter length	10 m	10 m	10 m
Allowable gaps of non-buffer	Not allowed	5 m	Not allowed
Maximum buffer width evaluated	200 m	100 m	200 m

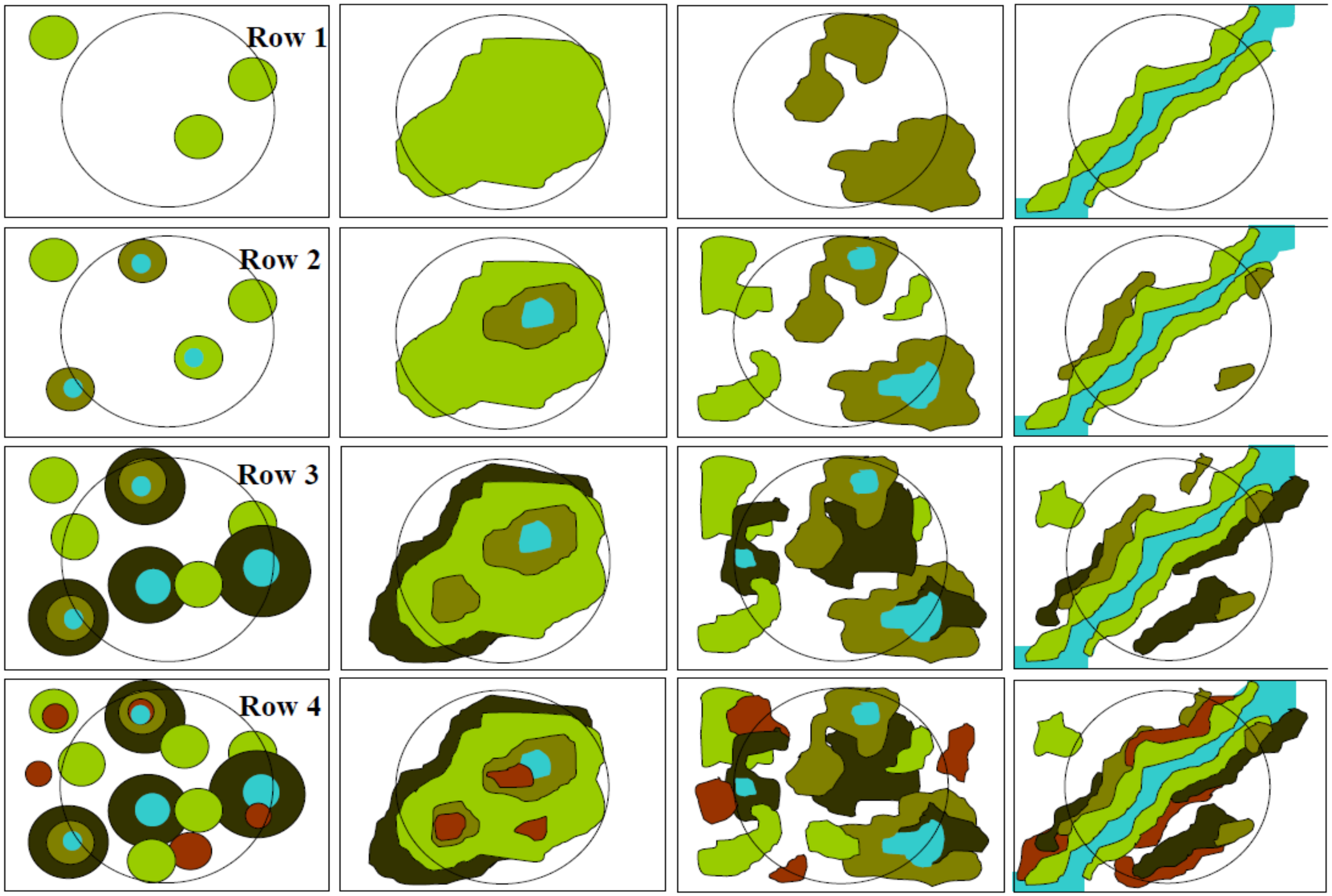
Interspersion Reference Card 1

EIA/USARAM Patches: Two distinct patches may occur within the same patch type (i.e. herbaceous) if each patch is dominated by a different plant species AND average height of dominant species differs between patches by >1 m. Patches types include the following:

- Forest/Woodland (trees or shrubs > 5 m tall that occupy > 30% cover within a patch)
- Shrubland (shrubs < 5 m tall occupy > 30% cover within a patch)
- Herbaceous (graminoids, forbs, or ferns)
- Submerged / Floating (rooted or floating aquatics dominant, not including emergent veg)
- Nonvascular (bryophytes, cryptogrammic crusts)
- Sparsely Vegetated (vegetation cover < 5 %)
- Open Water (unvegetated)
- Bare Ground / Rock (unvegetated)
- Natural organic debris (tree falls, flood deposits, etc.
- Patch types listed in table below

Patch Type	**Description**
Open water - river / stream	Areas of flowing water associated with a sizeable channel.
Open water - tributary / secondary channels	Areas of flowing water entering the main channel from a secondary source.
Open water – swales on floodplain or along shoreline	Swales are broad, elongated, vegetated, shallow depressions that can sometimes help to convey flood flow to and from vegetated floodplains. They lack obvious banks, regularly spaced deeps and shallows, or other characteristics of channels. Swales can entrap water after flood flows recede. They can act as localized recharge zones and they can sometimes receive emergent groundwater.
Open water - oxbow / backwater channels	Areas that hold stagnant or slow moving water from that has been partially or completely disassociated from the primary river channel.
Open water - rivulets / streamlet	Areas of flowing water associated with a small, diffuse channel. Often occurring near the outlet of a wet meadow or fen or at the very headwaters of a stream.
Open water - pond or lake	Medium to large natural water body.
Open water - pools	Areas that hold stagnant or slow moving water from groundwater discharge but are not associated with a defined channel.
Open water - beaver pond	Areas that hold stagnant or slow moving water behind a beaver dam.
Active beaver dams	Debris damming a stream, clearly constructed by beaver (note gnawed ends of branches).
Beaver canals	Canals cut through emergent vegetation by beaver.
Debris jams / woody debris in channel	Aggregated woody debris in stream channel deposited by high flows.
Pool / riffle complex	Deep, slow-moving pools alternating with shallow, fast-moving riffles along the relatively straight course of a stream or river.
Point bars	A low ridge of sediment (sand or gravel) formed on the inner bank of a meandering stream.
Interfluves on floodplain	The area between two adjacent streams or stream channels flowing in the same general direction.
Bank slumps or undercut banks in channel or along shoreline	A bank slope is the portion of a stream or other wetland bank that has broken free from the rest of the bank but has not eroded away. Undercuts are areas along the bank or shoreline of a wetland that have been excavated by waves or flowing water.
Adjacent or onsite seeps/springs	Localized point of emerging groundwater, often on or at the base of a sloping hillside.
Animal mounds or burrows	Many vertebrates make mounds or holes as a consequence of their forage, denning, predation, or other behaviors. The resulting disturbance helps to redistribute soil nutrients and influences plant species composition and abundance.
Mudflats	An accumulation of mud of the edge of shallow waters, such as a lake or pond. Often intermittently flooded and exposed.
Salt flats / alkali flats	Dry open areas of fine grained sediment and accumulated salts. Often wet in the winter months or with heavy precipitation.
Hummock / tussock	In fens, a mound composed of organic material (peat) either created by *Sphagnum,* other moss, or formed by sedges and grasses that have a tussock growth habit as they raise themselves on a pedestal of persistent rhizomes and roots.
Water tracks / hollows	In fens, a depression found between hummocks or mounds which remains permanently saturated or is inundated with slow moving surface water.
Floating mat	Mats of peat held together by roots and rhizomes of sedges. Floating mats are found along the edges of ponds and lakes and are slowing encroaching into open water. The mats are underlain by water and/or very loose peat.
Marl/Limonite beds	Marl is a calcium carbonate precipitate often found in calcareous fens. Limonite forms in iron fens when iron precipitates from the groundwater incorporating organic matter

Interspersion Reference Card 2



From The Environmental Protection Agency's National Wetland Condition Assessment Field Operations Manual: Online, www.epa.gov/wetlands/survey, accessed 2013.

Utah Noxious Weed List

The following weeds are hereby officially designated and published as noxious for the State of Utah, as per the authority vested in the Commissioner of Agriculture and Food under Section 4-17-3:

There are hereby designated three classes of noxious weeds in the state: Class A (EDRR) Class B (Control) and Class C (Containment).

Class A: Early Detection Rapid Response (EDRR)—Declared noxious weeds not native to the state of Utah that pose a serious threat to the state and should be considered a very high priority.

Black henbane	*Hyoscyamus niger(L.)*
Diffuse knapweed	*Centaurea diffusa(Lam.)*
Leafy spurge	*Euphorbia esula L.*
Medusahead	*Taeniatherum caput-medusae*
Ox-eye Daisy	*Chrysanthemum leucanthemum L.*
Perennial Sorghum spp. including but not limited to:	
Johnsongrass	*Sorghum halepense (L.) Pers*
and Sorghum almum	*Sorghum almum Parodi*
Purple loosestrife	*Lythrum salicaria L*
Spotted knapweed	*Centaurea maculosa Lam*.
Squarrose knapweed	*Centaurea squarrosa Gugle.*
St. Johnswort	*Hypericum perforatum L.*
Sulfur cinquefoil	*Potentilla recta L.*
Yellow starthistle	*Centaurea solstitialis L.*
Yellow toadflax	*Linaria vulgaris Mill*

Class B: Control—Declared noxious weeds not native to the state of Utah that pose a threat to the state and should be considered a high priority for control.

Bermudagrass*	*Cynodon dactylon(L.)Pers*.
Broad-leaved peppergrass (Tall whitetop)	*Lepidium latifoliumL*.
Dalmatian toadflax	*Linaria dalmatica(L.)Mill.*
Dyers woad	*Isatis tinctoria L.*
Hoary cress	*Cardaria spp.*
Musk thistle	*Carduus nutans L.*
Poison hemlock	*Conium maculatum L.*
Russian knapweed	*Centaurea repens L.*
Scotch thistle (Cotton thistle)	*Onopordium acanthium L*
Squarrose knapweed	*Centaurea virgata Lam. ss*

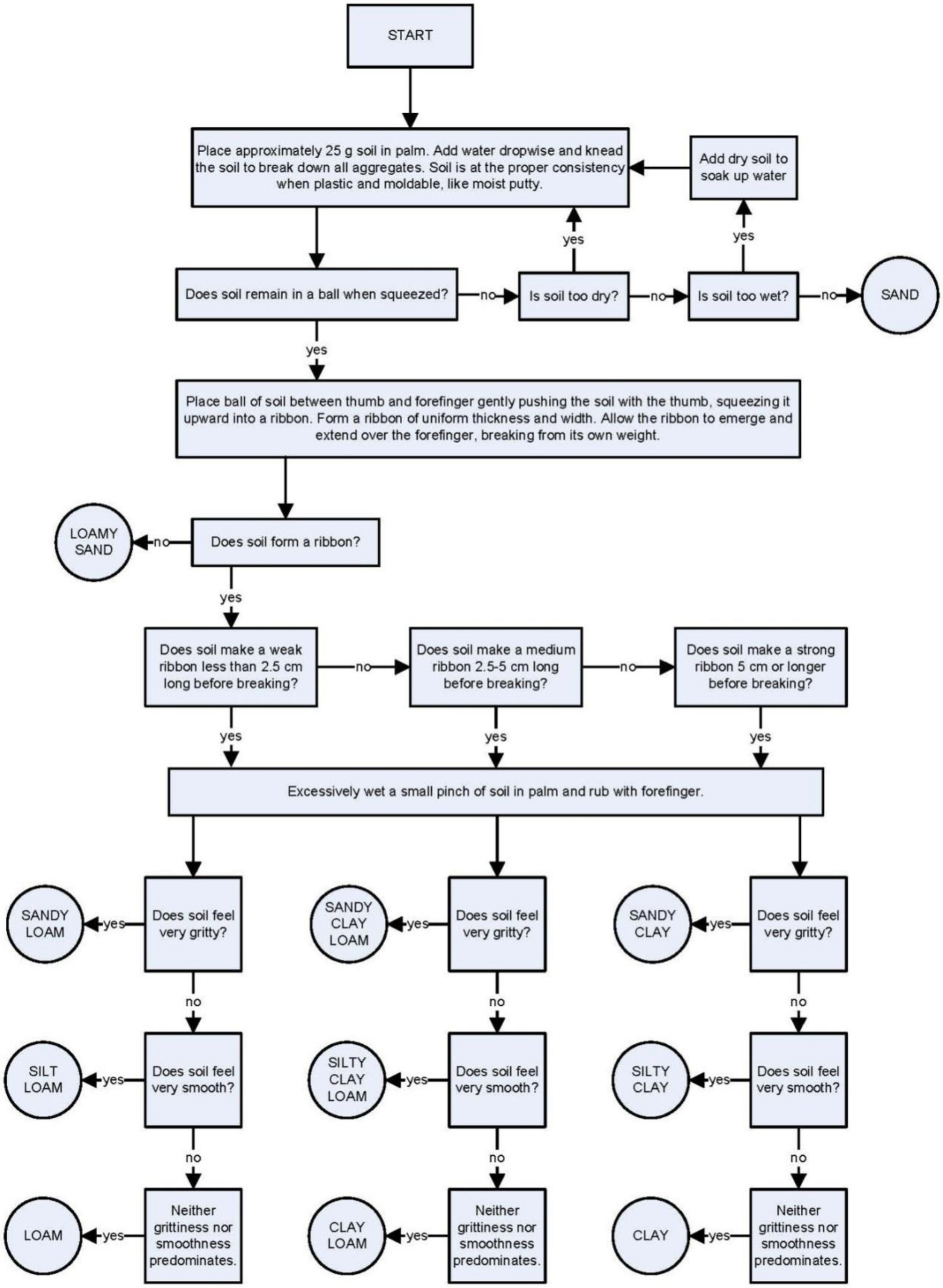
Class C: Containment— Declared noxious weeds not native to the state of Utah that are widely spread but pose a threat to the agricultural industry and agricultural products with a focus on stopping expansion.

Field bindweed (Wild morning-glory)	*Convolvulus pp.*
Canada thistle	*Cirsium arvense (L.) Scop.*
Houndstounge	*Cynoglossum officianale L.*
Saltcedar	*Tamarix ramosissima Ledeb.*
Quackgrass	*Agropyron repens(L.) Beauv.*

* Bermudagrass (*Cynodon dactylon*)shall not be a noxious weed in Washington County and shall not be subject to provisions of the Utah Noxious Weed Law within the boundaries of that county. It shall be a noxious weed throughout all other areas of the State of Utah and shall be subject to the laws therein.

From Utah Administrative Code Rule 68-9, Utah Noxious Weed Act: Online, http://www.rules.utah.gov, accessed 2013.

Soil Texture Flow Chart



Modified from S.J. Thien, 1979. *A flow diagram for teaching texture by feel analysis.* Journal of Agronomic Education. 8:54-55, available online from U.S. Natural Resources Conservation Service, http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/edu/kthru6/?cid=nrcs142p2_054311, accessed 2013.

Hydric Soil Indicators for the Arid West

All Soils – soils with any soil texture

A1. Histosol: Organic soil material**≥40cm** thick within the top **80cm**.

A2. Histic Epipedon: Organic soil material **≥20cm** thick above a mineral soil layer. Aquic conditions or artificial drainage *required,* but can be assumed if hydrophytic vegetation and wetland hydrology are present.

A3.BlackHistic: Very dark organic soil material**≥20cm** thick thatstarts**within15 cm** of soil surface. Color:hue = 10YRor yellower; value ≤ 3;chroma≤ 1. Aquic conditions or artificial drainage *not required. Rare in our region.*

A4. Hydrogen Sulfide: Rotten egg odor within **30cm** of the soil surface due to the reduction of sulfur. Most commonly found in areas that are permanently saturated or inundated; almost never at the wetland boundary.

A9. 1cm Muck: A layer of muck **1 cm** or more thick with a **value of ≤ 3** and **chroma of ≤1**, starting within **15 cm** of the soil surface.

A11. Depleted Below Dark Surface: Depleted (colorless) layer**≥15 cm** that starts **within 30cm** of the soil surface. Color: chroma ≤ 2. Redox features required if color = 4/1, 4/2, 5/2. Layers above must be dark. See Table 1 for specifics.

A12. Thick Dark Surface. Depleted (colorless) layer **≥15**cm that starts **below 30cm** of the soil surface. Color: chroma ≤ 2. Redox features required if color = 4/1, 4/2, 5/2. Layers above must be dark. See Table1 for specifics. *Not common in our region.*

NOTE: For the remaining indicators, unless otherwise indicated, all mineral layers above the indicators must have a dominant chroma of ≤ 2orthe layers with dominant chroma of> 2 must be <15 cm thick.

Sandy Soil Types Sandy soil indicators are generally shallower and thinner than loamy/clayey soil indicators.

S1. Sandy Mucky Mineral: A layer of mucky modified sandy soil material**≥5cm** starting**within15cm** of the soil surface. *Limited in our region ,*but found in swales associated with sand dunes.

S4. Sandy Gleyed Matrix: Gleyed matrix that occupies **≥60%**of a layer starting **within 15 cm** of the soil surface. No minimum thickness required. Gley colors are not synonymous with grey colors. They are found on the Gley page. *Rare in our region;* only found where sandy soils are almost continuously saturated.

S5. Sandy Redox: Redox features in a depleted(colorless)layer **≥10cm**that starts **within15cm**of the soil surface. Color: chroma ≤ 2. See Table 1 for specifics. *Most common indicator in our region of the wetland boundary for sandy soils.*

S6. Stripped Matrix: A layer starting **within 15cm** of the surface in which iron/manganese oxides and/or organic matter has been stripped and the base color of the soil material is exposed. Evident by faint, diffuse splotchy patterns of two or more colors. Stripped zones are ≥ 10% and~1–3 cm in diameter.

Loamy/ Clayey Soil Types Loamy/clayey soil indicators are generally deeper and thicker than sandy soil indicators.

F1.Loamy Mucky Mineral: A layer of mucky modified loamy or clayey soil material **≥ 10cm** starting within 15 cm of the soil surface. Difficult to tell without testing.

F2.Loamy Gleyed Matrix: Gleyed matrix that occupies **≥60%** of a layer starting **within 30cm**of the soil surface. No minimum thickness required. Gley colors are not synonymous with grey colors. They are found on the Gley page.

F3. Depleted Matrix: Depleted (colorless)layer**≥5 cm** thick**within15 cm** *or***≥15cm**thickw**ithin30 cm** of the soil surface. Color: chroma ≤ 2. Redox features required if color = 4/1, 4/2, 5/2. See Table 1 for specifics. *Most common indicator at wetland boundaries.*

F6.RedoxDarkSurface: A dark surface layer with **redox features.** Depth and location: **≥10cm** thick entirely**within30cm of** the mineral soil. Matrix color and redox features: matrix value ≤ 3 and chroma≤ 1 with ≥ 2% distinct, prominent redox concentrations OR matrix value ≤ 3 and chroma ≤ 2 with≥ 5% distinct, prominent redox concentrations. The chroma can be higher with more redox features. *Very common indicator to delineate wetlands,* though difficult to see in soils with high organic matter.

F7. Depleted Dark Surface: A dark surface layer with **redox depletions.** Depth and location:**≥10 cm** thick entirely **within 30 cm of** the mineral soil. Matrix color and redox depletions :matrix value ≤ 3 and chroma≤ 1 with ≥ 10%redoxdepletions OR matrix value ≤ 3 and chroma≤ 2 with ≥ 20%redox depletions. The chroma can be higher with more redox depletions. Redox depletions themselves should have value ≥ 5and chroma ≤ 2. *Rare in our region.*

F8.Redox Depressions: A layer**≥5 cm** thick entirely **within15cm** of soil surface with ≥5% distinct or prominent redox concentrations in closed depressions subject to ponding. *No color requirement for the matrix soil, but only applies to depressions in otherwise flat landscapes.*

F9. Vernal Pools: In closed depressions that are subject to ponding, presence of a depleted matrix with 60 percent or more chroma of 2 or less in a layer 2 in. (5 cm) thick entirely within the upper 6 in. (15 cm) of the soil.

Adapted from U.S. Army Corps of Engineers, 2008, Regional supplement to the Corps of Engineers wetland delineation manual—Arid west region, Version 2.0: Vicksburg, Mississippi, ERDC/EL TR-08-28, 133 p. **by** Lemly, J., and Gilligan, L., 2013, Ecological integrity assessment for Colorado wetlands—field manual version 1.0- review draft: Fort Collins, Colorado Natural Heritage Program, 92 p.

Field Key to Cowardin Classification and Notes

Key to Cowardin Systems, Subsystems, and Classes of Utah

Systems

(ESTUARINE and MARINE systems omitted)

1a. Persistent emergents, trees, shrubs, or emergent mosses cover ≥30% of the area…..........**Palustrine**

1b. Persistent emergents, trees, shrubs, or emergent mosses cover <30% of substrate, but non-persistent emergent may be widespread during some seasons of the year……………………………………………**2**

2a. Situated in a channel; water, when present, usually flowing…………………………………..**Riverine**

2b. Situated in a basin, catchment, or on level, sloping ground; water usually not flowing…………**3**

3a. Area 8 ha (20 acres) or greater……………………………………………………………….**Lacustrine**

3b. Area less than 8 ha...**4**

4a. Wave-formed or bedrock shoreline feature present or water depth 2 m or more……… ………………………………………………………………………………………………………..........**Lacustrine**

4b. No wave-formed or bedrock shoreline feature present and water less than 2m deep. ………**Palustrine**

Subsystem

Riverine

1a. Flowing water in channel throughout the year…………………………………………………………………………2

1b. Channel contains flowing water for only part of the year. When water is not flowing it may remain in isolated pools or surface water may be absent………………………………………………………………………**Intermittent**

2a. Gradient low and water velocity slow; No tidal influence and some water flows throughout the year; the substrate consists of mainly of sand and mud; oxygen deficits may sometimes occur, the fauna is composed mostly of species that reach their maximum abundance in still water, and true planktonic organisms are common; floodplain is well-developed……………………………………………………………………………………..............**Lower Perennial**

2b. Gradient high and water velocity fast; No tidal influence and some water flows throughout the year; the substrate consists of rock, cobbles, or gravel with occasional patches of sand; natural dissolved oxygen concentration is normally near saturation; fauna is characteristic of running water, and there are few or no plankton forms; very little floodplain development……………………………………………………………………………………......**Upper Perennial**

Lacustrine

1a. Water greater than 2 m deep, not all Lacustrine habitats include this subsystem………………….**Limnetic**

1b. Water less than 2 m deep, all wetland habitats in the Lacustrine System include this subsystem. Extends from the shoreward boundary of this system to a depth of 2 , below low water or to the maximum extent of non-persistent emergent, if these grow at depths >2 m…………...………………….**Littoral**

Classes

1a. During the growing season of most years, areal cover by vegetation is <30%………………………………..**2**

2a. Water regime subtidal, permanent flooded, intermittently exposed, semipermanently flooded. Substrate usually not soil………………………………………………………………………………………**3**

3a. Substrate of bedrock, boulders or stones occurring singly or in combination covers ≥75 of the area……………………………………………………………………………………**Rock Bottom**

3b. Substrate of organic material, mud, sand, gravel, or cobbles with <75% aerial cover of stones, boulders or bedrock…………………………………………...**Unconsolidated Bottom**

2b. Water regime irregularly exposed, regularly flooded, irregularly flooded, seasonally flooded, temporarily flooded, intermittently flooded, saturated, or artificially flooded. Substrate often soil……..**4**

4a. Contained within a stream channel that does not have permanent flowing water (i.e. Intermittent Subsystems of Riverine System)…………………………………………………**Streambed**

4b. Contained in channel with perennial water or not containing a channel…………………**5**

5a. Substrate of bedrock, boulders, or stones occurring singly or in combination cover ≥75% of the area……………………………………………………………..**Rocky Shore**

5b. Substrate of organic material, mud, sand, gravel, or cobbles; <75% of the cover consisting of stones, boulders, or bedrock………………**Unconsolidated Shore**

1b.During the growing season of most years, areal cover by vegetation is ≥30%……………..…………………….**6**

6a. Vegetation composed of pioneering annuals or seedling perennials, often not hydrophytes, occurring only at time of substrate exposure…………………………………………………………………………**7**

7a. Contained in a channel that does not have permanent flowing water……………………….. …………………………………………………………………………………………………….**Streambed (Vegetated)**

7b. Contained within a channel with permanent water or not contained in a channel……. ……………………………………………………………………………..**Unconsolidated Shore (Vegetated)**

6b. Vegetation composed of algae, bryophytes, lichens, and vascular plants that are usually hydrophytic perennials……**8**

8a. Vegetation composed predominately of nonvascular species………………………………….**9**

9a. Vegetation macrophytic algae, mosses, or lichens, growing in water or the splashzone of shores……………………………………………………………………**Aquatic Bed**

9b. Vegetation mosses or lichens usually growing on organic soils and always outside the splashzone of shores…………………………………….**Moss-Lichen Wetland**

8b. Vegetation composed predominant of vascular species………………………………………..**10**

10a. Vegetation herbaceous…………………………………………………………………………….**11**

11a. Vegetation emergent……………………………………..**Emergent Wetland**

11b. Vegetation submergent, floating-leaved, or floating…..**Aquatic Bed**

10b. Vegetation trees or shrubs…………………………………………………………………….**12**

12a. Dominants less than 6m tall………………………...**Scrub-Shrub Wetland**

12b. Dominants 6m taller or more…………………..…………**Forested Wetland**

Cowardin Water Regime Modifiers (in order from driest to wettest):

Intermittently Flooded (J): The substrate is usually exposed, but surface water is present for variable periods without detectable seasonal periodicity. Weeks, months, or even years may intervene between periods of inundation.

Temporarily Flooded (A): Surface water is present for brief periods during the growing season, but the water table usually lies well below the soil surface for most of the season. Plants that grow both in uplands and wetlands are characteristic of the temporarily flooded regime.

Saturated (B): The substrate is saturated to the surface for extended periods during the growing season, but surface water is seldom present. This modifier is applied to fen like areas with stable water tables regardless of their connectivity.

Seasonally Flooded (C): Surface water is present for extended periods especially early in the growing season, but is absent by the end of the season in most years. When surface water is absent, the water table is often near the land surface.

Semi-permanently Flooded (F): Surface water persists throughout the growing season in most years. When surface water is absent, the water table is usually at or very near the land surface.

Intermittently Exposed (G): Surface water is present throughout the year except in years of extreme drought. This is applied to large ponds and shallow lakes where the water does not appear likely to dry up.

Permanently Flooded (H): Water covers the land surface throughout the year in all years. Vegetation is composed of obligate hydrophytes. Mostly applied to deep water habitats such as lakes where there is no chance drying.

Cowardin Special Modifiers

Beaver (b): This modifier describes wetlands that are formed within and adjacent to streams by beaver activity.

Excavated (x): This modifier describes wetlands that were created through the excavation ofsoils.

Partially ditched/drained (d): This modifier describes manmade alterations to wetlands including ditches.

Diked/impounded (h): This modifier describes manmade alterations to wetlands where impoundments or dikes have been added.

Farmed (f): This modifier describes wetlands that have been altered due to farming practices.

Examples of Palustrine System:
To classify Palustrine wetlands, we combine the codes for the system, class, and water regime. The following are examples of types of wetlands and how they would be coded for wetland mapping purposes.

1. Cattail marsh that has standing water for most of the year: **PEMF**
2. A prairie pothole dominated by grasses and sedges that is only wet at the beginning of the growing season: **PEMA**
3. A fen in the subalpine zone: **PEMB**
4. A small shallow pond that has lily pads and other floating vegetation and holds water throughout the growing season: **PABF**
5. A small shallow pond with less than 30% vegetation and a muddy substrate that holds water for most of the year: **PUBF**
6. A wetland dominated by willows adjacent to a stream that is only periodically flooded: **PSSA**

Adapted from Cowardin, L.., Carter, V., Golet, F.C., and LaRoe, E.T., 1979, Classification of wetlands and deepwater habitats of the United States: Washington, D.C., U.S. Fish and Wildlife Service Northern Prairie Wildlife Research Center, Online, http://www.npwrc.usgs.gov/resource/wetlands/classwet/index.htm **and** Lemly, J., and Gilligan, L., 2013, Ecological integrity assessment for Colorado wetlands—field manual version 1.0- review draft: Fort Collins, Colorado Natural Heritage Program, 92 p.

Field Key to Wetland and Riparian Ecological Systems of Utah

1a. Riparian areas or floodplains associated with permanent, intermittent or ephemeral streams………..
………..TO BE COMPLETED
………………………………………..**Great Basin Foothill and Lower Montane Riparian Woodland and Shrubland**
………..**Introduced Riparian Vegetation**
……………………………**North American Warm Desert Lower Montane Riparian Woodland and Shrubland***
……………………………………………………………………..**North American Warm Desert Riparian Mesquite Bosque***
……………………………………………………**North American Warm Desert Riparian Woodland and Shrubland***
…………………………………………………………………………………………………**Northwestern Great Plains Riparian***
……………………………………….**Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland**
…………………………………………………………………………**Rocky Mountain Subalpine-Montane Riparian Shrubland**
…………………………………………………………………………**Rocky Mountain Subalpine-Montane Riparian Woodland**
……**Western Great Plains Floodplain**
………**Western Great Plains Riparian**

1b. Wetland areas not associate with streams……………………………………………………………………………………2

2a. Wetland defined by groundwater inflows and peat (organic soil) accumulation of at least 40 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 hectares (0.25 acres). If the wetland occurs as an isolated patch surrounded by upland, then there is no minimum size criteria. In Utah, this type is likely to only be found in montane areas including the Wasatch and Uinta Mountains, but may occur in small patches in association with spring-fed wetlands in other areas...............................
…………………………………………………………………………………......................**Rocky Mountain Subalpine-Montane Fen**

2b. Wetland does not have at least 40 cm of peat (organic soil) accumulation or occupies an area less than 0.1 hectares (0.25 acres) within a mosaic of other non-peat forming wetland or systems...........3

3a. Total herbaceous vegetation canopy cover generally 10% or more...4

4a. Small (<0.1 ha) depressional, herbaceous wetlands occurring within dune fields of the Great Basin, Wyoming Basin, and other small inter-montane basins...........................
……….. **Inter-Mountain Basins Interdunal Swale Wetland**

4b. Herbaceous wetlands not associated with dune fields…………………………..………………..…5

5a. Depressional wetlands occurring in areas with alkaline to saline clay soils with hardpans. Salt encrustations can occur on the surface. Species are typically salt-tolerant such as *Distichlis spicata*, *Puccinellia* spp., *Leymus* spp., *Poa secunda*, *Salicornia* spp., and *Schoenoplectus maritimus*. Communities within this system often occur in alkaline basins and swales and along the drawdown zones of lakes and ponds…….................**Inter-Mountain Basins Alkaline Closed Depression**

5b. Wetlands occurring in areas other than closed depressions, though sites may be alkaline and have surface salts, but will have some surface and subsurface flow or standing water for an extended period during the growing season……….6

6a. Wetlands associated with a high water table or overland flow, but typically lacking standing water. Sites with *no channel formation* are typically associated with snowmelt 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 and may be subjected to high disturbance events such as flooding (Riverine HGM Class). Vegetation is dominated by herbaceous species; typically graminoids have the highest canopy cover including *Carex* spp. and *Juncus* spp... ……………………………………………………………….**Rocky Mountain Alpine-Montane Wet Meadow**

6b. Wetlands with a permanent water source 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 species including species of *Scirpus*, *Schoenoplectus*, *Typha*, *Carex* spp., *Potamogeton*, *Polygonum*, and *Nuphar*.................................**Western North American Emergent Marsh**

3b. Total vegetation canopy cover generally less than 10%...7

7a. Sites are restricted to drainages with a variety of sparse or patchy vegetation including *Sarcobatus vermiculatus*, *Ericameria nauseosa*, *Artemisia cana*, *Artemisia tridentata*, *Grayia spinosa*, *Distichlis spicata*, and *Sporobolus airoides*............................... ....**Inter-Mountain Basins Wash**

7b. Sites occur on barren or sparsely vegetated playas that are intermittently flooded and may remain dry for several years. Soil is typically saline, and salt encrustrations are common. Plant species are salt-tolerant and can include *Sarcobatus vermiculatus*, *Distichlis spicata*, and *Atriplex* spp…..................................... **Inter-Mountain Basins Playa**

*These Ecological Systems are found to occur in Utah in the Terrestrial Ecological Systems of the United States (NatureServe), but Utah is not included in the comprehensive report of the system provided on the NatureServeExplorer. Because the types are more common in other states, they may not have been assessed in Utah.

Adapted from Lemly, J., and Gilligan, L., 2013, Ecological integrity assessment for Colorado wetlands—field manual version 1.0- review draft: Fort Collins, Colorado Natural Heritage Program, 92 p.

Field Key to the Hydrogeomorphic (HGM) Classes of Wetlands in the Rocky Mountains

1a. Entire wetland unit is flat and precipitation is the primary source (>90%) of water. Groundwater and surface water runoff are not significant sources of water to the unit ....**Mineral Flats HGM Class**

1b. Wetland does not meet the above criteria; primary water sources include groundwater and/or surface water **2**

2a. Entire wetland unit meets ***all*** of the following criteria: a) the vegetated portion of the wetland is on the shores of a permanent open water body at least 8 ha (20 acres) in size; b) at least 30% of the open water area is deeper than 2 m (6.6 ft.); c) vegetation in the wetland experiences bidirectional flow as the result of vertical fluctuations of water levels due to rising and falling lake levels. ....**Lacustrine Fringe HGM Class**

2b. Wetland does not meet the above criteria; wetland is not found on the shore of a water body, water body is either smaller or shallower, OR vegetation is not effected by lake water levels........................... **3**

3a. Entire wetland unit meets ***all*** of the following criteria: a) wetland unit is in a valley, floodplain, or along a stream channel where it is inundated by overbank flooding from that stream or river; b) overbank flooding occurs at least once every two years; and c) wetland does not receive significant inputs from groundwater. **NOTE:** *Riverine wetlands can contain depressions that are filled with water when the river is not flooding such as oxbows and beaver ponds*................................ **Riverine HGM Class**

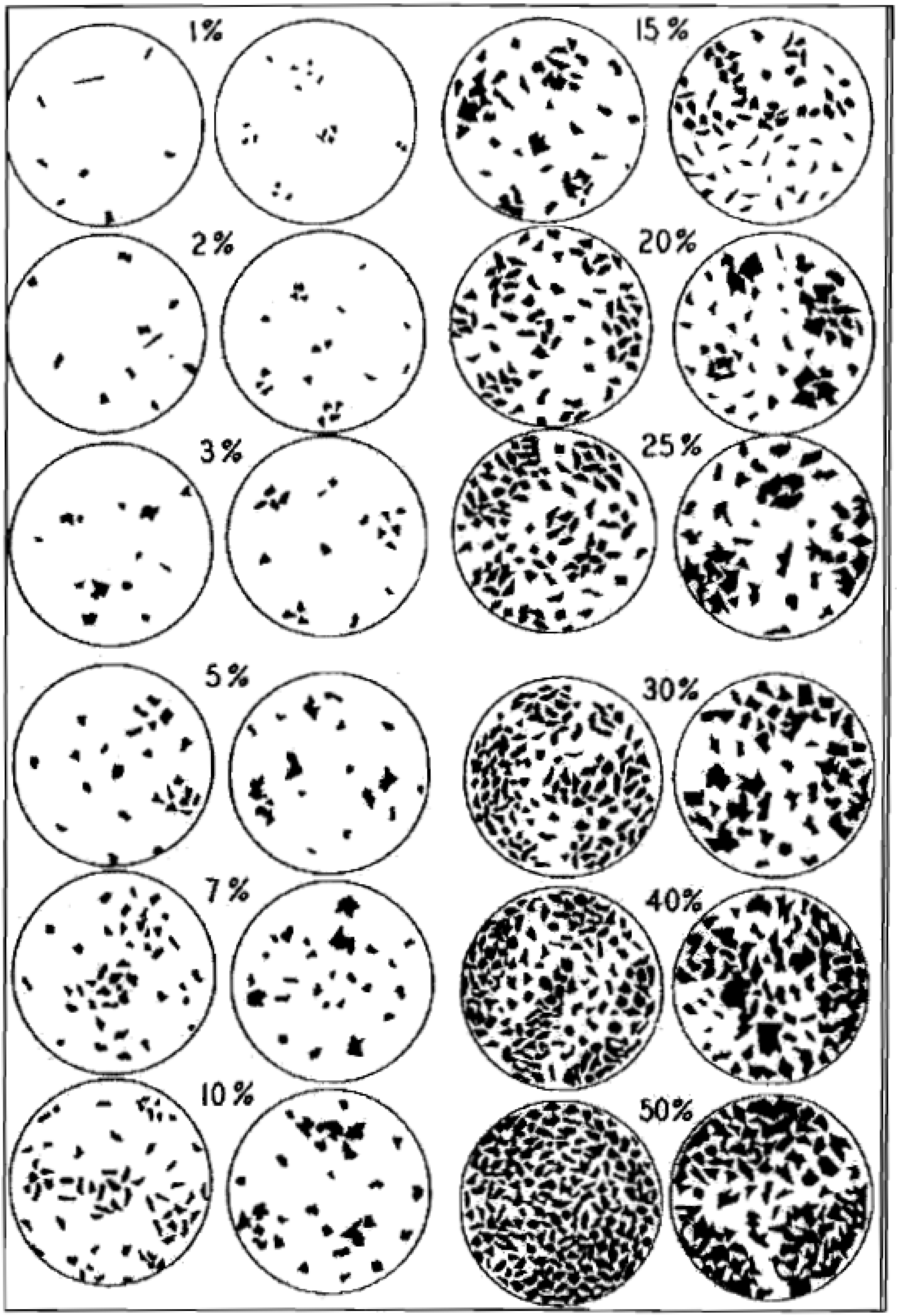
3b. Wetland does not meet the above criteria; if the wetland is located within a valley, floodplain, or along a stream channel, it is outside of the influence of overbank flooding or receives significant hydrologic inputs from groundwater. **4**

4a. Entire wetland unit meets ***all*** of the following criteria: a) wetland is on a slope (slope can be very gradual or nearly flat); b) groundwater is the primary hydrologic input; c) water, if present, flows through the wetland in one direction and usually comes from seeps or springs; and d) water leaves the wetland without being impounded. **NOTE:** *Small channels can form within slope wetlands, but are not subject to overbank flooding. Surface water does not pond in these types of wetlands, except occasionally in very small and shallow depressions or behind hummocks (depressions are usually < 3ft diameter and less than 1 foot deep)*...**Slope HGM Class**

4b. Wetland does not meet all of the above criteria. Entire wetland unit is located in a topographic depression in which water ponds or is saturated to the surface at some time during the year. **NOTE:** *Any outlet, if present, is higher than the interior of the wetland*..................................**Depressional HGM Class**

From Lemly, J., and Gilligan, L., 2013, Ecological integrity assessment for Colorado wetlands—field manual version 1.0- review draft: Fort Collins, Colorado Natural Heritage Program, 92 p.

Plant Cover Reference Card



From California Native Plant Society's cover diagrams (https://www.cnps.org/cnps/vegetation/protocol.php)

Threats to Wildlife

American Bullfrog (*Rana catesbeiana*)

Carl D. Howe, Creative Commons Attribution-Share Alike 2.5 Generic license

Jarek Tusyznski, Creative Commons Attribution- Share Alike 3.0 Unported license

- Bullfrogs are the largest real frog found in North America
- Adult bullfrog's are usually 3 ½ to 6 inches in length
- Color varies from brownish to shades of green, often with spots or blotches of a darker color around their backs
- Have easily identifiable circular eardrums, or tympanum, with a ridge that runs from the back of the eye around the tympanum and then stops

From New York State Department of Environmental Conservation, http://www.dec.ny.gov/animals/58652.html

Red-rim melania (*Melanoides tuberculata)*

Dennis L., Creative Commons Attribution 2.0 Generic license

- An elongate, conical shell with as many as 10 whorls, usually light brown marked with rust colored spots. Operculum present.
- Size: 40 mm; 80 mm max

From U.S. Geological Survey Nonindigenous Aquatic Species Fact Sheet, http://nas.er.usgs.gov/queries/FactSheet.aspx?speciesID=1037

***Common Carp* (*Cyprinus carpio*)**

Dexidor, Creative Commons Attribution 2.5 Generic license

- They have deep, thick body color is gray to brassy green or yellowish green
- Normally covered with very large scales, and have fleshy barbells on each side of mouth
- A large serrated spine is present at the front of the dorsal fin followed by more than 16 soft rays

From The National Park Service's Asian Carp Identification Guide,
http://www.nps.gov/miss/naturescience/loader.cfm?csModule=security/getfile&pageid=291273

***Largemouth Bass* (*Micropterus salmoides*)**

USGS, Florida Integrated Science Center

- Usually green with dark blotches that form a horizontal stripe along the middle of the fish on either side
- Underside ranges in color from light green to almost white
- They have a nearly divided dorsal fin with the anterior portion containing nine spines and the posterior portion containing 12 to 13 soft rays

From Texas Parks and Wildlife, http://www.tpwd.state.tx.us/huntwild/wild/species/lmb/

Western Mosquitofish (***Gambusia affinis***)

Female

Male

- 6.5 cm
- Dull grey or brown in color with no bars of bands on the sides, and has a rounded tail
- Body is short, its head flattened, and its mouth pointed upward for surface feeding
- Other common wetland fish in Utah include: least chub, plains killifish, speckled dace, Utah chub

From U.S. Geological Survey Nonindigenous Aquatic Species Fact Sheet, http://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=846

***Chytrid Fungus* (*Batrachochytrium dendrobatidis*)**

Chytrid fungus causes chytridiomycosis in amphibians.

Disease Progression

Chytridiomycosis is believed to adhere to the following course: zoospores first encounter amphibian skin and quickly give rise to sporangia, which produce new zoospores. The disease then progresses as these new zoospores reinfect the host. Morphological changes in amphibians infected with the fungus include a reddening of the ventral skin, convulsions with extension of hind limbs, accumulations of sloughed skin over the body, sloughing of the superficial epidermis of the feet and other areas, slight roughening of the surface with minute skin tags, and occasional small ulcers or hemorrhage. Behavioral changes can include lethargy, a failure to seek shelter, a failure to flee, a loss of righting reflex, and abnormal posture (e.g. sitting with the hind legs away from the body)

From Chytridiomycosis, http://en.wikipedia.org/w/index.php?title=Chytridiomycosis&oldid=598780305

Appendix G

Summary of species identification issues

Plant species that we were not able to identify in the field during 2013 surveys at Great Salt Lake and Snake Valley sites were brought to the office for later identification. To aid with identification, we used a dissecting microscope, standard set of plant dissection tools, and several plant treatments, including *A Utah Flora* (Welsh, Atwood, Goodrich, & Higgins, 2003), all volumes of the *Intermountain Flora* series (see introductory volume, Cronquist and others, 1972), *Vascular Plants of Northern Utah* (Shaw, Barkworth, & Goodrich, 1989), *Field Guide to Intermountain Sedges* (Hurd, Shaw, Mastrogiuseppe, Smithman, & Goodrich, 1998), and *Flora of North America* (http://floranorthamerica.org). Specimens that were particularly difficult to identify were taken to Utah State University's Intermountain Herbarium for comparison with known specimen and for consultation with Mary Barkworth and Michael Piep. With few exceptions, we used species scientific names as listed in U.S. Department of Agriculture Natural Resource Conservation Service's *Plants Database* (USDA Plants) (http://plants.usda.gov). Nativity was also determined using USDA Plants, with nativity for each species assumed to be the same as that species' nativity in the lower 48 states.

Considerable effort was made to properly identify plant specimen using the most up-to-date plant taxonomy available. When identification was highly uncertain due to missing key plant traits (i.e., fruits, flowers), uncertain taxonomy, or other issues, we generally left specimens unidentified to avoid the possible introduction of false data into Floristic Quality Assessment and wetland condition metrics. However, in some cases it made sense to assign scientific names to species despite some uncertainty. Assignments were made when differences between candidate species were minor (i.e. same or similar nativity and C-values) or when evidence from nearby sites indicated that there was only one likely species. We also compared our species identifications with those of Utah State University Ph.D. student Rebekah Downard, who is also studying flora of emergent Great Salt Lake wetlands. Our specimen identifications may change over time if new information becomes available or taxonomic experts study our material. Data analysis for 2013 field work was based on specimen determinations made through February 2, 2014, and will not reflect any name changes that occurred after this date. Following is a description of major taxonomic decisions made regarding plant specimens from the 2013 field season.

- *Agrostis:* We collected several specimens of *Agrostis* that could have been either *A. stolonifera* or *A. gigantean*. Both species are introduced and have the same C-value and wetland indicator status rating. We called them all *A. stolonifera* based on inflorescence characteristics, but specimens could have been either species.
- *Atriplex:* Out of 25 collected *Atriplex* specimens, only one specimen contained developed fruit, which is essential for species identification. We did not feel like we had enough information to try to identify our five *Atriplex* specimens from Snake Valley. However, we knew through comparison with herbarium records, examination of plant keys, and consultation with Downard that three *Atriplex* species were likely to be frequently encountered around Great Salt Lake, including the native *A. dioica* and the introduced *A. prostrata* and *A. micrantha.* We identified five vegetative specimens as *A. prostrata* based on growth habitat and comparison with Downard's specimens. We assigned some of the remaining *Atriplex* specimens to a group we called *Atriplex complex 1*, which included all specimens that appeared most similar to *A. dioica* and *A. micrantha.* Remaining specimens were not identified to species. We also changed the nativity of *A. prostrata* from native (as listed in USDA Plants) to introduced based on information in *Flora of North America* (http://www.efloras.org/florataxon.aspx?flora_id=1&taxon_id=242414719).

- *Bassia:* It is extremely difficult to differentiate between *B. scoparia* and *B. hyssopifolia* without well-developed fruit, which most of our *Bassia* specimen were lacking. We called the majority of *Bassia* that we encountered *B. hyssopifolia* unless we had strong evidence (well-developed fruit, leaf venation) that pointed towards *B. scoparia.* Downard also identified most of her *Bassia* as *B. hyssopifolia.* Both species are introduced with C-values of 0 and the same wetland indicator values for the arid west region.
- *Calamagrostis:* All uncollected *Calamagrostis* specimens from Snake Valley were updated to *C. stricta* based on the identity of two known collections.
- *Carex:* All uncollected *Carex simulata* specimens from Snake Valley were updated to *Carex sp.* because all collections identified as this species in the field were actually of *C. praegracilis*. Both *C. simulata* and *C. praegracilis* should be present and common in Snake Valley so we did not feel that it would be appropriate to updated all uncollected *C. simulata* to *C. praegracilis.*
- *Centaurium:* All uncollected *Centaurium* specimens from Snake Valley were updated to *C. exaltatum* based on the identity of collections.
- *Chara: Chara* is a multicellular green algae found in fresh water, often in areas with hard calcium-rich water. We sometimes mistook *Chara* for a vascular plant and made collections of it. We added *Chara* to our database of species and include *Chara* on species lists for sites. However, we excluded *Chara* from plant data before performing calculations. We also updated all uncollected *Ceratophyllum* to *Chara* because all specimens identified as the former species in the field turned out to be the latter.
- *Eleocharis: E. rostellata* and *E. quinqueflora* are similar species that are both likely to occur in Snake Valley. Key differences include the fact that the former species has no flower in the lowest scale, coarser stems, and stems that sometimes root at the tips. Of three collected specimens, two were from sites where we distinctly remembered the *Eleocharis* rooting at the tips. The *Eleocharis* at the third site did not have rooting tips, but the site was heavily grazed which may affect growth form. We identified all three specimens as *E. rostellata*. In addition, several species listed on plant lists as *E. quinqueflora* were not collected. Though we did not remember any *Eleocharis* rooting at the tips at these other sites, we decided to update all *E. quinqueflora* identifications to *E. rostellata* because of the lack of confirming specimens of the former species.
- *Galium:* All uncollected *Galium* specimens from Snake Valley were updated to *G. trifidum* based on the identity of collections.
- *Halogeton:* All uncollected *Halogeton* specimens from Snake Valley were updated to unknown forb because the two collections that were identified as *Halogeton* in the field turned out to be two different species (*Suaeda calceoliformis* and *Nitrophila occidentalis*).
- *Lycopus:* All uncollected *Lycopus* specimens from Snake Valley were updated to *L. asper* based on the identity of collections.
- *Mimulus:* All uncollected *Mimulus* and *M. tilingii* specimens from Snake Valley were updated to *M. guttatus* based on the identity of collections.
- *Muhlenbergia:* All uncollected *Muhlenbergia* specimens from Snake Valley were updated to *M. asperifolia* based on the identity of collections.

- *Phragmites australis*: We added two new entries to our database of plant names from USDA Plants, *P. australis* ssp. *australis* and *P. australis* ssp. *americanus*. We considered these two subspecies to be the introduced and native genotypes, respectively, of this species. These subspecies are not currently listed by the USDA *Plants Database*, but are mentioned in the *Manual of Grasses for North America* (http://herbarium.usu.edu/webmanual) developed for the Flora of North America project. Eric Hazelton, Ph.D. candidate at Utah State University and *P. australis* expert, trained field personnel on differentiation between native and introduced *P. australis*. However, training did not occur until near the end of the field season. Though we did not distinguish between genotypes in the field, we assumed that all *P. australis* recorded at Great Salt Lake sites to be the introduced genotype. This was a reasonable assumption because the vast majority of the species around the lake is introduced and because we did not record any *P. australis* at our sites where the native genotype would be most likely (Public Shooting Grounds, Locomotive Springs, and Salt Creek Waterfowl Management Areas and Hansel Valley). We collected *P. australis* from several areas in Snake Valley; these collections were identified as the native genotype by Hazelton.
- *Polygonum:* We sent samples of *Polygonum* fruit and flowers to Mihai Costea, associate professor and herbarium curator at Wilfrid Laurier University, to assist with specimens identification. We sent him *Polygonum* specimens that were most closely aligned with *P. ramosissimum, P. aviculare*, and *P. argyrocoleon* because these three species can be difficult to key out. Costea identified all specimens from Snake Valley as *P. aviculare* ssp. *neglectum*. Specimens from Great Salt Lake were tentatively identified as either *P. patulum,* an uncommon introduced species that has been found in several states in North America, or an unusual form of the native species, *P. ramosissimum,* with tubercled achenes, which has been recorded in salt-marshes of California. Two specimens collected by Downard around Great Salt Lake were identified as *P. aviculare* ssp. *aviculare* and *P. aviculare* ssp. *buxiforme.* There are collections of *P. ramosissimum* from as early as the late 1800s in the vicinity of Great Salt Lake (http://intermountainbiota.org), which indicates that this species (or a similar, but misidentified species) is most likely native to Great Salt Lake. We decided to call our specimens *P. ramosissimum* based on the assumption that it is more likely that this native species still persists than that an uncommon new introduced species has become very common around Great Salt Lake. *P. ramosissimum* has a C-value of 1 compared to *0 for P. patulum*, so the effect of this decision will be minimal on metrics that incorporate C-values. However, the choice of species designation will affect data on the cover and richness of native species.
- *Salicornia*: *Salicornia rubra* and the related perennial *Sarcocornia utahensis* can be differentiated based on the robustness of their root system and the arrangement of their flowers. We initially believe we had both species at our study sites and considered those species with thicker roots to be *S. utahensis.* However, upon examination of herbarium specimen at the Intermountain Herbarium, we decided that it was unlikely that we had encountered *S. utahensis* at any of our sites because *S. utahensis* specimen had much thicker roots than any we had encountered. Furthermore, though our specimens lacked flowers, Downard found that all of her specimen with flowers keyed to *S. rubra.*
- *Sisyrinchium:* All uncollected *Sisyrinchium* specimens from Snake Valley were updated to *S. demissum* based on the identity of collections.

- *Solidago:* All uncollected *Solidago* specimens from Snake Valley were updated to *S. spectabilis* based on the identity of collections.
- *Typha*: Two species of *Typha, T. latifolia* and *T. domingensis,* are known to be native to Utah. Additionally, hybrids between *T. latifolia* and *T. domingensis* are reported from Cache County, Utah, and land managers around Great Salt Lake sometimes declare that hybrid *Typha* is aggressively taking over wetlands. We attempted to distinguish between *T. latifolia, T. domingensis*, and hybrid *Typha* using the *Flora of North America* key, which includes hybrids and relies on observation of microscopic flower bracts (Smith, 2000) that may be deciduous and may not be present on underdeveloped flowers. We were able to identify some *Typha* specimen as *T. latifolia* and *T. domingensis*. The remaining specimens were either not identified to species because key traits were underdeveloped or identified as *Typha possible hybrid* if the specimen had intermediate traits that made hybrid status plausible. We did not observe any specimens that were definitively *Typha* hybrids. The *Typha* description in *Flora of North America* declares that few known collections of *T. domingensis* and *T. latifolia* crosses exist (and none from Utah) and that all but one are highly sterile (Smith, 2000), which lends doubt to our *Typha* hybrid identification. We assigned our potential *Typha* hybrids the same C-value (2) and nativity (native) as *T. domingensis* and *T. latifolia* because of the high likelihood that our hybrids are actually one of these two native species. Specimens identified as *Typha possible hybrid* and *Typha sp.* were not differentiated from one another for the sake of analysis

Appendix H

Non-metric multidimensional scaling evaluation and results

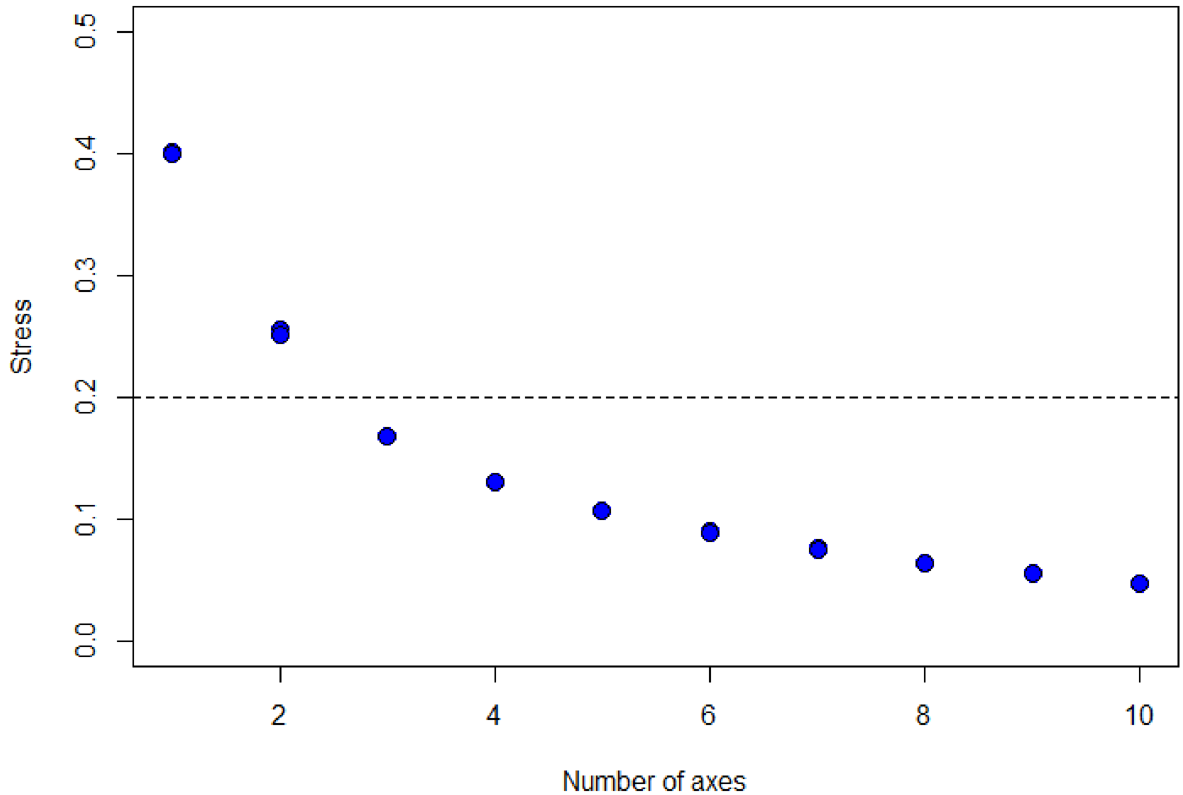


Figure H-1. Stress values obtained from 10 NMDS runs each for runs with between 1 and 10 axes. Each stress value obtained is plotted; however, because most runs converged on identical values, only a single point appears on the plot in most instances. Dashed line indicates value above which plot interpretation is not recommended.

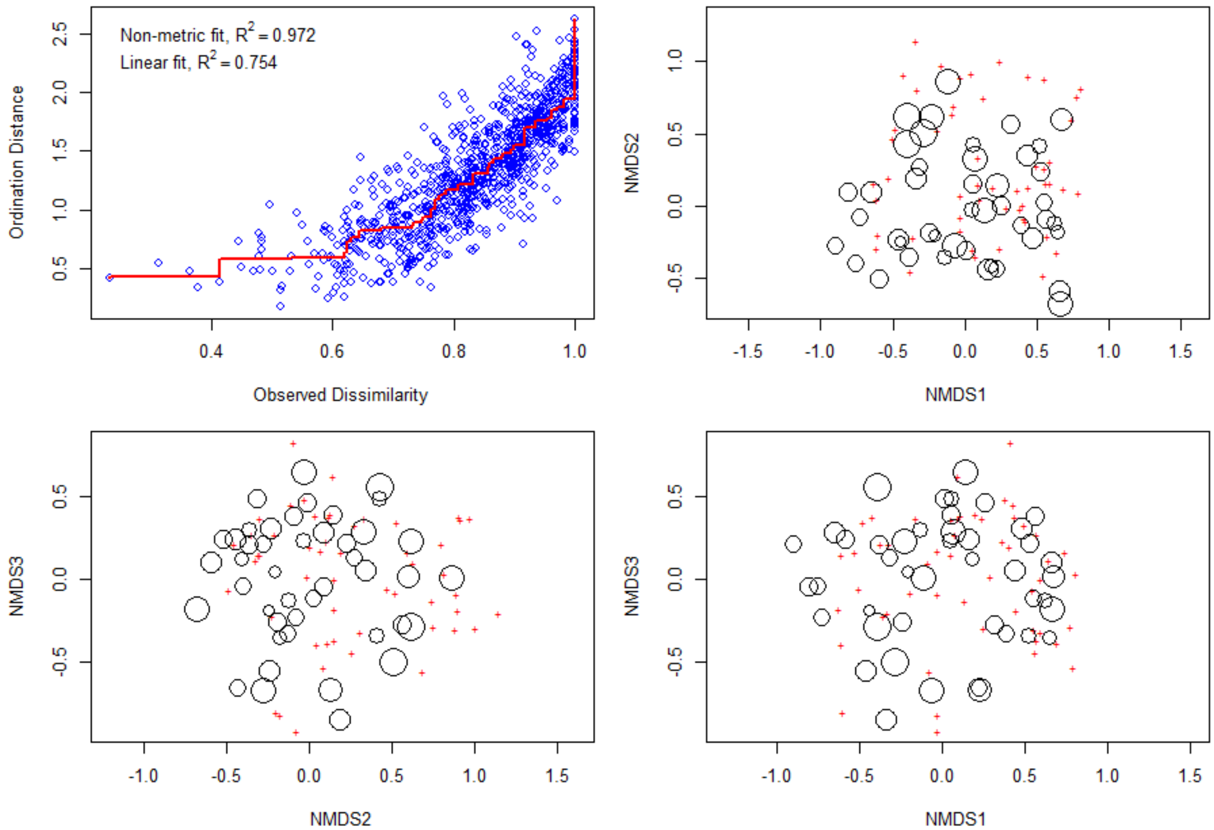


Figure H-2. Shepard plot showing observed similarity versus ordination distance (upper left plot), and species (red crosses) and site (black circles) scores plotted against NMDS axes. Size of each site's bubble is proportional to NMDS goodness of fit values for that site.

Table H-1. NMDS axes scores, R^2 and p-values, and species traits for species included in NMDS of plant community composition data for Great Salt Lake wetlands. Species with p-values ≤0.05 are in bold.

Symbol	Scientific Name	Nativity	Wetland Indicator	C-Value	Axis 1 Score	Axis 2 Score	Axis 3 Score	R^2	P
ATRPRO	*Atriplex prostrata*	Introduced	FACW		0.56	0.81	-0.19	0.06	0.483
ATRCOM	*Atriplex* spp.[1]				0.64	0.17	0.75	0.07	0.457
AZOSPP	***Azolla* spp.**				**-0.18**	**0.98**	**-0.11**	**0.20**	**0.005**
BASHYS	***Bassia hyssopifolia***	**Introduced**	**FAC**	**0**	**0.77**	**-0.10**	**0.63**	**0.16**	**0.026**
BASSCO	*Bassia scoparia*	Introduced	FAC	0	0.40	-0.11	0.91	0.13	0.126
BERERE	*Berula erecta*	Native	OBL	6	-0.49	-0.15	-0.86	0.10	0.222
CHERUB	*Chenopodium rubrum*	Native	FACW	3	0.12	0.70	0.70	0.13	0.124
CHESAL	***Chenopodium salinum***	**Native**			**-0.25**	**0.86**	**0.44**	**0.18**	**0.036**
CIRVUL	*Cirsium vulgare*	Introduced	FACU	0	0.38	0.85	-0.36	0.11	0.126
DISSPI	***Distichlis spicata***	**Native**	**FAC**	**4**	**0.92**	**-0.39**	**0.09**	**0.52**	**0.000**
ELEPAL	*Eleocharis palustris*	Native	OBL	4	-0.86	-0.34	-0.39	0.01	0.954
ELEPARI	*Eleocharis parishii*	Native	FACW		0.58	0.82	0.00	0.11	0.096
EPICIL	***Epilobium ciliatum***	**Native**	**FACW**	**4**	**0.09**	**0.94**	**-0.32**	**0.36**	**0.000**
HELANN	*Helianthus annuus*	Native	FACU	1	0.65	0.67	-0.35	0.12	0.150
HORJUB	*Hordeum jubatum*	Native	FAC	2	0.69	0.51	0.51	0.10	0.232
JUNARC	*Juncus arcticus*	Native	FACW	1	0.71	0.48	-0.51	0.12	0.163
LACSER	***Lactuca serriola***	**Introduced**	**FACU**	**0**	**0.81**	**0.43**	**-0.40**	**0.42**	**0.000**
LEMMIN	***Lemna minor***	**Native**	**OBL**	**2**	**-0.23**	**0.97**	**-0.05**	**0.30**	**0.001**
LEPLAT	***Lepidium latifolium***	**Introduced**	**FAC**	**0**	**0.71**	**0.44**	**0.55**	**0.22**	**0.010**
LEPPER	*Lepidium perfoliatum*	Introduced	FACU	0	0.96	0.27	-0.04	0.04	0.803
LEPFUS	*Leptochloa fusca ssp. fascicularis*	Native		4	-0.09	0.97	0.23	0.10	0.238
MUHASP	***Muhlenbergia asperifolia***	**Native**	**FACW**	**6**	**0.60**	**0.75**	**-0.26**	**0.18**	**0.022**
PHRAUSAUS	***Phragmites australis ssp. australis***	**Introduced**	**FACW**	**0**	**-0.80**	**-0.36**	**0.48**	**0.40**	**0.000**
POLLAP	***Polygonum lapathifolium***	**Native**	**FACW**	**1**	**0.06**	**0.98**	**-0.17**	**0.19**	**0.017**
POLPER	***Polygonum persicaria***	**Introduced**	**FACW**	**0**	**0.09**	**0.88**	**0.47**	**0.21**	**0.005**
POLRAM	*Polygonum ramosissimum*	Native	FAC	1	0.34	0.69	0.64	0.14	0.063
POLMON	***Polypogon monspeliensis***	**Introduced**	**FACW**	**0**	**0.34**	**0.34**	**0.88**	**0.14**	**0.050**
PUCNUT	*Puccinellia nuttalliana*	Native	FACW	6	0.31	-0.11	0.95	0.08	0.344
RANCYM	*Ranunculus cymbalaria*	Native	OBL	4	-0.28	0.95	-0.17	0.11	0.173
RANSCE	***Ranunculus sceleratus***	**Native**	**OBL**	**3**	**-0.17**	**0.98**	**0.06**	**0.19**	**0.002**
RORPAL	***Rorippa palustris***	**Native**	**OBL**	**4**	**-0.10**	**0.92**	**0.37**	**0.25**	**0.003**
RUMCRI	*Rumex crispus*	Introduced	FAC	0	0.72	0.52	0.45	0.07	0.431
RUMMAR	***Rumex maritimus***	**Native**	**FACW**	**3**	**-0.25**	**0.95**	**0.21**	**0.21**	**0.016**
RUMSTE	*Rumex stenophyllus*	Introduced	FACW	0	0.11	0.73	0.67	0.04	0.755
SALRUB	*Salicornia rubra*	Native	OBL	5	0.10	-0.43	0.90	0.09	0.257
SCHACU	***Schoenoplectus acutus***	**Native**	**OBL**	**4**	**-0.52**	**0.67**	**-0.53**	**0.22**	**0.005**
SCHAME	***Schoenoplectus americanus***	**Native**	**OBL**	**4**	**0.03**	**0.04**	**-1.00**	**0.55**	**0.000**
SCHMAR	*Schoenoplectus maritimus*	Native	OBL	6	0.27	-0.52	0.81	0.14	0.101
SCHPUN	*Schoenoplectus pungens*	Native	OBL	5	0.45	0.89	-0.05	0.14	0.050
SENHYD	*Senecio hydrophiloides*	Native	FACW	5	0.61	0.52	-0.60	0.10	0.214
SOLDUL	*Solanum dulcamara*	Introduced	FAC	0	0.25	0.90	-0.35	0.11	0.129
SONASP	***Sonchus asper***	**Introduced**	**FAC**	**0**	**0.68**	**0.59**	**-0.44**	**0.19**	**0.031**
SPEMAR	*Spergularia maritima*	Introduced	FACW	0	0.40	0.62	0.67	0.09	0.266

STUSPP	*Stuckenia* spp.				-0.24	0.60	-0.76	0.10	0.193
SUACAL	***Suaeda calceoliformis***	**Native**	**FACW**	**3**	**0.55**	**0.50**	**0.66**	**0.18**	**0.032**
TAMSPP	*Tamarix* spp.				0.09	0.38	0.92	0.11	0.185
TRIFRA	*Trifolium fragiferum*	Introduced	FACU	0	0.61	0.79	0.03	0.12	0.076
TRIMAR	*Triglochin maritima*	Native	OBL	7	0.99	-0.07	0.09	0.09	0.309
TYPDOM	*Typha domingensis*	Native	OBL	2	-0.67	-0.74	0.05	0.03	0.829
TYPLAT	***Typha latifolia***	**Native**	**OBL**	**2**	**-0.53**	**0.71**	**0.47**	**0.18**	**0.023**
TYPSPP	***Typha* spp.**		**OBL**		**-0.61**	**0.45**	**-0.65**	**0.25**	**0.004**
XANSTR	***Xanthium strumarium***	**Native**	**FAC**	**1**	**0.68**	**0.70**	**0.19**	**0.17**	**0.029**

[1]Includes only those *Atriplex* spp. that most closely resemble either *A. dioica* or *A. micrantha.*

Table H-2. NMDS axes scores and R^2 and p-values for site attribute variables fit to NMDS of plant community composition for Great Salt Lake wetlands. Variables with p-values ≤0.05 are in bold.

Symbol	Description	Axis 1 Score	Axis 2 Score	Axis 3 Score	R^2	P
Continuous Variables						
elev	**mean site elevation**	0.42	0.14	-0.89	0.34	<0.001
maxTemp	**maximum water year temperature, 30 year mean**	**-0.90**	**0.33**	**0.29**	**0.25**	**0.010**
meanTemp	**mean water year temperature, 30 year mean**	**-0.68**	**0.41**	**0.61**	**0.43**	**0.000**
precip	**total water year precipitation, 30 year mean**	**-0.65**	**0.44**	**0.62**	**0.27**	**0.005**
road	distance from site to nearest road	-0.08	-1.00	-0.05	0.04	0.682
updes	**distance from site to nearest point source facility[1]**	**0.39**	**-0.45**	**-0.80**	**0.27**	**0.002**
water	**% water in surrounding 3 km land cover**	**-0.24**	**-0.33**	**0.92**	**0.38**	**0.000**
dev	**% development in surrounding 3 km land cover**	**-0.78**	**0.62**	**-0.06**	**0.19**	**0.042**
wetland	% wetland in surrounding 3 km land cover	0.23	0.93	0.30	0.10	0.243
pasture	**% pasture in surrounding 3 km land cover**	**-0.45**	**0.79**	**-0.42**	**0.27**	**0.007**
ag	**% cultivated crops in surrounding 3 km land cover**	**0.00**	**0.72**	**-0.69**	**0.24**	**0.010**
barren	**% barren in surrounding 3 km land cover**	**0.49**	**-0.71**	**-0.51**	**0.27**	**0.004**
stress	**summary value of stressors recorded near site**	**-0.32**	**0.85**	**0.42**	**0.29**	**0.004**
eiaTotal	**total CNHP-EIA wetland condition score**	**0.40**	**-0.32**	**-0.86**	**0.47**	**0.000**
usaramTotal	total USA-RAM wetland condition score	0.26	-0.89	-0.37	0.13	0.120
uwaamTotal	**total UWAAM wetland condition score**	**0.34**	**-0.34**	**-0.88**	**0.23**	**0.014**
area	total area of assessment area	-0.21	-0.94	-0.28	0.12	0.163
day	day into study in which site was sampled	-0.20	0.18	-0.96	0.03	0.772
Categorical Variables						
HUC8- Curlew Valley		**0.18**	**-0.28**	**-0.55**	**0.30**	**<0.001**
HUC8- Jordan		**-0.02**	**0.14**	**0.25**		
HUC8- Lower Bear- Malad		**0.34**	**-0.04**	**-0.02**		
HUC8- Lower Weber		**-0.38**	**0.03**	**0.00**		
floodplain- outside		**0.32**	**-0.09**	**-0.51**	**0.12**	**<0.001**
floodplain- inside		**-0.05**	**0.01**	**0.08**		
Impounded status- impounded		-0.10	0.02	0.10	0.04	0.162
Impounded status- not impounded		0.09	-0.02	-0.09		
Hydric indicator- absent		0.23	-0.05	0.15	0.05	0.101
Hydric indicator- present		-0.07	0.01	-0.05		

[1]Facilities include publicly owned treatment works (POTW), concentrated animal feeding operation (CAFO), biosolids discharger, and any permitted facility classified as major.