Wetlands Monitoring Program Development

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Oklahoma Water Resources Board

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Final Report

I. INTRODUCTION

Comprehensive wetland management in the State of Oklahoma has been hindered by the limited accessibility of pertinent information. The National Wetlands Inventory (NWI) maps are housed at only one agency in Oklahoma, the U.S. Fish & Wildlife Service (USFWS), and are only available in hard copy, which constrains the utility of the data for in-depth evaluation and detailed management applications. This inaccessibility hampers planning and management of wetland resources for both the public and private sectors. To remedy this issue, the Oklahoma Conservation Commission (OCC) and the Oklahoma Water Resources Board (OWRB) worked to provide digital wetland data and computer interface features to the public and private sectors.

As the USFWS states on their web page, the NWI maps are a critical management tool used by scores of agencies and groups. These maps are widely viewed as a determinant factor in identification and subsequent management of wetland resources. This point alone illustrates the importance of unfettered accessibility to the resource.

> "Users of NWI maps and digital data are as varied as are the uses. Maps are used by all levels of government, academia, Congress, private consultants, land developers, and conservation organizations. The public makes extensive use of NWI maps in a myriad of applications including planning for watershed and drinking water supply protection; siting of transportation corridors; construction of solid waste facilities; and siting of schools and other municipal buildings. Resource managers in the Service and the States are provided with maps which are essential for effective habitat management and acquisition of important wetland areas needed to perpetuate migratory bird populations….for fisheries restoration; floodplain planning; and endangered species recovery plans. Regulatory agencies use the maps to help in advanced wetland identification procedures, and to determine wetland values and mitigation requirements. Private sector planners use the maps to determine location and nature of wetlands to aid in framing alternative plans to meet regulatory requirements. The maps are instrumental in preventing problems from developing and in providing facts that allow sound business decisions to be made quickly, accurately, and efficiently. Good planning protects the habitat value of wetlands for wildlife, preserves water quality, provides flood protection, and enhances ground water recharge, among many other wetland values."

The Emergency Wetland Resources Act of 1986 requires the development of a digital wetland database. However, due to the number of maps to be digitized and "the 100% user-pay basis on which NWI digitizes most of the wetland maps," a number of government and private agencies have initiated in-house digitization of NWI maps. In order to be able to accept NWI maps digitized by other entities, USFWS prepared a guidance document titled "*Procedures for Acceptance and Testing of Digital Data from Other Producing Agencies."* The document details procedures and quality assurance requirements for data to be included in USFWS national wetlands digital database.

With the creation of digital wetlands data, users within the state, as well as around the country and world, can access the information. By making the digitized wetland maps available through a web-based mapping system, such as ArcGIS map server, the public can access this information through a user-friendly interface. The ArcGIS site allows users to combine the wetland information with other data layers currently available in the State of Oklahoma such as digital orthophotography. This not only allows the public access to the important wetland data but also the ability to view this data with other information that would give the general user the ability to make informed decisions about their specific area of interest in Oklahoma. As an educational tool, this site can be combined with wetland related information to not only allow people to locate the wetlands in Oklahoma but also to educate them about the precious resource that is so valuable to the state.

As part of this project, digitized wetlands maps were merged into the existing wetlands shapefiles and the new/revised layers published on OWRB's ArcGIS map server. This system provides users with the ability to display and query wetlands coverages along with existing Oklahoma GIS coverages. The ability to create maps of the wetlands overlaid on other Oklahoma coverages such as digital orthophotos and watershed boundaries has been expanded. Custom features were added to the ArcGIS wetlands mapping system to increase application functionality. Users are now able to interactively select cities, counties, legal descriptions, and schools to easily locate nearby wetland areas. This will provide increased opportunities for students, researchers, and the public to study and learn about wetlands. The system will be a valuable tool for communities conducting watershed planning and government agencies in developing a comprehensive wetlands monitoring program.

The OCC and OWRB worked jointly to provide digital wetland data and computer interface features to the public and private sectors to make informed decisions under the guidance and oversight of the Office of the Secretary of the Environment (OSE). The OCC entered into agreement with the USFWS to digitize the NWI maps according to their specifications. In return, the digital information was provided to the USFWS for incorporation into their NWI system. The OWRB and the OCC worked together in developing a user-friendly access system that allows Oklahomans, as well as anyone else with web access, to directly interact with maps and several other information layers regarding wetlands within the state. The Oklahoma wetlands mapping system allows for an in-depth analysis of wetlands and, using USFSW codes, it creates wetland maps by type and analyzes the relationship of type to natural features such as geology, streams, aquifers, etc. Some examples of other data layers included are digital orthophotography, streams, lake, roads, cities and towns, water quality data, culture, and agriculture.

II. PROJECT DIGITIZING PROCEDURES

Oklahoma State University (OSU) was contracted by OCC to convert the National Wetlands Inventory (NWI) maps into a digital format. In most cases, two different formats of copies of finalized NWI maps were obtained from the USFWS for 709 1:24,000-scale quadrangle maps completed for the project (Appendix B). One format of the maps was a stable base, contact film copy only containing the NWI features for the map. The other format of the maps was a paper copy of the NWI map, complete with NWI features and labels as well as the underlying USGS topographic map features. In some cases, a third format or overlay was also received from USFWS. This third layer contained only the labels for the various wetland features and was generally not used by the project, since all of the necessary information was contained on the first two map formats.

It is important to note that none of the copies and formats of NWI maps were in “polygon only” format. In fact, all NWI maps contained all features. This condition meant that the project had to process all polygon features as well as all line features. This increased number of features as well as the spatial inter-relationship of the line and polygon features resulted in a significant amount of effort and time to process the project maps as opposed to maps that would have only contained polygon features.

For each quadrangle map area, the stable base, contact film copy was scanned at 800 dots per inch in a standard tiff format on an Altek optical scanner. The scanned output was then imported in a raster to vector conversion software package named R2V. After importation, the scanned image was registered to a geographic coordinate system (i.e., Latitude and Longitude) by using the four corners of the quadrangle as registration points. The data was then saved as a Geotiff image. Initial processing of the image included visually inspecting the raster image and identifying areas of concern. Areas in which the image was manually edited included any information present on the image that was outside of the quadrangle boundary as well as areas within the quadrangle boundary that needed further attention. Such areas in this latter category include locations where lines have “bled together” on the image due to the large dpi at which the data was scanned. Similarly, the scans resulted in most small water bodies being represented a large “blob” or area that had to be edited to produce a circle or boundary of the water body. In addition, lines and polygon boundaries were often incomplete or merged together where they should not have touched, resulting in other areas that required manual editing of the image. After most notable problem areas were edited, the software was then used to employ a series of commands in order to vectorize the raster image. That is, the raster image was converted to numerous vector features. Again, all obvious errors (i.e., locations where features touched each other and they should not or locations where features did not touch when they should connect) were then edited as needed. The vectorized data (line and area features) were then converted to polygons and another round of quality control commands were executed to identify errors in the data. A series of editing steps followed to ensure that all area features had been captured and were topologically (spatially related) correct.

At this point, the paper map that contained the features, labels, and background quadrangle information for the quadrangle was scanned at 200 dpi in a tiff format. This image was imported into the conversion software, geographically registered, and used as a “back drop” image, over which the newly created vector data was overlaid. All linear features where then labeled, using the image of the background map for identification. Finally, the vector data was exported from the R2V Conversion software in an ESRI Shape File Format.

The shape file was imported into ESRI’s ArcGIS software. The projection system was defined and the precision was set for double precision. All features were “edge-matched” to the features of adjoining quadrangles. The line and polygon features were separated into the ESRI Geodatabase provided to the project by the USFWS. The appropriate NWI attribute or code value was added to each polygon. Finally, the USFWS QA/QC software was executed on the entire geodatabase, and any errors identified by the QA/QC software were corrected by editing the data until no identified errors existed within the geodatabase. Copies of the geodatabase containing all features (lines and polygons) for all quadrangles were then sent to Mr. Chris DuBois, OCC, Oklahoma City, OK, and Mr. Jim Dick, USFWS, Albuquerque, NM.

III. PROBABILISTIC DESIGN TO DETERMINE NET LOSS/GAIN IN WETLAND RESOURCES IN THE DEEP FORK RIVER WATERSHED

A) Introduction

The Oklahoma Conservation Commission (OCC) is charged by state statute with development and implementation of Oklahoma's Wetlands Strategy. A pervading objective of this strategy is to monitor wetland resources to determine compliance with "no net loss" goals. Although a national imperative, "no net loss" determinations have proven difficult to achieve, and a standardized national methodology is not available. To this end, the OCC implemented a pilot project to advance a probabilistic approach to compare current and historic wetland coverage to determine net gain/loss of total wetland resources.

The Oklahoma Surface Water Monitoring Strategy has recognized probabilistic monitoring as a useful tool for assessing waters across the state, but it has yet to be implemented for wetlands. As part of the statewide strategy, the wetlands monitoring strategy will incorporate a probabilistic design in three phases: (1) track status and trends in wetlands gains and losses, (2) track status and trends for wetlands quality, and (3) determine beneficial use attainability. This project addressed the first phase of the strategy.

The Deep Fork watershed (Figure 1) in central Oklahoma was chosen for this pilot project because of the availability of adequate digital wetlands data to test the proposed process. These data include the digital version of the NWI maps that were created by the U.S. Fish and Wildlife Service (USFWS) in the early eighties from aerial photographs. According to USFWS, these maps were ground-truthed and incorporated all land cover types, including agricultural areas. Since the watershed's total wetland resources were mapped approximately 25 years ago, Oklahoma has a viable and exceptional opportunity to determine net gain/loss of wetland resources in comparison to recent and similar coverage for a large and unique watershed over a significant period of time (>20 years). In addition, the Deep Fork watershed is recognized by state and federal agencies for its high quality and unique wetland functions and its excellent fish and wildlife values. The results of this project are also a significant step toward the development of a statewide wetlands monitoring program, along with conservation and management of one of Oklahoma's unique resource areas.

Through this pilot project, the OCC implemented a probabilistic based visual assessment of current orthophotography to render a statistically qualified estimate of total wetlands in the Deep Fork watershed. This estimate was then compared to the Deep Fork census results of the NWI, allowing calculation of the net loss/gain in total wetlands

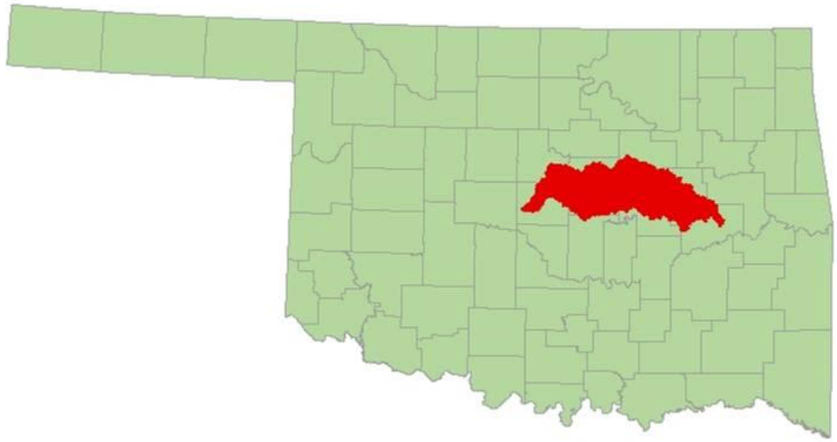


Figure 1: Previously Digitized Deep Fork Watershed Region

B) Methods

B.1) Spatially Balanced Sampling

The probabilistic design chosen to estimate the total wetland resources in the Deep Fork watershed was the unified strategy reviewed by Don Stevens and Anthony Olsen (2004). The basic premise of this sampling method is that sample sites that are evenly dispersed over a given resource are more efficient than random sample sites, and the technique is made possible by creating a function that maps two-dimensional space into one-dimensional space. The authors also highlight an extension of this basic technique, which allows any set of consecutively numbered points to be a spatially well-balanced sample. The result is a collection of sufficient study site candidates with adequate overdraw to guarantee the necessary target frame of sites for probabilistic based estimates of parameters of interest.

B.2) Survey Design Specifics

The watershed was divided into a grid (2 mi. x 2 mi. squares) with computer generated plot outlines using AutoCAD and ArcMap version 9.2 for the correct spatial coordinates, size, and projection. This grid acted as the foundation for selecting sample plots using a probabilistic design (Figure 2). The sample plots were fixed georeferenced areas (2 mi. x 2 mi. squares) that were used to monitor changes in wetland acreage for the watershed. The plots located on the watershed boundary were included in the sample draw if at least 10% of the plot was located within the watershed boundary. This limit was set so areas along the watershed boundary would be included in the sample draw but would not overly influence the sample site selection.

B.3) Constraints on Data Collection

As with any study design, there is always a potential for limitation in outcomes due to data elements, unknown/unforeseen sampling restrictions, etc. Use of data for this analysis was limited by 1) original NWI mapping techniques and 2) ability to determine differences between NWI maps and current aerial photography. Descriptions of these issues are presented below.

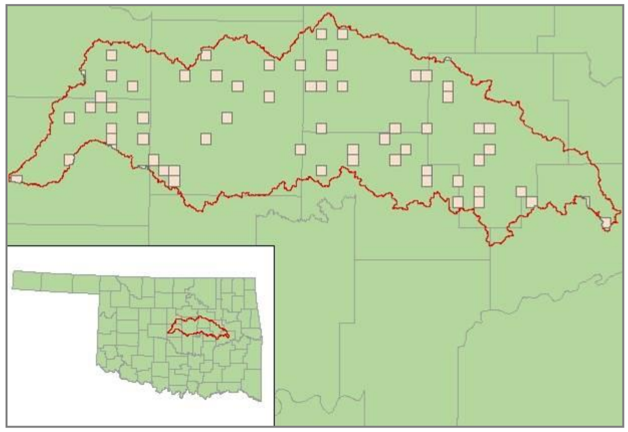


Figure 2: Probabilistically Selected Sample Sites in the Deep Fork River Watershed

B.3.1) Original NWI mapping techniques: The NWI maps were created by using aerial photography to determine wetland locations and areas. Wetlands were classified according to the hierarchy created by Cowardin et al. (1979). Based on this work, appropriate methods for classification have been and continue to be conveyed through Jim Dick with USFWS, Albuquerque, New Mexico. Although most classifying of the latest coverage was straightforward, some classes were more difficult than others to designate, particularly in the case of palustrine forested vegetation. Information provided by USFWS Status and Trends indicates much more of this vegetation type currently than has been previously delineated. Attempting to accurately assess this vegetation type outside of a direct survey was challenging, and best professional judgment was used to delineate these palustrine forested wetland areas.

B.3.2) Ability to determine differences between NWI maps and current aerial photography: The process of estimating the changes in wetland area between the early 1980s and the present was interactive. First, the NWI maps were overlain and adjusted to fit the current aerial photography to account for shifts of wetland polygons in the NWI layer on the aerial photographs to ensure false changes in wetland area were not recorded. Then, actual changes from the NWI maps and current aerial photography were mapped so the differences between the two periods could be calculated. Best professional judgment was used to determine shifts in NWI wetland polygon data and real changes in wetland area.

Identifying changes in wetland area was an iterative process involving analysis of existing data layers in Geographic Information Systems (GIS) in conjunction with aerial photograph interpretation. For the purposes of identification, wetlands were the areas identified by NWI mapping procedures and areas depicted from aerial photography as existing, created, or restored wetlands. GIS data involved in the analysis included the National Wetlands Inventory (NWI) layer and the National Agriculture Imaging Program (NAIP) imagery. Wetlands had been mapped in the NWI dataset in the Deep Fork watershed, and these areas were the target population. The NWI data layer was overlain on aerial photographs from the NAIP and reviewed to determine the current state of digitized wetlands and to identify additional wetlands that have been created or restored since the development of the NWI dataset in the 1980s. Aerial photography reviewed included imagery from 2003 through 2006 and 2008. The changes in wetland acreage, both positive and negative, were digitized in new datasets that were compared with the original NWI dataset to determine net gain or loss of wetland area.

C) Results

C.1) Aerial determination of Wetlands

It was determined that an average of 48 acres/mi^2 of wetlands (standard deviation 77 acres/mi^2) were within the sample plots based on recent aerial photography, while there were 36 acres/mi^2 of wetlands (standard deviation 65 acres/mi^2) depicted in the sample plots for the NWI data layer created in the early 1980s. Overall, between the time of the NWI wetland surveys and our current determinations of wetlands within the Deep Fork Watershed based on recent aerial photography (approximately 25 years), there was a net increase of 12 acres/mi^2 (28%) of wetlands (standard deviation 16 acres/mi^2) within the sample plots.

Palustrine forested wetlands were the dominant wetland type in the sample area within the Deep Fork watershed, occupying 7,830 of the 12,128 acres (65%) of wetlands in the sample area. Previous NWI palustrine forest designations within the sample area totaled 6,315 acres, so there was an increase of 6.3 acres/mi^2 of palustrine forested wetlands between the map periods. While a net 1515 acre increase is realized for this wetland type, it must be considered that some of this change could be due to differences in the application of the two mapping methods, especially in determining the presence of this type of wetland.

Comprising the remaining majority of net wetland expansion, impounded ponds experienced an obvious and significant increase from the time of the NWI survey through 2008. Such ponds are included as wetlands and are labeled as either PUBFh/x (if they are intermittently flooded) or PUBHh/x (if they are permanently flooded). The area of this type of wetland nearly doubled since the original NWI survey, from 1,071 acres to 1,969 acres in the sample area, an overall increase of 3.7 acres/mi^2. An example of such change may be found in Figure 3, which depicts a sample plot within the Deep Fork Watershed. There were 27 impounded ponds covering 12.7 acres noted by the original NWI data layer (red border), while the current analysis indicates 57 impounded ponds (green border) totaling 26.8 acres.

C.2) Field Verification

To qualify confidence in interpretations of the latter maps, six sample plots out of the total 65 were field verified on September 17, 2010. Within each of these sample plots, only a portion of wetlands were ground-truthed due to limited accessibility (landowner permissions). Where areas could be accessed, verification was 100% in agreement with 2008 wetland determinations. Figure 4 shows one of the six sample plots and demonstrates the level of ground-truthing within the sample plots. Wetlands enclosed in the red rectangular boxes were field-verified.

To further verify actual wetland loss versus artifacts of digitization, a certain number of NWI designated wetland areas which did not have a 2008 wetland designation were field examined to see if there was in fact a wetland there. In two instances, obvious human modifications of the landscape since the time of the initial NWI surveys had resulted

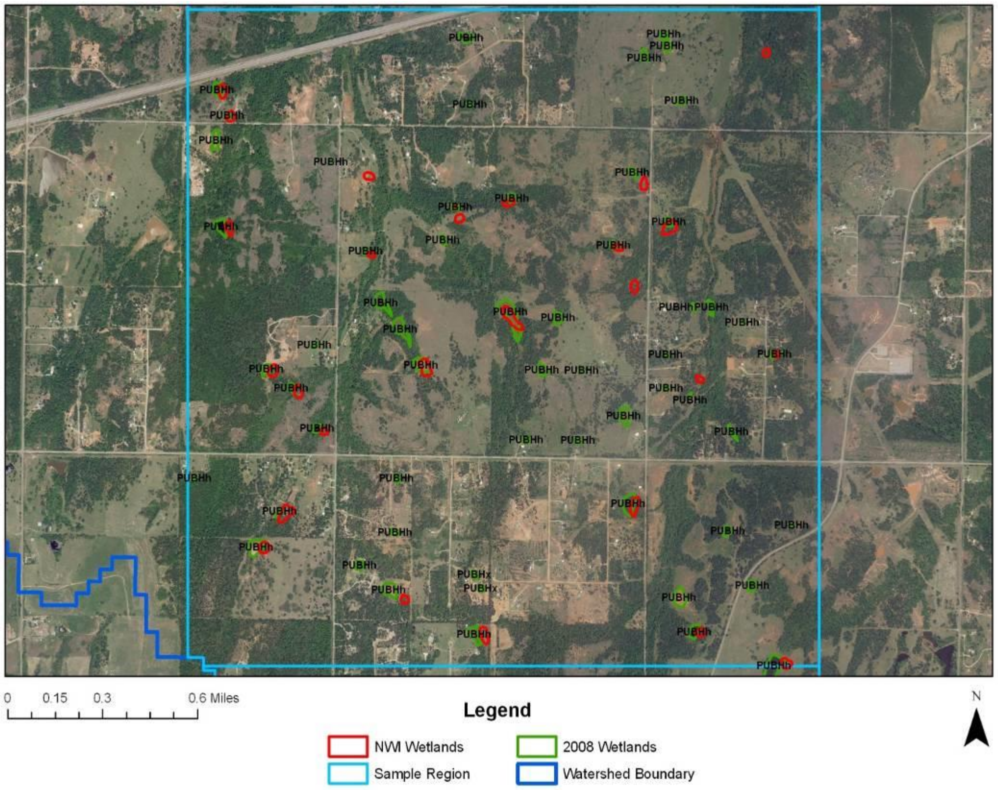


Figure 3. Comparison of wetland determinations based on original NWI methods and 2008 methods within a sample plot of the Deep Fork Watershed. Many of the 2008 wetlands (green) are artifical ponds classified as wetlands.

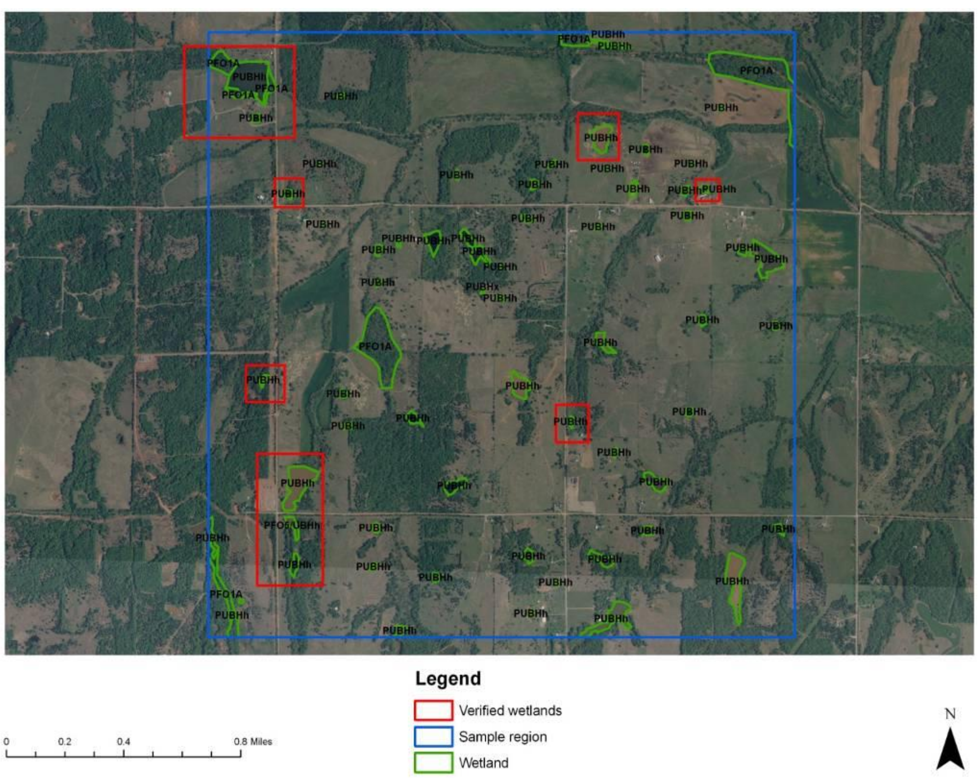


Figure 4. A sample plot within the Deep Fork Watershed. Wetlands shown here were digitized from aerial photographs. Wetlands within red boxes were field-verified.

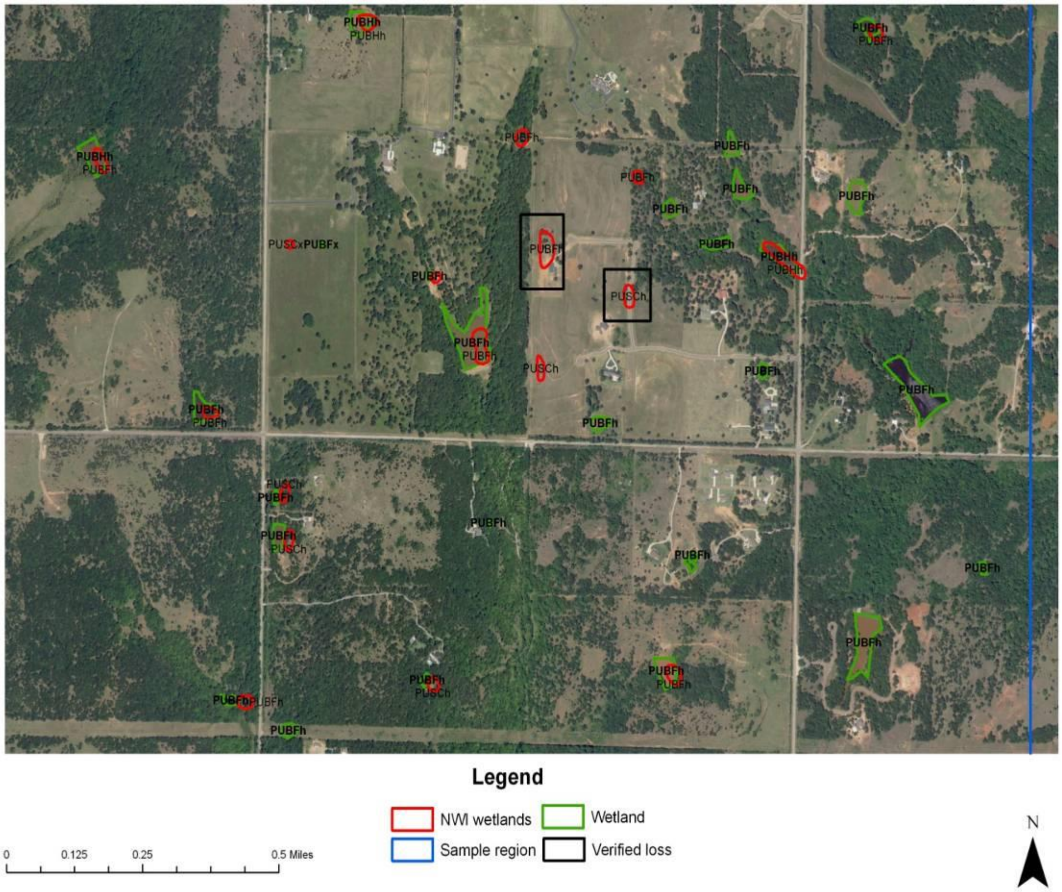


Figure 5. Field verified wetland loss due to development in one sample plot.

in wetland loss (Figure 5), which was the case for most sample plots. Nonetheless, field verification in one sample plot did note an area that seemed to clearly contain palustrine vegetation that had not been digitized. Although this was not an extensive finding, a greater field survey effort would be necessary to resolve the level of consistency in interpretation of these often ambiguous wetland areas.

D) Discussion

Based on this pilot study, desktop comparison of changes in digitized wetland resources through time is viable, with noted exceptions. Comparing wetlands which were delineated using original NWI methods with those delineated using more recent aerial photos to assess wetland gains and losses could result in some error when certain wetland types which are prone to misidentification are involved (e.g., palustrine forested wetlands). For areas where interpretive error for delineation is minimal, a similar approach should yield even stronger results.

Results of this study show an overall 28% increase in wetland resources from the early NWI map period through 2008. The bulk of the increase is attributed to increases in palustrine forested wetlands and man-made ponds (a subset of these). The reader is cautioned to interpret this increase with the following qualifications: 1) accurate digitization and attribution of palustrine forested wetlands is more difficult than other wetland types and could have affected the numbers, 2) the increased number of man-made ponds (which are classified as palustrine wetlands) inflated the total wetland area in the 2008 determination versus the original NWI determinations, and 3) programs such as the Wetland Reserve Program (WRP) have resulted in the protection and restoration of wetlands thus lessening any loss estimates.

The first possible cause of the calculated increase in wetlands results from the fact that palustrine forest designations are very difficult to make from aerial photography. Two sources were used to help make these designations, and these sources provided conflicting information. The NWI designations were generally conservative, designed to err on the side of omission, so small and/or drier wetlands or those difficult to interpret were not likely to be digitized in the original coverage. The U.S. Fish and Wildlife Service's Wetland Status and Trends dataset for 2004-2009, on the other hand, was much more liberal in defining what constituted palustrine forest wetland types. Figure 6 highlights a region within a Status and Trends sample plot labeled as palustrine forest.

Upon closer inspection, it appears that a small stream is running through this forested region, as evidenced by the thin strip of woody vegetation entering the broader area of forest in the upper portions of the image. This stream apparently creates marshy or swampy conditions within the forest and thus received a palustrine forest designation by the USFWS even though this region was not labeled as palustrine forest in the previous NWI wetland dataset. In similar instances in the Deep Fork study, it was difficult to decide what exactly constituted palustrine forest. Attempts were made to use a digital elevation model of the region and hydric soil information when determinations such as the one here were observed, but it was difficult to glean useful information from these two sources. For similar instances in future projects, it is recommended that the NWI

Figure 6. Designated palustring forest within a USFWS Status and Trends plot.

designation be used as the default to reduce any inflation/deflation bias in wetland gains/losses due to difference in digitization protocol.

The second potential source of the wetland gains calculated in the Deep Fork watershed is that the NWI data utilize the Cowardin system of classifying wetlands, which includes impounded ponds (palustrine unconsolidated bottom) as a wetland type. Thus, a significant portion of the observed increase in palustrine forested wetlands (ponds are a subset of these) may not actually be an increase at all, but rather a difference in the amount of area that was interpreted as wetland. Man-made ponds, although classified as wetlands for the purposes of this assessment, are low quality because they do not perform classic wetland function due to lack of general wetland vegetation and soils. This should be taken into account when analyzing the net change in wetland acreage. On paper, a net increase of 3.7 acres/mi^2 of wetlands is shown for impounded ponds which are classified as wetlands.

The third possible source of the observed wetland gains is that programs such as the WRP are successfully enhancing and expanding wetland areas. According to the Natural Resources and Conservation Services (NRCS), there are currently 4,364 acres enrolled in the WRP in the Deep Fork watershed under permanent easement and an additional 750 acres pending enrollment in the program. The WRP purchases easements (permanent and 30 year) to restore degraded wetlands and associated buffers. Restoration includes embankments, excavations, and water control structures, as well as bottomland hardwood plantings and native grass establishment in buffer areas. WRP started in Oklahoma in 1996 and currently has 60,000 acres enrolled in 50 counties statewide, so it is highly likely that at least some of the observed increase in wetland area is attributable to this program.

Overall, the assessment of the data in this project showed a net increase of 12 acres/mi^2 of wetlands from the initial maps to the current maps. It is most likely that a combination of the three potential reasons for this increase discussed above led to this result. Even if the increase in wetland area is accurate, this change is not statistically significant given the large overlap of variance for estimates between the two periods. The statistically qualified results of this study's probabilistic approach indicates, perhaps, the need for a greater target sample volume for this sort of analysis.

The original NWI maps provided a good basis for showing wetland areas, and when compared with the more recent maps, some indication of wetland gains and losses was possible. However, this project highlights the importance of being able to distinguish and exclude farm ponds from the NWI maps in order to prevent the artificial inflation of wetland gains. Obtaining information about newly installed ponds from local programs that provide funding to install ponds or from landowners themselves would greatly enhance the accuracy of the wetland maps. Perhaps this could be accomplished using a probabilistic scheme, as in this study, rather than obtaining information on every pond in a watershed, and then extrapolating the results to estimate the farm pond area relative to wetland area.

As more advanced imagery becomes readily available (e.g., Oklahoma will soon have the opportunity to obtain statewide color-infrared and Light Detection and Ranging [LIDAR] data), the state will be able to make more accurate estimates of wetland extent. Also, the inclusion of soils data should be considered further to better clarify areas which are hard to classify. Desktop delineation of wetland boundaries and tracking of wetland gains and losses as employed in this project has much potential, but it is necessary to address the issues uncovered through this study to increase the accuracy of these determinations.

E) References

Cowardin, L. M., V. Carter, F. C. Golet, and E. T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Fish & Wildlife Service, Washington, D.C.

Stevens, D.L. and A.R. Olsen. 2004. Spatially balanced sampling of natural resources. *Journal of the American Statistical Association* 99(465) March: 262-278.

IV. DEVELOPMENT OF THE INTERACTIVE WEB PAGE MAPPING SYSTEM

A) Hardware and Software Environment

The new Interactive Wetlands Mapping System (IWMS) was built using ESRI's ArcGIS Server 9.3.1 and the Silverlight application programming interface (API). This software is a web server based application for delivering interactive map data. The application is hosted on a Dell PowerEdge 2970 running Windows 2003 Server. The server is equipped with a single quad-core AMD processor and 4GB of RAM. Map files are stored on an external disk array. Equipment and software was provided by OWRB and is housed at the OWRB's main office.

B) National Wetlands Inventory (NWI) Data

The U.S. Fish & Wildlife Service maintains and hosts the digital NWI data in a geodatabase format. The completed Oklahoma NWI dataset was downloaded from this site.
(http://www.fws.gov/wetlands/)
The OWRB will periodically check the USFW's NWI site for updates and make changes as they become available.

C) Interactive Wetlands Mapping System Development

The standard ArcGIS Server user interface was extensively customized to increase usability. The user interface was developed using Microsoft's Silverlight API. This allows the maps to be accessed using most common web browsers including: Firefox, Internet Explorer, Chrome and Opera. A free Silverlight plug-in is required to use the IWMS.

Since the original IWMS was created, there have been several popular and user-friendly web mapping applications that been developed such as: Google Maps, Yahoo Maps, and Microsoft Bing Maps. The new IWMS was designed to have a similar appearance and functionality to these applications.

The wetlands mapping system has several map layers that the user can view depending on the type of information they would like to display. These layers are grouped into two categories, Map Layers and Base Layers.

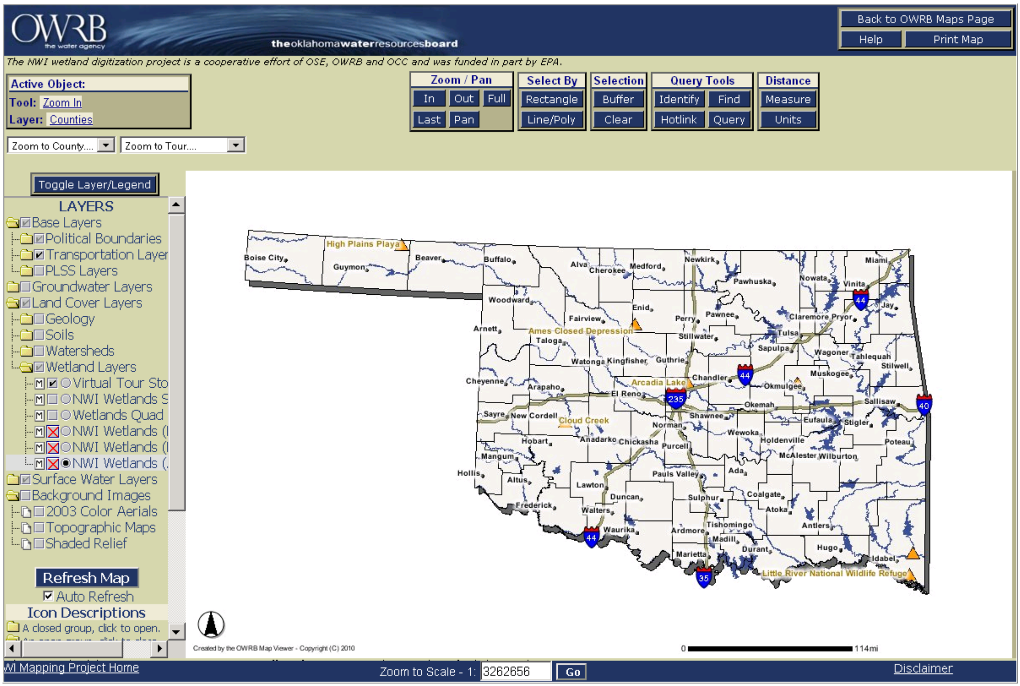
The Map Layers window contains six layers including: Virtual Tour Locations, NWI Wetlands, Hydric Soils, Public Lands, School Districts, and NWI Index Maps. The Virtual Tour Locations are linked to an interactive web site that describes the specific wetland characteristics of that particular wetland type. The NWI Wetlands layer contains the digitized wetland polygon areas. The Hydric Soils layer was included to aid in wetland identification. The School Districts layer was included to provide reference to educators and students wanting to identify wetland areas located near their schools. NWI Index maps provide the extent reference to the original NWI Wetlands paper maps.

The Base Layers window has four background options that the user can select. These include: Street Map, Aerial Imagery, Topographic, and Boundaries Only. The Street Map background contains transportation, hydrography, political boundaries, and places of interest. The Aerial Imagery background contains a combination of satellite imagery and aerial photography. The Topographic background displays the USGS topographic maps and shaded relief. The Boundaries Only background displays only the cities, county boundaries, and PLSS townships and sections.

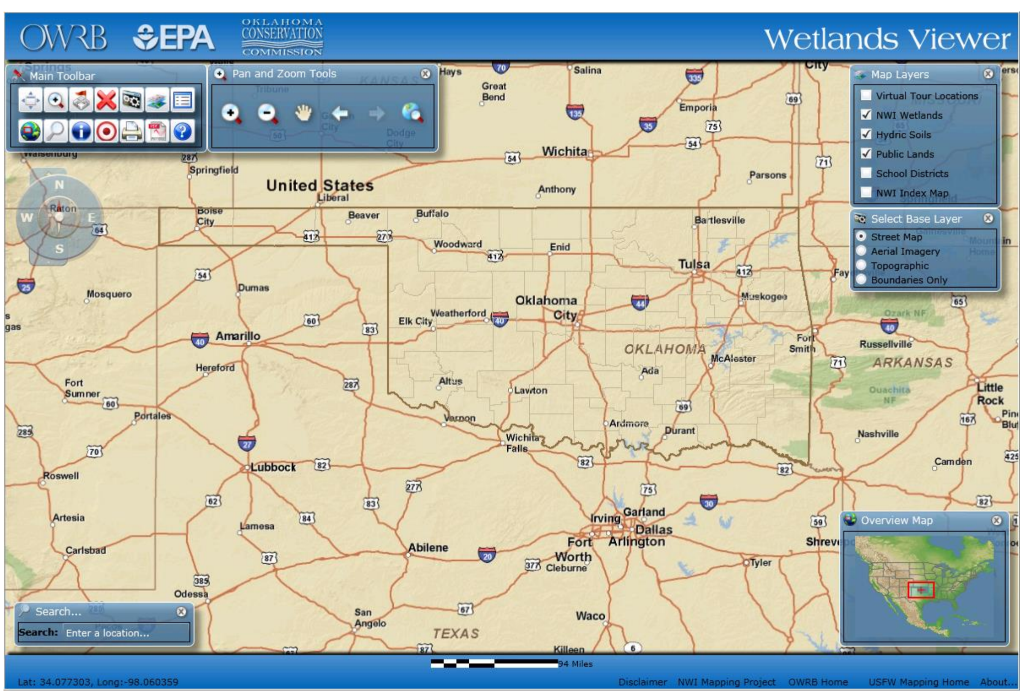
The IWMS can be accessed from the Oklahoma Water Resources Board's, NWI Mapping Project web site at: http://www.owrb.ok.gov/learn/wetlands/NWImaps.php

This page also contains links and information about exploring wetlands for professionals, wetland virtual tours, the Cowardin System Lookup, and scanned images of the individual historic NWI maps.

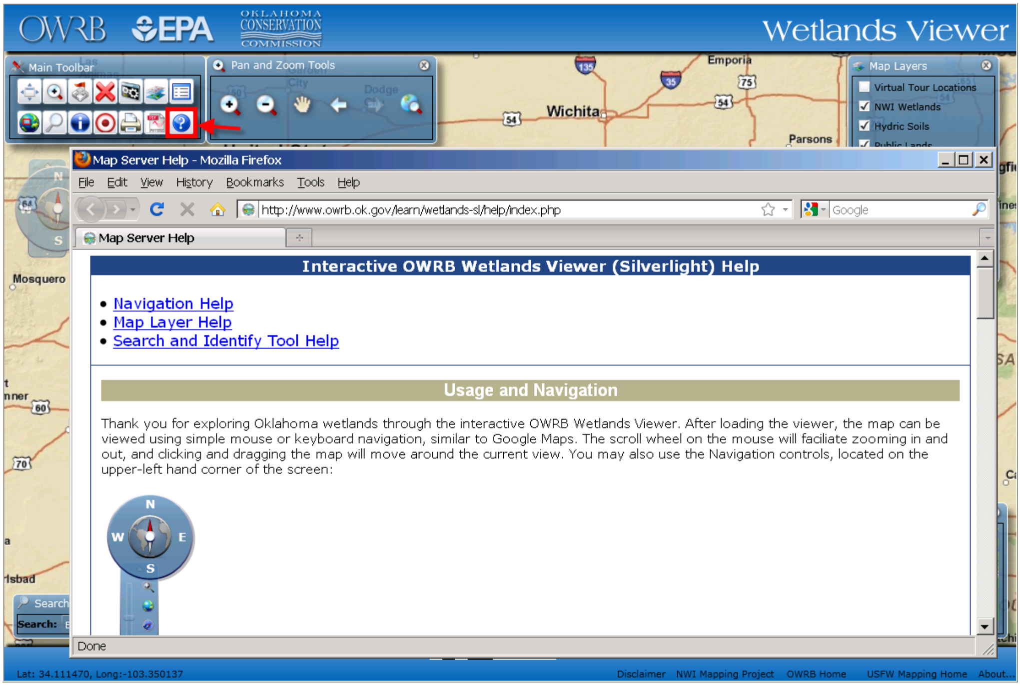
Original IMS Wetland Viewer



New ArcGIS Server Wetlands Viewer

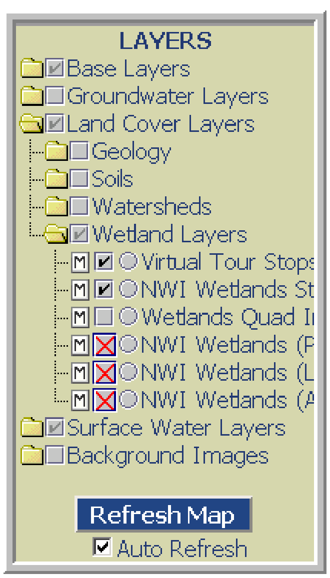


The standard ArcGIS Server user interface was customized to increase usability and to add query and analysis tools. To increase the site's usability, an interactive help page was developed. The help page can be accessed by clicking on the help icon in the Main Toolbar window, at the upper-left corner of the viewer. The page contains interactive demonstrations of the tools and features, answers to common questions, solutions to error messages, and a contact link to email questions for additional help.

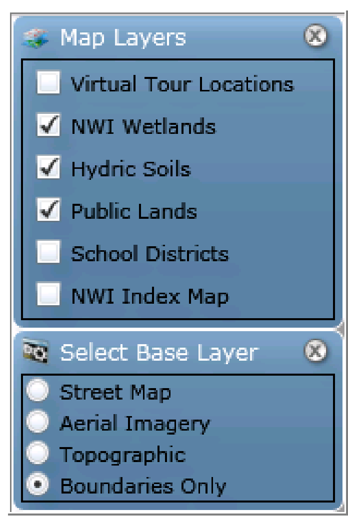


The table of contents, or Map Layers list, was redesigned to only include those layers specific to the Wetlands application. The other map layers are now combined in the Street Map base layer.

ArcIMS Map Layer List



ArcGIS Sever Map Layers List



V. FEATURES

In addition to the features provided by the software, custom features were added to make the IWMS system more user-friendly.

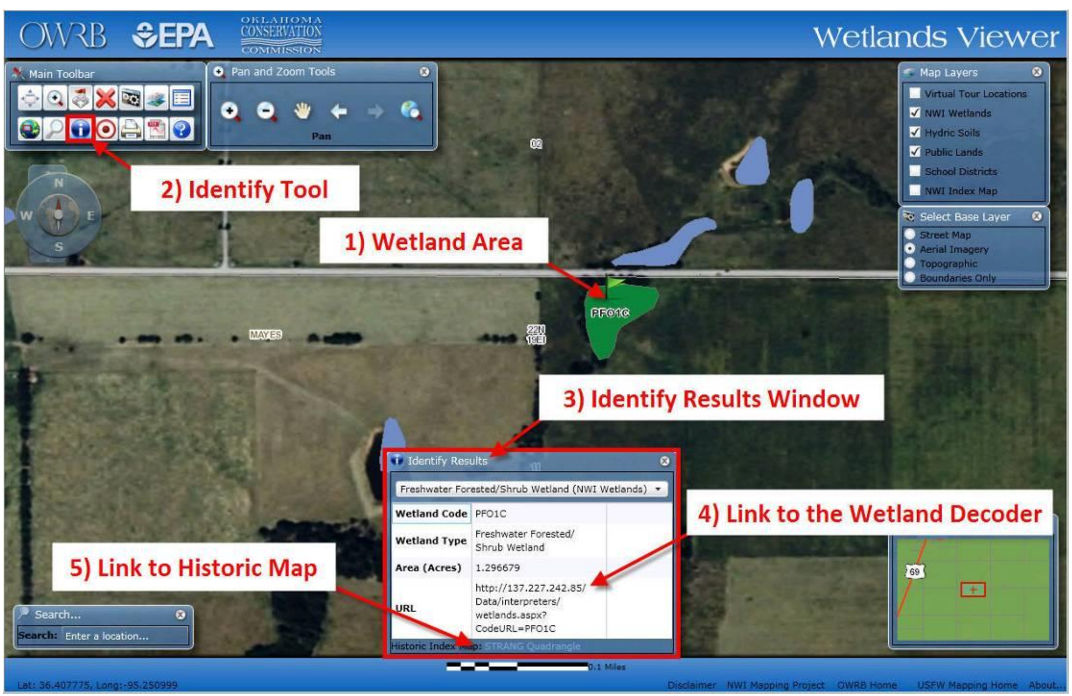
A) Wetland Identification

The “Wetland Code” field is the Cowardin system lookup code for the NWI wetland type. The explanation for the code can be found by clicking on the linked value in the “URL” field. This will open the Cowardin system lookup tool.

For this example the NWI wetland type for classification code “PFO1C” is:
(P)-Palustrine (FO)-Forested (1)-Broad-Leaved Deciduous (C)-Seasonally Flooded

The steps below describe how the user can obtain wetland information from the map viewer:

1) Zoom to a wetland area
2) Select the “Identify” tool from the Main Toolbar and then click on the wetland area.
3) The wetland attribute information will be displayed in the “Identity Results” window.
4) Click on the “URL” link in the “Identify Results” window to open the USFW NWI Wetlands Decoder Web Application
5) Click on the map name link to the right of the “Historic Index Map:” text. This will open a scanned image of the historic NWI Wetland Map.

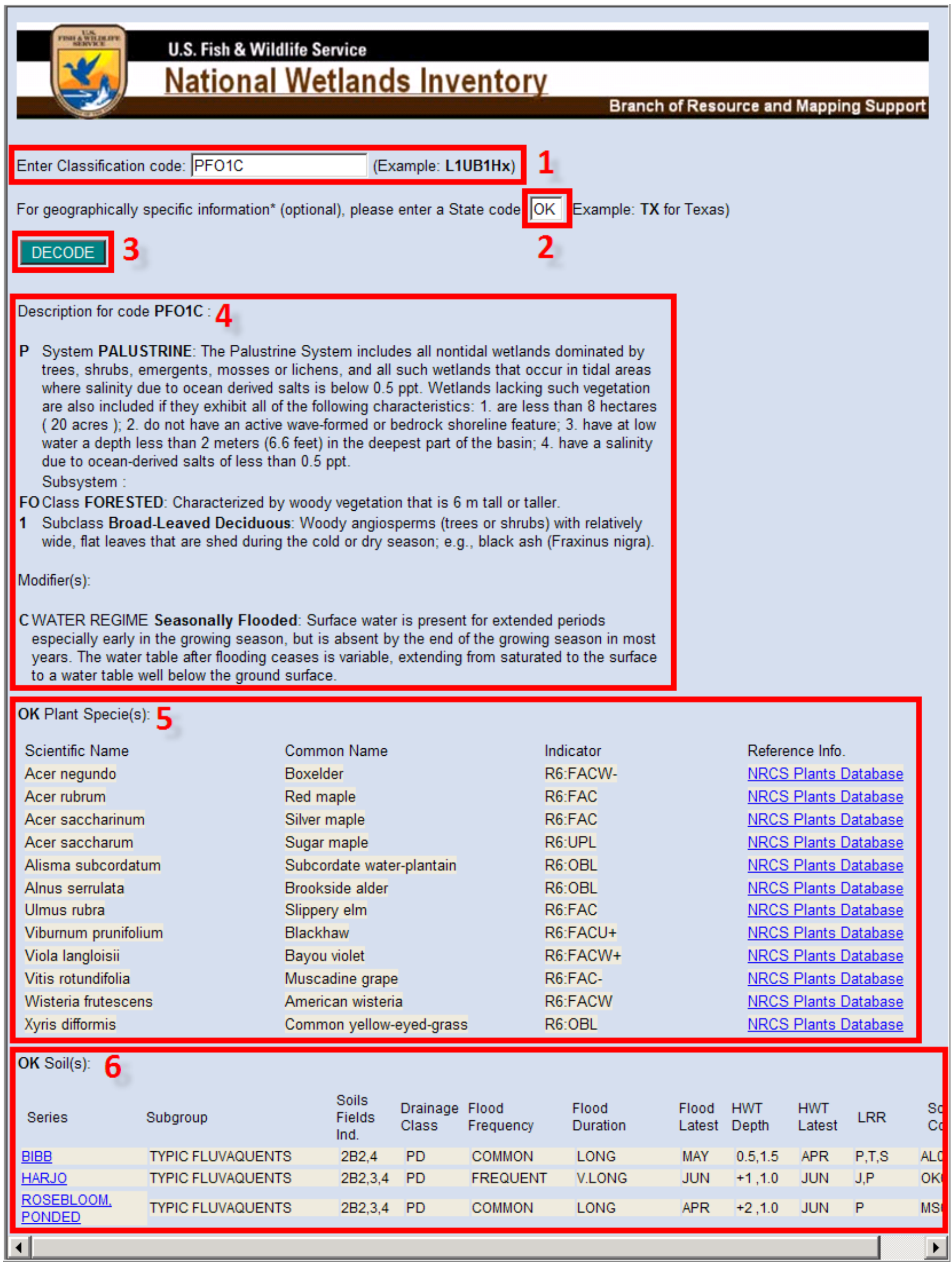


A new window will open displaying the information about the selected NWI wetland area.

USFW NWI Wetlands Decoder Web Application

1) Enter Classification Code: (This is automatically populated)
2) Enter the State Code: Enter [OK] for Oklahoma
3) Click the [Decode] button

Returned Classification Results
4) Description for the NWI Wetland Code
5) Displays plant species that are commonly associated with this wetland type
6) Displays soils that are commonly associated with this wetland type



U.S. Fish & Wildlife Service
National Wetlands Inventory
Branch of Resource and Mapping Support

Enter Classification code: PFO1C (Example: **L1UB1Hx**) 1

For geographically specific information* (optional), please enter a State code OK Example: **TX** for Texas)

DECODE 3 2

Description for code **PFO1C** : 4

P System **PALUSTRINE**: The Palustrine System includes all nontidal wetlands dominated by trees, shrubs, emergents, mosses or lichens, and all such wetlands that occur in tidal areas where salinity due to ocean derived salts is below 0.5 ppt. Wetlands lacking such vegetation are also included if they exhibit all of the following characteristics: 1. are less than 8 hectares (20 acres); 2. do not have an active wave-formed or bedrock shoreline feature; 3. have at low water a depth less than 2 meters (6.6 feet) in the deepest part of the basin; 4. have a salinity due to ocean-derived salts of less than 0.5 ppt.
Subsystem :
FO Class **FORESTED**: Characterized by woody vegetation that is 6 m tall or taller.
1 Subclass **Broad-Leaved Deciduous**: Woody angiosperms (trees or shrubs) with relatively wide, flat leaves that are shed during the cold or dry season; e.g., black ash (Fraxinus nigra).

Modifier(s):

C WATER REGIME **Seasonally Flooded**: Surface water is present for extended periods especially early in the growing season, but is absent by the end of the growing season in most years. The water table after flooding ceases is variable, extending from saturated to the surface to a water table well below the ground surface.

OK Plant Specie(s): 5

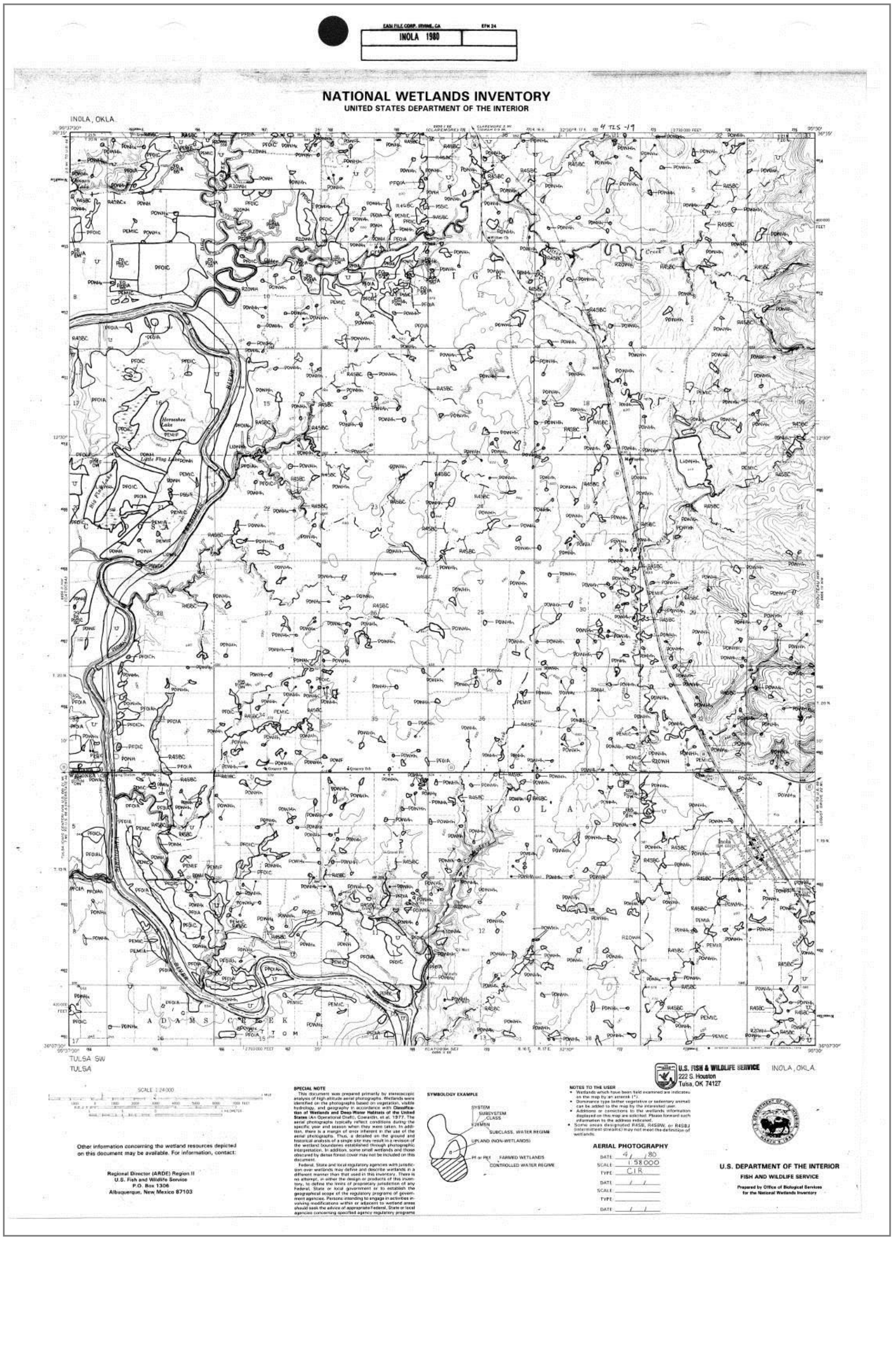
Scientific Name	Common Name	Indicator	Reference Info.
Acer negundo	Boxelder	R6:FACW-	NRCS Plants Database
Acer rubrum	Red maple	R6:FAC	NRCS Plants Database
Acer saccharinum	Silver maple	R6:FAC	NRCS Plants Database
Acer saccharum	Sugar maple	R6:UPL	NRCS Plants Database
Alisma subcordatum	Subcordate water-plantain	R6:OBL	NRCS Plants Database
Alnus serrulata	Brookside alder	R6:OBL	NRCS Plants Database
Ulmus rubra	Slippery elm	R6:FAC	NRCS Plants Database
Viburnum prunifolium	Blackhaw	R6:FACU+	NRCS Plants Database
Viola langloisii	Bayou violet	R6:FACW+	NRCS Plants Database
Vitis rotundifolia	Muscadine grape	R6:FAC-	NRCS Plants Database
Wisteria frutescens	American wisteria	R6:FACW	NRCS Plants Database
Xyris difformis	Common yellow-eyed-grass	R6:OBL	NRCS Plants Database

OK Soil(s): 6

Series	Subgroup	Soils Fields Ind.	Drainage Class	Flood Frequency	Flood Duration	Flood Latest	HWT Depth	HWT Latest	LRR	Sc Cc
BIBB	TYPIC FLUVAQUENTS	2B2,4	PD	COMMON	LONG	MAY	0.5,1.5	APR	P,T,S	AL
HARJO	TYPIC FLUVAQUENTS	2B2,3,4	PD	FREQUENT	V.LONG	JUN	+1 ,1.0	JUN	J,P	OK
ROSEBLOOM, PONDED	TYPIC FLUVAQUENTS	2B2,3,4	PD	COMMON	LONG	APR	+2 ,1.0	JUN	P	MS

Historic Map Index

The Historic Map Index is a link to scanned .pdf images of the individual NWI Wetlands maps. The maps can be downloaded and/or printed to the user's computer.

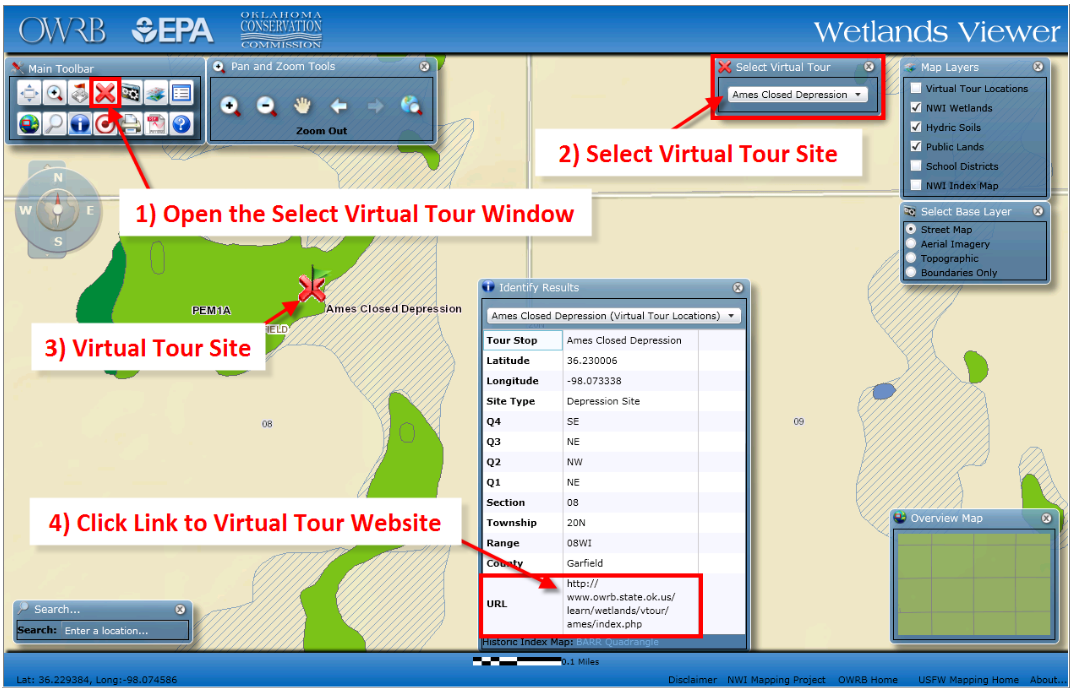


B) Custom Search Tools

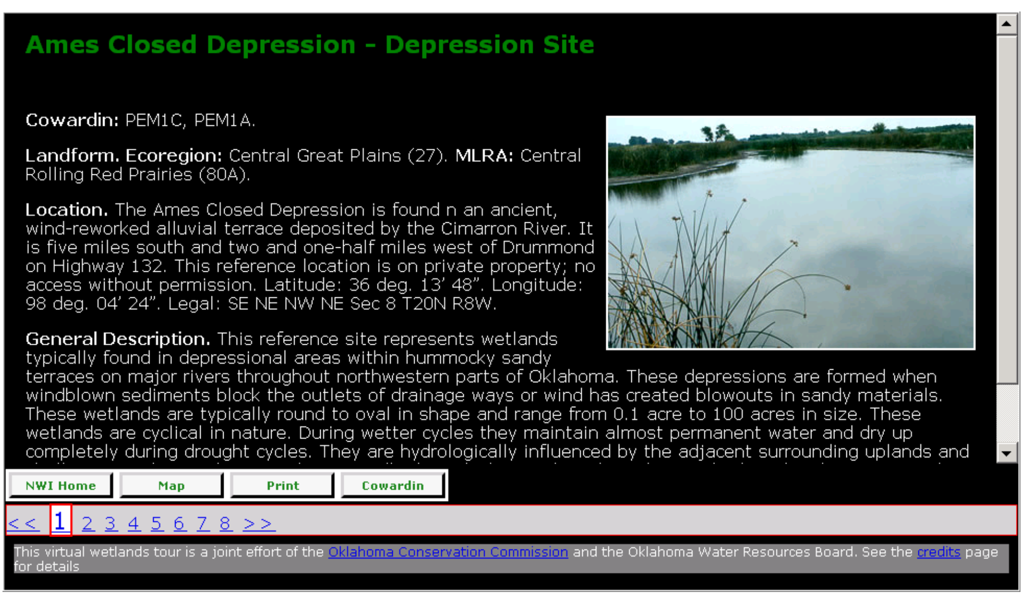
The “Select Virtual Tour”, “Select School District”, “Search”, and “Buffer a Point” custom search tools were added to allow the user to quickly zoom to a selected wetlands virtual tour stop, school district, place of interest, and NWI wetlands.

B.1) Select Virtual Tour:

The user clicks the “Select Virtual Tour” icon from the Main Toolbar and the selection window will open on the map. The user then selects which site they would like to visit and the map automatically zooms to the selected site. Attribute information about the site will open in the “Identify Results” window. The user can then click on the “URL” link to open the virtual tour web site for the site.



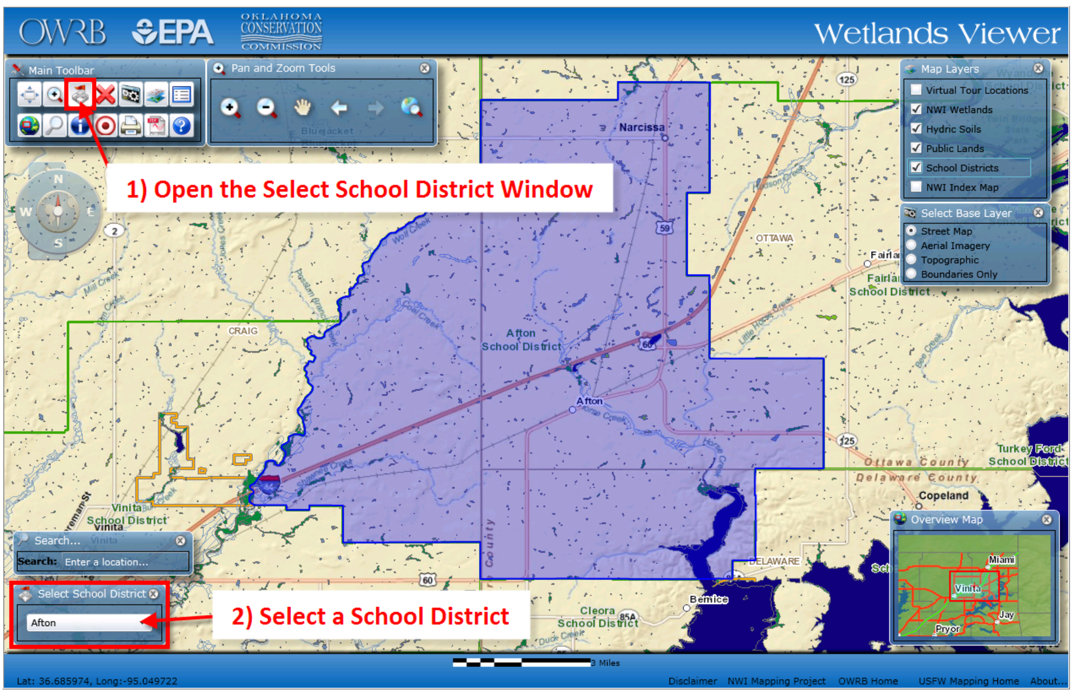
Virtual Wetlands Tour Website



The wetlands virtual tour application displays representative characteristics of the wetland type. These characteristics include; a general description of the site, wetland functions, vegetative community, hydrology, hydrologic indicators, soils, and wetland dependant wildlife species.

B.2) Select School District:

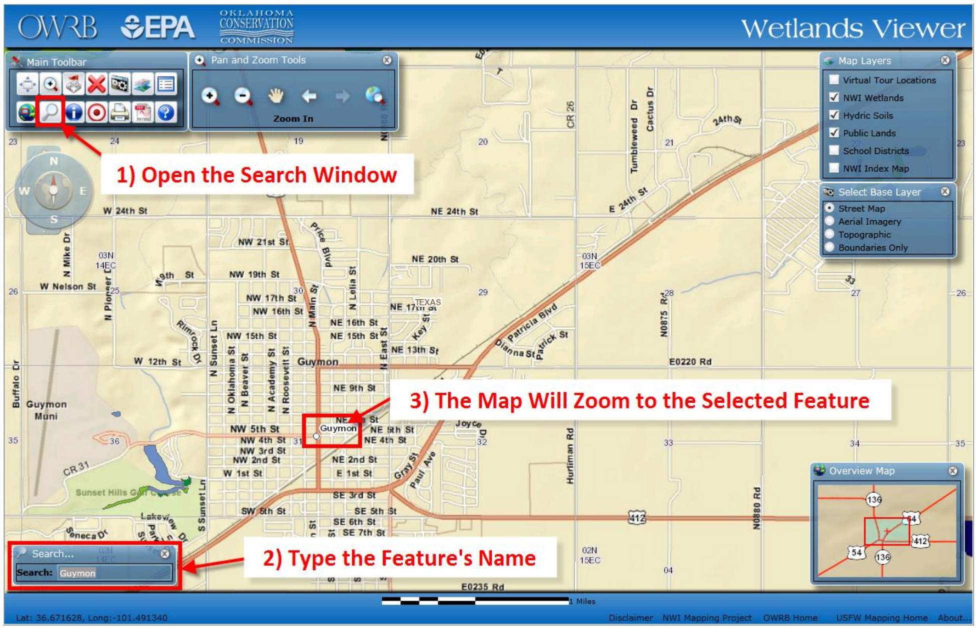
The user clicks the “Select School District” icon from the Main Toolbar and the selection window will open on the map. The user then selects which school district they would like to visit and the map automatically zooms to the selected district.



B.3) Search Tool:

The Search Tool can be used to select and zoom to cities, counties, places of interest, and other geographic features. The Search tool should be open when the map loads, but can also be turned on and off by clicking the “Show/Hide the Search Tool” icon from the Main Toolbar. The user then types in the feature name and the map automatically zooms to the selected feature.

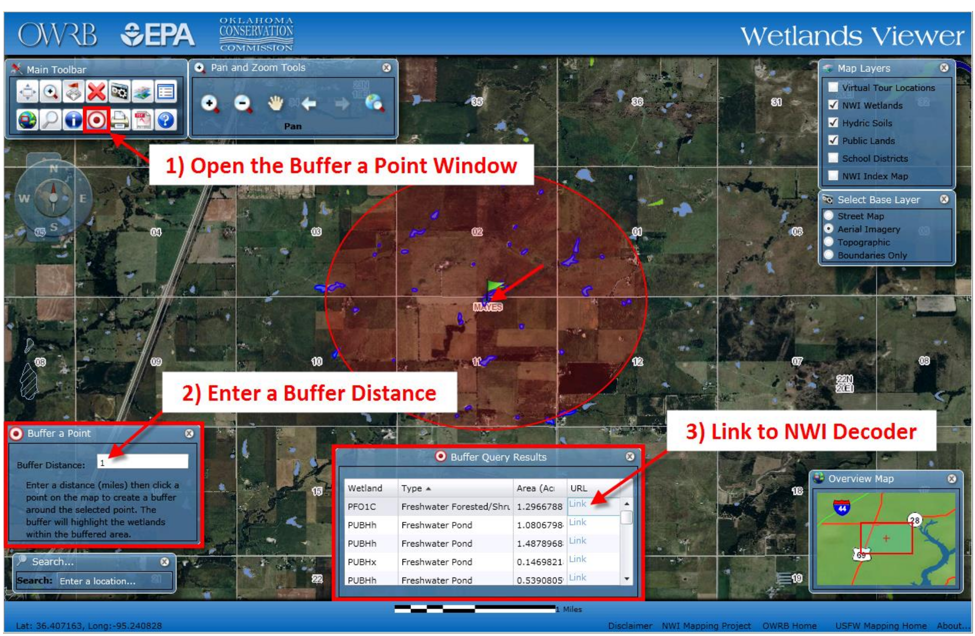
Search Tool



B.4) Buffer a Point Search Tool:

The Buffer a Point search tool allows the user to create a buffer around a user-defined point and selects all NWI wetland areas within the defined buffer radius. The tool can be turned on by clicking the “Buffer a Point” icon on the Main Toolbar. The user then enters a buffer distance and then clicks the point on the map where they would like to create the selection buffer. A list of the selected NWI wetland areas will be displayed in the Buffer Query Results window. The user can then click the URL Link to open the U.S. Fish & Wildlife NWI Classification Decoder page. The NWI classification code will automatically be populated. The user can enter “OK” in the State Code box and then click the “Decode” button. The page will then return the wetland description along with representative plant species and soil types.

Buffer Results



VI. CONCLUSION AND FUTURE PLANS

This project was a great success on several levels by utilizing partnerships among state and federal agencies, creating a usable digital format for wetlands maps, providing on-line access to wetland maps, enabling varied use of the maps through ArcGIS Server tools, and offering educational material to help users better understand wetland maps and wetland systems. The digital wetland coverage will be utilized by the state as a tool for tracking wetland status and trends, wetland monitoring, watershed planning, protecting and avoiding wetlands during development, locating areas for restoration, and updating the digital wetland coverage. The OWRB will continue to support, update, and maintain the Wetlands Viewer for the foreseeable future.

The OWRB and the Oklahoma Conservation Commission would like to give special thanks to Oklahoma State University, University of Oklahoma Center for Spatial Analysis, Oklahoma State Department of Education, Oklahoma Tax Commission Ad Valorem Division, U.S. Fish and Wildlife Service, U.S. Geological Survey, U.S. Natural Resources Conservation Service, ESRI, and the U.S. Environmental Protection Agency for their cooperation and/or use of data to support this project.