FUNCTIONAL ASSESSMENTS OF WETLANDS AND WILDLIFE IN THE SALT LAKE COUNTY SHORELANDS SAMP AREA

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CHAPTER 1: OVERVIEW OF THE SALT LAKE COUNTY SHORELANDS SPECIAL AREA MANAGEMENT PLAN (SAMP)

1.1 BACKGROUND AND PROJECT DESCRIPTION

As communities along the Wasatch Front grow, the shorelands and uplands of Great Salt Lake are experiencing greater development pressure each year. Relatively low land costs compared to adjacent urbanized areas, easy access to Interstate 80 (I-80) and the proposed Mountain View Corridor, and proximity to the Salt Lake City International Airport make the upland areas west of the airport attractive for economic growth in the area. The area (west of I-215 to Great Salt Lake's shore, and from the Salt Lake County/Davis County line down to 2100 South—approximately 80,000 acres) happens to encompass wetlands of the southern and southeastern shores of Great Salt Lake that are an invaluable resource for millions of migratory shorebirds and water birds each year. Because of the potential for increasing pressures from development on the wetlands and wildlife that use them, a need for a comprehensive wetlands planning process was identified by environmental and planning groups.

The key case that spurred Salt Lake County to participate in a comprehensive wetlands planning process was an application to establish an asphalt re-conditioning plant within the county limits and in close proximity to extensive wetlands. A planning process was subsequently initiated in 2002 and was designed to guide the preservation, restoration, and maintenance of the county's (and Salt Lake City's) high-functioning wetlands in perpetuity. The Shorelands Plan (Envision et al. 2003) was the first planning phase designed to set the stage for a regional plan. A special area management plan (SAMP) was subsequently initiated in 2003 and involved a science-based assessment of wetlands and associated habitat in the SAMP area to inform the SAMP process. This planning process is important and timely particularly for Salt Lake City, due to increasing pressures from landowners who wish to develop their property in the northwest quadrant of Salt Lake City.

1.2 GOALS AND OBJECTIVES OF THE SALT LAKE COUNTY SHORELANDS SAMP

The overarching goal in completing a SAMP for Salt Lake County (and Salt Lake City) is to preserve and enhance the quality of local wetlands and waters of the U.S. while encouraging responsible urban development within appropriate areas. To reach this goal, the SAMP that is developed must:

- identify high-quality wetlands suitable for preservation, other wetlands that have enhancement or restoration potential as mitigation for wetland impacts elsewhere in the SAMP area, and low-quality wetlands in which urban development could occur;
- be compatible with zoning ordinances; and
- be associated with a U.S. Army Corps of Engineers (ACOE), Utah Regulatory Office General Permit (under Section 404 of the Clean Water Act) that would regulate the

discharge of dredge and fill materials into wetlands and waters of the U.S. within the SAMP boundary.

Creation of the General Permit would enable landowners and developers to avoid the lengthy, expensive, and somewhat unpredictable process for obtaining individual Section 404 permits through the ACOE. Other benefits associated with an approved SAMP and General Permit include economy and ecology of scale, with respect to wetland mitigation. In compensating for unavoidable wetland impacts within the SAMP area, mitigation areas and costs will have been already identified, and a monitoring plan will have been already put in place. The General Permit would not only save the landowner/developer time and money in getting their project permitted, it would ensure that mitigation areas are interconnected and functional with other wetlands in the area. Finally, having the General Permit administered through the Salt Lake County Planning and Services Development Division and Salt Lake City Division of Planning would keep the regulatory process under local control. While the ACOE would monitor the process to ensure that the permit is being administered properly, County and City control would allow permitting personnel to be more accessible and responsive to landowners' needs.

CHAPTER 2: FUNCTIONAL ASSESSMENT OF WETLANDS IN THE SALT LAKE COUNTY SHORELANDS SAMP AREA VIA THE GREAT SALT LAKE (GSL) MODEL

In order to define appropriate areas for preservation, restoration or enhancement, and compensatory mitigation within a given area, the relative level of ecological function of all wetlands (e.g., groundwater recharge and discharge; wildlife, fish, and macroinvertebrate habitat; sediment, toxicant, and pathogen retention; sediment and shoreline stabilization) within that area must be determined. Therefore, a SAMP for a given area must be based on scientifically gathered information about the wetlands and related natural resources in that area. One tool that is commonly used to evaluate ecological function is a wetlands functional assessment.

2.1 SELECTION OF THE MODEL

Various models for wetlands functional assessments exist nationwide, yet most are region-specific and, thus, cannot be prudently adapted for use in wetlands of the Great Basin. Other methods of assessment, such as the habitat evaluation procedure (HEP) and hydrogeomorphic (HGM) assessment, are appropriate for use in the region but have other limitations. A HEP provides general information on relative presence of habitat that meets specified criteria by using inferential models to calculate basic habitat functions; however, it does not rely on empirical data to assess those functions. It is most useful for assessing total acreage of available habitat (converted to habitat units) prior to and after mitigation actions, not for parsing wetland habitat by quality of function. HGM assessment method (Brinson 1993; Brinson et al. 1995) utilizes chemical, physical, and biological processes to assess wetland functions, measure wetland ecological condition, and establish compensation ratios for mitigation-based projects. However, HGM models developed for use in Utah are generally in their preliminary stages.

So far, there are three Utah models known to be potentially appropriate for a wetlands functional assessment of the SAMP area:

1. UDOT Wetlands Functional Assessment Method (UDOT Model; latest draft 2005 [Johnson 2005]);
2. Functional Assessment Model for Slope – Spring and Seep Fed Wetlands of the Great Basin (Hill Air Force Base Model; Jones et al. 2003); and
3. Functional assessment of Great Salt Lake Ecosystem Slope and Depressional Wetlands (Great Salt Lake [GSL] Model; latest draft 2005 [Keate 2005]).

The ACOE has favored the GSL Model for use in several projects around Great Salt Lake—not only the Shorelands SAMP, but also the Legacy Parkway project, the Tooele SAMP, and the Mountain View Corridor project. From the beginning of the SAMP's assessment process, this model—both the 2001 version initially approved by the ACOE and the updated, 2005 version—was anticipated to be the most appropriate model of the three because it was developed specifically for wetland types associated with Great Salt Lake.

Both the 2001 and 2005 versions of the model classify wetlands by HGM setting (by class and subclass), define profiles of each class and subclass with reference sites, and evaluate wetland function. Although profiles of the various subclasses that fall under slope and depressional wetland HGM classes had not yet been defined in 2001 and a reference wetland network has yet to be developed, the basic construct of the model was available and appropriate for assessing wetland function within the Shorelands SAMP area since the beginning of the Shorelands SAMP process, in 2002.

None of the three wetlands functional assessment models for Utah adequately assesses wildlife habitat function—in this case, an important function for supporting migratory and nesting shorebirds and other waterbirds that use Great Salt Lake. In order to ensure the wetlands functional assessment of the Shorelands SAMP area was comprehensive, we developed a supplemental wildlife functional assessment based on empirical data. Ultimately, we anticipated that a useful planning tool for the SAMP would emerge from the combined results of the two functional assessments.

2.2 THE GSL MODEL: CAPABILITIES AND LIMITATIONS

The GSL Model initially developed in 2001 was designed to assess function of wetlands on a site-by-site basis. In 2005, it was adapted to assess wetland function and determine environmental consequences for large planning projects such as SAMPs (Tooele County, Salt Lake County), the environmental impact statement for the Legacy Parkway, and recently, identifying the least environmentally damaging practicable alternative (LEDPA) along the Mountain View Corridor. It also has applications for total maximum daily load (TMDL) determinations, such as the Cutler Reservoir TMDL. Using the GSL Model in a functional assessment approach to these large-scale planning projects has provided a consistent, scientifically defensible method for understanding existing wetland functions and ranking their functional capacities, determining future development-related impacts to wetlands, and developing adequate compensatory mitigation for development (Keate 2005).

The mathematical GSL Model utilizes algebraic formulas to calculate a score of 0 to 1 for six indices of wetlands functional capacities. For any given wetland, these six Functional Capacity Indices (FCIs):

- reflect the level of disturbance or degradation to the wetland's hydrology (by extrapolating interception and conveyance of groundwater and surface water [FCI_{hydro}, $FCI_{inhydro}$]);
- reflect the level of disturbance or degradation to a wetland's ability to improve water quality (by extrapolating the removal of dissolved elements and compounds and its capacity for particulate retention [$FCI_{dissolved}$, $FCI_{particulates}$]); or
- estimate the wetland's potential as wildlife habitat by assessing vegetation structure (as habitat support) and modeling habitat connectivity ($FCI_{habitat}$, $FCI_{connectivity}$).

All but $FCI_{habitat}$, which uses vegetation data collected from the SAMP area, rely on national averages of runoff and loading indices as related to various land uses (Nnadi 1997). The functions and variables used in the GSL Model are described in more detail below, in Section

2.3.4. Depending on the project objectives, any combination of the GSL Model's most applicable FCIs can be used.

To-date, the FCIs that are least used (or are most modified) are habitat support ($FCI_{habitat}$) and wildlife habitat connectivity ($FCI_{connectivity}$). Although most HGM models are not designed to assess wildlife habitat function, the GSL Model attempts to include wildlife habitat function because the Great Salt Lake wetlands are particularly important habitat to wildlife in the region. However, for several reasons, the model's wildlife component does not render an adequate assessment. It is derived from cases made in scientific literature on several species that do not occur or are not relevant to wetlands of Great Salt Lake; it is framed around barriers to wildlife that are relatively meaningless in determining habitat function for birds; and its buffer is based on species that may not be meaningful (or specific) to wetlands of Great Salt Lake. Other regional studies that have made use of the GSL Model have adapted it or added to it in order to more adequately assess wildlife habitat:

- For the Mountain View Corridor environmental impact statement, four of the six FCIs from the original model (Keate 2001) were used. Wildlife habitat quality and habitat connectivity FCIs ($FCI_{habitat}$ and $FCI_{connectivity}$, respectively) were excluded and replaced with a habitat evaluation procedure (HEP), which evaluated all habitat within the area of potential impact, not just wetlands. Unfortunately, while HEPs assess wildlife function, they do not typically rely on empirical data. Instead, they develop indices of habitat suitability from which an area is rated and can be either conservative or liberal.
- In the Tooele SAMP, all FCIs were used, but the formula (specifically, the use of the barrier variable) for $FCI_{connectivity}$ was modified (see Appendix B.4). The Shannon-Weaver Diversity Index was applied to one year of empirical avian data collected within the plan area, normalized to a scale of 0 to 1, and substituted for the barrier variable in the formula (Shannon and Weaver 1949). This modification based the assessment of avian habitat function on a relative index of species richness and evenness for each survey point and extrapolated to functional unit using a weighted mean.

The Shorelands SAMP uses all FCIs except $FCI_{connectivity}$. The supplemental wildlife functional assessment is used in place of $FCI_{connectivity}$, since shorebirds and other waterbirds use wetlands and associated habitat heavily in SAMP area, and because multiple years of empirical data were available. The supplemental wildlife functional assessment process is treated separately from the GSL Model wetlands functional assessment, and a detailed description of the process and its results are presented in Chapters 3 and 4.

2.3 The Wetlands Functional Assessment Design, Parameters, and Process

2.3.1 Vegetation Classification Mapping

2.3.1.1 Imaging

To provide baseline data for the wetlands functional assessment, mapping of wetland vegetation classification was conducted during 2002 and 2003.

IKONOS 4-m resolution satellite imagery with 4 bands (including near infrared) was collected for the plan area starting in July 2002. This type of imagery was chosen due to the large scale of the plan area and the cost, as well as because the same imagery could be collected at a later date to repeat a similar process for future comparisons. Furthermore, a near infrared band enhances the vegetation analysis by showing the energy emitted from living plants, as opposed to the sunlight they reflect. The ACOE and the Environmental Protection Agency (EPA) both agreed that imagery with a resolution of 4-×-4-m pixels would suffice, since the classification was not going to be used in lieu of a wetland delineation.

Imagery of the original plan area north of I-80 and west of I-215, as designated by Utah Reclamation Mitigation Conservation Commission (Mitigation Commission), was collected as three separate scenes on July 7, 2002—before the Shorelands SAMP Steering Committee convened—because there were limited windows within which imagery could be effectively collected. Once the SAMP process was initiated, the Steering Committee decided to expand the plan area to include areas south of I-80 that contained similar wetland types and open land. Thus, the same imagery was collected for the expanded SAMP area, south of I-80 and east of I-215, a year later on July 10, 2003, as one scene.

The scenes were all color balanced and mosaicked together as one image using ERDAS Imagine 8.4. The reflectance value difference between the scenes was negligible and did not warrant further processing. The changes in ground cover types, however, varied slightly between 2002 and 2003. The scene from 2002 showed that some of the ponds—in particular, one near the golf course next to the airport—had more water in them than in 2003. Also, there was a little more vegetation on the playas south of I-80 in 2002 than in 2003. However, these were not major discrepancies that would affect the outcome of the wetlands mapping.

2.3.1.2 Pilot Study

To check spectral signatures and the resolution of the satellite imagery, two pilot areas were selected for their diverse vegetation coverage and access and analyzed. One area was within Farmington Bay Waterfowl Management Area (FBWMA), and the other was in the National Audubon Society's South Shore Preserve. Field data of approximately 20 different ground cover types were collected using Trimble GeoIII GPS units and mapped. Transition zones and areas less than 4 × 4 m with multiple vegetation types were mapped for sample data.

2.3.1.3 Image Classification

Image classification is a computerized process that gives each pixel of a digital image a spectral signature based on its electromagnetic reflectance value. This iterative clustering process uses a minimum distance formula to repeat the clustering of pixels until either a maximum number of iterations have been performed, or until it reaches its convergence threshold. In this case, a 95% convergence threshold was used. This unsupervised method of classification performs the calculations with minimal user input and is less biased than other methods. ERDAS Imagine 8.4 was used to perform the classification using an algorithm called ISODATA (Iterative Self-Organizing Data Analysis Technique).

In image classification, the recommended number of classes to use is twice the number of intended classes (i.e., land cover types being mapped). It was assumed that we would have about 20-25 different types of land cover, and so the classification process was initially run with different output class numbers of 25, 50, and 100. After comparing the outcomes, 50 classes gave the most accurate results, with classes being neither too generalized nor too specific. Land cover types were assigned to the classes using the field data, imagery interpretation, and existing vegetation data. Because many urban surfaces have signature reflectance values similar to natural surfaces (e.g., concrete pavement and barren playas share similar signature reflectance values), major urban areas, including the airport, were clipped out of the imaging to diminish the confusion.

A process called cluster busting was applied to classes that contained more than one land cover type. Cluster busting breaks apart classes that have confused (not disaggregated) signatures. For example, some classes that shared similar values in certain areas of their spectral signatures were some types of emergent marsh vegetation and riparian shrubs, playa and disturbed bare ground, and floating aquatic vegetation and upland grasses.

Scatter plots, distribution curves, and the existing vegetation datasets were utilized during this cluster busting. Roads and canals were digitized from the imagery, using ArcView 9.1, and then buffered for their widths. These vector files were converted to raster datasets using ArcView 9.1 Spatial Analyst and then merged into the land cover classification. Field ground-truthing and verification were continued throughout this process to evaluate the accuracy of the classification results. At some level of detail, the cluster-busting process couldn't separate the classes any further, even though there was inaccurate classification in some areas. At that point, the land cover classes were grouped by the following wetland types and uplands: open water, emergent marsh, wet meadow, transitional wet meadow, playa/mudflat, vegetated playa, and playa. This classification scheme was kept purposefully simple to accommodate the limits of the 4-×-4-m resolution of the satellite data which, of course, was determined by the ACOE and the EPA to be adequate for use in the planning tool (in contrast to resolution needed for a more detailed wetland delineation).

We then used ERDAS Imagine's error matrix program to run an accuracy assessment of the data. The program generates an accuracy report based on the percentage of correctly classified data compared to the classification of known, reference data. A total of 350 stratified, random points, representing various wetland types, were used as the known reference data. Fifty points were assigned to each class, as well as to a wet meadow/emergent marsh type for a confused class. Congalton (1991) shows that more than 250 reference pixels (total) are needed to estimate the mean accuracy of a class to within ± 5%. Ground-truthed field data, existing wetlands delineation data, and higher resolution aerial photography were used to evaluate the true land cover type of each accuracy assessment point. The error matrix program indicated an 88.4% accuracy for the classification, which met the USGS-NPS Vegetation Mapping Program recommended standards of at least 80% accuracy (USGS and NPS 2006).

After the accuracy assessment was completed, areas known to be classified incorrectly due to limitations of the imagery's spatial and spectral resolution, were "hand edited" to achieve a more accurate classification. Using field data, existing delineation data, and other imagery, areas that needed to be changed were digitized as AOIs (Areas of Interest). A recoding model was used in Imagine to reassign classification values for these areas. A second accuracy assessment was not generated due to budget constraints; however, a more realistic classification was achieved.

The final step of the wetland classification process involved using ERDAS Imagine to run a spatial filtering process to diminish the speckled or "salt and pepper" appearance of the classification maps. A fuzzy convolution filter was applied using a 3-×-3 kernel, which is the smallest window of values available. This process allowed classes with a very small distance value to remain unchanged, though classes with higher distance values might change to a neighboring value.

Finally, in order to convert the raster classification data to vector polygons—a format required for further GIS analysis—a minimum mapping unit was established. Since the classification conducted for this project was for planning, not delineation, purposes, and since the ACOE does not claim jurisdiction over wetlands smaller than 1/10 acre, the ACOE agreed to a minimum mapping unit of 1/10 acre. A clump analysis was then performed to generalize the 4-m pixel data to the minimum mapping unit of 1/10 acre.

2.3.1.4 COWARDIN ET AL. (1979) WETLANDS CLASSIFICATION

The Shorelands open water and wetlands classifications resulting from this process are presented in Figure 2.1. Classes identified in the mapping are open water, emergent marsh, wet meadow, transitional wet meadow, playa, vegetated playa, and playa/mudflat.

- The **open water** classification indicates bodies of ponded or flowing water and Great Salt Lake.
- **Emergent marsh** is characterized by erect, rooted, herbaceous aquatic vegetation that remains standing until the next growing season (persistent subclass under Cowardin et al. 1979). Emergent vegetation is typically submerged at the roots by shallow water for most of the year, or its roots are associated with the water table during dry years. Examples of emergent vegetation in the Shorelands SAMP area are cattail (*Typha* spp.), hardstem bulrush (*Schoenoplectus acutus*), softstem bulrush (*Schoenoplectus tabernaemontani*), and phragmites (*Phragmites australis*).

  Wet 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.Examples of wet meadow vegetation in the Shorelands SAMP area are grass or grass-like species such as inland saltgrass (*Distichlis spicata*), arctic rush (*Juncus articus*), common spikerush (*Eleocharis palustris*), and foxtail barley (*Hordeum jubatum*).
- **Transitional wet meadow** is characterized by areas that have slightly more than 50% non-wetland grasses and forbs but have wet meadow vegetation as the remaining cover. This class is not recognized by any other classification scheme, but it is used here to identify areas that are in the process of converting into either upland or wetland habitat.

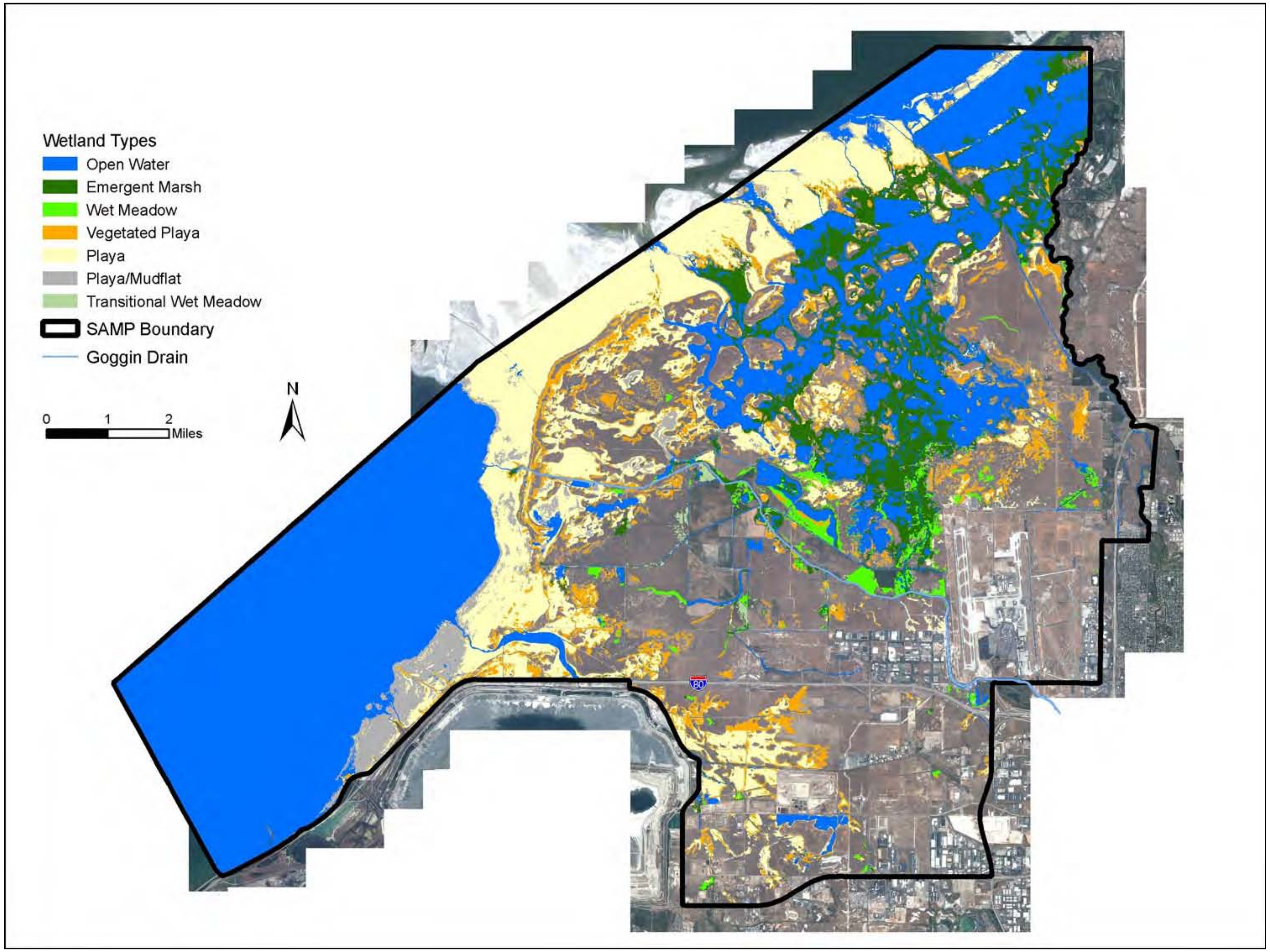

Figure 2.1. Wetlands classifications for the Shorelands SAMP area (based on Cowardin et al. 1979).

- **Playa** classification was subdivided into playa, vegetated playa, and playa/mudflat, due to different spectral signatures associated with vegetation, barrenness, and moisture.
  - **Playas** are shallow depressions of unconsolidated bottom that vary in soil salinity.
  - **Vegetated Playas** are areas within a playa that are vegetated with salt-tolerant vegetation. As surface salts are removed from the system, pickleweed (*Salicornia europaea*, which commonly grows in playas) gives way to less salt-tolerant species and eventually may fill in entirely with low- or non-salt tolerant species. Pioneer species that often invade playas are inland saltgrass, Nutall's alkaligrass (*Puccinellia nuttalliana*), little barley (*Hordeum pussilum*), and fivehorn smotherweed (*Bassia hyssopifolia*).
  - **Barren playas and/or mudflats** were grouped together as one class due to commonalties in their spectral signatures; they nonetheless occupy different niches or locations. Barren playas are enclosed depressions surrounded by halophytic (salt-tolerant) and upland vegetation such as iodine bush (*Allenrolfea occidentalis*), greasewood (*Sarcobatus vermiculatus*), and grasses. Mudflats form on gradual slopes toward small or large water bodies such as edges of shallow ponds or the shores of Great Salt Lake.

Riparian or scrub-shrub habitat exists along most of the water conveyances in the SAMP area, yet, except at the major water conveyances, the aerial coverage of this vegetation type was too small to sort out as a singular class. Scrub-shrub is characterized by Cowardin et al. (1979) as broad-leaved, deciduous, woody vegetation less than 20 feet tall. Examples of scrub-shrub vegetation in the SAMP area are coyote willow (*Salix exigua*), salt cedar (*Tamarix ramosissima*), and Russian olive (*Elaeagnus angustifolia*).

2.3.1.5 Slope/Depressional Wetlands Classification and Soil Salinity

Wetland types applicable to the GSL Model are classified according to different parameters—and more broadly—than those found typically described by the National Wetland Inventory or Cowardin et al. (1979). Following an HGM scheme (Brinson 1993), the GSL Model groups all Great Salt Lake ecosystem wetlands into two types: slope and depressional.

- **Slope wetlands** occur at points of surface change or breaks in slope. Groundwater is the primary water source, and water flow is unidirectional, down-gradient to streams, ponds, or depressions.
- **Depressional wetlands** are low areas relative to the surrounding landscape and have closed contours. Their hydrology is driven by groundwater and precipitation, typically in a vertical rather than horizontal hydrodynamic, but it may also include input from surface water (typically as surface runoff or sheet flow).

The GSL Model is also designed to consider local conditions found within the Great Basin, particularly near Great Salt Lake. In this closed system, which includes valleys that are filled with alluvium eroded from mountains, wetlands and other waters of the U.S. include saline depressions (playas); saline pans; salt flats; and fresh or saline ponds, wet meadows, and emergent marshes (Keate 2005). All of the watercourses leading to Great Salt Lake are developed for urban, agricultural, or wildlife management use. Small springs and artesian wells are common around the lake.

In general, there is an increasing salinity gradient towards Great Salt Lake and, along with depth to groundwater, salinity influences the composition of wetland vegetation communities. The GSL Model was specifically developed for local conditions and soil salinity ranging from < 8dS (slightly to non-saline) to > 16dS (strongly saline; see Appendix B.1).

2.3.2 Field Methodology

Field assessments are a necessary component of the wetlands functional assessment for three reasons:

1. ground-truthing the vegetative cover type and land use mapping classifications;
2. collecting vegetation data; and
3. noting hydrology and hydrologic modification barriers surrounding and within wetlands.

Ground-truthing the mapping classifications is done to assess the accuracy of the classifications (see Section 2.3.1). Depending on the size of the plan area and the objectives for a given project, vegetation data can be collected as a windshield survey with spot checks in areas of concern (as was done for the Mountain View Corridor project), a more traditional botanical methodology (as is done for the Shorelands SAMP), or a combination of both (as was done for the Tooele SAMP). For the Shorelands SAMP, hydrologic conditions in and around the wetlands determined whether a wetland was classified as slope or depressional, as well as other criteria for calculating variables of the FCIs. Hydrologic modification barriers noted in the field helped determine the extent to which wetland hydrological functions were affected and helped define the extent of wetland complexes.

For the Shorelands SAMP, the 350 computer-generated, randomly selected points were visited on foot in the field, not only to acquire accurate information, but because most of the SAMP area was inaccessible by vehicle. The random points were stratified such that more points were assigned for classification types that remained confused after the imaging classification process. At each point, four plots of 1 m^2 were assessed at 10 feet to the north, east, south and west of each point to evaluate ocular percent cover of dominant vegetation and species composition for native-to-non-native ratios. Hydrological modifications (e.g., roads, canals, or utility easements that may have disrupted the original hydrology of the wetland) and the amount (percentage) of wetland affected by human-related disturbance were noted at each point. A photograph was taken to document each point. Percent cover of native and non-native species per point was downloaded to a GIS layer.

Throughout the SAMP area, wetlands tend to occur in large complexes that are dominated by similar wetland types and partitioned by major hydrological modification barriers. Examples of such barriers are multi-lane highways (I-80, I-15), canals (Goggin Drain, North Point Consolidated Canal), and industrial/commercial complexes (International Center). To more accurately represent these complexes, the SAMP area was divided into 10 wetland units. Wetland units do not need to be of comparable size since they are hydrologically discrete.

At this point, the functional assessment analysis becomes a GIS process to calculate variables that in turn are used to calculate FCIs.

2.3.3 Land Use Classification via Geographic Information Systems (GIS)

Land use, a major component of the GSL Model wetland functional assessment, is considered a surrogate for human impacts on, or impairment of, wetland functions. Using a water-use file from Utah's Automated Geographic Reference Center (AGRC), ground-truthing, and verification with land owners, land uses were classified, compiled into a GIS land-use layer, and applied to the entire SAMP area. The GSL Model lists 23 different land use types, from roads and industrial areas to golf courses and cropland (Keate 2001; Appendix A). Twenty-one of the 23 listed land uses were found to occur within the Shorelands SAMP area.

Each land use type was assigned a coefficient[1] derived from a composite of studies conducted throughout the U.S. (Nnadi 1997), and these coefficients were used to calculate 11 of 12 model variables[2] associated with the 6 FCIs (Keate 2001). Although the runoff coefficients were developed from one study, it was the best available information. High-value coefficients (those close to 1) are associated with land uses that have relatively little impact on wetland function, such as rotational grazing. Low-value coefficients (those at or close to 0) correspond to land uses that have a relatively large impact on wetland function, such as high-intensity commercial development. Table 2.1 provides a sample of some of the coefficients used to calculate the variables, and the complete table of coefficients is listed in Appendix A.

Table 2.1. Sample Land Use Types and Associated Coefficients

	GSL Model Coefficients			
Land Use	**Runoff**	**Loading**	**Suspended Solids**	**Wildlife Habitat**
Dirt Road	0.71	0.92	0.97	0.30
High-intensity Commercial	0.13	0.00	0.00	0.00
Heavy Grazing	0.76	0.87	0.98	0.10
Multi-family Residential	0.38	0.69	0.16	0.10

Source: Keate 2001.

2.3.4 Functional Capacity Indices (FCIs) of the 2001 GSL Model

The FCIs of the GSL Model represent in mathematical terms the ability of a wetland to perform a specific wetland function. The six FCIs and their component variables (see Appendix B.1), as defined in the GSL Model (Keate 2001), are detailed here.

1. FCI_{hydro}

FCI_{hydro} measures a wetland's capacity for intercepting groundwater and surface water outside the wetland, as affected by land use and hydrologic modification:

$$FCI_{hydro} = \sqrt{(V_{mod} \times V_{runoff})}$$

where V_{mod} is a categorical scale that relates to how land use modifications have affected surface water hydrology in the area of the wetland.

[1] For the unlisted "tailings impoundment" land use, the coefficient for "industrial," a comparable land use, was used.
[2] The variables are related to runoff, pollutant loading, and suspended solid filtration both within and adjacent to the wetland.

where V_{runoff} is the average amount of overland flow or surface runoff reaching the wetland. Quantity and timing of water delivery is affected by soil permeability as related to land uses adjacent to the wetland.

2. $FCI_{inhydro}$

$FCI_{inhydro}$ measures the internal water flow as related to vegetative structure (as a measure of roughness and flow dissipation) as well as effects on soil permeability and vegetation type by land use within the wetland:

$$FCI_{inhydro} = (V_{vegstruct} + V_{runoffin}) \div 2$$

where $V_{vegstruct}$ is a measure of surface roughness associated with the quality and cover of wetland vegetation.

where $V_{runoffin}$ measures the impact of land use on soil permeability and water infiltration and flow within the wetland.

3. $FCI_{dissolved}$

$FCI_{dissolved}$ measures a wetland's capacity to remove dissolved elements or compounds through biotic, physical, and chemical processes:

$$FCI_{dissolved} = (V_{diswetuse} + V_{disload}) \div 2$$

where $V_{diswetuse}$ refers to the load of dissolved solids associated with land use within the wetland.

where $V_{disload}$ measures the amount of dissolved solids associated with land uses adjacent to the wetland.

4. $FCI_{particulates}$

$FCI_{particulates}$ measures the deposition and detention of inorganic and organic particulates due primarily to physical processes:

$$FCI_{particulates} = (V_{susload} + V_{suswetuse} + V_{mod}) \div 3$$

where $V_{susload}$ is total suspended solids (TSS), or particulate matter, associated with adjacent land uses and transported to surface waters of the wetland.

where $V_{suswetuse}$ is TSS, or particulate matter, associated with sources from land uses within the wetland.

where V_{mod} is a categorical scale that relates to how land use modifications have affected surface water hydrology in the area of the wetland.

5. $FCI_{habitat}$

$FCI_{habitat}$ is a measure of composition and characteristics of the living plant biomass as associated with human disturbances related to various land uses:

$$FCI_{habitat} = (V_{habwetuse} + V_{adjhab} + V_{vegstruct}) \div 3$$

where $V_{habwetuse}$ is a measure of habitat support of land uses within the wetland.

where V_{adjhab} is a measure of habitat support by adjacent land uses for wildlife utilization.

see function 2, $FCI_{inhydro}$, for $V_{vegstruct}$.

6. $FCI_{connectivity}$

$FCI_{connectivity}$ is a measure of the integrity of wildlife corridors surrounding the wetland. In the Shorelands SAMP, this FCI is replaced by the wildlife functional assessment:

$$FCI_{connectivity} = (V_{barrier} + V_{connectivity} + FCI_{hydro}) \div 3$$

where $V_{barrier}$ is a measure of habitat fragmentation of the wetland relative to its adjacent wetlands and native plant communities.

where $V_{connectivity}$ is a measure of the loss of habitat and fragmentation of habitat (from data based on explicit and implicit spatial models; Keate 2001).

see function 1 for FCI_{hydro}.

FCIs were calculated for each of the 10 wetland units in the SAMP area and apply only to the wetland types within the given wetland unit. The formulas for each variable are detailed in Appendix B.1. A summary of the FCI results is in Appendix B.2. The raw data used to calculate the Shorelands SAMP variables and FCIs are presented in a series of worksheets in Appendix B.3. Finally, an alternative to calculation of $FCI_{connectivity}$ from Keate's 2001 model is provided in Appendix B.4: use of the Shannon-Weaver Diversity Index in $FCI_{connectivity}$ for the Tooele SAMP. The first five FCIs for the Shorelands SAMP (excluding $FCI_{connectivity}$) are shown in Figure 2.2, by wetland unit.

2.3.5 Calculation of Functional Capacity Units (FCUs): An Example

Once FCIs are calculated, they can be converted to Functional Capacity Units (FCUs) by multiplying the FCI score by the acres of impact. This provides a standardized measure of the functional loss to each unit from the effects of each proposed action. Consequently, FCUs become the main currency of wetland analysis within the GSL Model. Converting FCIs into FCUs enables the regulating agency to determine LEDPAs and compensatory mitigation ratios, for example.

The Shorelands SAMP is not at the planning stage where acreage of impact can be determined (i.e., the Salt Lake City Master Plan for the northwest quadrant of the city must be completed before the SAMP process can continue). Therefore, to demonstrate how one could interpret the FCIs in the future, an example of the utility of FCUs from the Mountain View Corridor assessment is provided in Table 2.2. Combining FCI scores with acres of impact demonstrates a higher total functional loss from a small, high-functioning wetland than from a larger, low-functioning wetland.

Table 2.2. Sample Calculation of Functional Capacity Units (FCUs) from the Mountain View Corridor Wetlands Functional Assessment

Functional Unit	Functional Level	FCI_{hydro}	Acres of Impact	FCU
19	High Functioning	0.838	18	15.08
14	Medium Functioning	0.593	22	13.04
16	Low Functioning	0.327	26	8.50

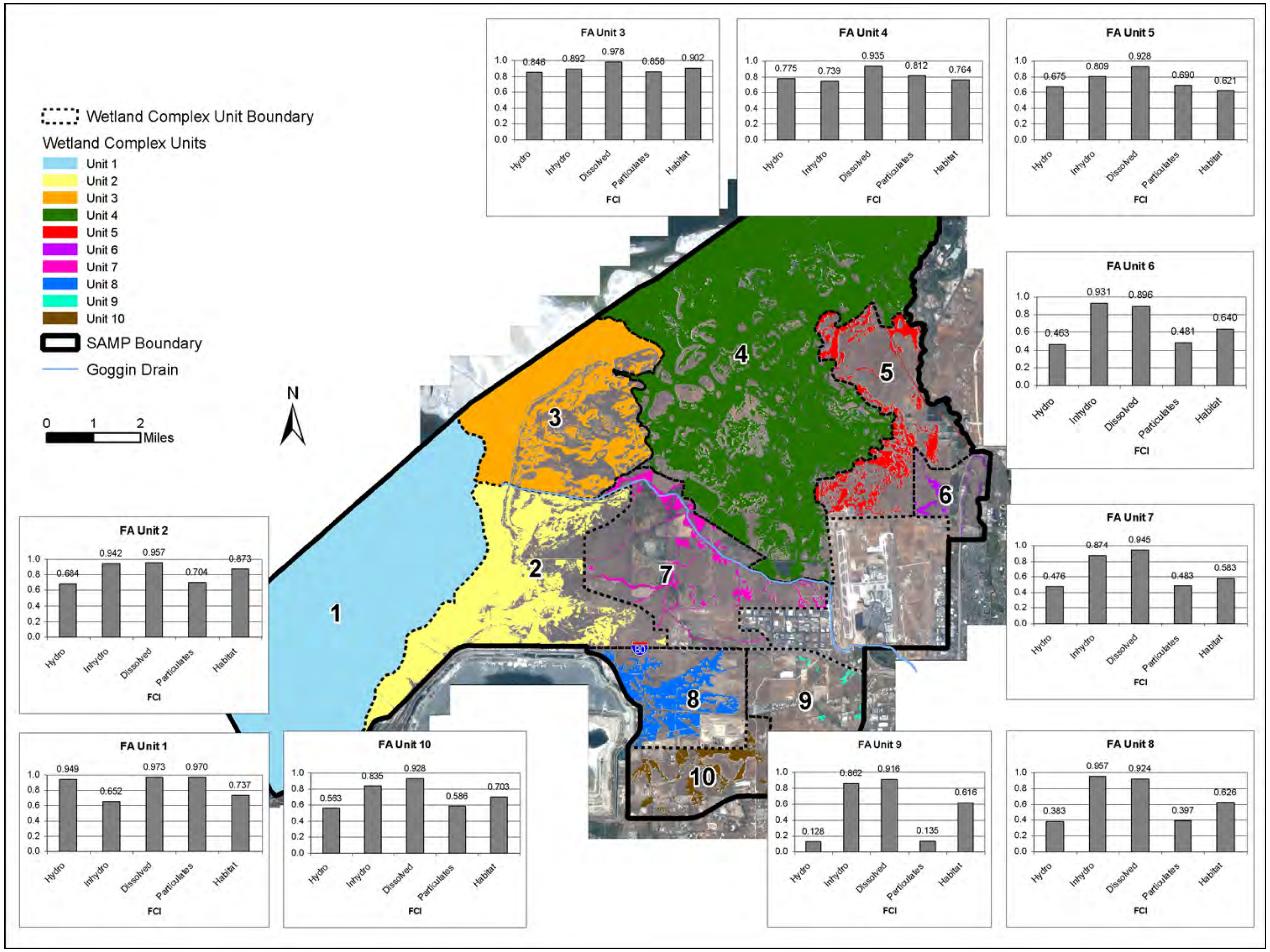

Figure 2.2. Results of five of six wetland Functional Capacity Indices (FCIs), by wetland unit.

CHAPTER 3: SUPPLEMENTAL FUNCTIONAL ASSESSMENT OF WILDLIFE IN THE SALT LAKE COUNTY SHORELANDS SAMP AREA

We developed a scientifically defensible and repeatable wildlife functional assessment (WFA) model using multi-year empirical data from a number of sources and enlisting the expertise of local wildlife specialists. We formed a WFA Team composed of locally and internationally recognized avian biologists, agency representatives from the U.S. Fish and Wildlife Service (USFWS) and the State of Utah Division of Wildlife Resources, a wildlife manager of a local shorebird reserve, a statistician, and wetland biologists (Table 3.1). Some of the team members also served as Steering Committee representatives for the SAMP. The objectives of the WFA Team were 1) to develop criteria for scoring the WFA that were defensible and representative of important wildlife resources or environmental influences to those resources within the SAMP area; 2) to determine a systematic approach for gathering data; and 3) to provide quality assurance of the results.

Table 3.1. Wildlife Functional Assessment (WFA) Team

Name	Organization	Role in Functional Assessment
Bryan Brown, PhD	SWCA	Avian biologist – generalist
John Cavitt, PhD	Weber State University	Avian biologist – shorebird use in SAMP area
Heidi Hoven, PhD	SWCA	Wetland scientist – wetland ecology in SAMP area
Nancy Keate, PhD	Utah Department of Wildlife Resources	Wetland scientist – author of GSL model
Kevin Lawlor	Medstatistics	Statistician – model design
John Luft	Utah Department of Wildlife Resources	Avian biologist – open water use by waterbirds
Ann Neville*	Kennecott Utah Copper	Avian biologist – wildlife manager of shorebird reserve in SAMP area
Don Paul, PhD	Great Basin Bird Conservation	Avian biologist – global importance of SAMP area to waterbirds
Chris Witt*	U.S. Fish and Wildlife Service	Wildlife biologist – generalist

* Shorelands SAMP Steering Committee representative.

3.1 TENETS AND GOALS

As the overall WFA concept began to form, the team developed a set of tenets and goals to guide the process.

1. Because significant numbers of waterbirds migrate through or nest in wetlands of the Shorelands SAMP area each year, and because there are several sources of multi-year

data on these birds, the first tenet is that waterbirds are the best indicators of wildlife function for wetlands and other suitable habitat associated with Great Salt Lake. The specific numbers and types of waterbird species used as indicators for important resource areas throughout the SAMP area are defined in Section 3.2, Waterbird Concentration Areas.

2. The second tenet is that wildlife use of an area can be substituted as a baseline measure of habitat function. Although empirical data were used to develop the model, we focused on wildlife use of wetlands rather than habitat function because of the inherent difficulties in measuring "function."

To support these tenets, the WFA Team established the following goals:

1. The first goal was to identify activity protection zones, established either by agency regulations or within the scientific literature. To accomplish this goal, we needed to identify important waterbird concentration areas using existing data and then apply activity protection zones to the concentration areas.
2. The second goal was to rate the wetlands and other suitable habitat of the SAMP area by their level of function as habitat to waterbirds. To accomplish this goal, a series of criteria for scoring wetlands and other suitable habitat within the SAMP area were developed.

3.2 Waterbird Concentration Areas

There are 57 known sites with sensitive or legally protected waterbird species and guilds (i.e., groups) in the Shorelands SAMP area (Table 3.2). These species and guilds serve as the indicators for this wildlife functional assessment, as they represent use of wildlife resources that are determined to be necessary for perpetuating the waterbird resources of the southeast shore of Great Salt Lake that are of global, hemispheric, national, and regional significance.

Information identifying the sites and the species composition of each group is presented in detail below and is depicted on figures in Appendix C (Figures C.1 through C.9). With the exception of the federally endangered and threatened species group, this list of important bird sites is not intended to be comprehensive, as it is not derived from any systematic surveys designed to detect all such sites. Instead, this list is a summary of various, non-systematic data points from various sources collected between the late 1980s and 2005, and it is likely that other important bird concentration sites are not documented here. Information sources included the following:

- published data from peer-reviewed journals or other publications;
- data from unpublished reports by agencies, academia, or consultants; and
- personal communications with local and regional wildlife professionals.

Important known bird areas along the southeast shore of Great Salt Lake (e.g., FBWMA, the Associated Duck Clubs, the Edward Lincoln and Charles F. Gillmor Wildlife Sanctuary, and the Inland Sea Shorebird Reserve) have been more thoroughly documented than those on privately owned land between 8800 West and the Salt Lake City International Airport. Several landowners in the latter area would not cooperate with our requests for information.

Table 3.2. Summary of Numbers of Important Bird Sites in the SAMP Area, by Group

Species/Guild Group	Number of Important Sites
Group 1. Federally endangered and threatened species.	4
Group 2. Utah State sensitive species:	
American white pelican	6
Long-billed curlew	5
Group 3. Nesting colonial wading and waterbirds.	6
Group 4. Nesting colonial shorebirds.	7
Group 5. Concentrations of migratory shorebirds.	12
Group 6. Concentrations of migratory waterfowl.	7
Group 7. Concentrations of migratory wading birds.	2
Group 8. Regionally important and unique species/guilds:	
Snowy plover	4
Migrating swallows	2
Peregrine falcon (nesting)	2
Total Important Sites	**57**

3.2.1 GROUP 1: FEDERALLY ENDANGERED AND THREATENED SPECIES

One eagle nest and three large communal eagle roosts are known to be within the SAMP area. The exact locations of these 4 sites are not described here due to their sensitive nature, but they have nonetheless been identified by SWCA (2004) and have been incorporated into the GIS layer as Group 1 sites.

3.2.2 GROUP 2: UTAH STATE SENSITIVE SPECIES

There are 11 sites important to Utah State waterbird species of concern (see Figures C.1 and C.2).

American white pelican (≥ 50 individuals; loafing and foraging; 6 sites; see Figure C.1):

1. The open-water ponds of the Salt Lake City Airport Authority Wetland Mitigation Site, where over 200 pelicans have been simultaneously observed (Sorenson 2001).
2. Open-water habitat on the Ambassador Duck and Harrison Duck Club properties and other properties, where access is obtained within the Associated Duck Club Area. Over 400 pelicans have been simultaneously observed (long-term mean = 263 pelicans) at this large site (Paul and Manning 2002:Appendix 4).
3. Southwest Pond on the Inland Sea Shorebird Reserve, where 49 pelicans have been simultaneously observed (SWCA 2003:Appendix B).
4. Open-water habitat on the New State Duck Club, where 325 pelicans have been simultaneously observed (long-term mean = 100 pelicans; Paul and Manning 2002: Appendix 4).

5. Open-water habitat on Bailey's Lake (Sec. 22 of T1N, R2W), where over 100 pelicans have simultaneously been observed (Ella Sorenson, personal communication, March 29, 2005).
6. Open-water habitat in an inundated playa adjacent to and on the south side of the Goggin Drain in the upper Bailey's Lake area (Secs. 25 and 26 of T1N, R2W), where 300-400 pelicans were simultaneously observed during the mid and late 1980s and early 1990s (Ella Sorenson, personal communication, March 29, 2005).

Long-billed curlew (regular occurrence by ≥ 5 individuals during nesting season; 5 sites; Figure 3.1a–c; see Figure C.2):

1. The Inland Sea Shorebird Reserve owned by the Kennecott Utah Copper Corporation (Paul and Manning 2002:Appendix 4; SWCA 2003:Appendix B; Brown et al. 2003:13).
2. The Edward Lincoln and Charles F. Gillmor Wildlife Sanctuary owned by the National Audubon Society (SWCA 1997:2; Paul and Manning 2002:Appendix 4).
3. The Ambassador Duck and Harrison Duck Club properties and other properties, where access is obtained within the Associated Duck Club Area (Paul and Manning 2002:Appendix 4).
4. Open grassland and playa approximately 1 mile south of Bailey's Lake at and to the east of the double 90° turns on the north-south gravel road splitting Sec. 27 of T1N, R2W, where curlews are present each year (Dick Gilbert and Pat Kelly, personal communication, March 1, 2005).
5. Areas immediately east of the Inland Sea Shorebird Reserve identified during Spring 2005 surveys (see Figure 3.1a–c).

3.2.3 Group 3: Nesting Colonial Wading and Waterbirds

This group includes western grebe, black-crowned night-heron, white-faced ibis, Forster's tern, and black tern. There are 6 sites important to nesting colonial herons/ibis/terns known to be in the SAMP area (see Figure C.3).

1. The Salt Lake City Airport Authority Wetland Mitigation Site, where a nesting colony of Forster's tern was reported by Sorenson (2001:Table B-3 and Appendix D).
2. An inundated playa adjacent to and on the south side of the Goggin Drain in the upper Bailey's Lake area (Secs. 25 and 26 of T1N, R2W), where a colony of nesting Forster's tern was initially reported during the early 1990s (Ella Sorenson, personal communication, March 29, 2005).
3. The head of Crystal Creek (NW¼ of Sec. 25 of T2N, R2W) on the FBWMA, where a colony of approximately 50 white-faced ibis nests in emergent marsh habitat (Don Paul, personal communication, February 3, 2005).
4. The Turpin Unit of the FBWMA (E½ of Sec. 17 of T2N, R1W), where a mixed colony of western grebes (20 nests), black-crowned night-herons (10 nests), and white-faced ibis (100-200 nests) occurs in emergent marsh habitat (Don Paul, personal communication, February 3, 2005).

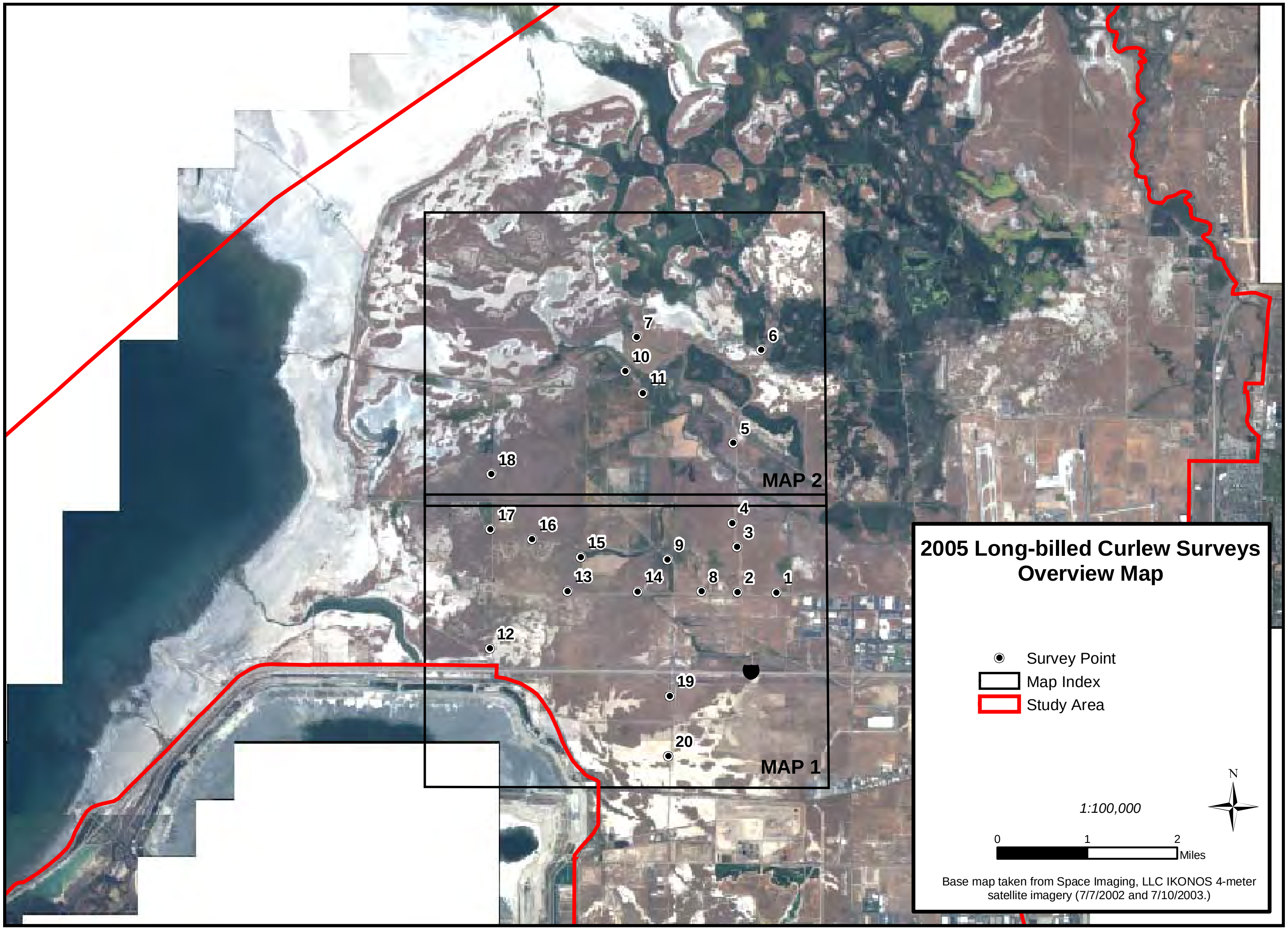

Figure 3.1a. Overview of long-billed curlew surveys, 2005.

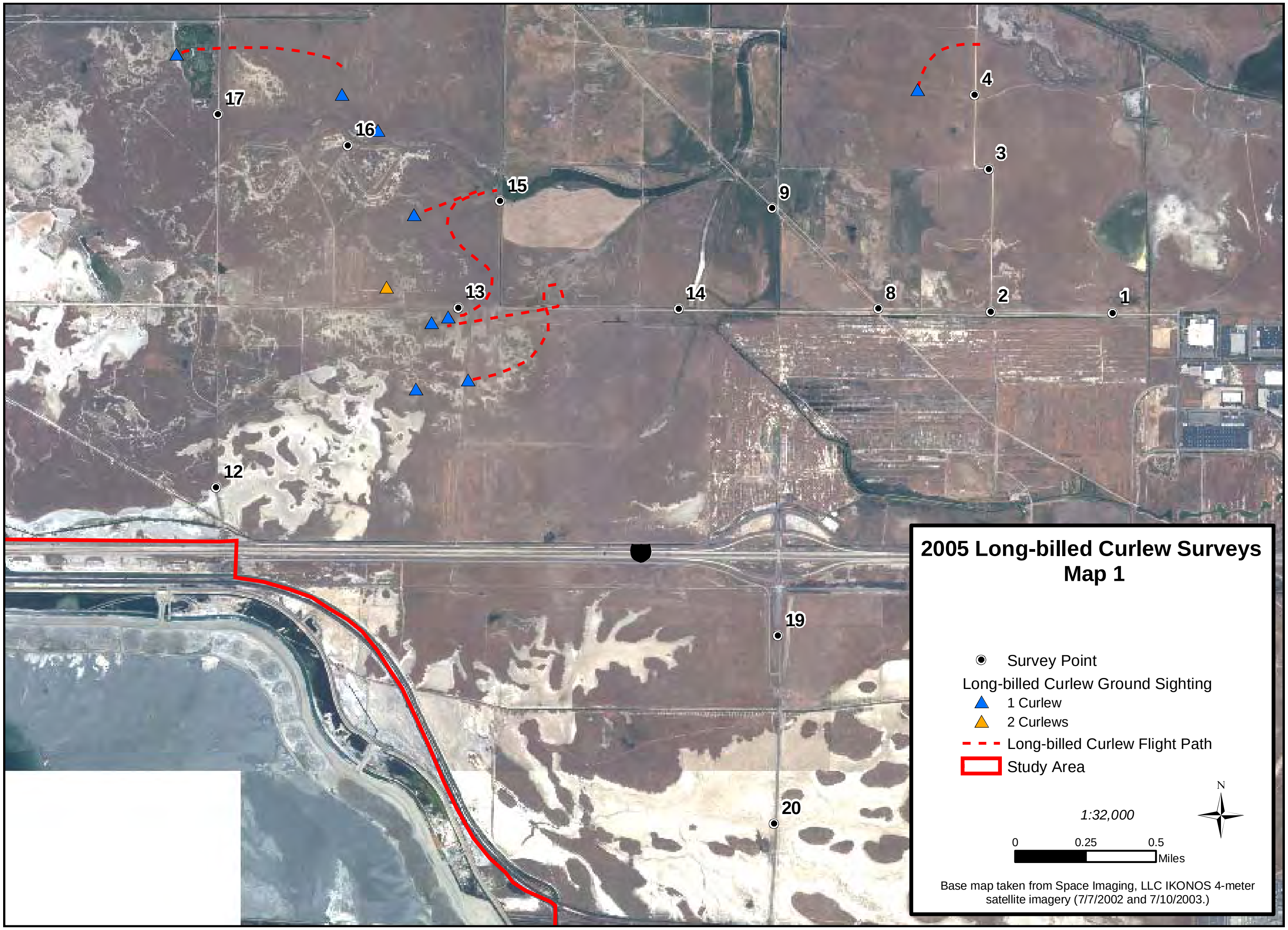

Figure 3.1b. Long-billed curlew surveys, 2005, Map 1 (southern).

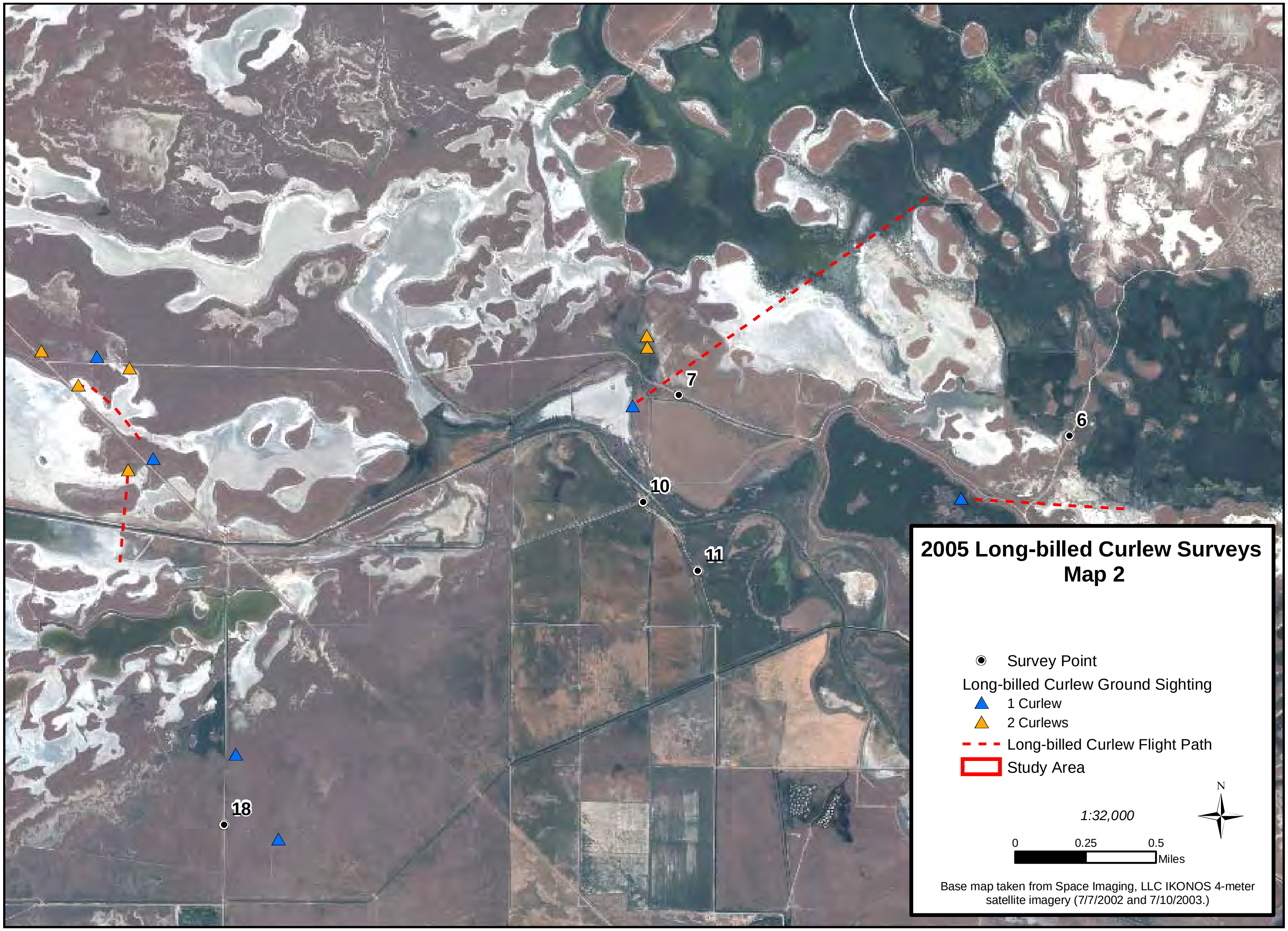

Figure 3.1c. Long-billed curlew surveys, 2005, Map 2 (northern).

5. An island dominated by emergent marsh habitat just north of "BenchMark 4212" on the Ambassador Duck Club (Sec. 2 of T1N, R2W), where a colony of nesting black terns occurs (Dick Gilbert and Pat Kelly, personal communication, March 1, 2005).
6. Emergent marshland (W½ of Sec. 2 of T1N, R2W and E½ of Sec. 3 of T1N, R2W) on the Ambassador Duck Club, where a colony of black-crowned night-herons occurs (Dick Gilbert and Pat Kelly, personal communication, March 1, 2005).

3.2.4 GROUP 4: NESTING COLONIAL SHOREBIRDS

This group consists of large colonies (≥ 50 individuals) of nesting black-necked stilts and American avocets. There are 7 sites important to nesting colonial shorebirds known for the SAMP area (see Figure C.4).

1. Mudflats, partially inundated playas, and wet meadows northeast of Bailey's Lake (S½ of Sec. 14 of T1N, R2W), where over 100 nesting avocets and stilts were simultaneously observed (Ella Sorenson, personal communication, March 29, 2005).
2. Mudflats, partially inundated playas, and partially vegetated playas at Bailey's Lake south of the Goggin Drain (common corner of Secs. 22, 23, 26, and 27 of T1N, R2W), where over 200 nesting avocets and stilts have been simultaneously observed (Ella Sorenson, personal communication, March 29, 2005).
3. Mudflats, partially inundated playas, and partially vegetated playas on the southern edge of Rabbit Knoll (NW¼ of Sec. 4 of T1N, R2W) on the Ambassador Duck Club, where approximately 100 nesting avocets and stilts have been observed (Dick Gilbert and Pat Kelly, personal communication, March 1, 2005).
4. Islands, mudflats, and partially inundated playas just east of the eastern end of Browns Island (SE¼ of Sec. 4 of T1N, R2W and NE¼ of Sec. 9 of T1N, R2W) on the Ambassador Duck Club, where approximately 250 nesting avocets and stilts have been observed (Dick Gilbert and Pat Kelly, personal communication, March 1, 2005).
5. Mudflats and partially inundated playas just south of Round Knoll (Sec. 3 of T1N, R2W) on the Ambassador Duck Club, where approximately 150 nesting avocets and stilts have been observed (Dick Gilbert and Pat Kelly, personal communication, March 1, 2005).
6. An island as well as mudflats, shorelines, and partially inundated playas immediately southeast of Round Knoll (Sec. 3 of T1N, R2W) on the Ambassador Duck Club, where approximately 200 nesting avocets and stilts have been observed (Dick Gilbert and Pat Kelly, personal communication, March 1, 2005).
7. Islands, mudflats, shorelines, and partially inundated playas northeast of "BenchMark 4212" (E½ of Sec. 2 of T1N, R2W and W½ of Sec. 1 of T1N, R2W), where approximately 200 nesting avocets and stilts have been observed (Dick Gilbert and Pat Kelly, personal communication, March 1, 2005).

3.2.5 GROUP 5: CONCENTRATIONS OF MIGRATORY SHOREBIRDS

There are 12 sites important to large concentrations of staging and migrating shorebirds of groups of ≥ 500 individuals (see Figure C.5).

1. The Inland Sea Shorebird Reserve in general (Paul and Manning 2002:Appendix 4; SWCA 2003:Appendix B).
2. Open and partially vegetated, occasionally inundated playa complex south of Bailey's Lake (SW¼ of Sec. 27 of T1N, R2W), where over 500 migratory shorebirds were simultaneously detected in either 1992 or 1993 (Ella Sorenson, personal communication, March 29, 2005).
3. Open mudflats and playas along and immediately adjacent to the Goggin Drain from the crossing of the North Point Consolidated Canal (Sec. 15 of T1N, R2W) downstream (west by northwest) to the eastern edge of Sec. 17 of T1N, R2W, where over 1,000 migratory shorebirds were simultaneously detected in the 1990s (Ella Sorenson, personal communication, March 29, 2005).
4. Open mudflats and playas along and immediately north of the Goggin Drain (Secs. 17 and 18 of T1N, R2W), where over 500 staging and migrating marbled godwits were detected in the early to mid 1990s, and where over 5,000 staging and migrating American avocets were simultaneously detected in the late 1990s (Ella Sorenson, personal communication, March 29, 2005).
5. Open mudflats and partially inundated playas south of Rabbit Knoll and east of Browns Island (Sec. 4 of T1N, R2W) on the Ambassador Duck Club, where 1,500–2,500 autumn staging and migrating avocets and stilts have been observed (Dick Gilbert and Pat Kelly, personal communication, March 1, 2005).
6. Open mudflats and playas south-southeast of Browns Island and one-half mile north of the Goggin Drain (E¼ of Sec. 8 of T1N, R2W and W½ of Sec. 9 of T1N, R2W) on the Ambassador Duck Club, where more than 1,000 spring staging and migrating avocets and stilts have been recorded (Dick Gilbert and Pat Kelly, personal communication, March 1, 2005).
7. The Salt Lake City Airport Authority Wetland Mitigation Site, where over 4,500 migrant shorebirds have been simultaneously observed (Sorenson 2001:Appendix D).
8. The Inland Sea Shorebird Reserve, including the Great Salt Lake shoreline between the old Saltair railroad grade and the Goggin Drain, including all of Lee Creek, where over 19,800 staging and migrating shorebirds have been detected in one day (Paul and Manning 2002:Appendix 4; SWCA 2003:Appendix B).
9. The Ambassador Duck and Harrison Duck Club properties and other properties where access is obtained within the Associated Duck Club Area, where over 1,700 staging and migrating shorebirds have been detected in one day (Paul and Manning 2002:Appendix 4).
10. The Edward Lincoln and Charles F. Gillmor Wildlife Sanctuary owned by the National Audubon Society, where over 1,200 staging and migrating shorebirds have been detected simultaneously (Paul and Manning 2002:Appendix 4).
11. The New State Duck Club, where over 1,300 staging and migrating shorebirds have been detected simultaneously (Paul and Manning 2002:Appendix 4).
12. Bailey's Meadow Mitigation Bank, where over 500 migrating shorebirds have been detected in one day (Jim Parraskeva, personal communication, February 2005).

3.2.6 GROUP 6: CONCENTRATIONS OF MIGRATORY WATERFOWL

This group includes geese, ducks, grebes, and coots. There are 7 sites important to large concentrations of staging and migrating waterfowl (see Figure C.6).

1. The Salt Lake City Airport Authority Wetland Mitigation Site, where over 7,900 migrating waterfowl have been simultaneously observed (Sorenson 2001:Appendix D).
2. The Ambassador Duck and Harrison Duck Club properties and other properties where access is obtained within the Associated Duck Club Area, where over 4,300 staging and migrating waterfowl have been detected in one day (Paul and Manning 2002:Appendix 4).
3. The New State Duck Club, where over 17,000 staging and migrating shorebirds have been detected simultaneously (Paul and Manning 2002:Appendix 4).
4. The Inland Sea Shorebird Reserve, including the Great Salt Lake shoreline between the old Saltair railroad grade and the Goggin Drain, including all of Lee Creek, where over 5,000 staging and migrating waterfowl have been detected in one day (Paul and Manning 2002:Appendix 4; SWCA 2003:Appendix B).
5. A large, inundated playa complex south-southwest of the KSL ratio towers (Sec. 32 of T1N, R2W), where over 1,000 staging and migratory waterfowl were simultaneously detected in the mid 1980s (Ella Sorenson, personal communication, March 29, 2005).
6. Open-water habitat on Bailey's Lake (Sec. 22 of T1N, R2W), where over 1,000 staging and migrating waterfowl have been observed simultaneously (Ella Sorenson, personal communication, March 29, 2005).
7. Open-water habitat in an inundated playa adjacent to and on the north side of the Goggin Drain, in the upper Bailey's Lake area (Secs. 25 and 26 of T1N, R2W), where over 1,000 staging and migrating waterfowl were simultaneously observed during the mid 1990s (Ella Sorenson, personal communication, March 29, 2005).

3.2.7 GROUP 7: CONCENTRATIONS OF MIGRATORY WADING BIRDS

There are 2 sites important to large concentrations of staging and migrating wading birds (see Figure C.7).

1. The wet and partially inundated playas and wet meadows on both sides of the dirt road north of the Harrison Duck Club and immediately north of the "flowing well" site (extreme eastern quarter of Sec. 15 and extreme western portion of Sec. 14 of T1N, R2W), where between 500 and 1,000 staging and migrating egrets and white-faced ibis have been seen simultaneously on a regular basis in autumn (Dick Gilbert and Pat Kelly, personal communication, March 1, 2005).
2. Wet meadows, mud flats, and intermittent open water in Bailey's Lake, north of the Goggin Drain (SW¼ of Sec. 23 of T1N, R2W), where over 2,000 white-faced ibis were detected simultaneously in the 1990s (Ella Sorenson, personal communication, March 29, 2005).

3.2.8 Group 8: Regionally Important and Unique Species/Guilds

In this group, there are 8 sites important to unique concentrations of regionally important species and guilds (see Figures C.8 and C.9).

Snowy plover (nesting, staging, and migrating; 4 sites; see Figure C.8):

1. The shoreline, open beaches, and all open playas from the mouth of Lee Creek to the Goggin Drain (including all of Lee Creek and its adjacent, open playas north of I-80), where one of the largest concentrations of nesting, staging, and migrating plovers at Great Salt Lake occurs (Paton 1997). Up to 495 plovers have been detected on one day within this area (Paton and Edwards 1990; Paton 1993; Moynahan and Brown 1995; Paton 1997; Paul and Manning 2002:Appendix 4; SWCA 2003:Appendix B).
2. The shoreline, open beaches, and all open playas north of the mouth of Goggin Drain to the Rabbit Knoll area, at the northern tip of Brown's Island on the Edward Lincoln and Charles F. Gillmor Wildlife Sanctuary (owned by the National Audubon Society). Hundreds of nesting, staging, and migrating plovers have been observed in this area from the 1990s through 2004 (Ella Sorenson, personal communication, March 29, 2005).
3. Open playa and mudflat west and southwest of Rabbit Knoll (Sec. 32 of T2N, R2W and Sec. 5 of T1N, R2W) on the Ambassador Duck Club and the Edward Lincoln and Charles F. Gillmor Wildlife Sanctuary, where a large concentration of nesting snowy plover occurs (Dick Gilbert and Pat Kelly, personal communication, March 1, 2005).
4. Lakeshore and mudflat southwest of the FBWMA, generally from the mouth of the Salt Lake City Sewage Canal southwest of the old causeway to Antelope Island, where 116 plovers were counted on June 7, 1997, by Justin Dolling and others (Paton 1997).

Migrating swallows (2 sites; see Figure C.9):

1. Wet mudflats in Northwest Pond on the Inland Sea Shorebird Reserve (Sec. 24 of T1N, R2W), where over 2,000 staging and migrating swallows were simultaneously detected during autumn in the late 1990s (SWCA 2003:Appendix B; Bryan Brown, personal observation).
2. Wet mudflats on the Inland Sea Shorebird Reserve (Sec. 25 of T1N, R2W), where over 1,500 staging and migrating swallows were simultaneously detected during autumn in the late 1990s (SWCA 2003:Appendix B; Bryan Brown, personal observation).

Peregrine falcon:

- At least 2 sites where nesting peregrine falcons have occurred or still occur are known within the SAMP area. The exact locations of these sites are not described here due to their sensitive nature, but they have been incorporated into the GIS layer as Group 8 falcon sites.

3.3 Activity Protection Zones and Setback Distances

Waterbirds associated with wetlands are generally sensitive to human activity, disturbance, and physical infrastructure. The degree of sensitivity and its consequences varies by species (Klein

1993; Rodgers and Smith 1995) and even individuals (Runyan and Blumstein 2004), depending on disturbance type, frequency, and duration, particularly when combined with annual life cycle considerations. For example, waterbirds are generally more sensitive when nesting than when migrating, and larger waterbirds are generally more sensitive than smaller species (Rodgers and Schwikert 2002). Activities such as a human approaching on foot or in a boat, human-induced noise, or a vehicle driving nearby can cause short-term disturbances to waterbirds that range from the seemingly benign (e.g., taking flight, modifying behavior, disruption of foraging, etc.) to disruptive (e.g., abandoning nests, young, or entire nesting colonial sites). But the cumulative influence of repeated, seemingly benign disturbances has strong potential to become disruptive in the long term. Human disturbance, in the form of heavy recreational use by hikers and OHV users in beach habitat, has been implicated as the cause of long-term declines of shorebird abundance at many important migration staging areas (Pfister et al. 1992).

Generally, the thresholds at which such long-term or permanent disruption happens are poorly understood for most waterbirds. Nonetheless, we know that the development of human infrastructure facilities has the potential to render adjacent wetlands less productive and even unusable by some sensitive waterbirds after a certain threshold has been exceeded. Examples of these developments include roads, houses, urbanization, outbuildings, trails, recreation sites, commercial structures and storage, and air transportation facilities. Habitat fragmentation and loss resulting from infrastructure development have been documented to significantly increase mortality and decrease food intake and energy reserves in some species of non-nesting shorebirds (Durell et al. 2005).

Human activity buffers (i.e., activity protection zones) and human infrastructure setback distances have been used to prevent future disturbance in areas where waterbird habitat and human development were likely to intersect, and zones and setback distances have been established for many waterbirds based on scientifically derived disturbance criteria (cf. cf. Rodgers and Smith 1995; Rodgers and Schwikert 2002). Activity protection zones typically have both spatial and temporal components. Some nesting waterbird species and/or guilds require larger activity protection zones and setback distances during the spring and early summer, while smaller zones may be adequate during migration.

The eight bird groups identified in Section 3.2 comprise waterbird species and guilds that warrant activity protection zones and setback distances within the Shorelands SAMP area. The zones and setback distances for each of these species and guilds, as described in Appendix D and as summarized in Table 3.3, are based on legal and/or ecological imperatives (i.e., agency regulations or scientific literature, respectively). Activity protection zones were incorporated in the wildlife functional assessment model by bird group and as an overall average suitable habitat buffer. Although infrastructure setback distances are discussed in this document, they have been included only for reference, not for use in the model. It should be noted that if no infrastructure setback distances are known for a species or guild, the activity protection zone is assumed to represent the minimum setback distance.

Table 3.3. Summary of Activity Protection Zones and Setback Distances for the Eight Bird Groups Considered in the Shorelands SAMP Wildlife Functional Assessment

Group	Species or Guild	Activity Protection Zone	Infrastructure Setback Distance	Literature Source
1. Federally endangered or threatened species	Nesting bald eagles	1 mile (1.6 km)	1 mile (1.6 km)	Romin and Muck 1999
	Communal-roosting bald eagles	0.5 mile (0.8 km)	0.5 mile (0.8 km)	Romin and Muck 1999:22
2. Utah State sensitive species	American white pelican (foraging)	1,240 feet (400 m)	≥ 1,240 feet (400 m)	Doran et al. 2004
	Long-billed curlew (nesting)	310 feet (100 m)	930 feet (300 m)	Dugger and Dugger 2002:12
3. Nesting colonial wading and waterbirds	Eared grebe	820-984 feet (250-300 m)	3,281 feet (1,000 m)	Extrapolated from great blue heron
	Western grebe	820-984 feet (250-300 m)	3,281 feet (1,000 m)	Extrapolated from great blue heron
	Clark's grebe	820-984 feet (250-300 m)	3,281 feet (1,000 m)	Extrapolated from great blue heron
	Double-crested cormorant	820-984 feet (250-300 m)	3,281 feet (1,000 m)	Extrapolated from great blue heron
	Great blue heron	820-984 feet (250-300 m)	3,281 feet (1,000 m)	Butler 1991; Quinn and Milner 2004
	Cattle egret	820-984 feet (250-300 m)	3,281 feet (1,000 m)	Extrapolated from great blue heron
	Snowy egret	820-984 feet (250-300 m)	3,281 feet (1,000 m)	Extrapolated from great blue heron
	Black-crowned night-heron	820-984 feet (250-300 m)	3,281 feet (1,000 m)	Extrapolated from great blue heron
	White-faced ibis	820-984 feet (250-300 m)	3,281 feet (1,000 m)	Extrapolated from great blue heron
	California gull	465 feet (150 m)	930 feet (300 m)	Experience of Wildlife Functional Assessment (WFA) Team
	Franklin's gull	465 feet (150 m)	930 feet (300 m)	Experience of WFA Team
	Forster's tern	465 feet (150 m)	930 feet (300 m)	Experience of WFA Team
	Caspian tern	465 feet (150 m)	930 feet (300 m)	Experience of WFA Team
	Black tern	465 feet (150 m)	930 feet (300 m)	Experience of WFA Team
4. Nesting colonial shorebirds	Black-necked stilt	310 feet (100 m)	≥ 310 feet (100 m)	Sordahl 1990
	American avocet	310 feet (100 m)	≥ 310 feet (100 m)	Sordahl 1990

Table 3.3. Summary of Activity Protection Zones and Setback Distances for the Eight Bird Groups Considered in the Shorelands SAMP Wildlife Functional Assessment

Group	Species or Guild	Activity Protection Zone	Infrastructure Setback Distance	Literature Source
5. Concentrations of migratory shorebirds	Nesting guild: Families Charadriidae, Recurvirostridae, and Scolopacidae	310 feet (100 m)	≥ 310 feet (100 m)	Sordahl 1990
	Staging/Migrating guild: Same as above	155 feet (50 m)	≥ 155 feet (50 m)	Laubhan and Fredrickson 1993
6. Concentrations of migratory waterfowl	Staging/Migrating guild: Families Podicipedidae, Anatidae, and Rallidae	620 feet (200 m)	1,240 feet (400 m)	Recommended by WFA Team
7. Concentrations of migratory wading birds	Staging/Migrating guild: Families Ardeidae and Threskiornithidae	310 feet (100 m)	≥ 310 feet (100 m)	Stolen 2003
8. Regionally important and unique species and guilds	Nesting, staging, and migrating snowy plovers	310 feet (100 m)	≥ 310 feet (100 m)	Extrapolated from American avocet
	Migrating, foraging, and staging swallows	620 feet (200 m)	≥ 620 feet (200 m)	Recommended by WFA Team

3.4 Criteria for Rating Wildlife Functional Assessment

Criteria were developed for a GIS process that would be used to score and ultimately rate wildlife function of wetlands and associated habitat used by the eight groups comprising waterbirds and regionally important and state sensitive birds. The criteria were established for both breeding and feeding (loafing, etc.) activities on potential habitat throughout the SAMP area. The four criteria used in this model are:

1. Presence of federally endangered or threatened species
2. Unique or disproportional concentration of Utah State sensitive species and other important species in Groups 3–8
3. Habitat suitability relative to proximity to anthropogenic disturbance or other land use stressors
4. Undeveloped land that provides wildlife refuge during high lake levels

As many as seven criteria were originally considered; however, only the above four were used due to the subjectivity of the framework and the lack of adequate data to fulfill those criteria. The additional criteria are discussed at the end of this section, as they provide an important perspective of the land-use planning efforts of the Shorelands SAMP.

3.5 GIS Analysis

The four criteria that were developed to rate wildlife function of wetlands and other suitable habitat were applied spatially as part of a GIS model, using ESRI's ArcGIS and Spatial Analyst 9.0. A scoring system was developed and applied to the data, depending on how the data met each criterion. The scores ranged from 0, for urban areas (no wildlife value), up to 4, for high-quality habitat.

3.5.1 Criterion 1 - Federally Listed Species

The only threatened or endangered species known to occur in the Shorelands SAMP area is the bald eagle. This species' known nest and roost locations were mapped from existing GPS data, and an activity protection zone was mapped at 1 mile from the nest and at 1/2 mile from the roosts, according to USFWS guidelines (Figure 3.2). Nest and roost areas and their protection zones were rated as 4; all other non-urban areas were assigned a score of 3, so as not to give an unfair weight to habitat that is potentially suitable to other wildlife. Urban areas (e.g., Salt Lake City International Airport, the International Center, and all other developed land) were given a 0 score.

3.5.2 Criterion 2 - State Species of Concern

Determining the Criterion 2 areas was a two-step process. First, large concentrations of species, including nesting colonial wading and waterbirds, nesting colonial shorebirds, migratory shorebirds, migratory wading birds, and migratory waterfowl; concentrations of regionally

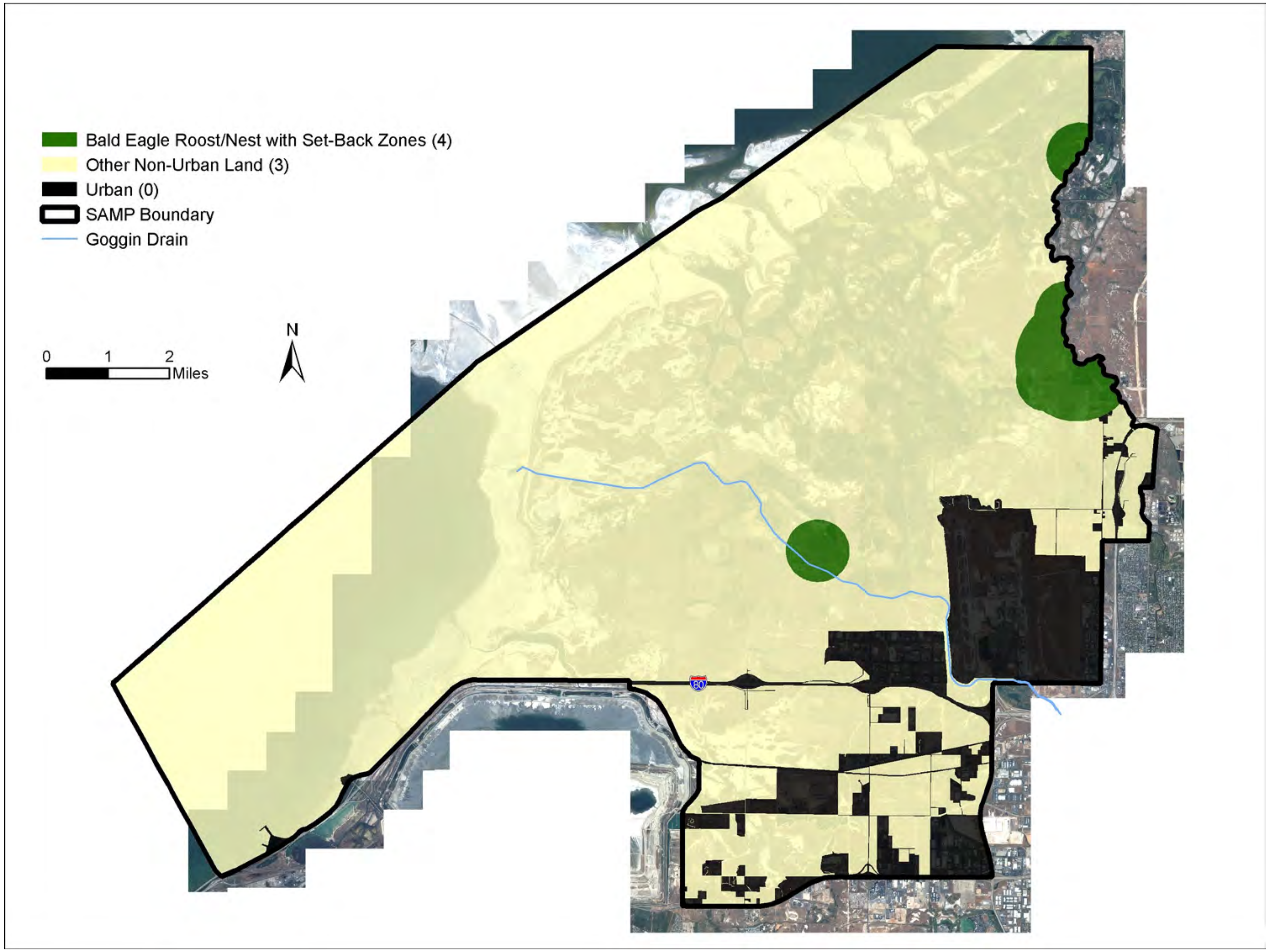

Figure 3.2. Federally threatened or endangered species known to be in the SAMP area (Criterion 1).

important and unique species (i.e., snowy plover, peregrine falcon, and migrating swallows); and Utah State sensitive species (i.e., nesting long-billed curlew and American white pelican) were mapped according to the criteria defining concentration size per bird group (see Section 3.2). These areas of known concentrations were digitized as one set of polygons per bird group from existing data collected between 1980 and 2005 (see Appendix C) and overlaid onto the wetlands coverage that was developed for the wetlands functional assessment (see figures in Appendix C).

Second, activity protection zones (see Section 3.3 and Appendix D) were applied to the concentration areas by bird group. In areas where bird species/guilds overlapped, the greatest protection zone distance was used. Essentially, activity protection zones were applied to the composite perimeter of all bird concentration areas, and the protection zones applied reflect bird populations adjacent to the perimeter (Figures 3.3 and 3.4). The mapped concentration areas and their protection zones were assigned a score of 4; all other non-urban areas were assigned a score of 3, so as not to give an unfair weight to habitat that is potentially suitable to other wildlife. Urban areas were assigned a score of 0.

3.5.3 Criterion 3 - Proximity to Disturbance

Determining the Criterion 3 areas was a three-step process.

First, a GIS layer of suitable habitat was created from a composite of 1) the NRCS Soil Survey Geographic database (SSURGO) for Salt Lake Area, Utah soil data and 2) the Shorelands SAMP wetlands functional assessment coverage data. Soil subclasses (including Bramwell BrB, Chipman Ck, Chipman Cl, Decker De, Decker Dk, Ironton, Jordan, Lasil LcA, Magna Mc, Saltair, and Terminal) were merged and regrouped in terms of supporting wetland habitat.[3] The soil data were merged with the wetlands coverage data to show lands that could support suitable habitat for wildlife associated with wetlands (excluding developed land; Figure 3.5). Sandy alluvial lands and water were also considered habitat, even if they didn't fall within the existing wetlands.

A wildlife habitat protection zone of 560 m was applied to the composite perimeter of suitable habitat, based on an average population protection zone distance taken from scientific literature (Appendix E). This average distance was determined from studies of species likely to occur within the Shorelands SAMP *wetlands* areas (e.g., wetland birds such as shorebirds, wading birds and waterfowl); references to other species that are not associated with wetlands within the SAMP area (e.g., amphibians and reptiles) or whose recommended distances were outliers (e.g., 2,000 feet for bats, 1,640 feet for red-winged blackbirds) were excluded (see Appendix E).

Second, a list of stressors (represented by the various land uses) that could affect wildlife (i.e., birds) within the Shorelands SAMP area was compiled not only from Keate's (2001) GSL Model, as was done for the wetlands functional assessment, but also from the California Rapid

[3] These soil subclasses were chosen based on depth to groundwater (less than 1 m) and occurrence of wetlands in these soil types within the Shorelands SAMP area. Wetlands ranged from nonsaline permanent depression (i.e., open water with fringing emergent marsh) with Magna Mc soil subclass to strongly saline semipermanent-permanent depression (i.e., vegetated and nonvegetated playa) with Saltair, Terminal, Decker Dk, or Bramwell BrB soil subclasses.

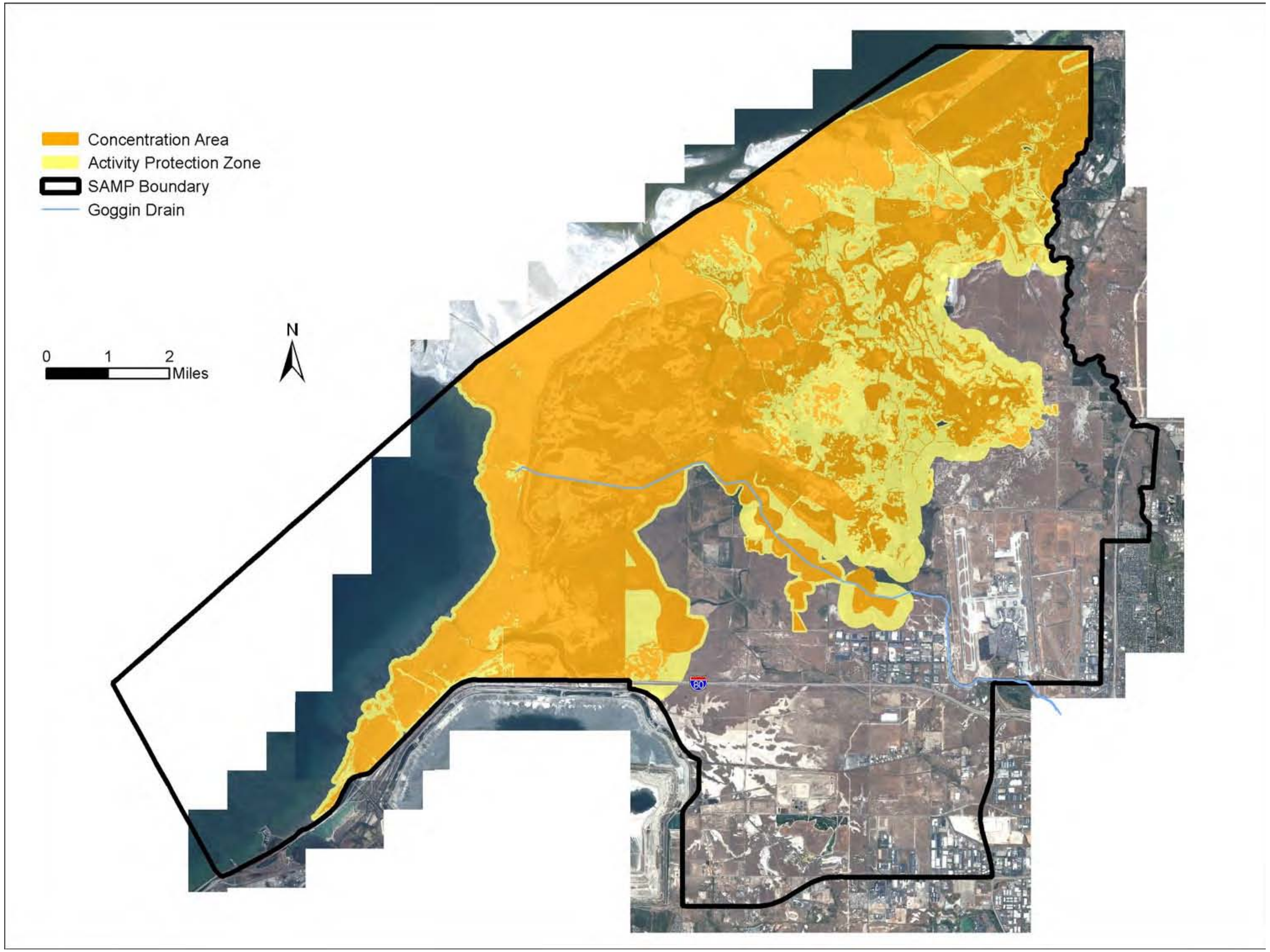

Figure 3.3. Unique or disproportional concentrations of species and Utah State sensitive species known to be in the SAMP area (Criterion 2).

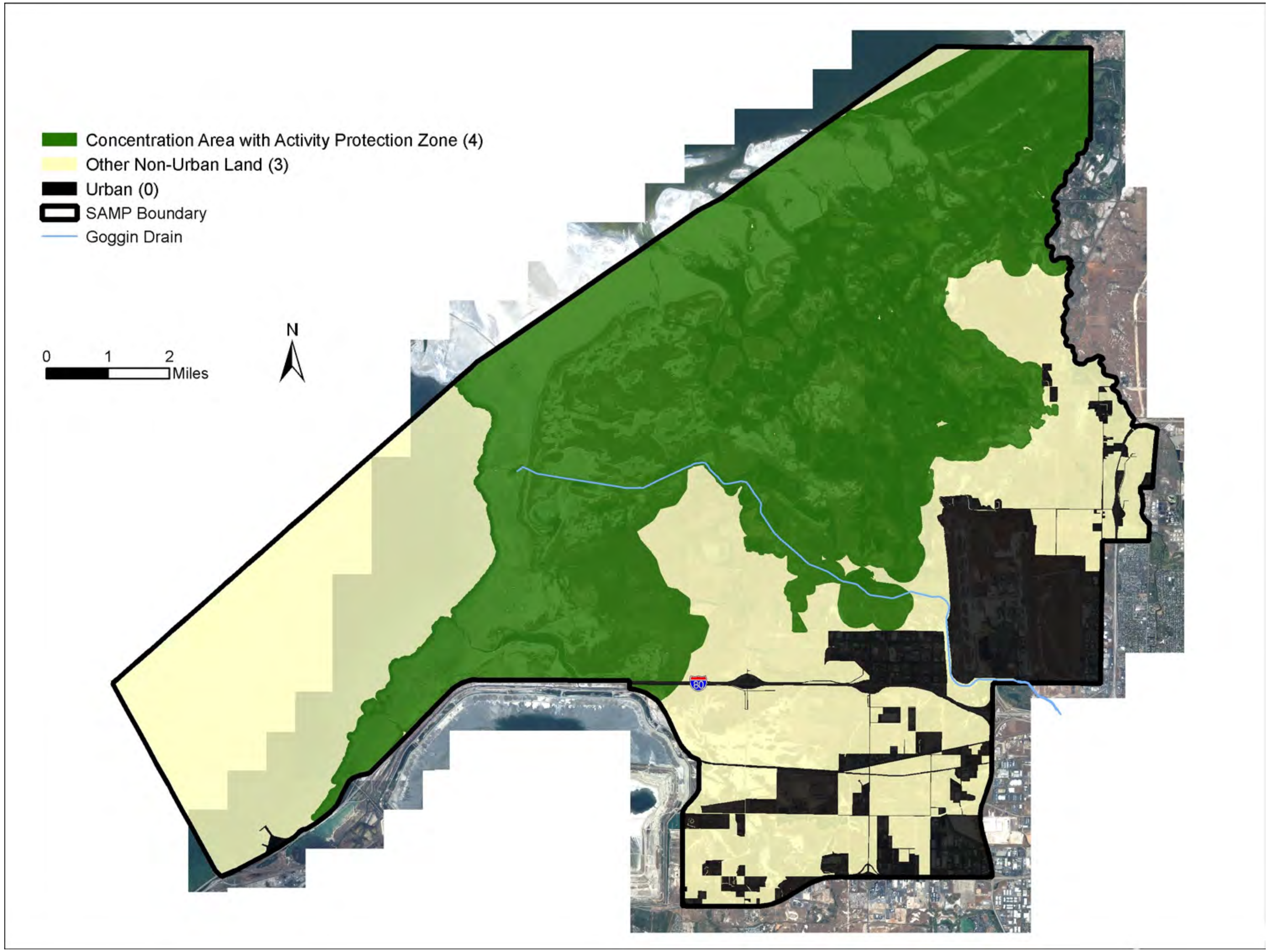

Figure 3.4. Important species concentration areas known to be in the SAMP area, by ranking (Criterion 2).

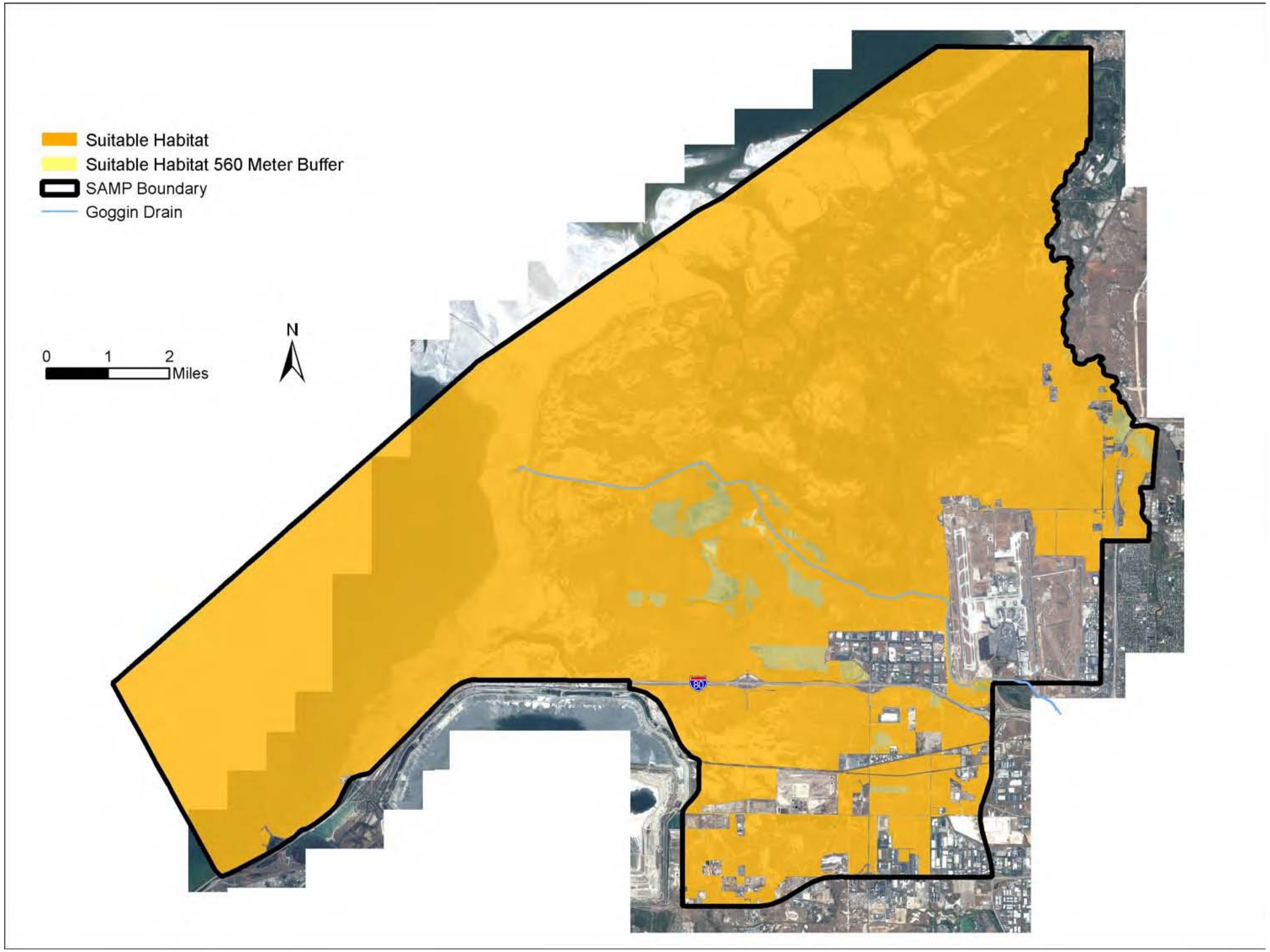

Figure 3.5. Suitable habitat known to be in the SAMP area (Criterion 3).

Assessment Method (Collins et al. 2004) and input from the WFA Team (Figure 3.6; see Appendix F). Stressors were organized into different classes of land uses, such as vehicular, pedestrian, agricultural, commercial, industrial, and urban, and a series of scores was developed for each stressor as it related to each bird group. Scores ranged from 0 to 4, with 0 being the lowest value (i.e., most affected by a stressor).

Finally, a land-use GIS layer showing the stressors throughout the SAMP area was created using the water-use file from AGRC, ground-truthing, and verification with land owners, as was done for the wetlands functional assessment (Figure 3.7). Suitable habitat (with wildlife habitat protection zones) was assigned a stressor score based on the level of disturbance the adjacent land use would have upon the species represented by each bird group (see Appendix C). When multiple bird groups used the same area (e.g., data polygons overlapped), the lowest score was applied. Data polygons with the highest scores (i.e., 4) were assigned a classification of highly suitable habitat. Data polygons with lower scores were assigned a classification of moderately-to-highly suitable habitat (score of 3), moderately suitable habitat (score of 2), or slightly suitable habitat (score of 1). Urban areas were assigned a score of 0. Note that not all land uses impose the same level of stress on all bird groups. For example, non-rotational and rotational grazing have no negative effects on bald eagles (Group 1) or the regionally important species group (Group 8; all assigned a score of 4).

3.5.4 Criterion 4 - Refugia

One of the unique characteristics of the hydrology of the Shorelands SAMP area is that it is part of a terminal basin, where Great Salt Lake is a catchment for all waters it receives and provides no outlet. The SAMP area is located on the southeastern edge of the lake and lies on gently graded alluvium. Because the topography is so subtle and flat, rises in lake elevation can have quite dramatic consequences. A rise of only one foot of water can cover an additional 45,000 acres of land. The average lake elevation is 4,200 feet and fluctuates about 20 feet annually, as affected by annual precipitation. During dry years (in 1963), the lake has been recorded as low as 4,191.35 feet, and in wet years (1873), as high as 4,211.50 feet (Austin and Stauffer 1977). According to a probability analysis, lake elevation is equal to or greater than 4,204 feet 10% of the time, which would occur once every 200 years (Austin and Stauffer 1977). Austin and Stauffer go on to say that the certainty of accurately predicting when future climactic conditions will impart flooding conditions is low, but that it is clear that the lake levels will rise again, possibly to levels that would incur extensive damage to development—and wildlife habitat—around the lake (1977). Subsequent to his analysis, Great Salt Lake did rise during the mid 1980s and flooded most of the Shorelands SAMP area (4,217 feet at a USGS benchmark at the Ambassador Duck Club) due to wind-driven currents.

Because of the dynamic nature of the hydrology associated with the lake and its concomitant effect on wildlife habitat, Criterion 4 addresses loss of critical waterbird habitat during high lake levels. Ten-meter digital elevation models (DEMs) from the USGS were used to map elevation contours in the SAMP area. Although a more refined detail of contours would provide better

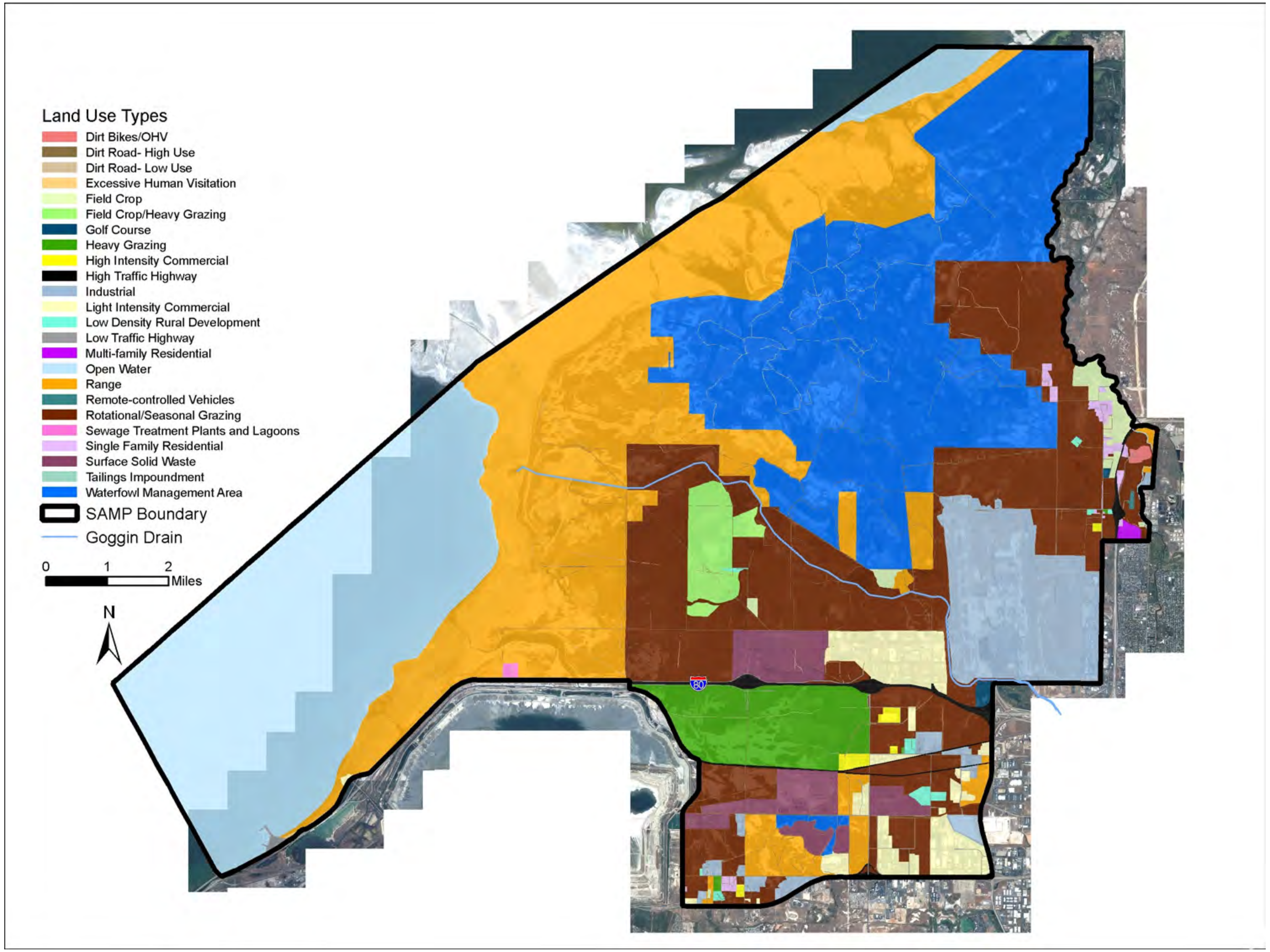

Figure 3.6. Stressor/Land use types in the SAMP area (Criterion 3).

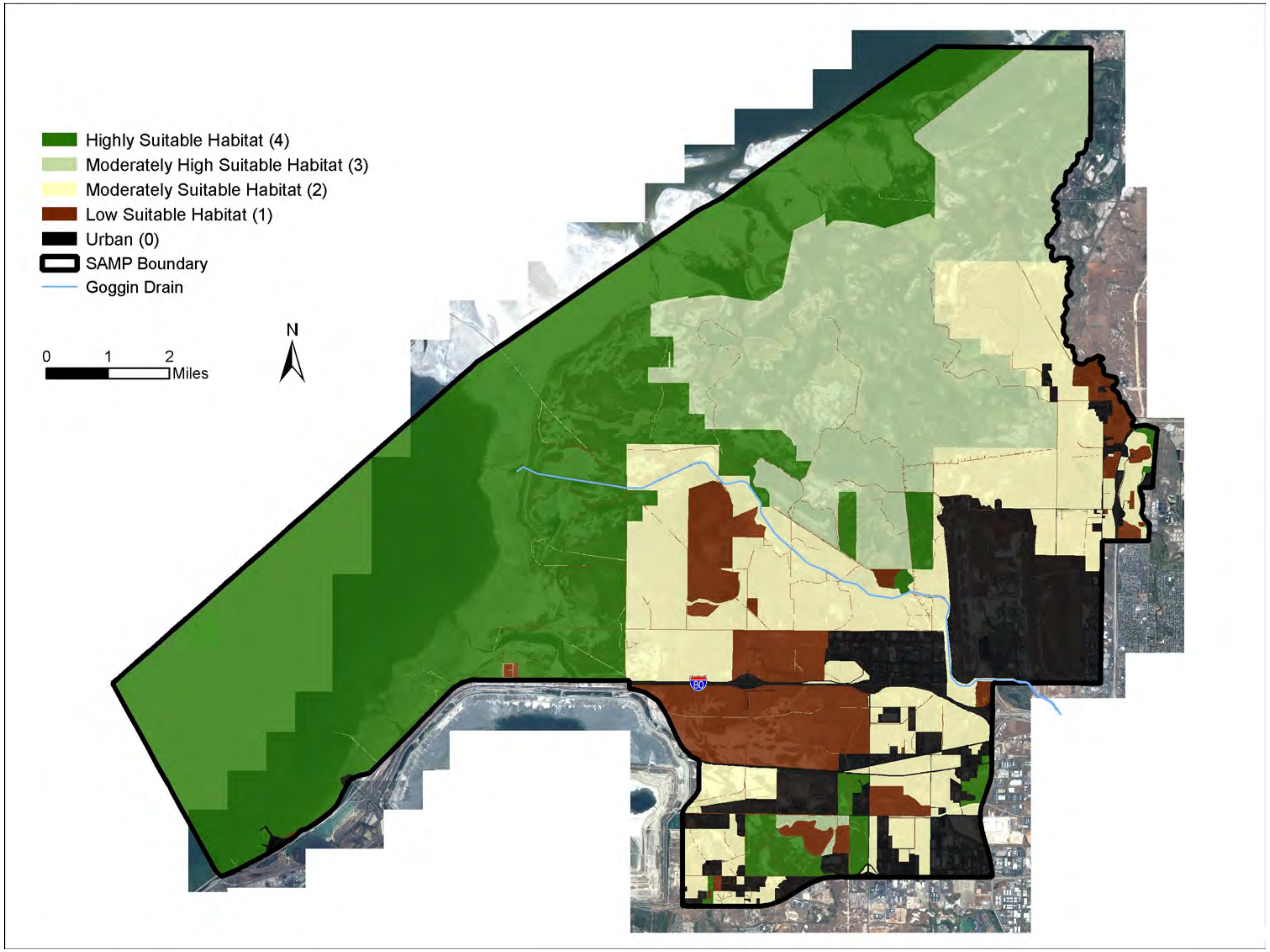

Figure 3.7. Suitable habitat based on land use stressor scores in the SAMP area (Criterion 3).

accuracy, the DEMs are the best available information when budgetary constraints are an issue. The statistical median of annual medians[4] of high lake elevation records (USGS 2006) was determined at 4,211 feet—the elevation above which non-urban land could provide refuge for wildlife during high lake levels (Figure 3.8). All non-urban land above 4,21l feet was assigned a score of 4, and all non-urban land below 4,211 feet was assigned a score of 3, since it has the potential to provide wildlife habitat during non-flood years. Urban land was assigned a score of 0.

3.6 Final Sensitivity Analyses

The four vector shapefiles (one per criterion) were converted to ESRI grids using Spatial Analyst 9.0. Their rate attributes were transferred as the cell values. All of the grids were given a 4-×-4-m cell size, so as to correspond to the resolution of the IKONOS satellite imagery originally acquired for mapping wetlands for the wetlands functional assessment. The four criterion grids were combined using a median statistical function to establish an overall rating per cell. After taking the statistical median of the cells by grid, the five scoring values of 0 to 4 originally assigned to the cells were expanded to 11 values ranging from 0 to 4, via Jenks Natural Breaks classification scheme. These natural breaks were then used to determine the number of classes to describe the 11 values. Seven classes described the values sufficiently (any more than seven rendered diminishing returns); these are shown in Table 3.4 with their value ranges and percentage of coverage within the project area:

Table 3.4. Percentage of Project Area Assigned to Each of Seven Habitat Value Classes

Value Range	Value Class	Percent Coverage
0.0	Urban	10
0.1-1.5	Low Value	<1
1.6-2.5	Moderately Low Value	<1
2.6-3.0	Moderate Value	21
3.1-3.3	Moderately High Value	39
3.4-3.5	High Value	26
3.6-4.0	Very High Value	3

The Spatial Analyst cell-based processing function uses the same overlapping grid pattern, which accounts for any randomness in the process. In an attempt to refine the results, a sensitivity analysis was performed to identify ratings that were unevenly weighted and to account for randomness of the data values, or rating scheme, used. When reviewing the initial results of the wildlife function analysis, some data from each criterion were lost, in that the results were too general and did not show much definition (Figure 3.9). In some cases, such as habitat along Bailey's Lake, curlew nesting habitat, and uplands north of the airport, areas of higher value habitat were not expressed because the rating scheme was not sensitive enough. To allow the high-value habitat to appear with adequate precision, the habitat value ranges and their resulting

[4] Medians were used because lake elevation records were not recorded regularly or even seasonally prior to 1980.

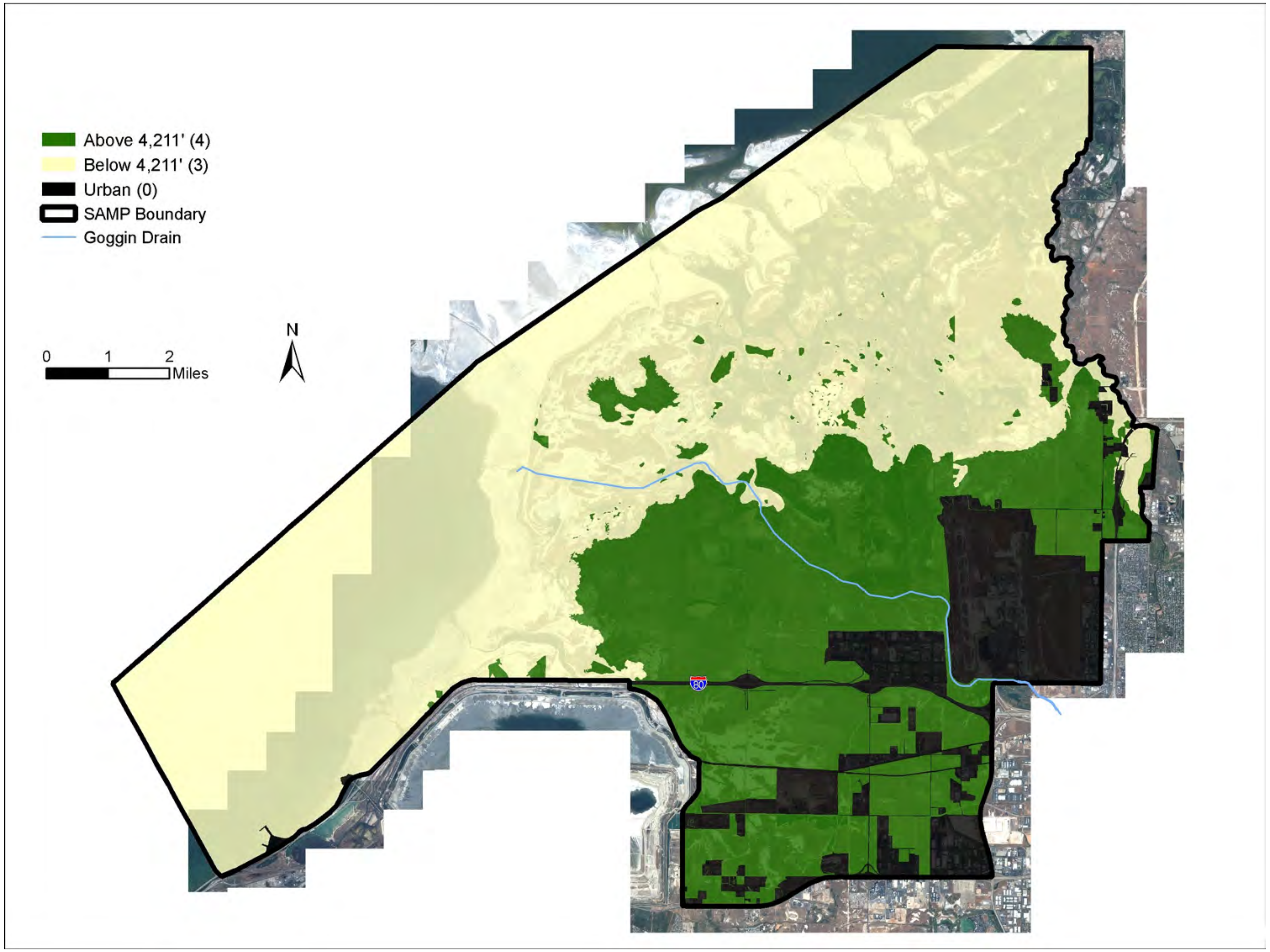

Figure 3.8. Distribution of non-urban lands in the SAMP area with ability to provide refuge for wildlife during high lake levels, by elevation (Criterion 4).

percentages were recalibrated. First, the highest value of each criterion was increased from 4 to 10. Then, all four datasets (criterion grids) were again merged with a median statistical function. A recalibrated scoring range of 0 to 5.5 with 17 total values rendered a more precise result (Figure 3.10). Jenks Natural Breaks classification scheme identified seven classes again, and the resulting value ranges and percentages of coverage within the project area are shown in Table 3.5.

Table 3.5. Percentage of Project Area Assigned to Each of Seven Habitat Value Classes, Recalibrated for High-value Habitat

Value Range	Value Class	Percent Coverage
0.0	Urban	10
0.1-2.0	Low Value	<1
2.1-3.2	Moderately Low Value	9
3.3-3.4	Moderate Value	12
3.5-3.8	Moderately High Value	36
3.9-4.4	High Value	30
4.5-5.5	Very High Value	3

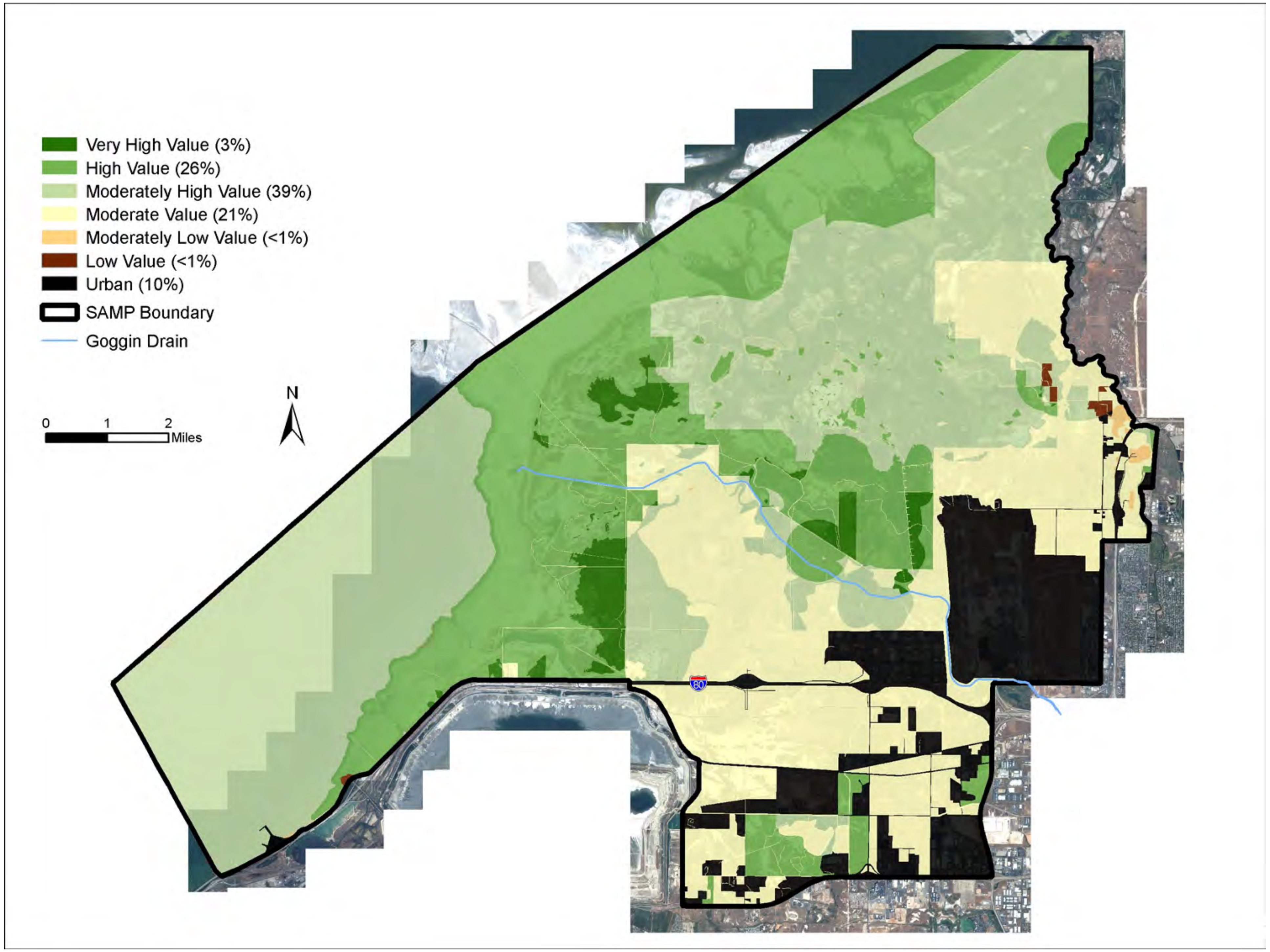

Figure 3.9. Wildlife functional assessment for the SAMP area, before sensitivity analysis.

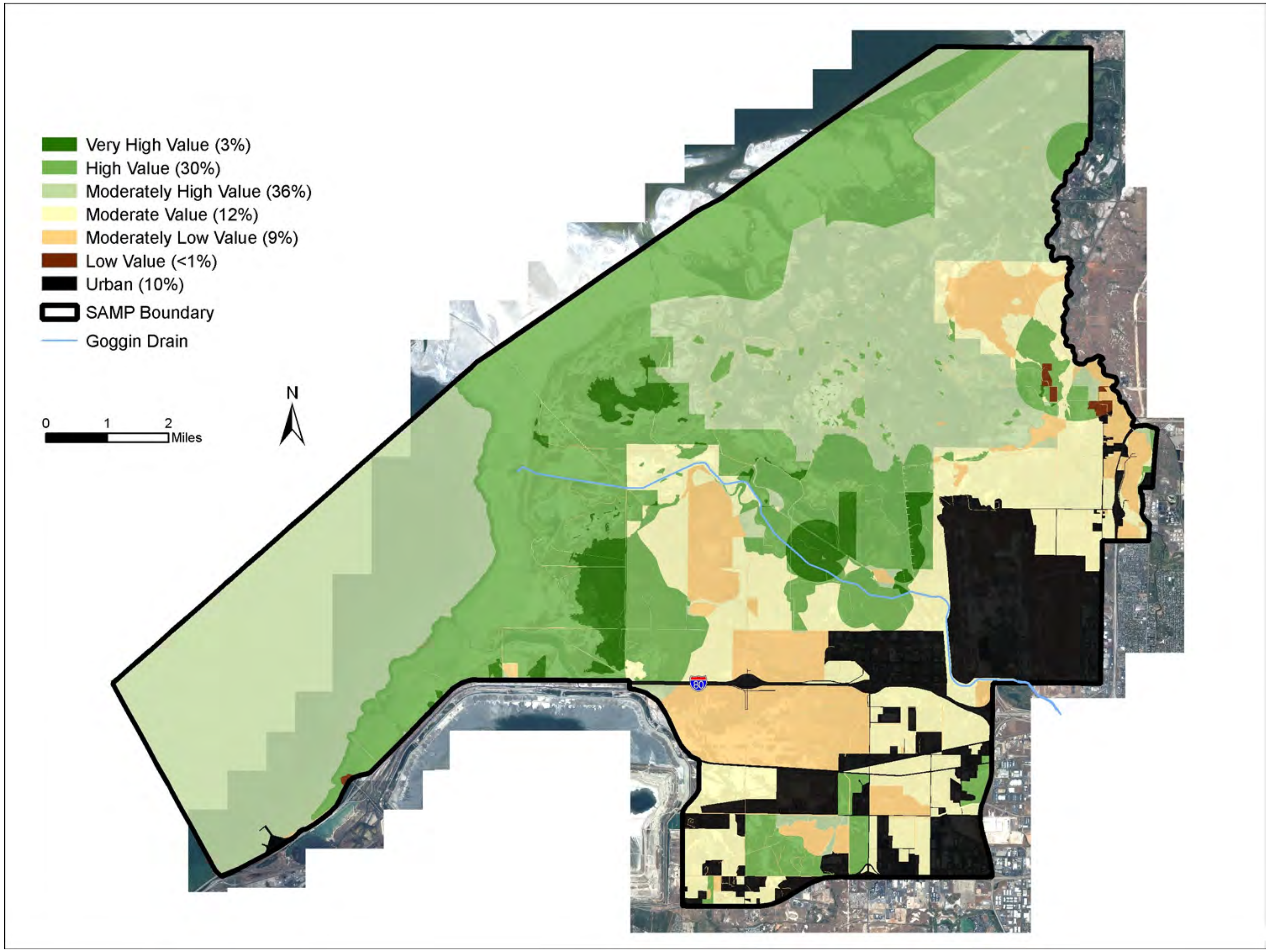

Figure 3.10. Wildlife functional assessment for the SAMP area, after sensitivity analysis.

CHAPTER 4: CREATING A PLANNING TOOL FOR SALT LAKE COUNTY AND CITY

Although the primary goal of performing both the wetland and wildlife functional assessments is to inform the Shorelands SAMP planning process, a secondary goal is to inform Salt Lake County and City of the quality and quantity of higher functioning wetland and wildlife habitats for their master planning processes. Before calculating Functional Capacity Units described in the wetlands functional assessment chapter, Functional Capacity Indices (FCIs) can be used in a different way to develop a planning tool.

4.1 MERGING WETLANDS AND WILDLIFE DATA

FCIs from the wetlands functional assessment (see Appendix C) and the final results from the wildlife functional assessment are not comparable, but their data (from the high functioning wetlands and the high-value wildlife habitat associated with those wetlands) can be combined into one GIS layer. By doing so, a visual representation of high functioning wetlands and habitat associated with wildlife that use the wetlands can be prepared to inform planning decisions for the Shorelands SAMP as well as master planning decisions.

The five FCIs (hydro, inhydro, dissolved, particulates, habitat; see Figure 2.2) from the 10 wetland units were plotted by function. Natural breaks were used to convert the numeric range of each FCI into categories of high, medium, and low functioning classes per function. High, medium and low classes were then assigned numeric equivalents (3, 2, and 1, respectively), and results of all functions were again grouped by wetland unit and tallied. The highest score that a wetland unit could receive was 15 (i.e., a score of 3 for each of the 5 FCIs). The tally of each wetland unit was converted to a percentage of a perfect score (x ÷ 15) and plotted (Figure 4.1). Wetland units with 80% of a perfect score or higher represent the highest functioning wetlands within the SAMP area (wetland units 1, 2, 3, 4, and 7).

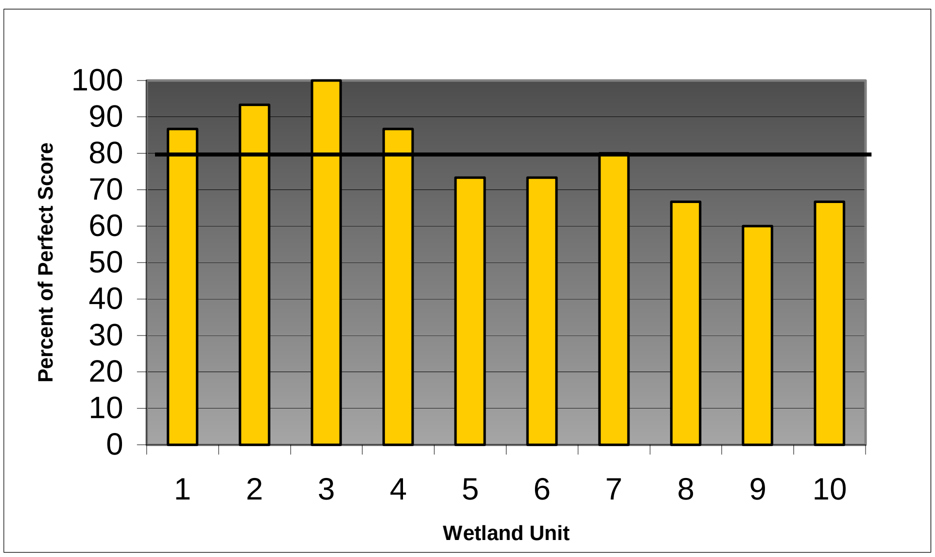

Figure 4.1. Wetland function relative to all wetlands assessed in the SAMP area.

These 5 highest functioning wetland units were merged as one GIS polygon and overlaid with the three highest functioning wildlife classes (moderately high value, high value and very high value habitat). The composite GIS layer shows high-functioning wetland and wildlife habitat in the Shorelands SAMP area and is recommended as a conservation area for planning purposes (Figure 4.2).

The conservation area is recommended for wetland-associated wildlife habitat support and links wetland resources with wildlife use. It is a conservative boundary, in that it is based on available data and likely has many data gaps—one of the reasons why several criteria originally considered for inclusion in the model were ultimately excluded. The benefits and disadvantages of utilizing those criteria are discussed below. They may be considered for use in future iterations of the wildlife functional assessment model outlined in this document, if the appropriate data are available.

4.2 Other Criteria to Consider

4.2.1 Water Use

Since wetlands require water for at least part of the growing season to function properly, we initially tried to identify the level of water development and the level of assurance that wetlands maintained adequate water during appropriate times of the year. The information exists; however, it is not readily available, because water rights data do not show what is currently approved for use (UDWaRi 2004). While it is possible to account for water use in areas managed for wildlife, it is difficult and costly to spend the time distinguishing between wetlands that have formed from natural hydrology and those that are artificially enhanced. However, a criterion of this nature could be added to the model at a later time to help define surface hydrology in the SAMP area.

4.2.2 Water Quality

Nutrient data collected at several sites in the SAMP area show elevated levels of phosphorous and nitrogen compared to national standards (data not shown but available from the State of Utah Department of Environmental Quality, Division of Water Quality). Yet for most of the SAMP area, the data do not exist. If a criterion were developed using available water quality data, areas *with* data would receive an inordinately low rating, and the rest of the area would have no score; this would introduce a bias into the overall score. When a larger water quality dataset is available, a criterion developed from it would be very useful, as it could potentially directly indicate the condition and quality of habitat.

4.2.3 Geomorphic and Fluvial Processes

The third criterion considered but abandoned would have evaluated wetland function related to geomorphologic and fluvial processes as the lake elevation rises. As the wetland-upland fringe migrates landward with rising lake elevations, new habitat is formed. In extreme flood conditions, wildlife will not only take refuge in upland areas, but the newly formed wetlands

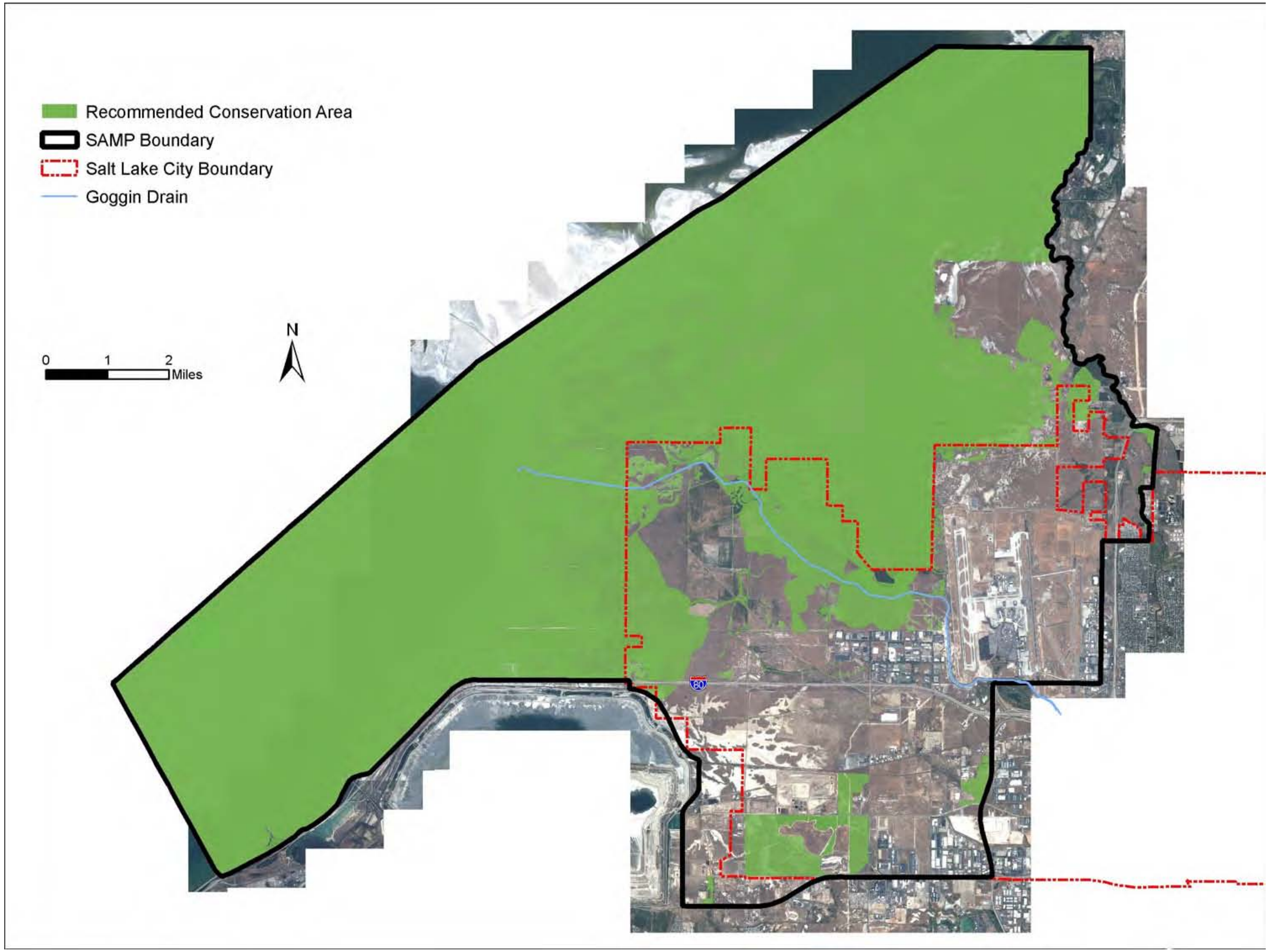

Figure 4.2. Recommended conservation area within the Shorelands SAMP area.

surrounding the remaining uplands provide treatment and attenuation of flood waters. A future version of this model could include more dynamic components that would capture flood-condition functions of wetlands.

If these and perhaps other criteria were developed and added to the current model, an even more definitive conservation area could be recommended. Nonetheless, the conservation area resulting from the current model is based on the best available information and is recommended for both Salt Lake County and Salt Lake City for their current planning needs.

A FINAL NOTE: The recommended conservation area was developed from biological and physical data specifically for the protection of wildlife habitat associated with wetlands in the Shorelands SAMP area. It is *not* intended to protect human health and safety. This point is particularly salient if and when lake levels rise above 4,211 feet and wind-driven currents push floodwaters onto land of higher elevations, where they begin to encroach on human development. Examples of data not included in this model that relate specifically to human health and safety are disease vectors by wetland biota (i.e., mosquitoes, birds) and liquefaction zones. Criteria for these kinds of data could be developed and included but are beyond the goals and objectives of this model.

ACKNOWLEDGEMENTS

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APPENDIX A: COMPLETE LIST OF COEFFICIENTS DETERMINED FOR LAND-USE IMPACTS UPON WETLANDS, GREAT SALT LAKE (GSL) MODEL (KEATE 2001, 2005)

Land Use	**Runoff (V_{runoff} and $V_{runoffin}$)**	**Loading ($V_{disload}$ and $V_{diswetuse}$)**	**Suspended Solids ($V_{susload}$ and $V_{suswetuse}$)**	**Wildlife Habitat (V_{adjhab} and $V_{habwetuse}$)**
1. Dirt Road (dirt or crushed or loose gravel, unpaved roads, local traffic)	0.71	0.92	0.97	0.30
2. Field Crop (actively plowed field)	0.95	0.94	1.00	0.10
3. Forested (woody vegetation 3 m or taller)	1.00	1.00	1.00	1.00
4. Clear-cut Forest	0.83	0.93	0.98	0.50
5. Golf Course (area manipulated for golf, manicured grass)	0.75	0.86	0.94	0.30
6.* High-intensity Commercial (area is entirely of commercial use and paved, e.g., shopping malls, construction yards, etc.)	0.13	0.00	0.00	0.00
7.* High-traffic Highway (4 lanes or larger, railroads, etc.)	0.26	0.43	0.48	0.00
8.* Industrial (intense production activity occurs on a daily basis, e.g., oil refineries, auto body and mechanic shops, welding yards, airports)	0.25	0.54	0.00	0.00
9.* Feedlot, Dairy	0.62	0.00	0.81	0.10
Heavy Grazing				
10. Non-rotational Grazing (year-round or mostly year-round grazing; vegetation is sparse and area trampled)	0.76	0.87	0.98	0.10
11. Rotational Grazing (grazing is for short periods during the year; vegetation is allowed to recover)	0.96	0.95	0.98	0.50
12.* Light-intensity Commercial (businesses that have large warehouses and showrooms; large patches of vegetation occur between buildings)	0.19	0.64	0.02	0.10
13. Low-density Rural Development (areas of small structures in a farm or ranch setting (e.g., silos, barns)	0.87	0.92	0.98	0.80
14.* Low-traffic Highway (2-3 lane paved highway)	0.26	0.69	0.16	0.00
15.* Multi-family Residential (subdivisions with lots of one-half acre or less)	0.38	0.55	0.61	0.10
16. Nursery (business where the production of nursery-grade vegetation occurs, e.g., greenhouses, outbuildings, and sales lots)	0.86	0.94	1.00	0.30
17. Orchards	0.86	0.93	0.99	0.30
18. Waterfowl Management Areas	0.86	0.91	0.98	0.85

Land Use	Runoff (V_{runoff} and $V_{runoffin}$)	Loading ($V_{disload}$ and $V_{diswetuse}$)	Suspended Solids ($V_{susload}$ and $V_{suswetuse}$)	Wildlife Habitat (V_{adjhab} and $V_{habwetuse}$)
19. Range (areas that have not been manipulated by humans, including irrigation or heavy grazing in natural state)	1.00	0.99	1.00	1.00
20. Single-family Residential (residential lots are greater than one-half acre with vegetation between houses)	0.75	0.86	0.94	0.50
21.* Surface Solid Waste (landfills and waste collection facilities)	0.71	0.87	0.61	0.10
22.* Sewage Treatment Plants and Lagoons	0.60	0.61	0.71	0.10
23.* Mining	0.76	0.94	0.80	0.01

Sources: Keate 2001, 2005:Table 1; Nnadi (1997).

NOTE: For the land uses marked by an asterisk (*) include a 2,000-foot buffer, then estimate the percentage of the wetland impacted by these land uses. The 2,000-foot buffer around the land uses marked by an asterisk applies ONLY to the wildlife habitat function $FCI_{habitat}$. For those land uses ***not*** marked by an asterisk (*), the percentage is based on the actual footprint of each land use.

Appendix B: All Formulas and Calculations of Variables and FCIs, as well as Supplemental Material

APPENDIX B.1. CALCULATION OF VARIABLES

V_{MOD}

V_{mod} is a categorical measure of the disruption of groundwater and surface water hydrology within a wetland and its adjacent, 300-foot perimeter (2,000-foot buffer used for $FCI_{habitat}$ and $FCI_{connectivity}$).

To calculate V_{mod}, identify all man-made disturbances (e.g., roads, berms, and ditches) that alter hydrology either by drying or storing water. Assign each modification a coefficient based on severity:

- 0.00 = 1, Extreme (e.g., four lane paved highway, ditches more than 3 feet deep)
- 0.50 = 2, Moderate (e.g., two-lane paved road, ditches 1-3 feet deep)
- 0.75 = 3, Slight (e.g., near-grade roads, ditches less than 1 foot deep)
- 1.00 = 4, None

Multiply the percentage of the wetland impacted by each modification by its coefficient. Sum them for a composite score (see example):

Example Calculation:
65% of wetland is unmodified (65% × 1.00 = 0.65)
20% of wetland is slightly modified (20% × 0.75 = 0.15)
15% of wetland is extremely modified (15% × 0.00 = 0.00)
$V_{mod} = 0.65 + 0.15 + 0.00 = 0.80$

$V_{VEGSTRUCT}$ (2001)

$V_{vegstruct}$ is one measure of surface roughness. It is an indicator of vegetation structure as a function of native and non-native species, based on wetland type or subclass.

The $V_{vegstruct}$ variable used for the Shorelands SAMP and other projects described in this document is the sum of the native species score and the score for herbaceous cover, divided by 2 (Keate 2001). Vegetation cover is determined at six inches above ground surface. The native species score is determined by dividing the number of individuals of the 5 dominant, native species by 5. If there are less than 5 dominant species, the total number of species is used as the divisor (e.g., if there are only 4 dominant, native species, the total number of individuals of those species is divided by 4).

Herbaceous cover scores are calculated by subclass, and scores are based upon relative level of salinity (see example below):

	Salinity	Actual Cover	Score
Slope Wetland Subclasses	< 8dS	≥ 0.83	1
	< 8dS	< 0.83	(2.87 × cover) - 1.40
	> 8dS	≤ 0.71	1
	> 8dS	> 0.71	3.46 × cover
Depressional Wetland Subclasses	< 8dS	≥ 0.82	1
	< 8dS	< 0.82	(0.43 × cover) + 0.39
	8dS – 16dS	≥ 0.76	1
	8dS – 16dS	< 0.76	(0.39 × cover) + 0.37
	> 16 dS	≤ 0.61	1
	> 16 dS	> 0.61	2.98 - (3.28 × cover)

Example Calculation:
Total number of dominant species = 5
Total number of native dominant species = 2
Native Species Score = 2 ÷ 5 = 0.40

For a depressional wetland with a salinity of 10 dS and an actual cover of 0.65:
Modified Herbaceous Cover Score = (0.39 × cover) + 0.37 = (0.39 × 0.65) + 0.37 = 0.62

$V_{vegstruct}$ = (Native Species Score + Modified Herbaceous Cover Score) ÷ 2
$V_{vegstruct}$ = (0.40 + 0.62) ÷ 2 = 0.51

$V_{VEGSTRUCT}$ (2005)

The revised $V_{vegstruct}$ variable is the sum of the native species score and the Similarity Index, divided by 2 (Keate 2005). To calculate the native species score for this variable, divide the number of native species that are dominant by the total number of dominant species (native and non-native), identifying no more then five. If there are fewer than five dominant plant species, use that number in the denominator (see example):

Example Calculation:
Total number of dominant species = 4
Total number of native dominant species = 3
Native Species Score = 3 ÷ 4 = 0.75

Determining the Similarity Index requires the use of wetland subclass profiles developed as part of this assessment and that contain data on reference standard conditions (e.g., plant species, work in progress, N. Keate 2005). To calculate the Similarity Index, divide the total number of total plant species in the wetland being assessed into the number of those species that occur in the reference standard for the type of wetland in which you are working (see example):

Example Calculation:

Total number of plant species in wetland = 5

Number of these species found in the reference standard for this wetland type = 3

Similarity Index = 3 ÷ 5 = 0.6

Having the native species score and the Similarity Index, you can calculate $V_{vegstruct}$:

$V_{vegstruct}$ = (Native Species Score + Similarity Index) ÷ 2

$V_{vegstruct}$ = (0.75 + 0.6) ÷ 2 = 0.68

V_{RUNOFF}

V_{runoff} is the average amount of overland flow reaching the wetland. It is affected by land use surrounding the wetland that reduces soil permeability and alters the quantity and timing of water delivery to the wetland. V_{runoff} coefficients were calculated from one Florida study and tabulated in a working paper by Nnadi (1997).

To calculate V_{runoff}, identify all land uses within a 300-foot perimeter of the wetland and determine the percentage of the total area that each use occupies. Multiply each percentage by its land use coefficient (see Appendix A). Sum them for a composite score (see example):

Example Calculation:

50% of perimeter is rotational grazing (50% × 0.96 = 0.48)

34% of perimeter is field crop (34% × 0.95 = 0.32)

16% of perimeter is light-intensity commercial development (16% × 0.19 = 0.03)

V_{runoff} = 0.48 + 0.32 + 0.03 = 0.83

$V_{RUNOFFIN}$

$V_{runoffin}$ measures the impact of land use within the wetland via surface roughness (as related to plant structure) and water infiltration and flow over wetland soils. $V_{runoffin}$ coefficients were calculated from one Florida study represented by a tabulation of multiple studies throughout the U.S. by Nnadi (1997).

To calculate $V_{runoffin}$, identify all land uses within the wetland and determine the percentage of the total area that each use occupies. Multiply each percentage by its land use coefficient (see Appendix A). Sum them for a composite score (see example):

Example Calculation:

62% of wetland is waterfowl management area (62% × 0.86 = 0.53)

21% of wetland is rotational grazing (21% × 0.96 = 0.20)

17% of wetland is dirt road (17% × 0.71 = 0.12)

$V_{runoffin}$ = 0.53 + 0.20 + 0.12 = 0.85

$V_{DISLOAD}$

$V_{disload}$ is a measure of the loading of the wetland with elements and compounds from land use from adjacent lands within a 300-foot perimeter. $V_{disload}$ coefficients were calculated from studies conducted throughout the U.S. and tabulated in a working paper by Nnadi (1997).

To calculate $V_{disload}$, identify all land uses within the 300-foot perimeter and determine the percentage of the total area that each use occupies. Multiply each percentage by its land use coefficient (see Appendix A). Sum them for a composite score (see example):

Example Calculation:

68% of perimeter is waterfowl management area (68% × 0.86 = 0.58)

21% of perimeter is rotational grazing (21% × 0.96 = 0.20)

11% of perimeter is sewage treatment lagoon (11% × 0.61 = 0.07)

$V_{disload}$ = 0.58 + 0.20 + 0.07 = 0.85

$V_{DISWETUSE}$

$V_{diswetuse}$ is a measure of the loading of the wetland with elements and compounds from land use within the wetland. $V_{diswetuse}$ coefficients were calculated from studies conducted throughout the U.S. and tabulated in a working paper by Nnadi (1997).

To calculate $V_{diswetuse}$, identify all land uses within the wetland and determine the percentage of the total area that each use occupies. Multiply each percentage by its land use coefficient (see Appendix A). Sum them for a composite score (see example):

Example Calculation:

54% of wetland is heavy grazing (54% × 0.87 = 0.47)

36% of wetland is forested (36% × 1.00 = 0.36)

10% of wetland is high traffic highway (10% × 0.43 = 0.04)

$V_{diswetuse}$ = 0.47 + 0.36 + 0.04 = 0.87

$V_{SUSLOAD}$

$V_{susload}$ is a measure of the relative volume of total suspended solids (TSS) carried into a wetland surface water from the surrounding landscape. $V_{susload}$ coefficients were calculated from studies conducted throughout the U.S. and tabulated in a working paper by Nnadi (1997).

To calculate $V_{susload}$, identify all land uses within the 2,000-foot perimeter and determine the percentage of the total area that each use occupies. Multiply each percentage by its land use coefficient (see Appendix A). Sum them for a composite score (see example):

Example Calculation:

74% of perimeter is low-density rural development (74% × 0.98 = 0.73)

16% of perimeter is surface solid waste (16% × 0.61 = 0.10)

10% of perimeter is dirt road (10% × 0.97 = 0.10)

$V_{susload}$ = 0.73 + 0.10 + 0.10 = 0.93

$V_{SUSWETUSE}$

$V_{suswetuse}$ is a measure of the relative volume of TSS carried into the wetland surface water from land uses within the wetland. $V_{suswetuse}$ coefficients were calculated from studies conducted throughout the U.S. and tabulated in a working paper by Nnadi (1997).

To calculate $V_{suswetuse}$, identify all land uses within the wetland and determine the percentage of the total area that each use occupies. Multiply each percentage by its land use coefficient (see Appendix A). Sum them for a composite score (see example):

Example Calculation:

35% of wetland is field crop (35% × 1.00 = 0.35)

33% of wetland is rotational grazing (33% × 0.98 = 0.32)

32% of wetland is range (32% × 1.00 = 0.32)

$V_{suswetuse}$ = 0.35 + 0.32 + 0.32 = 0.99

V_{ADJHAB}

V_{adjhab} is a measure of the habitat support of the land within the 2,000-foot perimeter for wildlife utilization. V_{adjhab} coefficients were calculated from studies conducted throughout the U.S. and tabulated in a working paper by Nnadi (1997).

To calculate V_{adjhab}, identify all land uses within the 2,000-foot perimeter and determine the percentage of the total area that each use occupies. Multiply each percentage by its land use coefficient (see Appendix A). Sum them for a composite score (see example):

Example Calculation:

45% of perimeter is light-intensity commercial (45% × 0.10 = 0.05)

25% of perimeter is multi-family residential (25% × 0.10 = 0.03)

17% of perimeter is single-family residential (17% × 0.50 = 0.09)

13% of perimeter is dirt road (13% × 0.30 = 0.04)

V_{adjhab} = 0.05 + 0.03 + 0.09 + 0.04 = 0.21

$V_{HABWETUSE}$

$V_{habwetuse}$ is a measure of the habitat support of the land within the wetland for wildlife utilization. $V_{habwetuse}$ coefficients were calculated from studies conducted throughout the U.S. and tabulated in a working paper by Nnadi (1997).

To calculate $V_{habwetuse}$, identify all land uses within the wetland and determine the percentage of the total area that each use occupies. Multiply each percentage by its land use coefficient (see Appendix A). Sum them for a composite score (see example):

Example Calculation:

78% of wetland is waterfowl management area (78% × 0.85 = 0.66)

22% of wetland is golf course (22% × 0.30 = 0.07)

$V_{habwetuse}$ = 0.66 + 0.07 = 0.73

V_{TSS} (2005)

V_{tss} is a measure of point source total suspended solids.

To determine V_{tss}, identify point source contributions to the wetlands, and select a coefficient based on the number of point source impacts:

- 0.25 = 1, Major point source impacts
- 0.50 = 2, Several point source impacts
- 0.75 = 3, Minor point source impacts
- 1.00 = 4, No point source impacts (see example)

  Example Calculation:

  V_{tss} = 0.75 if there are minor point source impacts from total suspended solids.

V_{WQ} (2005)

V_{wq} is a measure of point sources impact on water quality.

To determine V_{wq}, identify point source contributions to the wetlands. Select a coefficient based on the number of point source impacts:

- 0.25 = 1, Major point source impacts
- 0.50 = 2, Several point source impacts
- 0.75 = 3, Minor point source impacts
- 1.00 = 4, No point source impacts (see example):

  Example Calculation:

  V_{wq} = 0.25 if there are major point source impacts to water quality.

$V_{BARRIER}$

$V_{barrier}$ is a measure of habitat fragmentation of the wetland relative to its adjacent wetlands and native plant communities. It identifies barriers to non-avian wildlife movement, ranging from very small barriers such as unpaved roads and low-density housing to large hydrologic barriers such as canals and levied highways.

To calculate $V_{barrier}$, identify the types of barriers within 2,000 feet of the edge of the wetland. Assign each barrier a coefficient based on severity:

- 0.10 = 1, Large (e.g., four lane paved highway, large dikes, high density residential)
- 0.50 = 2, Moderate (e.g., two-lane paved road, single family residential, golf courses)
- 0.90 = 3, Small (e.g., near-grade roads, rural residential, field crops, utility easements)
- 1.00 = 4, No barrier to wildlife movement

Estimate the percentage of the wetland perimeter that is blocked by each barrier. Multiply the percentage of the perimeter by each barrier coefficient and sum them for a composite score (see example):

Example Calculation:

45% of wetland perimeter is affected by a large barrier (45% × 0.10= 0.045)

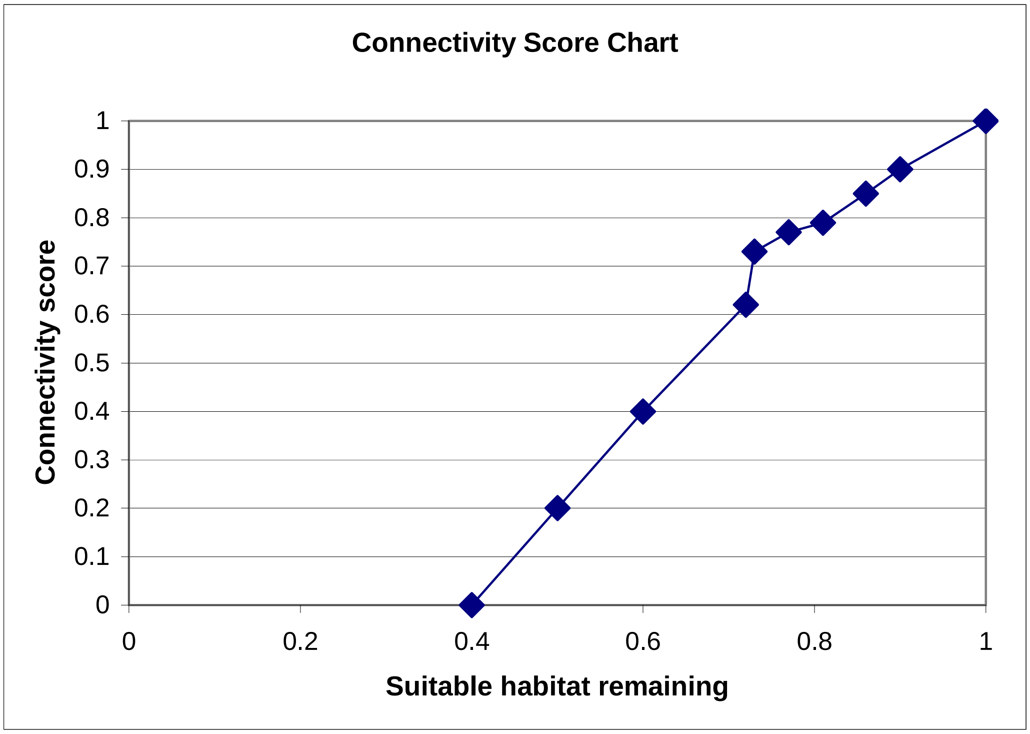
30% of wetland perimeter is affected by a small barrier (30% × 0.90 = 0.270)

25% of wetland perimeter has no barrier (25% × 1.00 = 0.250)

$V_{barrier}$ = 0.045 + 0.270 + 0.250 = 0.565

$V_{CONNECTIVITY}$

$V_{connectivity}$ is a measure of the loss of habitat and fragmentation of habitat. The $V_{connectivity}$ score is based on a direct relationship between connectivity and habitat suitability. For the model, a graph illustrating this relationship was derived based on explicit and implicit spatial models taken from the literature (Keate 2001; Nnadi 1997):



To calculate $V_{connectivity}$, estimate the portion of the area around the wetland within the 2000-foot buffer that still provides suitable habitat for many species. Identify this estimation on the x-axis and read the corresponding connectivity score from the y-axis (see example):

Example Calculation:

If 0.6 out of 1.0 is suitable habitat (i.e., 60%), then $V_{connectivity}$ = 0.4.

$V_{DIVERSITY}$

For the Tooele SAMP, $V_{diversity}$ was substituted for $V_{barrier}$ in calculating $FCI_{connectivity}$. This substitution reflected the ACOE and Tooele SAMP Steering Committee belief that the wildlife species most likely to use wetlands within the Tooele SAMP boundary—and thus the species of most concern—are birds, which are largely unaffected by surface barriers such as roads and dikes. $V_{diversity}$ is a measure of species richness (number of species in a given area) and evenness (number of individuals of each species) and is calculated using the Shannon-Weaver Diversity Index (Shannon and Weaver 1949):

$$H' = {}^{S^*}\sum_{i=1} (p_i \ln p_i)$$

where *H'* is the diversity index in a community made up of *S** species with known proportional abundances p1, p2, p3, ... pS*.

H' was calculated for each avian point count station and transect using a full year of survey data. Values were then normalized across all sampling units to provide a number between 0 and 1. For the most part, point count stations and transects were located within relatively homogeneous habitat types. Where there was more than one avian sampling unit within a given functional assessment unit, $V_{diversity}$ was calculated using a weighted average with weights equal to the proportion of that habitat type within the assessment unit.

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APPENDIX B.2. SUMMARY OF FCIS FOR THE SHORELANDS SAMP

Table B.2.1. Summary of Final FCIs, by Wetland Unit

FCI	FA Unit 1	FA Unit 2	FA Unit 3	FA Unit 4	FA Unit 5	FA Unit 6	FA Unit 7	FA Unit 8	FA Unit 9	FA Unit 10
Hydro	0.949	0.684	0.846	0.775	0.675	0.463	0.476	0.383	0.128	0.563
Inhydro	0.652	0.942	0.892	0.739	0.809	0.931	0.874	0.957	0.862	0.835
Dissolved	0.973	0.957	0.978	0.935	0.928	0.896	0.945	0.924	0.916	0.928
Particulates	0.970	0.704	0.858	0.812	0.690	0.481	0.483	0.397	0.135	0.586
Habitat	0.737	0.873	0.902	0.764	0.621	0.640	0.583	0.626	0.616	0.703

Table B.2.2. FCI Calculations at a Glance, by Wetland Unit

Wetland Unit	Variable 3	Variable 2	Variable 1	Formula	FCI
	—	V_{runoff}	V_{mod}	$\sqrt{(V_{runoff} \times V_{mod})}$	FCI_{hydro}
1	—	0.932	0.966	$\sqrt{(0.932 \times 0.966)}$	0.949
2	—	0.911	0.514	$\sqrt{(0.911 \times 0.514)}$	0.684
3	—	0.968	0.739	$\sqrt{(0.968 \times 0.739)}$	0.846
4	—	0.896	0.670	$\sqrt{(0.896 \times 0.670)}$	0.775
5	—	0.913	0.499	$\sqrt{(0.913 \times 0.499)}$	0.675
6	—	0.827	0.259	$\sqrt{(0.827 \times 0.259)}$	0.463
7	—	0.929	0.244	$\sqrt{(0.929 \times 0.244)}$	0.476
8	—	0.872	0.168	$\sqrt{(0.872 \times 0.168)}$	0.383
9	—	0.835	0.020	$\sqrt{(0.835 \times 0.020)}$	0.128
10	—	0.840	0.377	$\sqrt{(0.840 \times 0.377)}$	0.563
	—	$V_{runoffin}$	$V_{vegstruct}$	$(V_{runoffin} + V_{vegstruct}) \div 2$	$FCI_{inhydro}$
1	—	0.999	0.305	$(0.999 + 0.305) \div 2$	0.652
2	—	0.985	0.900	$(0.985 + 0.900) \div 2$	0.942
3	—	0.989	0.795	$(0.989 + 0.795) \div 2$	0.892

Table B.2.2. FCI Calculations at a Glance, by Wetland Unit

Wetland Unit	Variable 3	Variable 2	Variable 1	Formula	FCI
4	—	0.909	0.570	(0.909 + 0.570) ÷ 2	0.739
5	—	0.908	0.710	(0.908 + 0.710) ÷ 2	0.809
6	—	0.902	0.960	(0.902 + 0.960) ÷ 2	0.931
7	—	0.948	0.800	(0.948 + 0.800) ÷ 2	0.874
8	—	0.958	0.955	(0.958 + 0.955) ÷ 2	0.957
9	—	0.969	0.755	(0.969 + 0.755) ÷ 2	0.862
10	—	0.945	0.725	(0.945 + 0.725) ÷ 2	0.835
	—	**$V_{disload}$**	**$V_{diswetuse}$**	**($V_{disload}$ + $V_{diswetuse}$) ÷ 2**	**$FCI_{dissolved}$**
1	—	0.948	0.999	(0.948 + 0.999) ÷ 2	0.973
2	—	0.932	0.982	(0.932 + 0.982) ÷ 2	0.957
3	—	0.972	0.983	(0.972 + 0.983) ÷ 2	0.978
4	—	0.932	0.939	(0.932 + 0.939) ÷ 2	0.935
5	—	0.930	0.926	(0.930 + 0.926) ÷ 2	0.928
6	—	0.874	0.917	(0.874 + 0.917) ÷ 2	0.896
7	—	0.942	0.948	(0.942 + 0.948) ÷ 2	0.945
8	—	0.898	0.949	(0.898 + 0.949) ÷ 2	0.924
9	—	0.872	0.960	(0.872 + 0.960) ÷ 2	0.916
10	—	0.902	0.955	(0.902 + 0.955) ÷ 2	0.928
	V_{mod}	**$V_{suswetuse}$**	**$V_{susload}$**	**(V_{mod} + $V_{suswetuse}$ + $V_{susload}$) ÷ 3**	**$FCI_{particulates}$**
1	0.966	0.998	0.949	(0.966 + 0.998 + 0.949) ÷ 3	0.970
2	0.514	0.993	0.938	(0.514 + 0.993 + 0.938) ÷ 3	0.704
3	0.739	0.998	0.995	(0.739 + 0.998 + 0.995) ÷ 3	0.858
4	0.670	0.987	0.980	(0.670 + 0.987 + 0.980) ÷ 3	0.812
5	0.499	0.955	0.954	(0.499 + 0.955 + 0.954) ÷ 3	0.690
6	0.259	0.921	0.862	(0.259 + 0.921 + 0.862) ÷ 3	0.481

Table B.2.2. FCI Calculations at a Glance, by Wetland Unit

Wetland Unit	Variable 3	Variable 2	Variable 1	Formula	FCI
7	0.244	0.970	0.946	(0.244 + 0.970 + 0.946) ÷ 3	0.483
8	0.168	0.979	0.896	(0.168 + 0.979 + 0.896) ÷ 3	0.397
9	0.020	0.985	0.871	(0.020 + 0.985 + 0.871) ÷ 3	0.135
10	0.377	0.984	0.839	(0.377 + 0.984 + 0.839) ÷ 3	0.586
	$V_{vegstruct}$	V_{adjhab}	$V_{habwetuse}$	$(V_{vegstruct} + V_{adjhab} + V_{habwetuse}) \div 3$	**$FCI_{habitat}$**
1	0.305	0.908	0.998	(0.305 + 0.908 + 0.998) ÷ 3	0.737
2	0.900	0.773	0.946	(0.900 + 0.773 + 0.946) ÷ 3	0.873
3	0.795	0.934	0.977	(0.795 + 0.934 + 0.977) ÷ 3	0.902
4	0.570	0.825	0.895	(0.570 + 0.825 + 0.895) ÷ 3	0.764
5	0.710	0.554	0.599	(0.710 + 0.554 + 0.599) ÷ 3	0.621
6	0.960	0.453	0.509	(0.960 + 0.453 + 0.509) ÷ 3	0.640
7	0.800	0.459	0.500	(0.800 + 0.459 + 0.500) ÷ 3	0.586
8	0.955	0.425	0.499	(0.955 + 0.425 + 0.499) ÷ 3	0.626
9	0.755	0.463	0.630	(0.755 + 0.463 + 0.630) ÷ 3	0.616
10	0.725	0.561	0.821	(0.725 + 0.561 + 0.821) ÷ 3	0.703

Table B.2.3. Degree of Hydrological Modification, by Wetland Unit

Wetland Unit	Level of Hydrological Modification (HM)*	Perimeter Acres	Wetland Acres	Total Acres	% HM
1	1	21.70	40.17	61.87	0.003947
	2	112.04	558.60	670.64	0.042786
	3	66.03	477.89	543.92	0.034701
	4	613.83	13784.17	14398.00	0.918566
	Total	**813.60**	**14860.83**		**1.000000**
2	1	919.76	1172.58	2092.34	0.270325
	2	999.74	1389.61	2389.35	0.308698
	3	474.01	1427.26	1901.27	0.245640
	4	245.79	1111.33	1357.12	0.175337
	Total	**2639.30**	**5100.78**		**1.000000**
3	1	415.26	811.78	1227.04	0.171363
	2	0.00	0.00	0.00	0.000000
	3	1146.32	1417.96	2564.28	0.358116
	4	937.32	2431.83	3369.15	0.470521
	Total	**2498.90**	**4661.57**		**1.000000**
4	1	654.78	828.82	1483.60	0.063134
	2	934.43	6496.50	7430.93	0.316218
	3	2834.10	7400.41	10234.51	0.435523
	4	571.02	3779.32	4350.34	0.185126
	Total	**4994.33**	**18505.05**		**1.000000**
5	1	827.87	232.47	1060.34	0.260713
	2	707.15	343.69	1050.84	0.258377
	3	1266.66	538.96	1805.62	0.443960
	4	110.72	39.56	150.28	0.036950
	Total	**2912.40**	**1154.68**		**1.000000**
6	1	370.66	51.56	422.22	0.484147
	2	366.10	79.40	445.50	0.510842
	3	4.09	0.00	4.09	0.004690
	4	0.28	0.00	0.28	0.000321
	Total	**741.13**	**130.96**		**1.000000**
7	1	1375.30	492.23	1867.53	0.538800
	2	1205.76	218.31	1424.07	0.410858
	3	143.08	26.36	169.44	0.048885
	4	3.83	1.22	5.05	0.001457

Table B.2.3. Degree of Hydrological Modification, by Wetland Unit

Wetland Unit	Level of Hydrological Modification (HM)*	Perimeter Acres	Wetland Acres	Total Acres	% HM
	Total	**2727.97**	**738.12**		**1.000000**
8	1	789.55	833.57	1623.12	0.688688
	2	336.72	315.53	652.25	0.276749
	3	36.52	11.39	47.91	0.020328
	4	23.89	9.66	33.55	0.014235
	Total	**1186.68**	**1170.15**		**1.000000**
9	1	276.14	49.10	325.24	0.960884
	2	13.24	0.00	13.24	0.039116
	3	0.00	0.00	0.00	0.000000
	4	0.00	0.00	0.00	0.000000
	Total	**289.38**	**49.10**		**1.000000**
10	1	368.01	85.44	453.45	0.274414
	2	756.15	350.42	1106.57	0.669662
	3	55.44	36.96	92.40	0.055918
	4	0.01	0.00	0.01	0.000006
	Total	**1179.61**	**472.82**		**1.000000**

*Hydrological Modification (HM) Coefficients: 1 = 0; 2 = 0.5; 3 = 0.75; 4 = 1 (no modification).

Table B.2.4. Land Use (LU) Percentages

Wetland Unit	Perimeter LU Code	Wetland LU Code	Acreage	% of Total Acreage
1	1		0.73	0.000897
	3		478.28	0.587856
	7		64.55	0.079339
	8		0.00	0.000000
	12		1.73	0.002126
	14		7.87	0.009673
	19		260.44	0.320108
	Subtotal		**813.60**	**1.000000**
		1	1.53	0.000103
		3	14642.29	0.985294
		7	1.45	0.000098
		14	27.44	0.001846
		19	188.12	0.012659
		Subtotal	**14860.83**	**1.000000**
2	1		94.45	0.035786
	2		0.00	0.000000
	3		155.81	0.059035
	7		193.31	0.073243
	11		557.55	0.211249
	12		1.13	0.000428
	14		49.54	0.018770
	18		0.00	0.000000
	19		1575.08	0.596779
	21		6.79	0.002573
	22		1.28	0.000485
	24		4.36	0.001652
	Subtotal		**2639.30**	**1.000000**
		1	136.22	0.026706
		3	39.35	0.007715
		11	267.90	0.052521
		12	14.40	0.002823
		14	1.22	0.000239
		19	4607.08	0.903211
		21	0.03	0.000006
		22	34.58	0.006779

Table B.2.4. Land Use (LU) Percentages

Wetland Unit	Perimeter LU Code	Wetland LU Code	Acreage	% of Total Acreage
		Subtotal	**5100.78**	**1.000000**
3	1		32.25	0.012906
	3		67.05	0.026832
	11		145.53	0.058238
	18		466.34	0.186618
	19		1787.73	0.715407
	Subtotal		**2498.90**	**1.000000**
		1	2.05	0.000440
		3	38.15	0.008184
		11	112.97	0.024234
		18	335.19	0.071905
		19	4173.21	0.895237
		Subtotal	**4661.97**	**1.000000**
4	1		137.68	0.027567
	2		39.44	0.007897
	3		132.17	0.026464
	8		23.65	0.004735
	11		496.50	0.099413
	13		0.00	0.000000
	18		3132.55	0.627221
	19		1032.34	0.206702
	Subtotal		**4994.33**	**1.000000**
		1	71.22	0.003849
		2	1.77	0.000096
		3	806.51	0.043583
		8	4.78	0.000258
		11	210.70	0.011386
		18	11815.48	0.638500
		19	5594.59	0.302328
		Subtotal	**18505.05**	**1.000000**
5	1		45.58	0.015650
	2		188.23	0.064631
	7		3.53	0.001212
	8		74.68	0.025642
	11		1815.33	0.623311

Table B.2.4. Land Use (LU) Percentages

Wetland Unit	Perimeter LU Code	Wetland LU Code	Acreage	% of Total Acreage
	12		0.00	0.000000
	13		26.91	0.009240
	14		7.86	0.002699
	18		630.11	0.216354
	19		114.48	0.039308
	20		5.69	0.001954
	22		0.00	0.000000
	Subtotal		**2912.40**	**1.000000**
		1	3.48	0.003014
		2	15.51	0.013432
		7	0.04	0.000035
		8	29.21	0.025297
		11	720.25	0.623766
		13	1.03	0.000892
		14	0.02	0.000017
		18	382.48	0.331243
		19	2.65	0.002295
		20	0.01	0.000009
		Subtotal	**1154.68**	**1.000000**
6	1		21.35	0.028807
	2		17.88	0.024125
	5		1.99	0.002685
	6		0	0.000000
	7		55.37	0.074710
	8		38.07	0.051368
	10		0.07	0.000094
	11		468.19	0.631725
	12		2.04	0.002753
	13		21.16	0.028551
	14		20.12	0.027148
	15		11.98	0.016165
	18		16.6	0.022398
	19		54.00	0.072862
	20		12.31	0.016610
	Subtotal		**741.13**	**1.000000**

Table B.2.4. Land Use (LU) Percentages

Wetland Unit	Perimeter LU Code	Wetland LU Code	Acreage	% of Total Acreage
		1	0.78	0.005956
		2	0.26	0.001985
		7	3.07	0.023442
		8	4.82	0.036805
		11	103.83	0.792838
		13	0.83	0.006338
		14	1.26	0.009621
		15	1.75	0.013363
		18	0.38	0.002902
		19	12.56	0.095907
		20	1.42	0.010843
		Subtotal	**130.96**	**1.000000**
7	1		71.56	0.026232
	2		300.97	0.110327
	12		32.06	0.011752
	13		7.02	0.002573
	19		224.46	0.082281
	11		1898.75	0.696030
	21		192.43	0.070540
	14		0.72	0.000264
	Subtotal		**2727.97**	**1.000000**
		1	16.99	0.023018
		2	8.46	0.011462
		12	0.31	0.000420
		13	0.94	0.001274
		19	29.62	0.040129
		11	661.24	0.895843
		21	20.56	0.027855
		Subtotal	**738.12**	**1.000000**
8	1		21.67	0.018261
	7		81.44	0.068628
	11		973.99	0.820769
	14		3.36	0.002831
	21		78.56	0.066202
	24		27.66	0.023309

Table B.2.4. Land Use (LU) Percentages

Wetland Unit	Perimeter LU Code	Wetland LU Code	Acreage	% of Total Acreage
	Subtotal		**1186.68**	**1.000000**
		1	4.70	0.004017
		7	0.54	0.000461
		11	1164.08	0.994813
		14	0.00	0.000000
		21	0.52	0.000444
		24	0.31	0.000265
		Subtotal	**1170.15**	**1.000000**
9	1		3.92	0.013546
	7		36.25	0.125268
	8		4.42	0.015274
	11		204.03	0.705059
	12		6.17	0.021321
	14		4.46	0.015412
	19		30.13	0.104119
	Subtotal			**1.000000**
		1	0.14	0.002851
		7	0.03	0.000611
		11	36.09	0.735031
		14	0.00	0.000000
		19	12.84	0.261507
		Subtotal		**1.000000**
10	1		59.10	0.050101
	2		2.50	0.002119
	6		2.44	0.002068
	7		39.04	0.033096
	8		57.56	0.048796
	10		12.28	0.010410
	11		329.17	0.279050
	12		14.85	0.012589
	13		16.31	0.013827
	14		8.13	0.006892
	18		13.13	0.011131
	19		433.50	0.367494
	21		184.14	0.156102

Table B.2.4. Land Use (LU) Percentages

Wetland Unit	Perimeter LU Code	Wetland LU Code	Acreage	% of Total Acreage
	24		7.46	0.006324
	Subtotal		**1179.61**	**1.000000**
		1	1.89	0.003997
		3	0.00	0.000000
		6	0.02	0.000042
		7	0.31	0.000656
		8	0.25	0.000529
		10	0.61	0.001290
		11	117.20	0.247874
		12	0.54	0.001142
		13	0.27	0.000571
		14	0.48	0.001015
		18	131.39	0.277886
		19	216.81	0.458547
		21	2.85	0.006028
		24	0.20	0.000423
		Subtotal	**472.82**	**1.000000**

APPENDIX B.3. WORKSHEETS FOR CALCULATIONS OF VARIABLES AND FCIS FROM RAW DATA, BY WETLAND UNIT OF THE SHORELANDS SAMP

WETLAND UNIT 1: FCI_{hydro} Worksheet

V_{runoff}

LU Code	LU %*	LU Coefficient	Product (LU % × LU Coefficient)
1*	0.0009	0.71	0.0006
3	0.5879	1.00	0.5879
7	0.0793	0.26	0.0206
8	0.0000	0.25	0.0000
12	0.0021	0.19	0.0004
14	0.0097	0.26	0.0025
19	0.3201	1.00	0.3201
	V_{runoff} (Sum of Products) =		**0.9321**

LU = Land Use.

* % land use (perimeter-contributing).

** For slope wetlands only: the upslope and flanking land uses within the 2,000-foot wetland perimeter. For slope wetlands, look at barriers upslope that affect hydrology (flow). For depressional wetlands, look at entire perimeter.

V_{mod}

Level of HM (Code)	% Wetland Modified	HM Coefficient	Product (% Wetland × HM Coefficient)
1	0.0039	0.00	0.0000
2	0.0428	0.50	0.0214
3	0.0347	0.75	0.0260
4*	0.9186	1.00	0.9186
	V_{mod} (Sum of Products) =		**0.9660**

* No modification.

$$FCI_{hydro} = \sqrt{(V_{runoff} \times V_{mod})} = \sqrt{(0.932 \times 0.966)} = 0.949$$

WETLAND UNIT 1: $FCI_{inhydro}$ Worksheet

$V_{vegstruct}$

Herbaceous Cover Score Rules (Slope vs. Depressional):

Slope, non- to slightly saline (< 8 dS):

- if cover ≥ 0.83, then = 1
- if cover < 0.83, then = (2.87 × cover) – 1.40

Slope, moderately to extremely saline (> 8 dS):

- if cover ≤ 0.71, then = 1
- if cover > 0.71, then = 3.46 – (3.52 × cover)

Depression, non- to slightly saline (< 8 dS):

- if cover ≥ 0.82, then = 1
- if cover < 0.82, then = (0.39 × cover) + 0.39

Depression, moderately saline (8–16 dS):

- if cover ≥ 0.76, then = 1
- if cover < 0.76, then = (0.39 × cover) + 0.37

Depression, highly saline (> 16 dS):

- if cover ≤ 0.61, then = 1
- if cover > 0.61, then = 2.98 – (3.28 × cover)

Native Species Score	% Herbaceous Cover (Actual)	Modified Herbaceous Cover Score*	$V_{vegstruct}$**
0.000	0.000	0.610	**0.305**

* Assumed depressional, highly saline.

** (Native Species Score + Modified Herbaceous Cover Score) ÷ 2.

$V_{runoffin}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0001	0.71	0.0001
3	0.9853	1.00	0.9853
7	0.0001	0.26	0.0000
14	0.0018	0.26	0.0005
19	0.0127	1.00	0.0127
		$V_{runoffin}$ (Sum of Products) =	**0.9985**

LU = Land Use.

$FCI_{inhydro} = (V_{runoffin} + V_{vegstruct}) \div 2 = (0.999 + 0.305) \div 2 = 0.652$

WETLAND UNIT 1: FCI$_{dissolved}$ Worksheet

V$_{disload}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0009	0.92	0.0008
3	0.5879	1.00	0.5879
7	0.0793	0.43	0.0341
8	0.0000	0.54	0.0000
12	0.0021	0.64	0.0014
14	0.0097	0.69	0.0067
19	0.3201	0.99	0.3169
	V$_{disload}$ (Sum of Products) =		**0.9477**

LU = Land Use.

* For slope wetlands only: the upslope and flanking land uses within the 300-foot wetland perimeter.

V$_{diswetuse}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0001	0.92	0.0001
3	0.9853	1.00	0.9853
7	0.0001	0.43	0.0000
14	0.0018	0.69	0.0013
19	0.0127	0.99	0.0125
	V$_{diswetuse}$ (Sum of Products) =		**0.9992**

LU = Land Use.

FCI$_{dissolved}$ = (V$_{disload}$ + V$_{diswetuse}$) ÷ 2 = (0.948 + 0.999) ÷ 2 = 0.973

WETLAND UNIT 1: $FCI_{particulates}$ Worksheet

$V_{susload}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0009	0.97	0.0009
3	0.5879	1.00	0.5879
7	0.0793	0.48	0.0381
8	0.0000	0.00	0.0000
12	0.0021	0.02	0.0000
14	0.0097	0.16	0.0015
19	0.3201	1.00	0.3201
		$V_{susload}$ (Sum of Products) =	**0.9485**

LU = Land Use.

* For slope wetlands only: the upslope and flanking land uses within the 2,000-foot wetland perimeter.

$V_{suswetuse}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0001	0.97	0.0001
3	0.9853	1.00	0.9853
7	0.0001	0.48	0.0000
14	0.0018	0.16	0.0003
19	0.0127	1.00	0.0127
		$V_{suswetuse}$ (Sum of Products) =	**0.9984**

LU = Land Use.

V_{mod} (see FCI_{hydro}) = 0.966

$FCI_{particulates} = (V_{mod} + V_{suswetuse} + V_{susload}) \div 3 = (0.966 + 0.998 + 0.949) \div 3 = 0.970$

WETLAND UNIT 1: $FCI_{habitat}$ Worksheet

V_{adjhab}

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0009	0.30	0.0003
3	0.5879	1.00	0.5879
7	0.0793	0.00	0.0000
8	0.0000	0.00	0.0000
12	0.0021	0.10	0.0002
14	0.0097	0.00	0.0000
19	0.3201	1.00	0.3201
		V_{adjhab} (Sum of Products) =	**0.9084**

LU = Land Use.

$V_{habwetuse}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0001	0.30	0.0000
3	0.9853	1.00	0.9853
7	0.0001	0.00	0.0000
14	0.0018	0.00	0.0000
19	0.0127	1.00	0.0127
		$V_{habwetuse}$ (Sum of Products) =	**0.9980**

LU = Land Use.

$V_{vegstruct}$ (see $FCI_{inhydro}$) = 0.305

$FCI_{habitat} = (V_{vegstruct} + V_{adjhab} + V_{habwetuse}) \div 3 = (0.305 + 0.908 + 0.998) \div 3 = 0.737$

WETLAND UNIT 2: FCI_{hydro} Worksheet

V_{runoff}

LU Code	LU %*	LU Coefficient	Product (LU % × LU Coefficient)
1*	0.0358	0.71	0.0254
2	0.0000	0.95	0.0000
3	0.0590	1.00	0.0590
7	0.0732	0.26	0.0190
11	0.2112	0.96	0.2028
12	0.0004	0.19	0.0001
14	0.0188	0.26	0.0049
18	0.0000	0.86	0.0000
19	0.5968	1.00	0.5968
21	0.0026	0.71	0.0018
22	0.0005	0.60	0.0003
24	0.0017	0.25	0.0004
	V_{runoff} (Sum of Products) =		**0.9106**

LU = Land Use.

* % land use (perimeter-contributing).

** For slope wetlands only: the upslope and flanking land uses within the 2,000-foot wetland perimeter. For slope wetlands, look at barriers upslope that affect hydrology (flow). For depressional wetlands, look at entire perimeter.

V_{mod}

Level of HM (Code)	% Wetland Modified	HM Coefficient	Product (% Wetland × HM Coefficient)
1	0.2703	0.00	0.0000
2	0.3087	0.50	0.1543
3	0.2456	0.75	0.1842
4*	0.1753	1.00	0.1753
	V_{mod} (Sum of Products) =		**0.5139**

* No modification.

$$FCI_{hydro} = \sqrt{(V_{runoff} \times V_{mod})} = \sqrt{(0.911 \times 0.514)} = 0.684$$

WETLAND UNIT 2: $FCI_{inhydro}$ Worksheet

$V_{vegstruct}$

Herbaceous Cover Score Rules (Slope vs. Depressional):

Slope, non- to slightly saline (< 8 dS):
- if cover ≥ 0.83, then = 1
- if cover < 0.83, then = (2.87 × cover) – 1.40

Slope, moderately to extremely saline (> 8 dS):
- if cover ≤ 0.71, then = 1
- if cover > 0.71, then = 3.46 – (3.52 × cover)

Depression, non- to slightly saline (< 8 dS):
- if cover ≥ 0.82, then = 1
- if cover < 0.82, then = (0.39 × cover) + 0.39

Depression, moderately saline (8–16 dS):
- if cover ≥ 0.76, then = 1
- if cover < 0.76, then = (0.39 × cover) + 0.37

Depression, highly saline (> 16 dS):
- if cover ≤ 0.61, then = 1
- if cover > 0.61, then = 2.98 – (3.28 × cover)

Native Species Score	% Herbaceous Cover (Actual)	Modified Herbaceous Cover Score*	$V_{vegstruct}$**
0.800	0.530	1.000	**0.900**

* Assumed depressional, highly saline.

** (Native Species Score + Modified Herbaceous Cover Score) ÷ 2.

$V_{runoffin}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0267	0.71	0.0190
3	0.0077	1.00	0.0077
11	0.0525	0.96	0.0504
12	0.0028	0.19	0.0005
14	0.0002	0.26	0.0001
19	0.9032	1.00	0.9032
21	0.0000	0.71	0.0000
22	0.0068	0.60	0.0041
		$V_{runoffin}$ (Sum of Products) =	**0.9850**

LU = Land Use.

$FCI_{inhydro} = (V_{runoffin} + V_{vegstruct}) \div 2 = (0.985 + 0.900) \div 2 = 0.942$

WETLAND UNIT 2: $FCI_{dissolved}$ Worksheet

$V_{disload}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0358	0.92	0.0329
2	0.0000	0.94	0.0000
3	0.0590	1.00	0.0590
7	0.0732	0.43	0.0315
11	0.2112	0.95	0.2007
12	0.0004	0.64	0.0003
14	0.0188	0.69	0.0130
18	0.0000	0.91	0.0000
19	0.5968	0.99	0.5908
21	0.0026	0.87	0.0022
22	0.0005	0.61	0.0003
24	0.0017	0.54	0.0009
	$V_{disload}$ (Sum of Products) =		**0.9316**

LU = Land Use.

* For slope wetlands only: the upslope and flanking land uses within the 300-foot wetland perimeter.

$V_{diswetuse}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0267	0.92	0.0246
3	0.0077	1.00	0.0077
11	0.0525	0.95	0.0499
12	0.0028	0.64	0.0018
14	0.0002	0.69	0.0002
19	0.9032	0.99	0.8942
21	0.0000	0.87	0.0000
22	0.0068	0.61	0.0041
	$V_{diswetuse}$ (Sum of Products) =		**0.9825**

LU = Land Use.

$FCI_{dissolved} = (V_{disload} + V_{diswetuse}) \div 2 = (0.932 + 0.982) \div 2 = 0.957$

WETLAND UNIT 2: $FCI_{particulates}$ Worksheet

$V_{susload}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0358	0.97	0.0347
2	0.0000	1.00	0.0000
3	0.0590	1.00	0.0590
7	0.0732	0.48	0.0352
11	0.2112	0.98	0.2070
12	0.0004	0.02	0.0000
14	0.0188	0.16	0.0030
18	0.0000	0.98	0.0000
19	0.5968	1.00	0.5968
21	0.0026	0.61	0.0016
22	0.0005	0.71	0.0003
24	0.0017	0.00	0.0000
		$V_{susload}$ (Sum of Products) =	**0.9376**

LU = Land Use.

* For slope wetlands only: the upslope and flanking land uses within the 2,000-foot wetland perimeter.

$V_{suswetuse}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0267	0.97	0.0259
3	0.0077	1.00	0.0077
11	0.0525	0.98	0.0515
12	0.0028	0.02	0.0001
14	0.0002	0.16	0.0000
19	0.9032	1.00	0.9032
21	0.0000	0.61	0.0000
22	0.0068	0.71	0.0048
		$V_{suswetuse}$ (Sum of Products) =	**0.9932**

LU = Land Use.

V_{mod} (see FCI_{hydro}) = 0.514

$FCI_{particulates} = (V_{mod} + V_{suswetuse} + V_{susload}) \div 3 = (0.514 + 0.993 + 0.938) \div 3 = 0.704$

WETLAND UNIT 2: $FCI_{habitat}$ Worksheet

V_{adjhab}

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0358	0.30	0.0107
2	0.0000	0.10	0.0000
3	0.0590	1.00	0.0590
7	0.0732	0.00	0.0000
11	0.2112	0.50	0.1056
12	0.0004	0.10	0.0000
14	0.0188	0.00	0.0000
18	0.0000	0.85	0.0000
19	0.5968	1.00	0.5968
21	0.0026	0.10	0.0003
22	0.0005	0.10	0.0000
24	0.0017	0.10	0.0002
		V_{adjhab} (Sum of Products) =	**0.7727**

LU = Land Use.

$V_{habwetuse}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0267	0.30	0.0080
3	0.0077	1.00	0.0077
11	0.0525	0.50	0.0263
12	0.0028	0.10	0.0003
14	0.0002	0.00	0.0000
19	0.9032	1.00	0.9032
21	0.0000	0.10	0.0000
22	0.0068	0.10	0.0007
		$V_{habwetuse}$ (Sum of Products) =	**0.9462**

LU = Land Use.

$V_{vegstruct}$ (see $FCI_{inhydro}$) = 0.900

$FCI_{habitat} = (V_{vegstruct} + V_{adjhab} + V_{habwetuse}) \div 3 = (0.900 + 0.773 + 0.946) \div 3 = 0.873$

WETLAND UNIT 3: FCI_{hydro} Worksheet

V_{runoff}

LU Code	LU %*	LU Coefficient	Product (LU % × LU Coefficient)
1*	0.0129	0.71	0.0092
3	0.0268	1.00	0.0268
11	0.0582	0.96	0.0559
18	0.1866	0.86	0.1605
19	0.7154	1.00	0.7154
	V_{runoff} (Sum of Products) =		**0.9678**

LU = Land Use.

* % land use (perimeter-contributing).

** For slope wetlands only: the upslope and flanking land uses within the 2,000-foot wetland perimeter. For slope wetlands, look at barriers upslope that affect hydrology (flow). For depressional wetlands, look at entire perimeter.

V_{mod}

Level of HM (Code)	% Wetland Modified	HM Coefficient	Product (% Wetland × HM Coefficient)
1	0.1714	0.00	0.0000
2	0.0000	0.50	0.0000
3	0.3581	0.75	0.2686
4*	0.4705	1.00	0.4705
		V_{mod} (Sum of Products) =	**0.7391**

* No modification.

$$FCI_{hydro} = \sqrt{(V_{runoff} \times V_{mod})} = \sqrt{(0.968 \times 0.739)} = 0.846$$

WETLAND UNIT 3: $FCI_{inhydro}$ Worksheet

$V_{vegstruct}$

Herbaceous Cover Score Rules (Slope vs. Depressional):

Slope, non- to slightly saline (< 8 dS):

if cover ≥ 0.83, then = 1

if cover < 0.83, then = (2.87 × cover) – 1.40

Slope, moderately to extremely saline (> 8 dS):

if cover ≤ 0.71, then = 1

if cover > 0.71, then = 3.46 – (3.52 × cover)

Depression, non- to slightly saline (< 8 dS):

if cover ≥ 0.82, then = 1

if cover < 0.82, then = (0.39 × cover) + 0.39

Depression, moderately saline (8–16 dS):

if cover ≥ 0.76, then = 1

if cover < 0.76, then = (0.39 × cover) + 0.37

Depression, highly saline (> 16 dS):

if cover ≤ 0.61, then = 1

if cover > 0.61, then = 2.98 – (3.28 × cover)

Native Species Score	% Herbaceous Cover (Actual)	Modified Herbaceous Cover Score*	$V_{vegstruct}$**
0.590	0.340	1.000	**0.795**

* Assumed depressional, highly saline.

** (Native Species Score + Modified Herbaceous Cover Score) ÷ 2.

$V_{runoffin}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0004	0.71	0.0003
3	0.0082	1.00	0.0082
11	0.0242	0.96	0.0233
18	0.0719	0.86	0.0618
19	0.8952	1.00	0.8952
		$V_{runoffin}$ (Sum of Products) =	**0.9888**

LU = Land Use.

$FCI_{inhydro} = (V_{runoffin} + V_{vegstruct}) \div 2 = (0.989 + 0.795) \div 2 = 0.892$

WETLAND UNIT 3: $FCI_{dissolved}$ Worksheet

$V_{disload}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0129	0.92	0.0119
3	0.0268	1.00	0.0268
11	0.0582	0.95	0.0553
18	0.1866	0.91	0.1698
19	0.7154	0.99	0.7083
	$V_{disload}$ (Sum of Products) =		**0.9721**

LU = Land Use.

* For slope wetlands only: the upslope and flanking land uses within the 300-foot wetland perimeter.

$V_{diswetuse}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0004	0.92	0.0004
3	0.0082	1.00	0.0082
11	0.0242	0.95	0.0230
18	0.0719	0.91	0.0654
19	0.8952	0.99	0.8863
	$V_{diswetuse}$ (Sum of Products) =		**0.9833**

LU = Land Use.

$FCI_{dissolved} = (V_{disload} + V_{diswetuse}) \div 2 = (0.972 + 0.983) \div 2 = 0.978$

WETLAND UNIT 3: $FCI_{particulates}$ Worksheet

$V_{susload}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0129	0.97	0.0125
3	0.0268	1.00	0.0268
11	0.0582	0.98	0.0571
18	0.1866	0.98	0.1829
19	0.7154	1.00	0.7154
		$V_{susload}$ (Sum of Products) =	**0.9947**

LU = Land Use.

* For slope wetlands only: the upslope and flanking land uses within the 2,000-foot wetland perimeter.

$V_{suswetuse}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0004	0.97	0.0004
3	0.0082	1.00	0.0082
11	0.0242	0.98	0.0237
18	0.0719	0.98	0.0705
19	0.8952	1.00	0.8952
		$V_{suswetuse}$ (Sum of Products) =	**0.9981**

LU = Land Use.

V_{mod} (see FCI_{hydro}) = 0.739

$FCI_{particulates} = (V_{mod} + V_{suswetuse} + V_{susload}) \div 3 = (0.739 + 0.998 + 0.995) \div 3 = 0.858$

WETLAND UNIT 3: $FCI_{habitat}$ Worksheet

V_{adjhab}

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0129	0.30	0.0039
3	0.0268	1.00	0.0268
11	0.0582	0.50	0.0291
18	0.1866	0.85	0.1586
19	0.7154	1.00	0.7154
		V_{adjhab} (Sum of Products) =	**0.9339**

LU = Land Use.

$V_{habwetuse}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0004	0.30	0.0001
3	0.0082	1.00	0.0082
11	0.0242	0.50	0.0121
18	0.0719	0.85	0.0611
19	0.8952	1.00	0.8952
		$V_{habwetuse}$ (Sum of Products) =	**0.9768**

LU = Land Use.

$V_{vegstruct}$ (see $FCI_{inhydro}$) = 0.795

$FCI_{habitat} = (V_{vegstruct} + V_{adjhab} + V_{habwetuse}) \div 3 = (0.795 + 0.934 + 0.977) \div 3 = 0.902$

WETLAND UNIT 4: FCI_{hydro} Worksheet

V_{runoff}

LU Code	LU %*	LU Coefficient	Product (LU % × LU Coefficient)
1*	0.0276	0.71	0.0196
2	0.0079	0.95	0.0075
3	0.0265	1.00	0.0265
8	0.0047	0.25	0.0012
11	0.0994	0.96	0.0954
13	0.0000	0.87	0.0000
18	0.6272	0.86	0.5394
19	0.2067	1	0.2067
	V_{runoff} (Sum of Products) =		**0.8963**

LU = Land Use.

* % land use (perimeter-contributing).

** For slope wetlands only: the upslope and flanking land uses within the 2,000-foot wetland perimeter. For slope wetlands, look at barriers upslope that affect hydrology (flow). For depressional wetlands, look at entire perimeter.

V_{mod}

Level of HM (Code)	% Wetland Modified	HM Coefficient	Product (% Wetland × HM Coefficient)
1	0.0631	0.00	0.0000
2	0.3162	0.50	0.1581
3	0.4355	0.75	0.3266
4*	0.1851	1.00	0.1851
	V_{mod} (Sum of Products) =		**0.6699**

* No modification.

$$FCI_{hydro} = \sqrt{(V_{runoff} \times V_{mod})} = \sqrt{(0.896 \times 0.670)} = 0.775$$

WETLAND UNIT 4: $FCI_{inhydro}$ Worksheet

$V_{vegstruct}$

Herbaceous Cover Score Rules (Slope vs. Depressional):

Slope, non- to slightly saline (< 8 dS):

if cover ≥ 0.83, then = 1

if cover < 0.83, then = (2.87 × cover) – 1.40

Slope, moderately to extremely saline (> 8 dS):

if cover ≤ 0.71, then = 1

if cover > 0.71, then = 3.46 – (3.52 × cover)

Depression, non- to slightly saline (< 8 dS):

if cover ≥ 0.82, then = 1

if cover < 0.82, then = (0.39 × cover) + 0.39

Depression, moderately saline (8–16 dS):

if cover ≥ 0.76, then = 1

if cover < 0.76, then = (0.39 × cover) + 0.37

Depression, highly saline (> 16 dS):

if cover ≤ 0.61, then = 1

if cover > 0.61, then = 2.98 – (3.28 × cover)

Native Species Score	% Herbaceous Cover (Actual)	Modified Herbaceous Cover Score*	$V_{vegstruct}$**
0.500	0.700	0.640	**0.570**

* Assumed depressional, moderately saline.

** (Native Species Score + Modified Herbaceous Cover Score) ÷ 2.

$V_{runoffin}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0038	0.71	0.0027
2	0.0001	0.95	0.0001
3	0.0436	1.00	0.0436
8	0.0003	0.25	0.0001
11	0.0114	0.96	0.0109
18	0.6385	0.86	0.5491
19	0.3023	1.00	0.3023
		$V_{runoffin}$ (Sum of Products) =	**0.9088**

LU = Land Use.

$FCI_{inhydro} = (V_{runoffin} + V_{vegstruct}) \div 2 = (0.909 + 0.570) \div 2 = 0.739$

WETLAND UNIT 4: $FCI_{dissolved}$ Worksheet

$V_{disload}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0276	0.92	0.0254
2	0.0079	0.94	0.0074
3	0.0265	1.00	0.0265
8	0.0047	0.54	0.0026
11	0.0994	0.95	0.0944
13	0.0000	0.92	0.0000
18	0.6272	0.91	0.5708
19	0.2067	0.99	0.2046
	$V_{disload}$ (Sum of Products) =		**0.9317**

LU = Land Use.

* For slope wetlands only: the upslope and flanking land uses within the 300-foot wetland perimeter.

$V_{diswetuse}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0038	0.92	0.0035
2	0.0001	0.94	0.0001
3	0.0436	1.00	0.0436
8	0.0003	0.54	0.0001
11	0.0114	0.95	0.0108
18	0.6385	0.91	0.5810
19	0.3023	0.99	0.2993
	$V_{diswetuse}$ (Sum of Products) =		**0.9385**

LU = Land Use.

$$FCI_{dissolved} = (V_{disload} + V_{diswetuse}) \div 2 = (0.932 + 0.939) \div 2 = 0.935$$

WETLAND UNIT 4: $FCI_{particulates}$ Worksheet

$V_{susload}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0276	0.97	0.0267
2	0.0079	1.00	0.0079
3	0.0265	1.00	0.0265
8	0.0047	0.00	0.0000
11	0.0994	0.98	0.0974
13	0.0000	0.98	0.0000
18	0.6272	0.98	0.6147
19	0.2067	1.00	0.2067
		$V_{susload}$ (Sum of Products) =	**0.9799**

LU = Land Use.

* For slope wetlands only: the upslope and flanking land uses within the 2,000-foot wetland perimeter.

$V_{suswetuse}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0038	0.97	0.0037
2	0.0001	1.00	0.0001
3	0.0436	1.00	0.0436
8	0.0003	0.00	0.0000
11	0.0114	0.98	0.0112
18	0.6385	0.98	0.6257
19	0.3023	1.00	0.3023
		$V_{suswetuse}$ (Sum of Products) =	**0.9866**

LU = Land Use.

V_{mod} (see FCI_{hydro}) = 0.670

$FCI_{particulates} = (V_{mod} + V_{suswetuse} + V_{susload}) \div 3 = (0.670 + 0.987 + 0.980) \div 3 = 0.812$

WETLAND UNIT 4: $FCI_{habitat}$ Worksheet

V_{adjhab}

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0276	0.30	0.0083
2	0.0079	0.10	0.0008
3	0.0265	1.00	0.0265
8	0.0047	0.00	0.0000
11	0.0994	0.50	0.0497
13	0.0000	0.80	0.0000
18	0.6272	0.85	0.5331
19	0.2067	1.00	0.2067
	V_{adjhab} (Sum of Products) =		**0.8251**

LU = Land Use.

$V_{habwetuse}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0038	0.30	0.0012
2	0.0001	0.10	0.0000
3	0.0436	1.00	0.0436
8	0.0003	0.00	0.0000
11	0.0114	0.50	0.0057
18	0.6385	0.85	0.5427
19	0.3023	1.00	0.3023
	$V_{habwetuse}$ (Sum of Products) =		**0.8955**

LU = Land Use.

$V_{vegstruct}$ (see $FCI_{inhydro}$) = 0.570

$FCI_{habitat} = (V_{vegstruct} + V_{adjhab} + V_{habwetuse}) \div 3 = (0.570 + 0.825 + 0.895) \div 3 = 0.764$

WETLAND UNIT 5: FCI_{hydro} Worksheet

V_{runoff}

LU Code	LU %*	LU Coefficient	Product (LU % × LU Coefficient)
1*	0.0157	0.71	0.0111
2	0.0646	0.95	0.0614
7	0.0012	0.26	0.0003
8	0.0256	0.25	0.0064
11	0.6233	0.96	0.5984
12	0.0000	0.19	0.0000
13	0.0092	0.87	0.0080
14	0.0027	0.26	0.0007
18	0.2164	0.86	0.1861
19	0.0393	1.00	0.0393
20	0.0020	0.75	0.0015
22	0.0000	0.60	0.0111
	V_{runoff} (Sum of Products) =		**0.9132**

LU = Land Use.

* % land use (perimeter-contributing).

** For slope wetlands only: the upslope and flanking land uses within the 2,000-foot wetland perimeter. For slope wetlands, look at barriers upslope that affect hydrology (flow). For depressional wetlands, look at entire perimeter.

V_{mod}

Level of HM (Code)	% Wetland Modified	HM Coefficient	Product (% Wetland × HM Coefficient)
1	0.2607	0.00	0.0000
2	0.2584	0.50	0.1292
3	0.4440	0.75	0.3330
4*	0.0370	1.00	0.0370
	V_{mod} (Sum of Products) =		**0.4991**

* No modification.

$FCI_{hydro} = \sqrt{(V_{runoff} \times V_{mod})} = \sqrt{(0.913 \times 0.499)} = 0.675$

WETLAND UNIT 5: $FCI_{inhydro}$ Worksheet

$V_{vegstruct}$

Herbaceous Cover Score Rules (Slope vs. Depressional):

Slope, non- to slightly saline (< 8 dS):
- if cover ≥ 0.83, then = 1
- if cover < 0.83, then = (2.87 × cover) – 1.40

Slope, moderately to extremely saline (> 8 dS):
- if cover ≤ 0.71, then = 1
- if cover > 0.71, then = 3.46 – (3.52 × cover)

Depression, non- to slightly saline (< 8 dS):
- if cover ≥ 0.82, then = 1
- if cover < 0.82, then = (0.39 × cover) + 0.39

Depression, moderately saline (8–16 dS):
- if cover ≥ 0.76, then = 1
- if cover < 0.76, then = (0.39 × cover) + 0.37

Depression, highly saline (> 16 dS):
- if cover ≤ 0.61, then = 1
- if cover > 0.61, then = 2.98 – (3.28 × cover)

Native Species Score	% Herbaceous Cover (Actual)	Modified Herbaceous Cover Score*	$V_{vegstruct}$**
0.800	0.650	0.620	**0.710**

* Assumed depressional, moderately saline.

** (Native Species Score + Modified Herbaceous Cover Score) ÷ 2.

$V_{runoffin}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0030	0.71	0.0021
2	0.0134	0.95	0.0128
7	0.0000	0.26	0.0000
8	0.0253	0.25	0.0063
11	0.6238	0.96	0.5988
13	0.0009	0.87	0.0008
14	0.0000	0.26	0.0000
18	0.3312	0.86	0.2849
19	0.0023	1.00	0.0023
20	0.0000	0.75	0.0000
		$V_{runoffin}$ (Sum of Products) =	**0.9080**

LU = Land Use.

$FCI_{inhydro} = (V_{runoffin} + V_{vegstruct}) \div 2 = (0.908 + 0.710) \div 2 = 0.809$

WETLAND UNIT 5: $FCI_{dissolved}$ Worksheet

$V_{disload}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0157	0.92	0.0144
2	0.0646	0.94	0.0608
7	0.0012	0.43	0.0005
8	0.0256	0.54	0.0138
11	0.6233	0.95	0.5921
12	0.0000	0.64	0.0000
13	0.0092	0.92	0.0085
14	0.0027	0.69	0.0019
18	0.2164	0.91	0.1969
19	0.0393	0.99	0.0389
20	0.0020	0.86	0.0017
22	0.0000	0.61	0.0000
	$V_{disload}$ (Sum of Products) =		**0.9295**

LU = Land Use.

* For slope wetlands only: the upslope and flanking land uses within the 300-foot wetland perimeter.

$V_{diswetuse}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0030	0.92	0.0028
2	0.0134	0.94	0.0126
7	0.0000	0.43	0.0000
8	0.0253	0.54	0.0137
11	0.6238	0.95	0.5926
13	0.0009	0.92	0.0008
14	0.0000	0.69	0.0000
18	0.3312	0.91	0.3014
19	0.0023	0.99	0.0023
20	0.0000	0.86	0.0000
	$V_{diswetuse}$ (Sum of Products) =		**0.9262**

LU = Land Use.

$FCI_{dissolved} = (V_{disload} + V_{diswetuse}) \div 2 = (0.930 + 0.926) \div 2 = 0.928$

WETLAND UNIT 5: $FCI_{particulates}$ Worksheet

$V_{susload}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0157	0.97	0.0152
2	0.0646	1.00	0.0646
7	0.0012	0.48	0.0006
8	0.0256	0.00	0.0000
11	0.6233	0.98	0.6108
12	0.0000	0.02	0.0000
13	0.0092	0.98	0.0091
14	0.0027	0.16	0.0004
18	0.2164	0.98	0.2120
19	0.0393	1.00	0.0393
20	0.0020	0.94	0.0018
22	0.0000	0.71	0.0000
		$V_{susload}$ (Sum of Products) =	**0.9539**

LU = Land Use.

* For slope wetlands only: the upslope and flanking land uses within the 2,000-foot wetland perimeter.

$V_{suswetuse}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0030	0.97	0.0029
2	0.0134	1.00	0.0134
7	0.0000	0.48	0.0000
8	0.0253	0.00	0.0000
11	0.6238	0.98	0.6113
13	0.0009	0.98	0.0009
14	0.0000	0.16	0.0000
18	0.3312	0.98	0.3246
19	0.0023	1.00	0.0023
20	0.0000	0.94	0.0000
		$V_{suswetuse}$ (Sum of Products) =	**0.9555**

LU = Land Use.

V_{mod} (see FCI_{hydro}) = 0.499

$FCI_{particulates} = (V_{mod} + V_{suswetuse} + V_{susload}) \div 3 = (0.499 + 0.955 + 0.954) \div 3 = 0.690$

WETLAND UNIT 5: $FCI_{habitat}$ Worksheet

V_{adjhab}

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0157	0.30	0.0047
2	0.0646	0.10	0.0065
7	0.0012	0.00	0.0000
8	0.0256	0.00	0.0000
11	0.6233	0.50	0.3117
12	0.0000	0.10	0.0000
13	0.0092	0.80	0.0074
14	0.0027	0.00	0.0000
18	0.2164	0.85	0.1839
19	0.0393	1.00	0.0393
20	0.0020	0.50	0.0010
22	0.0000	0.10	0.0000
	V_{adjhab} (Sum of Products) =		**0.5544**

LU = Land Use.

$V_{habwetuse}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0030	0.30	0.0009
2	0.0134	0.10	0.0013
7	0.0000	0.00	0.0000
8	0.0253	0.00	0.0000
11	0.6238	0.50	0.3119
13	0.0009	0.80	0.0007
14	0.0000	0.00	0.0000
18	0.3312	0.85	0.2816
19	0.0023	1.00	0.0023
20	0.0000	0.50	0.0000
	$V_{habwetuse}$ (Sum of Products) =		**0.5987**

LU = Land Use.

$V_{vegstruct}$ (see $FCI_{inhydro}$) = 0.710

$FCI_{habitat} = (V_{vegstruct} + V_{adjhab} + V_{habwetuse}) \div 3 = (0.710 + 0.554 + 0.599) \div 3 = 0.621$

WETLAND UNIT 6: FCI_{hydro} Worksheet

V_{runoff}

LU Code	LU %*	LU Coefficient	Product (LU % × LU Coefficient)
1*	0.0288	0.71	0.0205
2	0.0241	0.95	0.0229
5	0.0027	0.75	0.0020
6	0.0000	0.13	0.0000
7	0.0747	0.26	0.0194
8	0.0514	0.25	0.0128
10	0.0001	0.76	0.0001
11	0.6317	0.96	0.6065
12	0.0028	0.19	0.0005
13	0.0286	0.87	0.0248
14	0.0271	0.26	0.0071
15	0.0162	0.38	0.0061
18	0.0224	0.86	0.0193
19	0.0729	1.00	0.0729
20	0.0166	0.75	0.0125
22	0.0000	0.60	0.0000
	V_{runoff} (Sum of Products) =		**0.8273**

LU = Land Use.

* % land use (perimeter-contributing).

** For slope wetlands only: the upslope and flanking land uses within the 2,000-foot wetland perimeter. For slope wetlands, look at barriers upslope that affect hydrology (flow). For depressional wetlands, look at entire perimeter.

V_{mod}

Level of HM (Code)	% Wetland Modified	HM Coefficient	Product (% Wetland × HM Coefficient)
1	0.4841	0.00	0.0000
2	0.5108	0.50	0.2554
3	0.0047	0.75	0.0035
4*	0.0003	1.00	0.0003
		V_{mod} (Sum of Products) =	**0.2593**

* No modification.

$$FCI_{hydro} = \sqrt{(V_{runoff} \times V_{mod})} = \sqrt{(0.827 \times 0.259)} = 0.463$$

WETLAND UNIT 6: $FCI_{inhydro}$ Worksheet

$V_{vegstruct}$

Herbaceous Cover Score Rules (Slope vs. Depressional):

Slope, non- to slightly saline (< 8 dS):
- if cover ≥ 0.83, then = 1
- if cover < 0.83, then = (2.87 × cover) – 1.40

Slope, moderately to extremely saline (> 8 dS):
- if cover ≤ 0.71, then = 1
- if cover > 0.71, then = 3.46 – (3.52 × cover)

Depression, non- to slightly saline (< 8 dS):
- if cover ≥ 0.82, then = 1
- if cover < 0.82, then = (0.39 × cover) + 0.39

Depression, moderately saline (8–16 dS):
- if cover ≥ 0.76, then = 1
- if cover < 0.76, then = (0.39 × cover) + 0.37

Depression, highly saline (> 16 dS):
- if cover ≤ 0.61, then = 1
- if cover > 0.61, then = 2.98 – (3.28 × cover)

Native Species Score	% Herbaceous Cover (Actual)	Modified Herbaceous Cover Score*	$V_{vegstruct}$**
0.920	0.950	1.000	**0.960**

* Assumed depressional, moderately saline.

** (Native Species Score + Modified Herbaceous Cover Score) ÷ 2.

$V_{runoffin}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0060	0.71	0.0042
2	0.0020	0.95	0.0019
7	0.0234	0.26	0.0061
8	0.0368	0.25	0.0092
11	0.7928	0.96	0.7611
13	0.0063	0.87	0.0055
14	0.0096	0.26	0.0025
15	0.0134	0.38	0.0051
18	0.0029	0.86	0.0025
19	0.0959	1.00	0.0959
20	0.0108	0.75	0.0081
		$V_{runoffin}$ (Sum of Products) =	**0.9022**

LU = Land Use.

$FCI_{inhydro} = (V_{runoffin} + V_{vegstruct}) \div 2 = (0.902 + 0.960) \div 2 = 0.931$

WETLAND UNIT 6: $FCI_{dissolved}$ Worksheet

$V_{disload}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0288	0.92	0.0265
2	0.0241	0.94	0.0227
5	0.0027	0.86	0.0023
6	0.0000	0.00	0.0000
7	0.0747	0.43	0.0321
8	0.0514	0.54	0.0277
10	0.0001	0.87	0.0001
11	0.6317	0.95	0.6001
12	0.0028	0.64	0.0018
13	0.0286	0.92	0.0263
14	0.0271	0.69	0.0187
15	0.0162	0.55	0.0089
18	0.0224	0.91	0.0204
19	0.0729	0.99	0.0721
20	0.0166	0.86	0.0143
		$V_{disload}$ (Sum of Products) =	**0.8740**

LU = Land Use.

* For slope wetlands only: the upslope and flanking land uses within the 300-foot wetland perimeter.

$V_{diswetuse}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0060	0.92	0.0055
2	0.0020	0.94	0.0019
7	0.0234	0.43	0.0101
8	0.0368	0.54	0.0199
11	0.7928	0.95	0.7532
13	0.0063	0.92	0.0058
14	0.0096	0.69	0.0066
15	0.0134	0.55	0.0073
18	0.0029	0.91	0.0026
19	0.0959	0.99	0.0949
20	0.0108	0.86	0.0093
		$V_{diswetuse}$ (Sum of Products) =	**0.9172**

LU = Land Use.

$FCI_{dissolved} = (V_{disload} + V_{diswetuse}) \div 2 = (0.874 + 0.917) \div 2 = 0.896$

WETLAND UNIT 6: $FCI_{particulates}$ Worksheet

$V_{susload}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0288	0.97	0.0279
2	0.0241	1.00	0.0241
5	0.0027	0.94	0.0025
6	0.0000	0.00	0.0000
7	0.0747	0.48	0.0359
8	0.0514	0.00	0.0000
10	0.0001	0.98	0.0001
11	0.6317	0.98	0.6191
12	0.0028	0.02	0.0001
13	0.0286	0.98	0.0280
14	0.0271	0.16	0.0043
15	0.0162	0.61	0.0099
18	0.0224	0.98	0.0220
19	0.0729	1.00	0.0729
20	0.0166	0.94	0.0156
22	0.0000	0.71	0.0000
		$V_{susload}$ (Sum of Products) =	**0.8623**

LU = Land Use.
* For slope wetlands only: the upslope and flanking land uses within the 2,000-foot wetland perimeter.

$V_{suswetuse}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0060	0.97	0.0058
2	0.0020	1.00	0.0020
7	0.0234	0.48	0.0113
8	0.0368	0.00	0.0000
11	0.7928	0.98	0.7770
13	0.0063	0.98	0.0062
14	0.0096	0.16	0.0015
15	0.0134	0.61	0.0082
18	0.0029	0.98	0.0028
19	0.0959	1.00	0.0959
20	0.0108	0.94	0.0102
		$V_{suswetuse}$ (Sum of Products) =	**0.9208**

LU = Land Use.

V_{mod} (see FCI_{hydro}) = 0.259

$FCI_{particulates} = (V_{mod} + V_{suswetuse} + V_{susload}) \div 3 = (0.259 + 0.921 + 0.862) \div 3 = 0.481$

WETLAND UNIT 6: $FCI_{habitat}$ Worksheet

V_{adjhab}

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0288	0.30	0.0086
2	0.0241	0.10	0.0024
5	0.0027	0.30	0.0008
6	0.0000	0.00	0.0000
7	0.0747	0.00	0.0000
8	0.0514	0.00	0.0000
10	0.0001	0.10	0.0000
11	0.6317	0.50	0.3159
12	0.0028	0.10	0.0003
13	0.0286	0.80	0.0228
14	0.0271	0.00	0.0000
15	0.0162	0.10	0.0016
18	0.0224	0.85	0.0190
19	0.0729	1.00	0.0729
20	0.0166	0.50	0.0083
22	0.0000	0.10	0.0000
		V_{adjhab} (Sum of Products) =	**0.4527**

LU = Land Use.

$V_{habwetuse}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0060	0.30	0.0018
2	0.0020	0.10	0.0002
7	0.0234	0.00	0.0000
8	0.0368	0.00	0.0000
11	0.7928	0.50	0.3964
13	0.0063	0.80	0.0051
14	0.0096	0.00	0.0000
15	0.0134	0.10	0.0013
18	0.0029	0.85	0.0025
19	0.0959	1.00	0.0959
20	0.0108	0.50	0.0054
		$V_{habwetuse}$ (Sum of Products) =	**0.5086**

LU = Land Use.

$V_{vegstruct}$ (see $FCI_{inhydro}$) = 0.960

$FCI_{habitat} = (V_{vegstruct} + V_{adjhab} + V_{habwetuse}) \div 3 = (0.960 + 0.453 + 0.509) \div 3 = 0.640$

WETLAND UNIT 7: FCI_{hydro} Worksheet

V_{runoff}

LU Code	LU %*	LU Coefficient	Product (LU % × LU Coefficient)
1*	0.0262	0.71	0.0186
2	0.1103	0.95	0.1048
12	0.0118	0.19	0.0022
13	0.0026	0.87	0.0022
19	0.0823	1.00	0.0823
11	0.6960	0.96	0.6682
21	0.0705	0.71	0.0501
14	0.0003	0.26	0.0001
		V_{runoff} (Sum of Products) =	**0.9285**

LU = Land Use.

* % land use (perimeter-contributing).

** For slope wetlands only: the upslope and flanking land uses within the 2,000-foot wetland perimeter. For slope wetlands, look at barriers upslope that affect hydrology (flow). For depressional wetlands, look at entire perimeter.

V_{mod}

Level of HM (Code)	% Wetland Modified	HM Coefficient	Product (% Wetland × HM Coefficient)
1	0.5388	0.00	0.0000
2	0.4109	0.50	0.2054
3	0.0489	0.75	0.0367
4*	0.0015	1.00	0.0015
		V_{mod} (Sum of Products) =	**0.2435**

* No modification.

$$FCI_{hydro} = \sqrt{(V_{runoff} \times V_{mod})} = \sqrt{(0.929 \times 0.244)} = 0.476$$

WETLAND UNIT 7: $FCI_{inhydro}$ Worksheet

$V_{vegstruct}$

Herbaceous Cover Score Rules (Slope vs. Depressional):

Slope, non- to slightly saline (< 8 dS):

if cover ≥ 0.83, then = 1

if cover < 0.83, then = (2.87 × cover) – 1.40

Slope, moderately to extremely saline (> 8 dS):

if cover ≤ 0.71, then = 1

if cover > 0.71, then = 3.46 – (3.52 × cover)

Depression, non- to slightly saline (< 8 dS):

if cover ≥ 0.82, then = 1

if cover < 0.82, then = (0.39 × cover) + 0.39

Depression, moderately saline (8–16 dS):

if cover ≥ 0.76, then = 1

if cover < 0.76, then = (0.39 × cover) + 0.37

Depression, highly saline (> 16 dS):

if cover ≤ 0.61, then = 1

if cover > 0.61, then = 2.98 – (3.28 × cover)

Native Species Score	% Herbaceous Cover (Actual)	Modified Herbaceous Cover Score*	$V_{vegstruct}$**
0.600	0.810	1.00	**0.800**

* Assumed depressional, moderately saline.

** (Native Species Score + Modified Herbaceous Cover Score) ÷ 2.

$V_{runoffin}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0230	0.71	0.0163
2	0.0115	0.95	0.0109
12	0.0004	0.19	0.0001
13	0.0013	0.87	0.0011
19	0.0401	1.00	0.0401
11	0.8958	0.96	0.8600
21	0.0279	0.71	0.0198
		$V_{runoffin}$ (Sum of Products) =	**0.9483**

LU = Land Use.

$$FCI_{inhydro} = (V_{runoffin} + V_{vegstruct}) \div 2 = (0.948 + 0.800) \div 2 = 0.874$$

WETLAND UNIT 7: $FCI_{dissolved}$ Worksheet

$V_{disload}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0262	0.92	0.0241
2	0.1103	0.94	0.1037
12	0.0118	0.64	0.0075
13	0.0026	0.92	0.0024
19	0.0823	0.99	0.0815
11	0.6960	0.95	0.6612
21	0.0705	0.87	0.0614
14	0.0003	0.69	0.0002
	$V_{disload}$ (Sum of Products) =		**0.9420**

LU = Land Use.

* For slope wetlands only: the upslope and flanking land uses within the 300-foot wetland perimeter.

$V_{diswetuse}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0230	0.92	0.0212
2	0.0115	0.94	0.0108
12	0.0004	0.64	0.0003
13	0.0013	0.92	0.0012
19	0.0401	0.99	0.0397
11	0.8958	0.95	0.8511
21	0.0279	0.87	0.0242
	$V_{diswetuse}$ (Sum of Products) =		**0.9484**

LU = Land Use.

$$FCI_{dissolved} = (V_{disload} + V_{diswetuse}) \div 2 = (0.942 + 0.948) \div 2 = 0.945$$

WETLAND UNIT 7: $FCI_{particulates}$ Worksheet

$V_{susload}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0262	0.97	0.0254
2	0.1103	1.00	0.1103
12	0.0118	0.02	0.0002
13	0.0026	0.98	0.0025
19	0.0823	1.00	0.0823
11	0.6960	0.98	0.6821
21	0.0705	0.61	0.0430
14	0.0003	0.16	0.0000
		$V_{susload}$ (Sum of Products) =	**0.9460**

LU = Land Use.

* For slope wetlands only: the upslope and flanking land uses within the 2,000-foot wetland perimeter.

$V_{suswetuse}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0230	0.97	0.0223
2	0.0115	1.00	0.0115
12	0.0004	0.02	0.0000
13	0.0013	0.98	0.0012
19	0.0401	1.00	0.0401
11	0.8958	0.98	0.8779
21	0.0279	0.61	0.0170
		$V_{suswetuse}$ (Sum of Products) =	**0.9701**

LU = Land Use.

V_{mod} (see FCI_{hydro}) = 0.244

$FCI_{particulates} = (V_{mod} + V_{suswetuse} + V_{susload}) \div 3 = (0.244 + 0.970 + 0.946) \div 3 = 0.483$

WETLAND UNIT 7: $FCI_{habitat}$ Worksheet

V_{adjhab}

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0262	0.30	0.0079
2	0.1103	0.10	0.0110
12	0.0118	0.10	0.0012
13	0.0026	0.80	0.0021
19	0.0823	1.00	0.0823
11	0.6960	0.50	0.3480
21	0.0705	0.10	0.0071
14	0.0003	0.00	0.0000
		V_{adjhab} (Sum of Products) =	**0.4595**

LU = Land Use.

$V_{habwetuse}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0230	0.30	0.0069
2	0.0115	0.10	0.0011
12	0.0004	0.10	0.0000
13	0.0013	0.80	0.0010
19	0.0401	1.00	0.0401
11	0.8958	0.50	0.4479
21	0.0279	0.10	0.0028
		$V_{habwetuse}$ (Sum of Products) =	**0.4999**

LU = Land Use.

$V_{vegstruct}$ (see $FCI_{inhydro}$) = 0.800

$FCI_{habitat} = (V_{vegstruct} + V_{adjhab} + V_{habwetuse}) \div 3 = (0.800 + 0.459 + 0.500) \div 3 = 0.586$

WETLAND UNIT 8: FCI_{hydro} Worksheet

V_{runoff}

LU Code	LU %*	LU Coefficient	Product (LU % × LU Coefficient)
1*	0.0183	0.71	0.0130
7	0.0686	0.26	0.0178
11	0.8208	0.96	0.7879
14	0.0028	0.26	0.0007
21	0.0662	0.71	0.0470
24	0.0233	0.25	0.0058
		V_{runoff} (Sum of Products) =	**0.8723**

LU = Land Use.

* % land use (perimeter-contributing).

** For slope wetlands only: the upslope and flanking land uses within the 2,000-foot wetland perimeter. For slope wetlands, look at barriers upslope that affect hydrology (flow). For depressional wetlands, look at entire perimeter.

V_{mod}

Level of HM (Code)	% Wetland Modified	HM Coefficient	Product (% Wetland × HM Coefficient)
1	0.6887	0.00	0.0000
2	0.2767	0.50	0.1384
3	0.0203	0.75	0.0152
4*	0.0142	1.00	0.0142
		V_{mod} (Sum of Products) =	**0.1679**

* No modification.

$FCI_{hydro} = \sqrt{(V_{runoff} \times V_{mod})} = \sqrt{(0.872 \times 0.168)} = 0.383$

WETLAND UNIT 8: $FCI_{inhydro}$ Worksheet

$V_{vegstruct}$

Herbaceous Cover Score Rules (Slope vs. Depressional):

Slope, non- to slightly saline (< 8 dS):

- if cover ≥ 0.83, then = 1
- if cover < 0.83, then = (2.87 × cover) – 1.40

Slope, moderately to extremely saline (> 8 dS):

- if cover ≤ 0.71, then = 1
- if cover > 0.71, then = 3.46 – (3.52 × cover)

Depression, non- to slightly saline (< 8 dS):

- if cover ≥ 0.82, then = 1
- if cover < 0.82, then = (0.39 × cover) + 0.39

Depression, moderately saline (8–16 dS):

- if cover ≥ 0.76, then = 1
- if cover < 0.76, then = (0.39 × cover) + 0.37

Depression, highly saline (> 16 dS):

- if cover ≤ 0.61, then = 1
- if cover > 0.61, then = 2.98 – (3.28 × cover)

Native Species Score	% Herbaceous Cover (Actual)	Modified Herbaceous Cover Score*	$V_{vegstruct}$**
0.910	0.160	1.000	**0.955**

* Assumed depressional, moderately saline.
** (Native Species Score + Modified Herbaceous Cover Score) ÷ 2.

$V_{runoffin}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0040	0.71	0.0029
7	0.0005	0.26	0.0001
11	0.9948	0.96	0.9550
14	0.0000	0.26	0.0000
21	0.0004	0.71	0.0003
24	0.0003	0.25	0.0001
		$V_{runoffin}$ (Sum of Products) =	**0.9584**

LU = Land Use.

$FCI_{inhydro} = (V_{runoffin} + V_{vegstruct}) \div 2 = (0.958 + 0.955) \div 2 = 0.957$

WETLAND UNIT 8: $FCI_{dissolved}$ Worksheet

$V_{disload}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0183	0.92	0.0168
7	0.0686	0.43	0.0295
11	0.8208	0.95	0.7797
14	0.0028	0.69	0.0020
21	0.0662	0.87	0.0576
24	0.0233	0.54	0.0126
	$V_{disload}$ (Sum of Products) =		**0.8982**

LU = Land Use.

* For slope wetlands only: the upslope and flanking land uses within the 300-foot wetland perimeter.

$V_{diswetuse}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0040	0.92	0.0037
7	0.0005	0.43	0.0002
11	0.9948	0.95	0.9451
14	0.0000	0.69	0.0000
21	0.0004	0.87	0.0004
24	0.0003	0.54	0.0001
	$V_{diswetuse}$ (Sum of Products) =		**0.9495**

LU = Land Use.

$FCI_{dissolved} = (V_{disload} + V_{diswetuse}) \div 2 = (0.898 + 0.949) \div 2 = 0.924$

WETLAND UNIT 8: $FCI_{particulates}$ Worksheet

$V_{susload}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0183	0.97	0.0177
7	0.0686	0.48	0.0329
11	0.8208	0.98	0.8044
14	0.0028	0.16	0.0005
21	0.0662	0.61	0.0404
24	0.0233	0.00	0.0000
		$V_{susload}$ (Sum of Products) =	**0.8958**

LU = Land Use.

* For slope wetlands only: the upslope and flanking land uses within the 2,000-foot wetland perimeter.

$V_{suswetuse}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0040	0.97	0.0039
7	0.0005	0.48	0.0002
11	0.9948	0.98	0.9749
14	0.0000	0.16	0.0000
21	0.0004	0.61	0.0003
24	0.0003	0.00	0.0000
		$V_{suswetuse}$ (Sum of Products) =	**0.9793**

LU = Land Use.

V_{mod} (see FCI_{hydro}) = 0.168

$FCI_{particulates} = (V_{mod} + V_{suswetuse} + V_{susload}) \div 3 = (0.168 + 0.979 + 0.896) \div 3 = 0.397$

WETLAND UNIT 8: $FCI_{habitat}$ Worksheet

V_{adjhab}

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0183	0.30	0.0055
7	0.0686	0.00	0.0000
11	0.8208	0.50	0.4104
14	0.0028	0.00	0.0000
21	0.0662	0.10	0.0066
24	0.0233	0.10	0.0023
		V_{adjhab} (Sum of Products) =	**0.4248**

LU = Land Use.

$V_{habwetuse}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0040	0.30	0.0012
7	0.0005	0.00	0.0000
11	0.9948	0.50	0.4974
14	0.0000	0.00	0.0000
21	0.0004	0.10	0.0000
24	0.0003	0.10	0.0000
		$V_{habwetuse}$ (Sum of Products) =	**0.4987**

LU = Land Use.

$V_{vegstruct}$ (see $FCI_{inhydro}$) = 0.955

$FCI_{habitat} = (V_{vegstruct} + V_{adjhab} + V_{habwetuse}) \div 3 = (0.955 + 0.425 + 0.499) \div 3 = 0.626$

WETLAND UNIT 9: FCI_{hydro} Worksheet

V_{runoff}

LU Code	LU %*	LU Coefficient	Product (LU % × LU Coefficient)
1*	0.0135	0.71	0.0096
7	0.1253	0.26	0.0326
8	0.0153	0.25	0.0038
11	0.7051	0.96	0.6769
12	0.0213	0.19	0.0041
14	0.0154	0.26	0.0040
19	0.1041	1.00	0.1041
	V_{runoff} (Sum of Products) =		**0.8350**

LU = Land Use.

* % land use (perimeter-contributing).

** For slope wetlands only: the upslope and flanking land uses within the 2,000-foot wetland perimeter. For slope wetlands, look at barriers upslope that affect hydrology (flow). For depressional wetlands, look at entire perimeter.

V_{mod}

Level of HM (Code)	% Wetland Modified	HM Coefficient	Product (% Wetland × HM Coefficient)
1	0.9609	0.00	0.0000
2	0.0391	0.50	0.0196
3	0.0000	0.75	0.0000
4*	0.0000	1.00	0.0000
	V_{mod} (Sum of Products) =		**0.0196**

* No modification.

$$FCI_{hydro} = \sqrt{(V_{runoff} \times V_{mod})} = \sqrt{(0.835 \times 0.020)} = 0.128$$

WETLAND UNIT 9: $FCI_{inhydro}$ Worksheet

$V_{vegstruct}$

Herbaceous Cover Score Rules (Slope vs. Depressional):

Slope, non- to slightly saline (< 8 dS):

if cover ≥ 0.83, then = 1

if cover < 0.83, then = (2.87 × cover) – 1.40

Slope, moderately to extremely saline (> 8 dS):

if cover ≤ 0.71, then = 1

if cover > 0.71, then = 3.46 – (3.52 × cover)

Depression, non- to slightly saline (< 8 dS):

if cover ≥ 0.82, then = 1

if cover < 0.82, then = (0.39 × cover) + 0.39

Depression, moderately saline (8–16 dS):

if cover ≥ 0.76, then = 1

if cover < 0.76, then = (0.39 × cover) + 0.37

Depression, highly saline (> 16 dS):

if cover ≤ 0.61, then = 1

if cover > 0.61, then = 2.98 – (3.28 × cover)

Native Species Score	% Herbaceous Cover (Actual)	Modified Herbaceous Cover Score*	$V_{vegstruct}$**
0.850	0.749	0.660	**0.755**

* Assumed depressional, highly saline.

** (Native Species Score + Modified Herbaceous Cover Score) ÷ 2.

$V_{runoffin}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0029	0.71	0.0020
7	0.0006	0.26	0.0002
11	0.7350	0.96	0.7056
14	0.0000	0.26	0.0000
19	0.2615	1.00	0.2615
		$V_{runoffin}$ (Sum of Products) =	**0.9693**

LU = Land Use.

$FCI_{inhydro} = (V_{runoffin} + V_{vegstruct}) \div 2 = (0.969 + 0.755) \div 2 = 0.862$

WETLAND UNIT 9: $FCI_{dissolved}$ Worksheet

$V_{disload}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0135	0.92	0.0125
7	0.1253	0.43	0.0539
8	0.0153	0.54	0.0082
11	0.7051	0.95	0.6698
12	0.0213	0.64	0.0136
14	0.0154	0.69	0.0106
19	0.1041	0.99	0.1031
	$V_{disload}$ (Sum of Products) =		**0.8717**

LU = Land Use.

* For slope wetlands only: the upslope and flanking land uses within the 300-foot wetland perimeter.

$V_{diswetuse}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0029	0.92	0.0026
7	0.0006	0.43	0.0003
11	0.7350	0.95	0.6983
14	0.0000	0.69	0.0000
19	0.2615	0.99	0.2589
	$V_{diswetuse}$ (Sum of Products) =		**0.9601**

LU = Land Use.

$$FCI_{dissolved} = (V_{disload} + V_{diswetuse}) \div 2 = (0.872 + 0.960) \div 2 = 0.916$$

WETLAND UNIT 9: $FCI_{particulates}$ Worksheet

$V_{susload}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0135	0.97	0.0131
7	0.1253	0.48	0.0601
8	0.0153	0.00	0.0000
11	0.7051	0.98	0.6910
12	0.0213	0.02	0.0004
14	0.0154	0.16	0.0025
19	0.1041	1.00	0.1041
		$V_{susload}$ (Sum of Products) =	**0.8712**

LU = Land Use.

* For slope wetlands only: the upslope and flanking land uses within the 2,000-foot wetland perimeter.

$V_{suswetuse}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0029	0.97	0.0028
7	0.0006	0.48	0.0003
11	0.7350	0.98	0.7203
14	0.0000	0.16	0.0000
19	0.2615	1.00	0.2615
		$V_{suswetuse}$ (Sum of Products) =	**0.9849**

LU = Land Use.

V_{mod} (see FCI_{hydro}) = 0.020

$FCI_{particulates} = (V_{mod} + V_{suswetuse} + V_{susload}) \div 3 = (0.020 + 0.985 + 0.871) \div 3 = 0.135$

WETLAND UNIT 9: FCI$_{habitat}$ Worksheet

V$_{adjhab}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0135	0.30	0.0041
7	0.1253	0.00	0.0000
8	0.0153	0.00	0.0000
11	0.7051	0.50	0.3525
12	0.0213	0.10	0.0021
14	0.0154	0.00	0.0000
19	0.1041	1.00	0.1041
		V_{adjhab} (Sum of Products) =	**0.4628**

LU = Land Use.

V$_{habwetuse}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0029	0.30	0.0009
7	0.0006	0.00	0.0000
11	0.7350	0.50	0.3675
14	0.0000	0.00	0.0000
19	0.2615	1.00	0.2615
		$V_{habwetuse}$ (Sum of Products) =	**0.6299**

LU = Land Use.

$V_{vegstruct}$ (see $FCI_{inhydro}$) = 0.755

$FCI_{habitat} = (V_{vegstruct} + V_{adjhab} + V_{habwetuse}) \div 3 = (0.755 + 0.463 + 0.630) \div 3 = 0.616$

WETLAND UNIT 10: FCI_{hydro} Worksheet

V_{runoff}

LU Code	LU %*	LU Coefficient	Product (LU % × LU Coefficient)
1*	0.0501	0.71	0.0356
2	0.0021	0.95	0.0020
6	0.0021	0.13	0.0003
7	0.0331	0.26	0.0086
8	0.0488	0.25	0.0122
10	0.0104	0.76	0.0079
11	0.2790	0.96	0.2679
12	0.0126	0.19	0.0024
13	0.0138	0.87	0.0120
14	0.0069	0.26	0.0018
18	0.0111	0.86	0.0096
19	0.3675	1.00	0.3675
21	0.1561	0.71	0.1108
24	0.0063	0.25	0.0016
	V_{runoff} (Sum of Products) =		**0.8402**

LU = Land Use.

* % land use (perimeter-contributing).

** For slope wetlands only: the upslope and flanking land uses within the 2,000-foot wetland perimeter. For slope wetlands, look at barriers upslope that affect hydrology (flow). For depressional wetlands, look at entire perimeter.

V_{mod}

Level of HM (Code)	% Wetland Modified	HM Coefficient	Product (% Wetland × HM Coefficient)
1	0.2744	0.00	0.0000
2	0.6697	0.50	0.3348
3	0.0559	0.75	0.0419
4*	0.0000	1.00	0.0000
	V_{mod} (Sum of Products) =		**0.3768**

* No modification.

$$FCI_{hydro} = \sqrt{(V_{runoff} \times V_{mod})} = \sqrt{(0.840 \times 0.377)} = 0.563$$

WETLAND UNIT 10: $FCI_{inhydro}$ Worksheet

$V_{vegstruct}$

Herbaceous Cover Score Rules (Slope vs. Depressional):

Slope, non- to slightly saline (< 8 dS):
- if cover ≥ 0.83, then = 1
- if cover < 0.83, then = (2.87 × cover) – 1.40

Slope, moderately to extremely saline (> 8 dS):
- if cover ≤ 0.71, then = 1
- if cover > 0.71, then = 3.46 – (3.52 × cover)

Depression, non- to slightly saline (< 8 dS):
- if cover ≥ 0.82, then = 1
- if cover < 0.82, then = (0.39 × cover) + 0.39

Depression, moderately saline (8–16 dS):
- if cover ≥ 0.76, then = 1
- if cover < 0.76, then = (0.39 × cover) + 0.37

Depression, highly saline (> 16 dS):
- if cover ≤ 0.61, then = 1
- if cover > 0.61, then = 2.98 – (3.28 × cover)

Native Species Score	% Herbaceous Cover (Actual)	Modified Herbaceous Cover Score*	$V_{vegstruct}$**
0.860	0.560	0.590	**0.725**

* Assumed depressional, moderately saline.

** (Native Species Score + Modified Herbaceous Cover Score) ÷ 2.

$V_{runoffin}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0040	0.71	0.0028
3	0.0000	1.00	0.0000
6	0.0000	0.13	0.0000
7	0.0007	0.26	0.0002
8	0.0005	0.25	0.0001
10	0.0013	0.76	0.0010
11	0.2479	0.96	0.2380
12	0.0011	0.19	0.0002
13	0.0006	0.87	0.0005
14	0.0010	0.26	0.0003
19	0.4585	1.00	0.4585
21	0.0060	0.71	0.0043
24	0.0004	0.25	0.0001
18	0.2779	0.86	0.2390
		$V_{runoffin}$ (Sum of Products) =	**0.8350**

LU = Land Use.

$FCI_{inhydro} = (V_{runoffin} + V_{vegstruct}) \div 2 = (0.945 + 0.725) \div 2 = 0.835$

WETLAND UNIT 10: $FCI_{dissolved}$ Worksheet

$V_{disload}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0501	0.92	0.0461
2	0.0021	0.94	0.0020
6	0.0021	0.00	0.0000
7	0.0331	0.43	0.0142
8	0.0488	0.54	0.0263
10	0.0104	0.87	0.0091
11	0.2790	0.95	0.2651
12	0.0126	0.64	0.0081
13	0.0138	0.92	0.0127
14	0.0069	0.69	0.0048
18	0.0111	0.91	0.0101
19	0.3675	0.99	0.3638
21	0.1561	0.87	0.1358
24	0.0063	0.54	0.0034
	$V_{disload}$ (Sum of Products) =		**0.9015**

LU = Land Use.

$V_{diswetuse}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0040	0.92	0.0037
3	0.0000	1.00	0.0000
6	0.0000	0.00	0.0000
7	0.0007	0.43	0.0003
8	0.0005	0.54	0.0003
10	0.0013	0.87	0.0011
11	0.2479	0.95	0.2355
12	0.0011	0.64	0.0007
13	0.0006	0.92	0.0005
14	0.0010	0.69	0.0007
19	0.4585	0.99	0.4540
21	0.0060	0.87	0.0052
24	0.0004	0.54	0.0002
18	0.2779	0.91	0.2529
	$V_{diswetuse}$ (Sum of Products) =		**0.9551**

LU = Land Use.

$FCI_{dissolved} = (V_{disload} + V_{diswetuse}) \div 2 = (0.902 + 0.955) \div 2 = 0.928$

WETLAND UNIT 10: $FCI_{particulates}$ Worksheet

$V_{susload}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0501	0.97	0.0486
2	0.0021	1.00	0.0021
6	0.0021	0.00	0.0000
7	0.0331	0.48	0.0159
8	0.0488	0.00	0.0000
10	0.0104	0.98	0.0102
11	0.2790	0.98	0.2735
12	0.0126	0.02	0.0003
13	0.0138	0.98	0.0136
14	0.0069	0.16	0.0011
18	0.0111	0.98	0.0109
19	0.3675	1.00	0.3675
21	0.1561	0.61	0.0952
24	0.0063	0.00	0.0000
		$V_{susload}$ (Sum of Products) =	**0.8388**

LU = Land Use.
* For slope wetlands only: the upslope and flanking land uses within the 2,000-foot wetland perimeter.

$V_{suswetuse}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0040	0.97	0.0039
3	0.0000	1.00	0.0000
6	0.0000	0.00	0.0000
7	0.0007	0.48	0.0003
8	0.0005	0.00	0.0000
10	0.0013	0.98	0.0013
11	0.2479	0.98	0.2429
12	0.0011	0.02	0.0000
13	0.0006	0.98	0.0006
14	0.0010	0.16	0.0002
19	0.4585	1.00	0.4585
21	0.0060	0.61	0.0037
24	0.0004	0.00	0.0000
18	0.2779	0.98	0.2723
		$V_{suswetuse}$ (Sum of Products) =	**0.9837**

LU = Land Use.

V_{mod} (see FCI_{hydro}) = 0.377

$FCI_{particulates} = (V_{mod} + V_{suswetuse} + V_{susload}) \div 3 = (0.377 + 0.984 + 0.839) \div 3 = 0.586$

WETLAND UNIT 10: $FCI_{habitat}$ Worksheet

V_{adjhab}

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0501	0.30	0.0150
2	0.0021	0.10	0.0002
6	0.0021	0.00	0.0000
7	0.0331	0.00	0.0000
8	0.0488	0.00	0.0000
10	0.0104	0.10	0.0010
11	0.2790	0.50	0.1395
12	0.0126	0.10	0.0013
13	0.0138	0.80	0.0111
14	0.0069	0.00	0.0000
18	0.0111	0.85	0.0095
19	0.3675	1.00	0.3675
21	0.1561	0.10	0.0156
24	0.0063	0.10	0.0006
	V_{adjhab} (Sum of Products) =		**0.5613**

LU = Land Use.

$V_{habwetuse}$

LU Code	LU %	LU Coefficient	Product (LU % × LU Coefficient)
1	0.0040	0.30	0.0012
3	0.0000	1.00	0.0000
6	0.0000	0.00	0.0000
7	0.0007	0.00	0.0000
8	0.0005	0.00	0.0000
10	0.0013	0.10	0.0001
11	0.2479	0.50	0.1239
12	0.0011	0.10	0.0001
13	0.0006	0.80	0.0005
14	0.0010	0.00	0.0000
19	0.4585	1.00	0.4585
21	0.0060	0.10	0.0006
24	0.0004	0.10	0.0000
18	0.2779	0.85	0.2362
	$V_{habwetuse}$ (Sum of Products) =		**0.8212**

LU = Land Use.

$V_{vegstruct}$ (see $FCI_{inhydro}$) = 0.725

$FCI_{habitat} = (V_{vegstruct} + V_{adjhab} + V_{habwetuse}) \div 3 = (0.725 + 0.561 + 0.821) \div 3 = 0.703$

APPENDIX B.4. SAMPLE OF USE OF THE SHANNON-WEAVER DIVERSITY INDEX IN $FCI_{CONNECTIVITY}$ FOR THE TOOELE SAMP

Worksheet for $FCI_{connectivity}$

Use of the Shannon-Weaver Diversity Index in $FCI_{connectivity}$ was thought to provide a better estimate of wildlife function than $V_{barrier}$ because it was calculated using empirical data from one year of bird surveys at transects and points located throughout the plan area. This approach was approved by the ACOE and the Tooele SAMP Technical Advisory Committee (including the EPA) on February 18, 2004.

- Original formula for $FCI_{connectivity}$ (Keate 2001): $(V_{barrier} + V_{connectivity} + FCI_{hydro}) \div 3$
- Revised formula for $FCI_{connectivity}$ used in the Tooele SAMP: $(V_{diversity} + V_{connectivity} + FCI_{hydro}) \div 3$

  where $V_{diversity}$ is the Shannon-Weaver Diversity Index variable described in Appendix B.1 (see below).

  where $V_{connectivity}$ is derived from measure of the loss of habitat and fragmentation of habitat, based on a direct relationship between connectivity and habitat suitability (see the graph in Appendix B.1).

  see function 1 for FCI_{hydro}.

CALCULATING $V_{DIVERSITY}$

At each FA Point, record the number of individuals of each species. Sum to find the total number of individuals of all species (see example):

34	individual American avocet
7	individual horned lark
+ 4	individual snowy plover
45	total individuals

Next, to find the Shannon-Weaver Diversity Index (Shannon) Value for a given species, divide the number of individuals of the given species by the total individuals. Then take the negative, natural logarithm of the quotient and multiply it by the quotient (see example):

34 individual American avocet ÷ 45 total individuals = 0.756

$-LN(0.756) \times 0.756 = 0.212$

Shannon-Weaver Diversity Index (Shannon) Value = 0.212

Sum these final values, one for each species, to get the total Shannon Value at that FA Point.

****

Calculate the Shannon Value and note the corrected value and habitat at each FA Point:

FA Point	Shannon-Weaver Diversity Index (Shannon) Value	Corrected Shannon Value*	Habitat
1	1.837	1.837	Persistent Emergent Marsh/Open Water
2	2.068	2.068	Open Water/Saline Playa/Seasonal marsh (Wet meadow)*

FA Point	Shannon-Weaver Diversity Index (Shannon) Value	Corrected Shannon Value*	Habitat
3	1.974	1.974	Open Water/Saline Playa/Seasonal marsh (Wet meadow)*
4	0.000	0.000	Saline Playa/Upland
5	0.000	0.000	Seasonal marsh (Wet meadow)
6	0.000	0.000	Saline Playa
7	0.000	0.000	Saline Playa/Open Water
8	1.804	1.804	Seasonal marsh (Wet meadow)
9	1.263	1.263	Open Water/Saline Playa
10	0.821	0.821	Open Water/Saline Playa (flooded)
11	1.277	1.277	Open Water/Saline Playa (flooded)
12	1.504	1.504	Open Water/Saline Playa (flooded)
13	2.516	1.696	Open Water/Saline Playa
14	2.744	2.230	Open Water/Persistent Emergent Marsh
15	2.206	2.206	Seasonal marsh (Wet meadow)/Open Water
16	2.503	1.667	Man influenced Wetlands (Canal)
17	2.214	1.196	Open Water/Upland
19	2.785	2.252	Shrub scrub
20	2.186	1.855	Persistent Emergent Marsh/Island
20a	1.346	0.730	Persistent Emergent Marsh
100	0.779	0.779	Open Water/Saline Playa
101	1.527	1.527	Persistent Emergent Marsh/Open Water/Saline Playa
102	1.508	1.508	Persistent Emergent Marsh/Open Water/Saline Playa

*Corrected Shannon Value consolidates all ducks, gulls, sandpipers, and phalaropes into single records (e.g., *Caladris* spp.).

Set the maximum corrected value to 1.000 and normalize all other values:

FA Point	Corrected Shannon Value	Normalized Shannon Value	Habitat
1	1.837	0.816	Persistent Emergent Marsh/Open Water
2	2.068	0.918	Open Water/Saline Playa/ Seasonal marsh (Wet meadow)*
3	1.974	0.876	Open Water/Saline Playa/ Seasonal marsh (Wet meadow)*
4	0.000	0.000	Saline Playa/Upland
5	0.000	0.000	Seasonal marsh (Wet meadow)
6	0.000	0.000	Saline Playa
7	0.000	0.000	Saline Playa/Open Water
8	1.804	0.801	Seasonal marsh (Wet meadow)

FA Point	Corrected Shannon Value	Normalized Shannon Value	Habitat
9	1.263	0.561	Open Water/Saline Playa
10	0.821	0.365	Open Water/Saline Playa (flooded)
11	1.277	0.567	Open Water/Saline Playa (flooded)
12	1.504	0.668	Open Water/Saline Playa (flooded)
13	1.696	0.753	Open Water/Saline Playa
14	2.230	0.990	Open Water/Persistent Emergent Marsh
15	2.206	0.979	Seasonal marsh (Wet meadow)/ Open Water
16	1.667	0.740	Man influenced Wetlands (Canal)
17	1.196	0.531	Open Water/Upland
19	2.252	1.000	Shrub scrub
20	1.855	0.824	Persistent Emergent Marsh/Island
20a	0.730	0.324	Persistent Emergent Marsh
100	0.779	0.346	Open Water/Saline Playa
101	1.527	0.678	Persistent Emergent Marsh/Open Water/Saline Playa
102	1.508	0.670	Persistent Emergent Marsh/Open Water/Saline Playa

NOTE: Shaded values reflect the maximum normalized to 1.000.

Note which FA Points fall within which Wetland Unit and substitute the corresponding Normalized Shannon Value for the point:

Wetland Unit:	1	2	3	5	6	7	8	10	13	14	15
	0.990	0.740	0.365	0.918	0.918	0.918	0.000	0.918	0.816	1.000	0.753
	0.824	0.531	0.567	0.990	0.990	0.990	0.000		0.876		
	0.324		0.753	0.824	0.824	0.824	0.000		0.346		
				0.324	0.324	0.324	0.000		0.678		
							0.801		0.670		

Note the habitat type at each FA Point/Normalized Shannon Value. Approximate the percentage of the Wetland Unit that this habitat type occupies. Multiply the Normalized Shannon Value by the habitat proportion to get a Weighted Shannon Value. Sum these for a final value for each Wetland Unit.

Wetland Unit	Normalized Shannon Value at Each FA Point	Habitat's Proportion of Wetland Unit	Weighted Shannon Value for FA Point/ Habitat (Product)	Weighted Shannon Value for Wetland Unit (Sum for $V_{diversity}$)
1	0.990	0.20	0.198	
	0.824	0.35	0.288	
	0.324	0.45	0.146	
				0.632

Wetland Unit	Normalized Shannon Value at Each FA Point	Habitat's Proportion of Wetland Unit	Weighted Shannon Value for FA Point/ Habitat (Product)	Weighted Shannon Value for Wetland Unit (Sum for $V_{diversity}$)
2	0.740	0.7	0.518	
	0.531	0.3	0.159	
				0.677
3	0.365	0.33	0.120	
	0.567	0.33	0.187	
	0.753	0.34	0.256	
				0.563
5	0.918	0.100	0.092	
	0.990	0.200	0.198	
	0.824	0.400	0.329	
	0.324	0.300	0.097	
				0.716
6	0.918	0.300	0.275	
	0.990	0.300	0.297	
	0.824	0.200	0.165	
	0.324	0.200	0.065	
				0.802
7	0.918	0.100	0.092	
	0.990	0.200	0.198	
	0.824	0.400	0.329	
	0.324	0.300	0.097	
				0.716
8	0.000	0.200	0.000	
	0.000	0.300	0.000	
	0.000	0.200	0.000	
	0.000	0.200	0.000	
	0.801	0.200	0.000	
				0.080
10	0.918	1.000	0.918	
				0.918
13	0.816	0.300	0.245	
	0.876	0.100	0.088	
	0.346	0.200	0.069	
	0.678	0.200	0.136	
	0.670	0.200	0.134	
				0.672

Wetland Unit	Normalized Shannon Value at Each FA Point	Habitat's Proportion of Wetland Unit	Weighted Shannon Value for FA Point/ Habitat (Product)	Weighted Shannon Value for Wetland Unit (Sum for $V_{diversity}$)
14	1.000	1.000	1.000	
				1.000
15	0.753	1.000	0.753	
				0.753

Therefore, for Wetland Unit 7, above:

$V_{diversity}$ = 0.717

$V_{connectivity}$ (see graph in Appendix B.1) = 0.870

FCI_{hydro} = 0.733

$FCI_{connectivity} = (V_{diversity} + V_{connectivity} + FCI_{hydro}) \div 3 = (0.717 + 0.870 + 0.733) \div 3 = 0.773$

APPENDIX C: MAPS OF BIRD SPECIES/GUILD GROUP LOCATIONS IN THE SAMP AREA

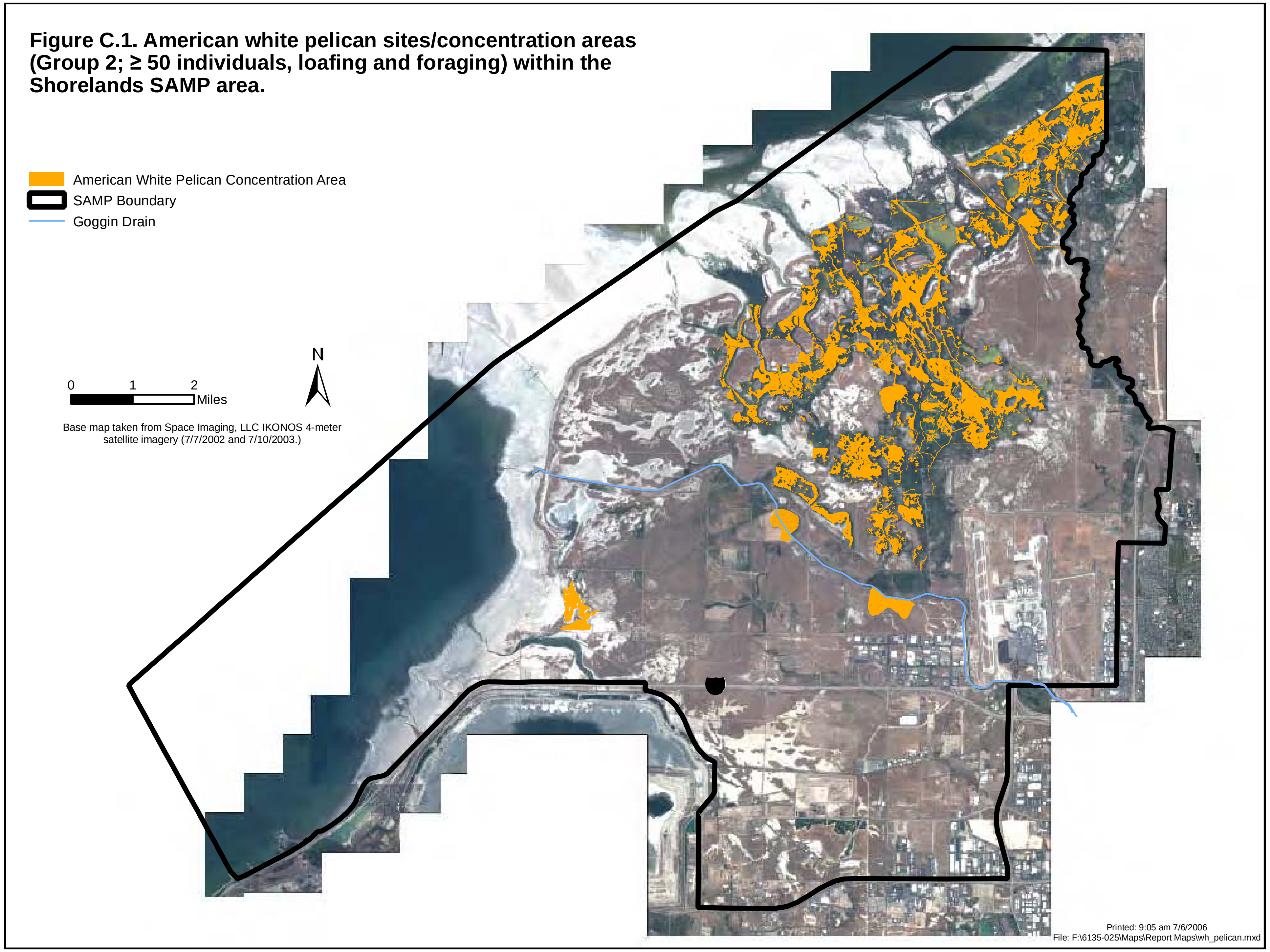

Figure C.1. American white pelican sites/concentration areas (Group 2; ≥50 individuals, loafing and foraging) within the Shorelands SAMP area.

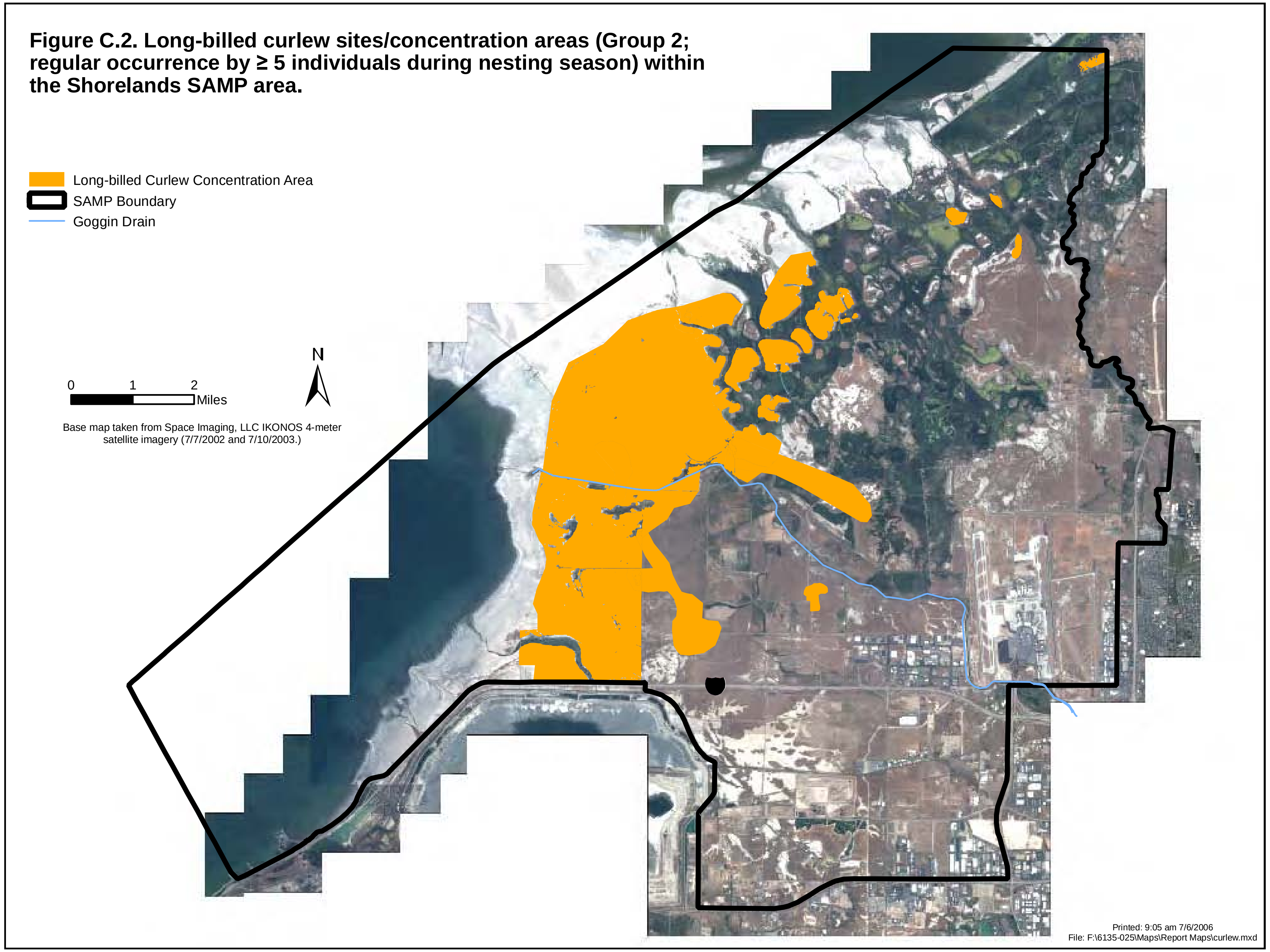

Figure C.2. Long-billed curlew sites/concentration areas (Group 2; regular occurrence by ≥5 individuals during nesting season) within the Shorelands SAMP area.

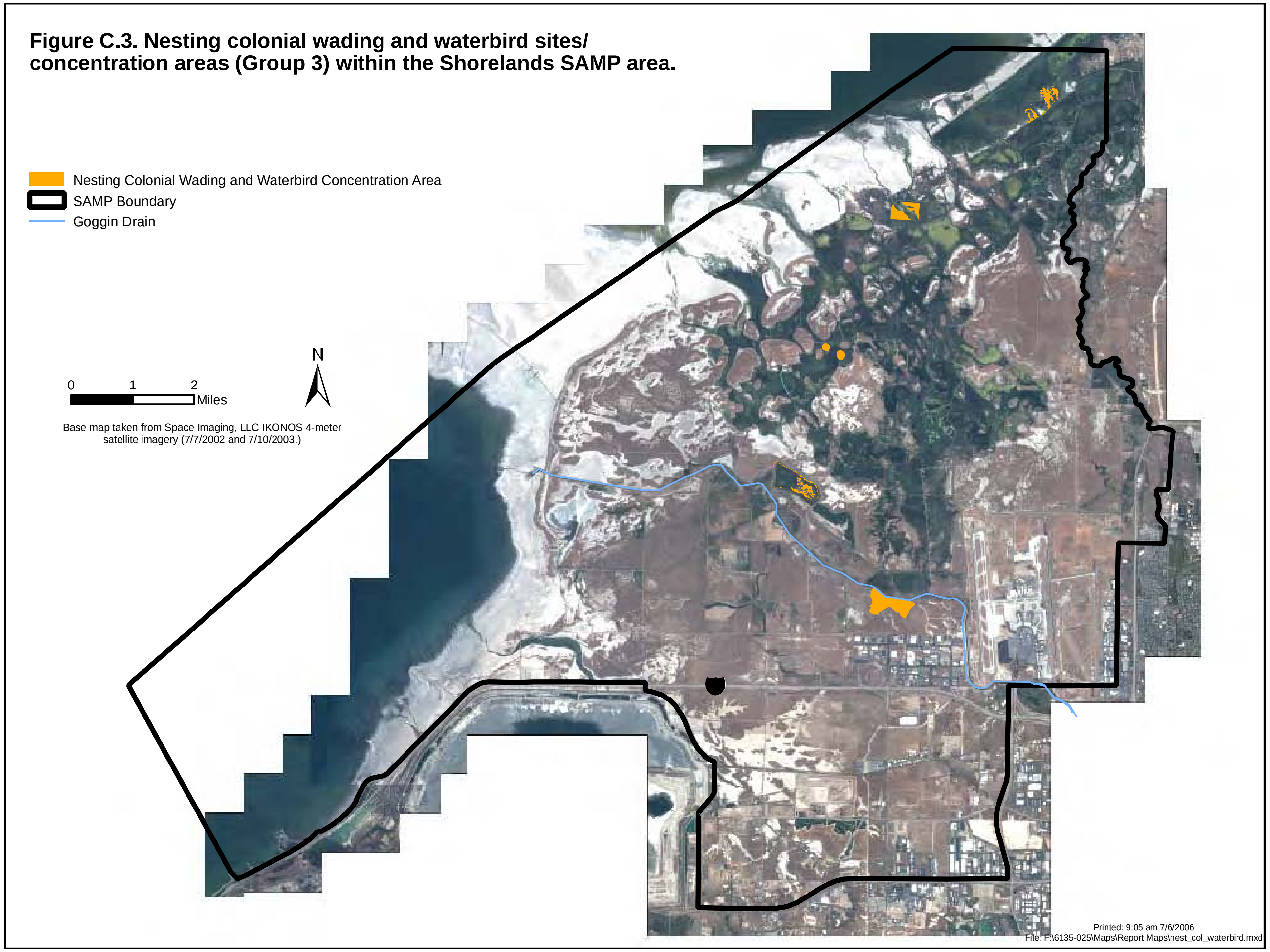

Figure C.3. Nesting colonial wading and waterbird sites/concentration areas (Group 3) within the Shorelands SAMP area.

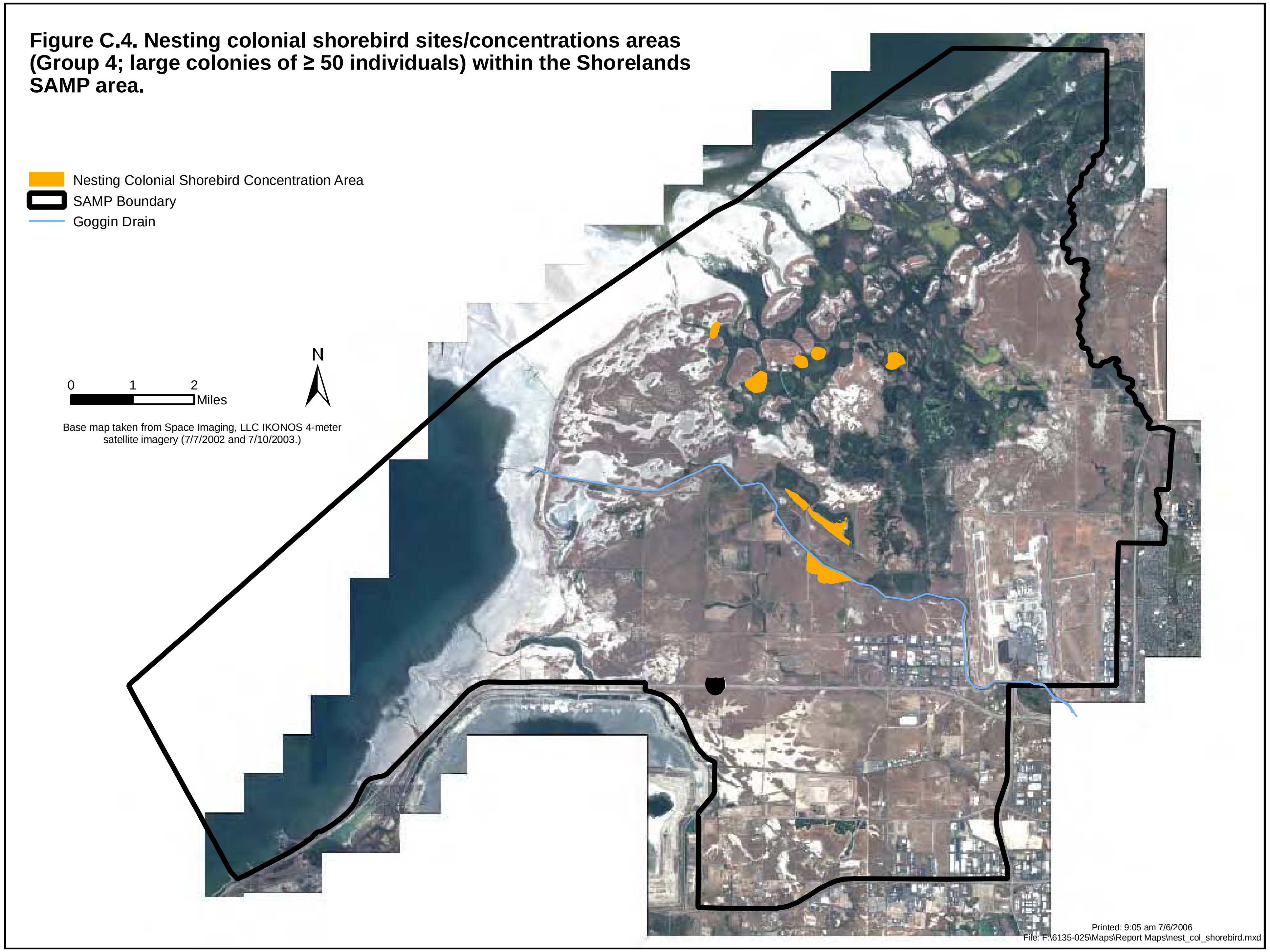

Figure C.4. Nesting colonial shorebird sites/concentrations areas (Group 4; large colonies of ≥50 individuals) within the Shorelands SAMP area.

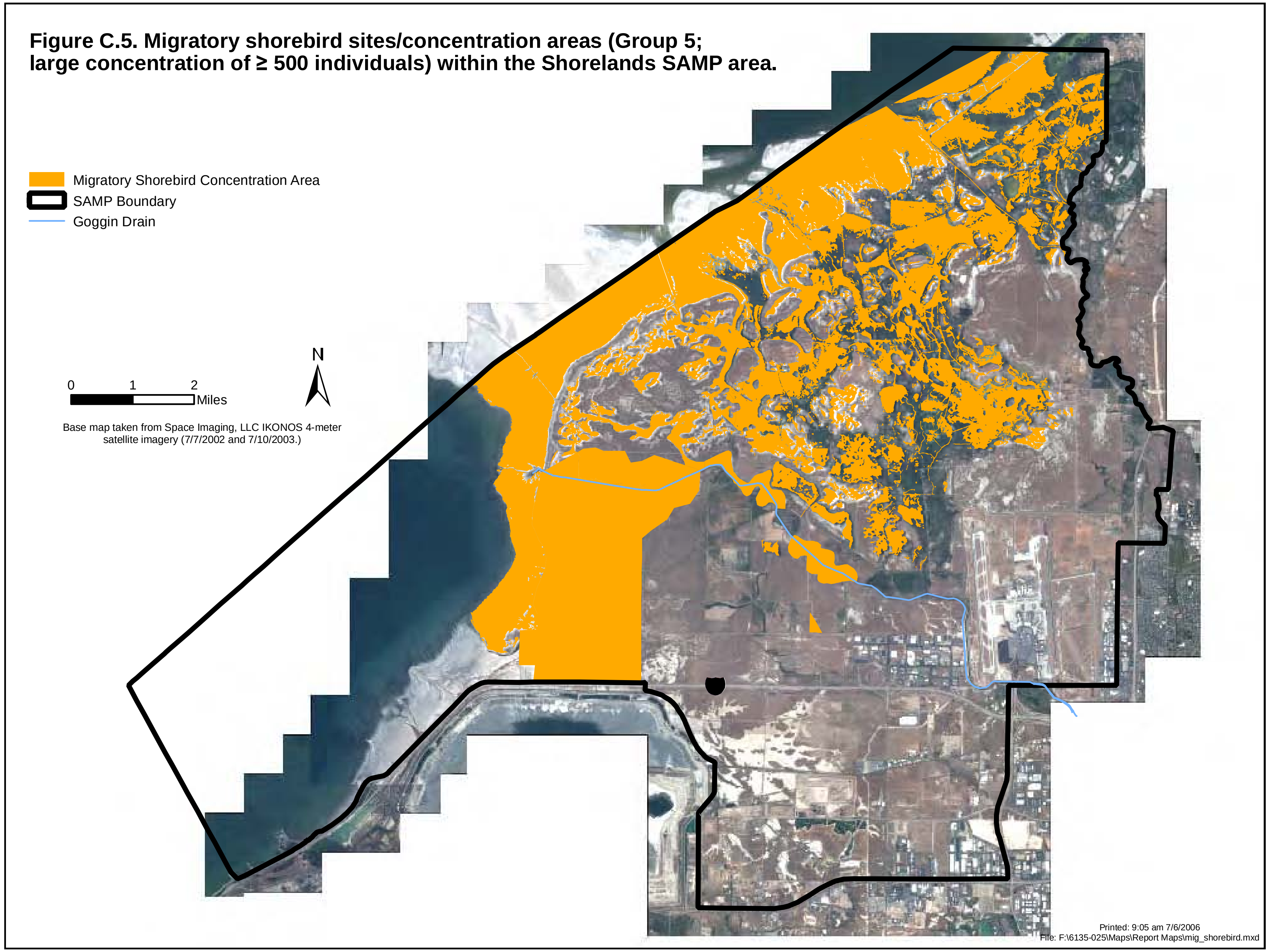

Figure C.5. Migratory shorebird sites/concentration areas (Group 5; large concentration of ≥500 individuals) within the Shorelands SAMP area.

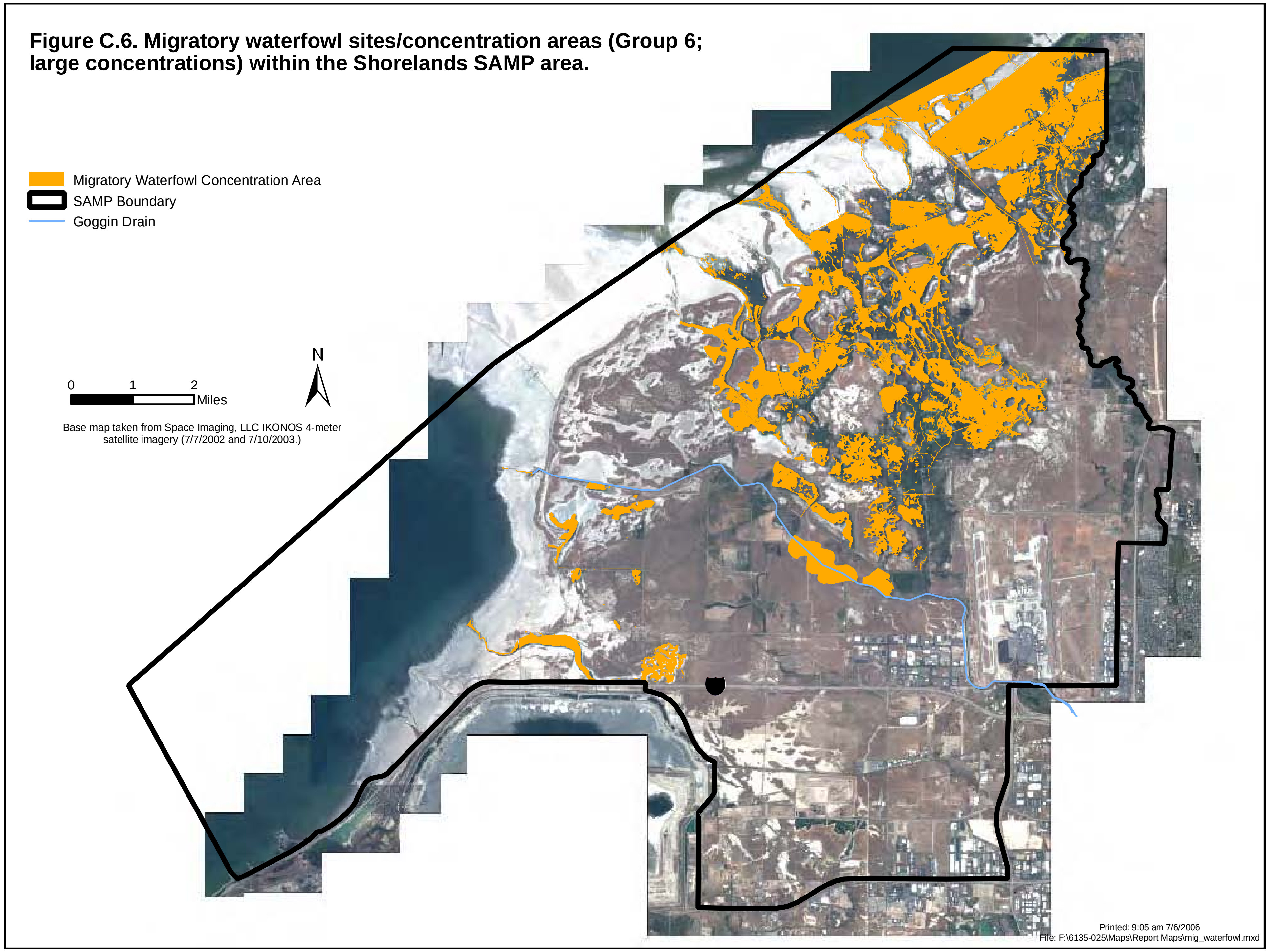

Figure C.6. Migratory waterfowl sites/concentration areas (Group 6; large concentrations) within the Shorelands SAMP area.

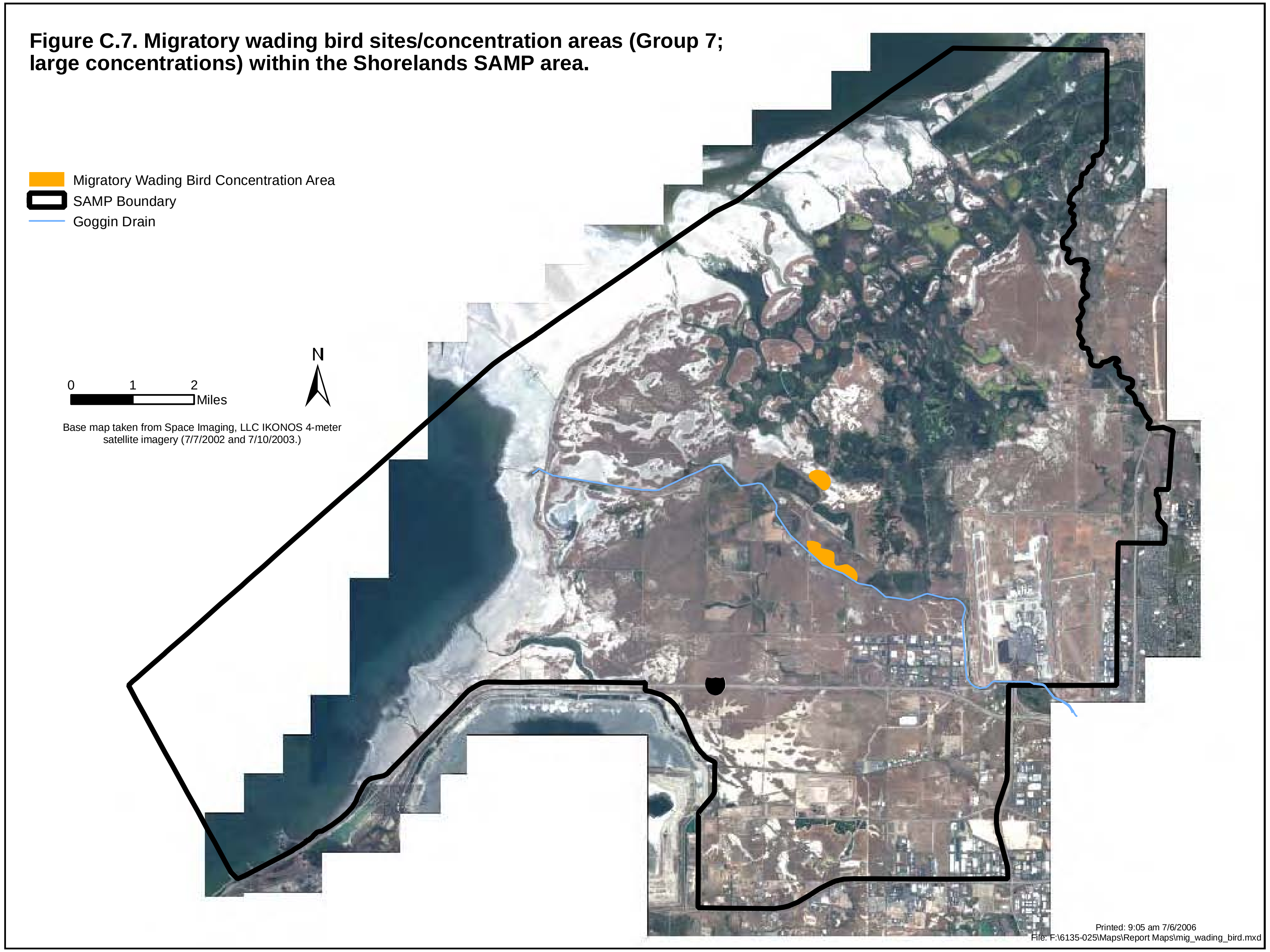

Figure C.7. Migratory wading bird sites/concentration areas (Group 7; large concentrations) within the Shorelands SAMP area.

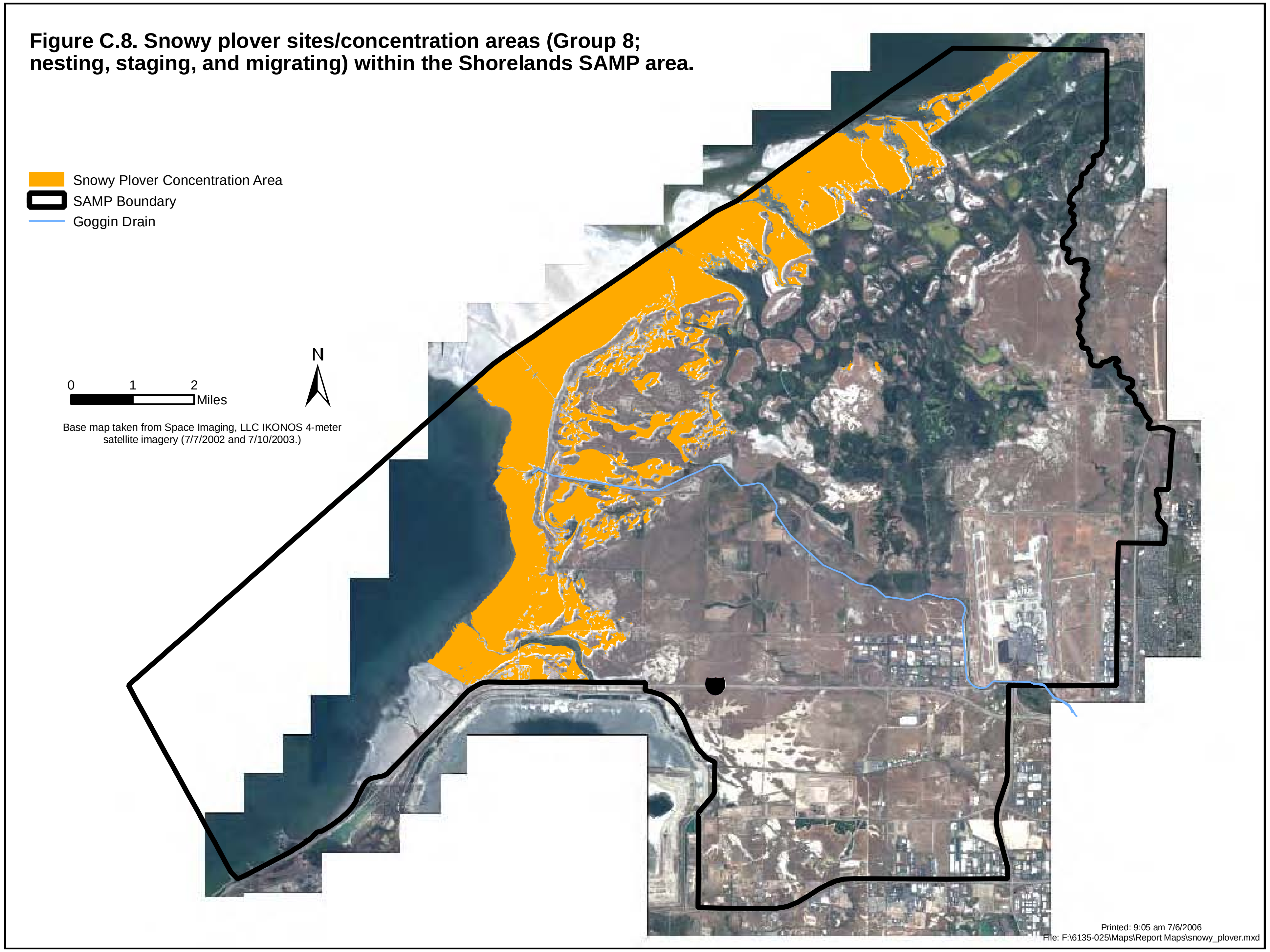

Figure C.8. Snowy plover sites/concentration areas (Group 8; nesting, staging, and migrating) within the Shorelands SAMP area.

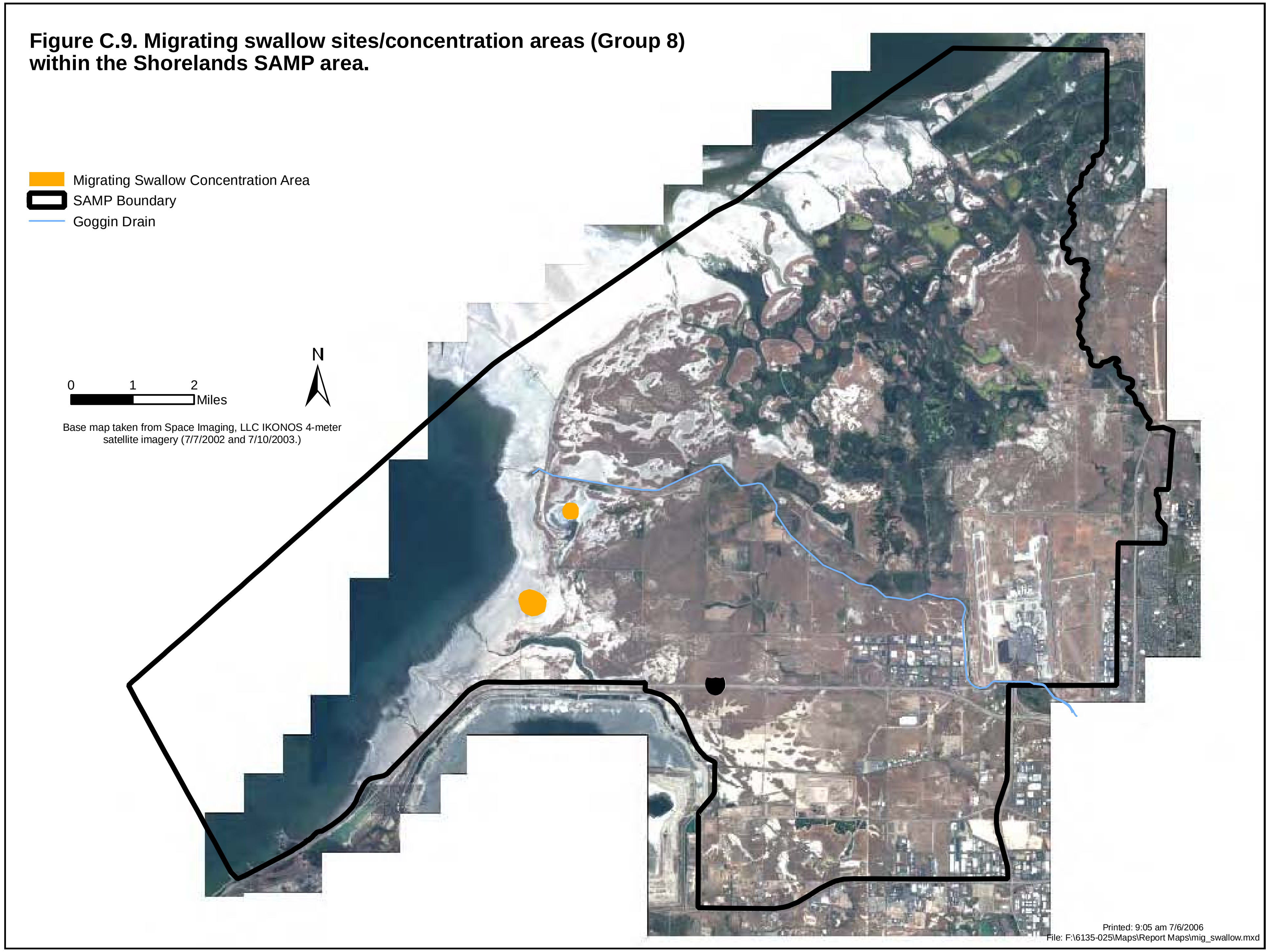

Figure C.9. Migrating swallow sites/concentration areas (Group 8) within the Shorelands SAMP area.

APPENDIX D: THE ESTABLISHMENT OF ACTIVITY PROTECTION ZONES FOR BIRD GROUPS

GROUP 1

The bald eagle is the only federally listed (i.e., federally threatened) species that regularly occurs within the SAMP area. Nesting, wintering, and migrating eagles occur at various times of the year.

NESTING BALD EAGLES

The only known, active bald eagle nest in the SAMP area is along the Jordan River less than 155 feet (50 m) east of the SAMP area. This nest and its pair of eagles are frequently the focus of legal, management, political, and public interest:

- The Endangered Species Act of 1973 (ESA), the Migratory Bird Treaty Act of 1918 (MBTA), and the Bald Eagle and Golden Eagle Protection Act of 1940 protect this nesting pair and its nest from "harassment, harm, or take" due to new construction, structure, or infrastructure development.
- Furthermore, U.S. Fish and Wildlife Service (USFWS) management guidelines establish a 1-mile spatial buffer zone around bald eagle nests, in which no disturbance is to occur, from January 1 to August 31 of each year (Romin and Muck 1999:29).
- Additionally, the U.S. Army Corps of Engineers (ACOE) Section 404 Permit issued to the Utah Department of Transportation (UDOT) in 2001 to construct the Legacy Parkway stipulated that no Parkway-associated activities were to occur within a 1.0-mile (1.6-km) buffer of the nest from January 1 to May 21 or within a 0.5-mile (0.8-km) buffer from May 21 to August 31.

Although most of the area encompassed by the nest's 1-mile buffer is outside of the SAMP area on land owned by UDOT and managed as the Legacy Nature Preserve, substantial amounts of privately-owned land also fall within the buffer zone west of the Jordan River. Regularly used paved and dirt roads, power transmission towers and lines, occupied homes and ranches, and airport control infrastructure facilities occur within the 1-mile buffer. Intensive agricultural activities and seasonal hunting commonly occur within 0.25 mile (0.4 km) of the nest while it is active. Yet the eagle pair appear to have largely habituated to the current level of human disturbance and infrastructure, as indicated by the high annual productivity of the nesting pair.

The threshold at which future construction, development, and human disturbance within the 1-mile buffer zone might cause the pair to abandon the nest is unknown. Therefore, it is prudent to acknowledge the 1-mile buffer zone and to let the USFWS utilize the ESA Section 7 consultation process to regulate the permitting of development and to determine the cumulative impact of any future infrastructure development on the nesting pair of eagles.

MIGRATING AND WINTERING BALD EAGLES

Migrating and wintering bald eagles occur with the SAMP area from November through March. Large concentrations of roosting and feeding eagles occur, primarily from January through mid-March, along and near the Great Salt Lake shoreline and at three known, communal winter roosts—comprising one or multiple living or dead trees—that are predictably used year after year. The ESA, the Bald Eagle and Golden Eagle Protection Act, the MBTA, and USFWS management guidelines (Romin and Muck 1999) protect eagles and their communal roosts from "harassment, harm, or take." The USFWS has established default, 0.5-mile (0.8-km) human disturbance buffers around all known eagle roosts within the SAMP area (Romin and Muck 1999:22). The 0.5-mile buffer zone also constitutes the infrastructure setback distance until the USFWS establishes interim guidelines for setback distances.

Although some of the area encompassed within the 0.5-mile buffers is on land owned by UDOT and managed as the Legacy Nature Preserve or on land owned by the Salt Lake City International Airport, substantial amounts of privately-owned land also exist within the roost buffers. Regularly used paved and dirt roads, power transmission towers and lines, occupied homes and ranches, and airport control infrastructure facilities also occur within some of the buffers. Intensive agricultural activities and seasonal hunting commonly occur within close proximity of some roosts during winter, occasionally causing the birds in the disturbed roosts to temporarily abandon them.

The threshold at which future construction, development, and human disturbance within the 0.5-mile buffer zones might cause permanent roost abandonment is unknown. Therefore, it is prudent to acknowledge the default, USFWS 0.5-mile buffer zones and to let the ESA Section 7 consultation process determine the cumulative impact of any future infrastructure development on eagle roosts.

GROUP 2

The American white pelican and long-billed curlew are the only Utah State waterbird species of concern that regularly occur within the SAMP area.

Pelicans at Great Salt Lake nest only in colonies on predator-free, remote islands in the lake. Flocks of nesting pelicans undertake a daily movement (31-50 miles [50-80 km]) from their nesting islands to the eastern shore of the lake, where freshwater ponds, lakes, and bays provide foraging and loafing habitat.

Human disturbance of important foraging and loafing habitat within the SAMP area can disrupt pelican feeding, reduce caloric intake, and even force pelicans to abandon preferred foraging areas. Therefore, buffer zones of 1,240 feet (400 m) are recommended to deny access to boats and humans at important foraging areas for large concentrations of pelicans during spring, summer, and fall (Doran et al. 2004:2-7). Data on infrastructure setback distances for pelican management is unavailable, but as a rule, setback distances should equal or exceed activity protection zone width.

Long-billed curlew populations in northern Utah have been declining for reasons that are unclear (Paton and Dalton 1994) but are likely related to habitat alteration and increased predation by red fox and/or coyote (Dugger and Dugger 2002). Curlews are very sensitive to human disturbance while nesting, particularly during brood-rearing. Excessive vehicle traffic on dirt roads through nesting habitat, off-road vehicle use, moderate recreational foot traffic in nesting habitat, and heavy grazing may result in disruption of critical parental behaviors that can cause nest abandonment or direct destruction of nests (Dugger and Dugger 2002:21). This can have long-term, negative influences on curlew productivity and recruitment, because each pair lays only one clutch of eggs per year and does not re-nest after abandonment or destruction of their first attempt (Paton and Dalton 1994:79).

No management guidelines, buffer zone recommendations, or setback distances have been established to protect areas with high nesting curlew densities. However, anecdotal data indicate that curlews typically initiate disturbance-related behavior in response to an approaching human at approximately 310 feet (100 m) from active nests (Forsythe 1972:89). A conservative activity protection zone, therefore, should be at least 310 feet. An infrastructure setback distance should be at least 930 feet (300 m), because curlews defend relatively large territories (15-35 acres; [6-14 ha]), surrounded by a larger zone of undefended habitat from 930 to 1,550 feet wide (300 to 500 m wide), where most foraging occurs (Dugger and Dugger 2002:12).

GROUP 3

Several species of nesting colonial wading birds and gulls/terns are summer residents within the SAMP area. Nesting colonies of grebes, cormorants, herons, egrets, ibis, gulls, and terns are all extremely sensitive to human disturbance, and their habitats are frequently the target of vandalism where they are accessible (Quinn and Milner 2004). Furthermore, colonies may include several species of waterbirds nesting together in close proximity (Hayward et al. 1976:44); in these cases, human disturbance can impact more than one species. For this group, quantitative data on the impacts human disturbance and infrastructure development are abundant for great blue heron and are almost completely lacking for other species of nesting colonial waterbirds present within the SAMP area.

Great blue heron colonies are known to have been abandoned in response to repeated human intrusions, housing and industrial development, road construction, and vehicle traffic. In a 2004 study, Quinn and Miller determined that colonies of herons decreased in size as distance to the nearest human activity within 984 feet (300 m) decreased, and as the amount of human infrastructure development increased within the same distance (Quinn and Milner 2004). In the same study, the productivity of heron young was found to be more than double for colonies farthest from infrastructure development, compared to colonies closer to development. Although habituation to disturbance and infrastructure development is known to occur in some cases, an activity protection zone of 820-984 feet (250-300 m) and an infrastructure development setback distance of 3,281 feet (1,000 m) is recommended by Quinn and Milner (2004). These distances directly dispute those of Rodgers and Smith (1995), who recommended an activity protection zone of approximately 310 feet (100 m) around Florida wading bird colonies (e.g., cormorants, herons, egrets, ibis, and night-herons). Rodgers and Smith (1995) based their distances on a model of questionable design using inappropriate data, and their recommendation is discounted here and has been discounted by Quinn and Milner (2004).

Although habituation and tolerance for human disturbance and infrastructure have been documented to occur occasionally for some species, anecdotal and qualitative data indicate that nesting colonies of grebes, cormorants, other heron species, egrets, ibis, gulls, and terns are typically harmed by human disturbance and infrastructure development (Storer and Nuechterlein 1992:14; Burger and Gochfeld 1994:18; Dunn and Agro 1995:16; Winkler 1996:18-19; Cuthbert and Wires 1999:22; McNicholl et al. 2001:17). Nesting terns may be even more sensitive to human disturbance, as they typically exhibit an initial panic or initial mass-upflight response when first disturbed (Erwin 1989).

It is recommended that buffer zone and infrastructure setback distances for great blue heron be applied to the entire guild of nesting colonial wading birds. Nesting colonies of gulls and terns are recommended to have a buffer zone of 465 feet (150 m) and an infrastructure setback distance of 930 feet (300 m), based on personal experience and observations of members of the Wildlife Functional Assessment (WFS) Team and personal communications with other experts in the field.

GROUP 4

Large concentrations of nesting shorebirds occur frequently within the SAMP area, primarily in locales closer to the lakeshore. Extensive research conducted at Great Salt Lake on the effects of human disturbance on nesting American avocets (*Recurvirostra americana*) and Black-necked stilts (*Himantopus mexicanus*) supports the use of these species as indicators of human disturbance for the nesting shorebird guild.

Avocets and stilts nesting in non-colonial situations begin to exhibit agitation behavior in response to disturbance at an average distance of 125 feet (40 m; range up to 570 feet [183 m]; Sordahl 1990:531). Since adult avocets and stilts typically are absent from the nest while performing their distraction displays in response to human disturbance, eggs and young are exposed to predation by gulls, crows, ravens, snakes, and mammals. An approaching human will often create chaos within a nesting colony, causing young birds to run in all directions, where they are usually attacked and killed by other, non-parental, adult avocets and stilts (Gibson 1971:452). Even an occasionally used dirt road, though in an area of apparently suitable habitat, is sufficient to prevent nesting in these species (Hamilton 1975:77).

Based on existing literature, a conservative disturbance buffer zone of 310 feet (100 m) should be established around large concentrations of nesting shorebirds (Sordahl 1990). Since no known infrastructure setback distance exists for nesting shorebird concentrations, the setback distance should be at least the same as an activity protection zone.

GROUP 5

Staging and migratory shorebirds differ from most other migratory species, in that they have very narrow habitat requirements that limit them to relatively few, highly productive stopover and staging areas that are predictably used year after year (Helmers 1992:4). Large concentrations of staging and migrating shorebirds have been documented at various localities throughout the SAMP area; up to 252,000 avocets have been documented at Great Salt Lake at the peak of fall migration, making it the largest known staging concentration of this species in the U.S. (Robinson et al. 1997:20).

Areas with high densities of staging or migrating shorebirds should, therefore, be managed to avoid or minimize disturbance (Laubhan and Fredrickson 1993:339). This could be accomplished through total closure or through restrictions on access for recreational activities during appropriate seasons. Buffer zones to prevent human disturbance to individuals or small flocks are recommended to be a minimum of 155 feet (50 m) from the mean high waterline (Howe et al. 1989); therefore, the WFA Team recommends a buffer zone of 310 feet (100 m) around locales known to exhibit large concentrations (> 500) of staging and migrating shorebirds. A buffer zone of 310 feet (100 m) is recommended to prevent human disturbance to non-breeding sandpipers from disturbance by personal watercraft and outboard-powered boats (Rodgers and Schwikert 2002). There is no known infrastructure setback distance for staging and migrating shorebirds, but should be at least equivalent to recommended activity protection zones.

GROUP 6

Large concentrations of staging and migrating waterfowl, including geese, ducks, grebes, and coots, are negatively affected by human disturbance when such activities cause them to take flight, change food habits, feed only at night, lose weight, or abandon important foraging areas (Korschgen and Dahlgren 1992).

Some waterfowl, particularly diving ducks (e.g., canvasback and lesser scaup) and geese (brants and snow goose), are very sensitive to disturbance (Korschgen and Dahlgren 1992). Of the species in this group that occur in the SAMP area, the large flocks of snow geese are more susceptible to human disturbance than small flocks (Belanger and Bedard 1989:717). In one study, in 1977, larger flocks of brant (geese) were observed to take flight at greater distances than smaller flocks due to human disturbance (Owens 1977). Based on a study by Korschgen and Dahlgren, migrating pink-footed geese are known to have been disturbed at a distance of 1,550 feet (500 m), when more than 20 cars per day used a nearby road (Korschgen and Dahlgren 1992). As few as 10 cars per day negatively influenced habitat use by the geese at the same distance. Based on these studies, an infrastructure setback distance (roads in this instance) of 1,550 feet (500 m) would be appropriate for large migratory concentrations of geese.

Other waterfowl species are less sensitive to disturbance, and habituation can occur under some circumstances for some species. However, quantitative data establishing buffer zones and infrastructure setback distances are virtually nonexistent for most migrating and staging waterfowl species present at Great Salt Lake (excepting the duck and goose species above). In the absence of such guidelines, the WFA Team recommends a human disturbance buffer zone of 1,550 feet (500 m) and an infrastructure setback distance of at least that distance around wetlands known to support large concentrations of migrating and staging waterfowl (i.e., ≥ 1,000 individuals). This recommendation is based on the known literature, personal experience and observations of members of the WFA Team, and personal communications with other experts in the field.

GROUP 7

Large concentrations of staging and migrating wading birds (i.e., ≥ 500 individuals) are sensitive to human disturbance, but empirical data that would serve to identify buffer zones and infrastructure setback distances are generally lacking.

A buffer zone of 550 feet (180 m) is recommended for non-breeding wading birds to prevent disturbance from personal watercraft and outboard-powered boats (Rodgers and Schwikert 2002). Rodgers and Schwikert (2003) also recommend a 765-foot (247-m) buffer zone for airboat use adjacent to non-breeding groups of great blue herons and a 640-foot (207-m) buffer zone for airboats adjacent to non-breeding groups of snowy egrets. In the absence of more regionally appropriate guidelines for habitat around Great Salt Lake, the WFA Team recommends a human disturbance buffer zone of 310 feet (100 m) and an infrastructure setback distance of ≥ 310 feet (100 m) around wetlands known to support large concentrations of migrating and staging wading birds. This recommendation is based on the personal experience of members of the WFA Team and personal communications with other experts in the field.

GROUP 8

Unique concentrations of two important regional wetland-associated species occur at Great Salt Lake: snowy plover and migrating flocks of swallows.

The current breeding population of snowy plovers in the U.S. is 21,000 individuals, more than half of which are concentrated at several locations around the shore of Great Salt Lake (Page et al. 1995:15). Snowy plover thus qualifies as a unique, regional species. It typically runs when disturbed, but effects of such disturbance have been poorly quantified (Page et al. 1995). Increased recreational use of coastal beaches in California by hikers was correlated with a 69-72% increase in the rate of chick mortality when all other factors were controlled (Ruhlen et al. 2003). Golden plover, a closely-related species in the United Kingdom, avoids areas within 620 feet (200 m) of unpaved footpaths and areas within 155 feet (50 m) of paved footpaths due to the increased tendency of hikers to stray off of unpaved footpaths (Finney et al. 2005).

More than 50 nesting, staging, or migrating plovers qualifies a site for a buffer zone and setback distance. As for Group 7 species, a buffer zone of 310 feet (100 m) around groups of non-breeding plovers is recommended to prevent disturbance from personal watercraft and outboard-powered boats (Rodgers and Schwikert 2002). Although there is no literature regarding buffer zones and setback distances for plovers, it is reasonable to extrapolate these from American avocet zones and distances, because both the avocet and plover are shorebirds, and both react similarly at similar distances. Thus, the 310-foot (100-m) buffer zone and setback distance for American avocet is extrapolated to plovers.

Migrating swallows are highly dependent on productive wetlands for foraging during migration, and Great Salt Lake hosts one of the largest known concentrations of migrating swallows in North America (Paton and Fellows 1994:55). Migratory flocks of more than 10,000 swallows have been observed perched on the ground foraging on brine flies in open playa habitat around Great Salt Lake. Migratory swallows, therefore, also qualify as a regionally important guild.

No empirical data that would serve to recommend human disturbance buffers or infrastructure setback distances from sites frequented by large concentrations (≥ 1,000 individuals) of migrating swallows are known. However, anecdotal observations made at Great Salt Lake indicate that large migrating concentrations of ground-foraging swallows take to flight when a human approaches to within 310-620 feet (100-200 m). In the absence of established guidelines, the WFA Team recommends a human disturbance buffer zone of 620 feet (200 m) and an infrastructure setback distance of ≥ 620 feet (200 m) around wetlands known to support large concentrations of migrating, foraging, and staging swallows. This recommendation is based on the personal experience of members of the team and personal communications with other experts in the field.

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APPENDIX E: GSL MODEL SPECIES DISTURBANCE DISTANCES, BASED ON EXISTING LITERATURE

Species	Disturbance Type	Disturbance Distance	Disturbance Notes	Source Material
1. Godwit	Low-traffic highway Moderate-traffic highway High-traffic highway Ribbon development Farms Home	625; 720 m 1,050; 1,125 m 2,000 m 1,000; 1,000 m 470; 500; 875 m 220 m	Nesting density	Van Der Vande et al. 1980
2. Coot	Low-traffic highway	315 m	Population density	Reijnen et al. 1996
	High-traffic highway	1,150 m		
Shoveler	Low-traffic highway	265 m		
	High-traffic highway	1,030 m		
Godwit	Low-traffic highway	560 m		
	High-traffic highway	1,690 m		
3. Waterfowl	Disturbance of upland cover	350 m	Nesting success	Johnson and Temple 1990
4. Geese	Low-traffic highway	1230 feet	Population density	Keller 1991
5. White pelican	Generalized disturbance	400-800 m	Nesting success/foraging	Larsen et al. 2004
6. Blue heron	Construction	1,000 m	Nesting success	Larsen et al. 2004; Butler 1991
7. Black-necked stilt	Generalized disturbance	100 m	—	Sordahl 1990a, 1990b
8. American avocet	Generalized disturbance	100 m	—	Sordahl 1990a, 1990b
9. Staging and migrating shorebirds	Generalized disturbance	100; 50 m	—	Sordahl 1990a, 1990b; Laubhan and Fredrickson 1993
10. Staging, migrating waterfowl, grebes and coots	Generalized disturbance	400 m	—	Recommended by the Wildlife Functional Assessment (WFA) Team
11. Staging and migrating wading birds	Generalized disturbance	100 m	—	Stolen 2003

Species	Disturbance Type	Disturbance Distance	Disturbance Notes	Source Material
12. Eared grebe Western grebe Clark's grebe Double-crested cormorant Cattle egret Snowy egret Black-crowned night heron White-faced ibis	Generalized disturbance	1,000 m	—	Extrapolated from #6, great blue heron
13. California gull Franklin's gull Forster's tern Caspain tern Black tern	Generalized disturbance	300 m	—	Experience of the WFA Team
14. Nesting, staging and migrating snowy plovers	Generalized disturbance	100 m	—	Extrapolated from #8, American avocet
15. Long-billed curlew	Generalized disturbance	300-500 m	Nesting/Breeding	Experience of the WFA Team

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APPENDIX F: CRITERION 3 SCORING SHEETS INDICATING LAND-USE STRESSORS TO WILDLIFE

Wildlife Functional Assessment Criterion #3 Scoring Sheets

Adjacent Land Use (Biotic and Physical Structures)	Group 1	Group 2 (Nesting)	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8
VEHICULAR								
Dirt Road (or loose gravel) - High Use	2	1	1	3	3	3	2	2
Dirt Road - Low Use	3	2	1	3	3	3	3	3
High Traffic Highway and Transportation Corridors (4-lane roads or larger; railroads)	1	1	1	1	1	1	1	1
Low Traffic Highway (2-3 lane paved highways)	1	1	1	2	2	2	1	1
Mountain Bikes	1	1	1	3	2	2	2	2
Dirt Bikes/OHV	1	1	1	3	1	1	1	1
Remote-controlled Aircraft	1	1	1	1	1	1	1	1
PEDESTRIAN								
Passive Recreation (bird-watching, golfing, hiking, photography, etc.)	1	2	1	3	2	2	2	2
Wildlife Management Activities (assumes BMPs)	3	3	3	3	3	3	3	3
Hunting Only	2*	3*	3*	1	1	1	1	3*
Excessive Human Visitation/Harassment	1	1	1	3	1	1	1	1
AGRICULTURAL								
Field Crop (actively plowed/disked field)	3	1	na	3	3	na	3	na
Feedlot, Dairy	1	1	na	1	1	1	1	na
Non-rotational Grazing, Heavy (year-round or mostly year-round grazing in sparse, trampled vegetation)	4	1	1	2	2	3	4	na
Rotational Grazing (grazing is for short periods during the year; vegetation is allowed to recover)	4	2	2	2	2	3	4	na
Orchards								

Wildlife Functional Assessment Criterion #3 Scoring Sheets

Adjacent Land Use (Biotic and Physical Structures)	Group 1	Group 2 (Nesting)	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8
COMMERCIAL								
Golf Course (area manipulated for golf; manicured grass)	1	1	2	2	1	1	1	na
High-intensity Commercial (area is entirely of commercial use and paved, e.g., shopping malls, construction yards)	1	1	1	3	1	1	1	1
Light-intensity Commercial (businesses have large warehouses and showrooms; large patches of vegetation occur between buildings; includes plant nurseries)	1	1	1	3	1	1	1	1
INDUSTRIAL								
Industrial (intense production activity occurs on a daily basis, e.g., oil refineries, auto body and mechanic shops, welding yards, airports)	1	1	1	3	1	1	1	1
Surface Solid Waste (landfills and waste collection facilities)	2	1	1	3	1	1	1	1
Sewage Treatment Plants and Lagoons	1	1	1	3	3	3	3	3
Tailings Impoundment	2	1	1	3	3	3	2	1
Physical Resource Extraction (sediment/groundwater, oil/gas)	1	1	1	3	2	2	2	3
URBAN								
Multi-family Residential (subdivisions with lots one-half acre or less)	1	1	1	3	1	1	1	1
Low-density Rural Development (areas of small structures in a farm or ranch setting, e.g., silos, barns)	3	2	2	3	3	3	3	3
Treatment of Invasive and Nuisance Plant Species	2	2	2	3	3	3	3	3
Pesticide Application of Vector Control	1	1	1	2	1	2	1	1

Wildlife Functional Assessment Criterion #3 Scoring Sheets

Adjacent Land Use (Biotic and Physical Structures)	Group 1	Group 2 (Nesting)	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8
Predation and Habitat Destruction by Feral Animals	1	3	1	3	1	1	1	1
Single-family Residential (residential lots are greater than one-half acre with vegetation between houses)	1	1	1**	3	2**	2**	1**	1**
NONPOINT SOURCE POLLUTION ***								
Excessive Sediment or Organic Debris from Watershed								
Excessive Runoff from Watershed								
OTHER								
Power lines and maintenance ***	2	3	2	3	3	3	2	2

4 is highest value; 1 is lowest value. Scores are left blank where the land use is not currently observed in SAMP area. All stressors considered at the population level except for bald eagle due to its threatened status. All stressors consider only what is present now and not in the future.

Group 1: Federally endangered/threatened species.

Group 2: Utah State sensitive species.

Group 3: Nesting colonial wading and waterbirds.

Group 4: Nesting colonial shorebirds.

Group 5: Concentrations of migratory shorebirds.

Group 6: Concentrations of migratory waterfowl.

Group 7: Concentrations of migratory wading birds.

Group 8: Regionally important and unique species/guilds.

* October through January.

** e.g., TNC property at Layton.

***Water quality data for open water areas and disturbance from power lines have not been included at this point due to incomplete data.