Remote Sensing Tools for Wetland Determinations

This is a description of remote sensing tools used by Pennsylvania NRCS for the completion of Certified Wetland Determinations. The use of remote sensing tools for Preliminary Data Gathering is described in Part IV, Section B of the 1987 Corps of Engineers Wetlands Delineation Manual ('87 Manual). NRCS staff use these and additional tools, as described below, to complete both Level 1 (Onsite Inspection Unnecessary) and Level 3 (Combination of Level 1 and Level 2 Onsite Inspection Necessary) Food Security Act (FSAct) wetland determinations. Part of "Job Approval Authority" to make FSAct determinations includes training in the selection and use of remote sensing tools, including historical aerial imagery, climate information, and geospatial data provided by the State GIS Specialist, Compliance Specialist, and within the NRCS Planning website Conservation Desktop.

Use of the following tools is described below:

- NRCS Wetland Tool
- USGS Topo Maps
- National Wetland Inventory (NWI)
- NRCS Soil Survey
- Digital Aerial Photography
- WETS Weather Data
- LiDAR

NRCS Wetland Tool - Pennsylvania NRCS utilizes an automated "Wetland Tool" developed by NRCS to synthesize geospatial information in ArcGIS for offsite evaluation of wetland criteria. Geospatial layers that are required for the Wetland Tool include the Farm Service Agency's CLU layer, SSURGO hydric soils data, LiDAR high resolution digital elevation models (DEMs), Ortho imagery, USGS National Hydrography Dataset (NHD), National Wetland Inventory (NWI), and the Statewide Certified Wetland Determination (CWD) layer.

USGS Topo Maps – Also referred to as USGS Topographic digital raster graphics and United States Geological Survey (USGS) 7.5 Minute Series Quadrangle Maps. These are part of the the standard data provided in geodata distributed by the State Office and Conservation Desktop. The data is also be accessed on the National Map (http://nationalmap.gov/). USGS topo maps provide marsh or swamp symbols for wetter areas as well as the general agricultural status of the land relative to the date of the map (e.g. cleared ground that could be either cropland or pastureland, forested, or urban). Water bodies such as streams and ponds are identified and manipulations to those waters such as channelization or existing levees may be noted. Site relief is one of the most important aspects of the topographic map. Contours enable the user to make decisions relative to the site's ability to charge and retain wetness, and to recognize drainage patterns.

Limitations -

1. Check the date on the map or in the metadata for the date of revision. This may help determine a time range when changes occurred.

2. USGS protocol was generally to delineate the wet areas mapped based on the driest season of the year, which may have missed several wetlands.

National Wetland Inventory (NWI) - The U.S. Fish and Wildlife Service NWI is an offsite delineation of potential wetlands that began in Pennsylvania in the late 1970's. The NWI is an available tool that mapped potential wetlands when wetland losses were accelerating in the 1970's and 80's due to agricultural conversions and other wetland stressors. The NWI is accepted by USFWS, USACOE, EPA and NRCS as a first cut indicator tool for the presence of wetlands. The NWI data is provided as a standard provided in geodata distributed by the State Office. Alternatively, the most current NWI maps can be found at http://www.fws.gov/wetlands/.

Plant community and hydrologic condition are key components of the NWI, and these interpretations were made at a time critical for making decisions relative to the Act. Because the first iterations of NWI in Pennsylvania were commenced in the 1970's, the historical data provides an indication of the status of wetlands around the critical December 23, 1985 date. Hydrologic condition was interpreted using several water regime modifiers. The 1987 Corps Wetland Delineation Manual states in Part IV, Section B chapter 54 that areas mapped as "wetter" than temporarily flooded and intermittently flooded have extremely high probabilities of meeting the wetland criteria (in excess of 90 percent). The historical NWI also indicates possible manipulations to wetlands that were photo-interpreted from the base map utilized in the evaluation.

Limitations -

1. The NWI mapping protocol was developed prior to the accepted federal definition of wetlands contingent on the three parameters of soils, hydrology, and plants. Consequently, some of the early delineations may have only been based on the two parameters of hydrology and plant species. This was somewhat corrected with soils between the draft remote sensing interpretations and the final interpretations.
2. The inventory was remotely sensed with generally no more than 5% ground truthing in any given state.
3. The inventory often fails to capture open land wetlands, such as farmed wetlands, as defined under the Food Security Act of 1985, as amended, because of cropping activities and/or disturbance of plant communities.

NRCS Soil Survey - Soils information and whether soils are "hydric" is a primary tool for making offsite wetland determinations. Soils information is easily acquired and reviewed on the NRCS field office geodata server and Conservation Desktop. It is also available on the following websites:

1. State Soil Data Access (SDA) Hydric Soils List:
   https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcseprd1316619.html

2. Web Soil Survey:
   https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm
   1) Navigate to your area; 2) Define area of interest; 3) Select Soils Data Explorer Tab; 4) Select Soil Reports Tab; 5) Land Classification; 6) Hydric Soils, then click on ViewSoil Report

3. SoilWeb and SoilWebEarth:
   https://casoilresource.lawr.ucdavis.edu/soilweb-apps/

4. Official Soil Series Descriptions (OSDs): https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/geo/?cid=nrcs142p2_053587

Soil map unit hydric rations include: "all hydric," "partially hydric," "not hydric," or "unknown hydric," depending on the rating of the soil map unit's respective components. "All hydric" means that all components listed for a given map unit are rated as being hydric, while "not hydric" means that all components are rated as not hydric. "Partially hydric" refers to a soil that has at least one component of the map unit that is rated as hydric and at least one component that is rated as not hydric. "Unknown hydric" indicates that at least one component is not rated so a definitive rating for the map unit cannot be made. For offsite determinations, personnel are trained to identify landform position using LiDAR hillshade and contours to evaluate whether soil map unit components are in a of landform position that is in a concave or water receiving position.

Limitations -

The published soils data is a tool that provides evidence to the possible presence of a wetland. However, some of the limitations to the published soil survey relative to offsite hydric soil determinations are:

1. All soil surveys rely on, and therefore reflect, data that were gathered during a specific period of time. Natural events, land use changes, or human manipulations may have affected the landscape and now result in outdated or inaccurate soils data. Additionally, some wetlands, such as floodplain wetlands, naturally evolve over time into non-wetlands.
2. A "hydric soil" component listed in the report may have properties that do meet hydric soil criteria. However, the entire range of characteristics of soil components classified to the series level may not be entirely within the range of properties for a "hydric soil." Hydric soil criteria were developed separately from Soil Taxonomy. Therefore, any given component (series) may have a range of characteristics that is not entirely within the range for hydric soils even though the series is poorly or very poorly drained.
3. Almost all of the soil maps in the state were originally drawn at a relatively small scale (either 1;12,000 or 1:24,000), so some minor displacement of soil lines may be observed. Additionally, much of the digital spatial data available were created by recompiling and digitizing these hard copy maps. Errors such as mislabeled map units and spatial displacement are accidentally introduced as a result of the analog to digital conversion process. If an error is suspected for any reason, an original hard copy of the information should be consulted when available.

Digital aerial photography

The Farm Service Agency (FSA) aerial imagery products are NHAP, NAPP, and NAIP. Available imagery types may be Color infrared (CIR), Natural Color (NC), and Black/White (BW).

The currently acquired imagery by FSA, NAIP, is digital ortho imagery acquired during the agricultural growing season (leaf on) and the FSA uses this imagery primarily to verify agricultural conditions for USDA programs. The NAIP provides one meter ground sample distance (GSD) ortho imagery rectified within +/- 6 meters to true ground at a 95% confidence level.

From the 1980's through the 1990's, the FSA purchased county-wide high altitude flights for resource assessments, verification of fields planted, and types of crops grown. The spring flights make these sources of imagery very valuable for wetland determinations because they occur during the normal hydrologic period of recharge for the majority of the wetlands in the state. The NAIP imagery in GIS is available in all field offices, and certain flight years have the capability of being displayed either in natural color and CIR.

Because Farm Service Agency imagery may be available on or around the key years for the FSA of 1985 and 1990, and because the timing of photos coincides with normal hydrology for many wetlands, **this imagery is one of the most important tools available for making good offsite wetland determinations or decisions for requiring onsite investigations**.

In addition to FSA, aerial imagery is available from a number of sources, such as:

- Google Earth – Timeline of imagery from 1990s to present.
- Penn Pilot photos from the 30's, 60's, and 70's (http://www.pennpilot.psu.edu/)
- Imagery acquired locally from the County Tax Office.
- USGS EarthExplorer site (http://earthexplorer.usgs.gov/).

Limitations -

Some of the limitations of aerial photography are:

1. Many of these sources are not geo-referenced and therefore cannot be added to a base map.
2. Low crop producing counties may have fewer available years of imagery.
3. Many counties in the state have discarded early years of crop compliance slides.
4. Early year crop compliance slides have no mapping index and consequently are hard to organize and use.
5. Based on the actual flight date and the type of film, the imagery may be limiting relative to some interpretations. For example, flights in the growing season (e.g. leaf on) may result in mis-interpretations of potential wetland features. In natural color images water, wetland understory plants, and drainage patterns may be obscured by the canopy of a mature forested cover.
6. Normal climatic conditions (i.e. pre-flight rainfall patterns) assessed for the flight may still not accurately reflect the actual onsite condition due to local variability.
7. Early year crop compliance slides may experience some fading of colors, although this rarely results in the masking of gross landscape features.

Determining the date of the imagery is critical when using photo-interpretations of imagery for wetland determinations. The actual date of the flight allows the reviewer to evaluate the climatic condition both for growing season decisions and for rainfall amounts and time of storm events. Actual days of the flight may be printed on the hard copy imagery or can be found in the metadata of digital imagery.

WETS Normalization Tables -

WETS normalization tables have been produced for all the Pennsylvania climate stations and provided to aid in aerial image reviews of wetland hydrology. The normalization tables use the WETS precipitation data to compute past moisture in the vicinity of the station. The computation determines whether

conditions captured in an aerial image would have been relatively "normal", "wet" or "dry" during the months for which rainfall records are available.

The pre-flight climatic assessment (antecedent moisture condition) supports the quality of each flight year of imagery as a tool. By documenting that the normal condition relative to rainfall existed just prior to the flight, good wetland hydrology decisions can be made. Flight dates that occur within the growing season support the wetland definition. However, imagery flown outside of growing seasons should still be considered tangible evidence for the hydrologic condition during the growing season if similar rainfall amounts are expected during growing season months. Such leaf off imagery may better display drainage patterns.

The methodology to complete this climatic assessment can be found in Chapter 19 of the NRCS National Engineering Field Handbook (Hydrology Tools for Making Wetland Determinations). Each month's rainfall amount is determined to be within the range of normal when it is within 30% to 70% of the monthly average. The three-month rainfall period is then assessed as a weighted average for the imagery, with more emphasis placed on the period just preceding the flight date. This assessment is used to determine the climatic condition prior to the flight.

Normalization tables were created from the WETS tables are available online at: http://agacis.rcc-acis.org/ . The weather station closest to the potential wetland site should be the first source of rainfall data. If rainfall data is unavailable for the needed period of assessment, analyze rainfall records from more than one station on each side of the site in order to bracket the site and support that the site received rainfall amounts similar to station data results.

Wetness signature interpretations:

Wetness signature is a change in appearance of a site from the surrounding land readily visible on aerial photography due to excessive moisture or wetness for this offsite wetland determination method. Indicators of wetness signature include:

a. Standing water;
b. Flooded or drowned areas within agriculture fields;
c. Stressed vegetation (e.g. leaf yellowing, timber kills, etc.);
d. Differences in vegetation color due to management, such as delayed planting or harvesting;
e. Isolated and/or irregularly shaped areas not managed similar to rest of the agricultural field (i.e. not cropped, not harvested);
f. Patches of lush or greener vegetation, which may be especially pronounced in a drier than normal image or during a drought.

It is important to confirm the landscape position and relief of the site when making wetness signature interpretations. Recognize that similar irregular patterns on upland sloping agricultural areas may be such things as fertilizer skips, seeding skips, gully erosion, herbicide drift, or exposed subsoil rather than wetness signature.

Ground-truthing is not required to make an offsite wetland determination. However, it is an important consideration for making sound remote sensing interpretations and should be a part of the training protocol for any wetland specialist using this method.

Wetness signature is always easier to detect from imagery in open agricultural areas because of the physical responses of plant communities to wetness or dryness after periodic agricultural disturbances. In cropped areas, bare ground will periodically be the condition of the site in some flights. Forested areas are harder to remote sense for wetness signature due to leaf cover, shadows, lack of disturbance and lack of visible response by the forest community to minor changes in wetness. For that reason, the user may be able to interpret wetness signature within forested areas from the open agricultural areas adjacent to those areas when characteristics such as relief and drainage pattern are considered.

Digital Elevation Models and LiDAR

In wetland applications, LiDAR Digital Elevation Models (DEMs) and other LiDAR derivatives can be used as a remote sensing tool to aid in determining potential wetland geomorphology and detailed local drainage patterns by providing very accurate elevation, relief, contour, and slope maps. DEM, hillshade relief, slope, and contours are standard LiDAR derivatives that are available in the Wetland Tool.

LiDAR Limitations

1. LiDAR data was collected after enactment of the Food Security Act. As a result, LiDAR data may not always be useful in interpreting presence/absence of manmade drainage features such as ditches prior to 1985.
2. Depending on the date of the LiDAR data collection, LiDAR data may not depict recent changes to the landscape including ditch cleaning, diversions, terraces, etc.