GeoSpatial Services
Saint Mary's University
OF MINNESOTA

Quality Assurance Project

Missisquoi River Basin Wetland Mapping

Quality Assurance Project Plan

Missisquoi River Basin Wetland Mapping

Prepared for:

Vermont Department of Environmental Conservation – Laura Lapierre, Wetland Program Manager

VERMONT
DEPARTMENT OF ENVIRONMENTAL CONSERVATION

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Prepared by:

Kevin Stark and Andy Robertson
Saint Mary's University of Minnesota, GeoSpatial Services
Prairie Island Field Station
890 Prairie Island Road
Winona, Minnesota 45987

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Acronyms

CWA	Clean Water Act
DEM	Digital Elevation Model
DOQQs	Digital Ortho Photo Quarter Quads
DRG	Digital Raster Graphics
EPA	United States Environmental Protection Agency
ESRI	Environmental Systems Research Institute (GIS software company)
FGDC	Federal Geospatial Data Committee
FTP	File Transfer Protocol
GIS	Geographic Information Systems
GPS	Geographic Positioning System
GSD	Ground Sample Distance
GSS	Saint Mary's University of Minnesota, Geospatial Services
HGM	Hydrogeomorphic
HUC	Hydrologic Unit Codes
LLWW	Landscape Position-Landform-Water Flow Path-Water Body Type
NAIP	National Agriculture Imagery Program
NRCS	National Resources Conservation Service
NSDI	National Spatial Data Infrastructure
NWI	National Wetlands Inventory
PA	Producer's Accuracy
QAPP	Quality Assurance Project Plan
QA	Quality Assurance

QC	Quality Control
QAPP	Quality Assurance Project Plan
RA	Rapid Assessment
RGB	Red Green Blue
RGIS	Resource Geographic Information System
SOP	Standard Operating Procedures
SSURGO	Soil Survey Geographic Database
TMU	Target Mapping Unit (aka minimum mapping unit)
U	Uplands or Unwanted NWI codes
UA	User's Accuracy
US EPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
VDEC	Vermont Department of Environmental Conservation
WPS	Watershed Protection Section
WQPD	Water Quality Protection Division

1.0 Project Management

1.1 Distribution List

The VDEC Wetlands Program Manager will distribute copies of this approved Quality Assurance Project Plan (QAPP) and any subsequent revisions to the project personnel listed below.

Vermont Department of Environmental Conservation, Watershed Management Division, Wetlands Program

Wetland Program Manager:	Laura Lapierre	phone:(802) 490-6177
Wetland Ecologist:	Brock Freyer	phone:(802) 490-6758
Wetland Scientist	Charlie Hohn	phone:(802) 505-3883

Saint Mary's University of Minnesota, Geospatial Services

Director:	Andrew Robertson	phone: (507) 457-8706
Project Manager:	Kevin Stark	phone: (507) 457-8750
GIS Analyst:	David Rokus	phone: (507) 457-8752
Wetland Image Analyst:	John Anderson	phone: (612) 728-5168

U.S. Environmental Protection Agency Region 1

State and Tribal Programs Section:	Beth Alafat	phone: (617) 918-1399

U.S. Fish and Wildlife Service Region 5 (Northeast)

Acting Regional Wetlands Coordinator:	Herb Berquist	phone: (414) 253-8621

1.2 Project Organization

This section lists the roles and responsibilities of persons that will collect and/or use the information gathered using geospatial techniques and image interpretation processes to remotely map and classify wetlands in the Missisquoi River Basin in Vermont. The Project Officers will ensure that any staff responsible for conducting work in accordance with this QAPP will be provided a copy to read and acknowledge the QAPP requirements by signing the acknowledgement form provided as Appendix 2. Table 1 shows names, organization they belong to, their project level roles and responsibilities, and their contact information. The Wetlands Program Project Officers will maintain the acknowledgement forms with the project files, as applicable to each project areas.

Table 1. Project Roles and Responsibilities

Name	Organization	Role	Responsibilities	Contact Information
Laura Lapierre	VDEC Wetlands Program	VDEC / Wetland Project Manager	Review and approve QAPP, ensure consistency among wetlands projects, participate in planning meetings, review and submit reports to EPA. Manage progress of project, QAPP distribution, file management for the project, data transfer and distribution activities, prepare semi-annual and final project reports	(802) 490-6177 Laura.lapierre@ vermont.gov
Brock Freyer	VDEC Wetlands Program	VDEC / Wetland Project Officer #1	file management for the project, assist in ground-truthing site selection, data transfer and distribution activities, prepare field and/or project reports	Brock.Freyer@ vermont.gov
Charlie Hohn	VDEC Wetlands Program	VDEC / Wetland Project Officer #2	Assist in: ground-truthing site selection, data transfer and distribution activities, preparation of field and/or project reports	Charlie.Hohn@ vermont.gov
Ryan Knox	ANR GIS	VDEC / GIS Coordinator	Ensure compatibility of products with VDEC GIS	Ryan.knox@vermont.gov
Andrew Robertson	Saint Mary's University of Minnesota, Geospatial Services	Contractor / Director	General project oversight and administration of the contractor's role in project.	(507) 457-8746 aroberts@smumn.edu

Kevin Stark	Saint Mary's University of Minnesota, Geospatial Services	Contractor/ Project Manager	Schedule meetings, primary communication with VDEC team, develop and review QAPP, oversee project on contractors side, oversee quality control of data	(507) 457-8750 kjstar06@smumn.edu
Dave Rokus	Saint Mary's University of Minnesota, Geospatial Services	Contractor/ Senior Wetland Image Analyst	Photo interpretation, Data creation, data prep, review VDEC feedback on mapping and, quality assurance and quality control, GIS data management	(507) 457-8752 ddroku04@smumn.edu
John Anderson	Saint Mary's University of Minnesota, Geospatial Services	Contractor/ Wetland Image Analyst and QA/QC Specialist	Internal (to contractor) data validation and accuracy checking	(612) 728-5168 janders@smumn.edu
Beth Alafat	U.S. EPA	EPA Project Officer	QAPP review and approval	Alafat.beth@EPA.gov
Herb Berquist	USFWS Region 1	USFWS / Acting Regional Wetlands Coordinator	Acceptance and Quality Assurance/Quality Control for National Wetlands Inventory	(414)253-8621 h_berquist@fws.gov

1.3 Problem Definition/Background

The Vermont Department of Environmental Conservation Wetlands Program (hereto forward just VDEC) has received Environmental Protection Agency (EPA) Wetland Program Development Grant dollars to fund wetland mapping work for the Missisquoi River Basin in Northwestern Vermont. This project is to be completed by GeoSpatial Services, Saint Mary's University of Minnesota (GSS), the Contractor. This QAPP covers the wetland mapping and classification in the project area defined by an 8-digit hydrologic unit code (HUC) (HUC 04150407) that falls within the boundaries of the state of Vermont (Figure **1**)[1]. Two pilot sub watersheds within the project area will be mapped first and reviewed by VDEC team members. These pilot areas are Mud Creek (12-digit HUC – 04150407104) and Headwaters Trout River (12-digit HUC - 04150407301). Wetlands will be mapped and classified using: the National Wetlands Inventory (NWI) classification system (Cowardin et al., 1992); the Landscape Position-Landform-Water Flow Path-Water Body Type (LLWW) classification (Tiner, 2014).

The Program has stated a need to improve their knowledge of wetland extant and value throughout the State of Vermont. The Missisquoi River Basin has a water quality problem with phosphorus pollution mostly from agriculture. Understanding where and what type of wetlands are in this area is an important piece to managing water quality. The main objective of this project is to improve the knowledge of wetland extent and value within the Missisquoi River Basin of the Lake Champlain Basin in the North-Northwestern portion of the state and to pilot a new means of updating wetland mapping. In all, more than 767,246 acres of land comprise the watershed of Missisquoi Bay with approximately 58% of the watershed located in Vermont. Over half of the basin is forested, a quarter is agricultural, and 6% is urban.

The VDEC Wetlands Program has contracted with GSS (Contractor) to create of high quality National Wetlands Inventory Plus (NWIPlus) level mapping of the Missisquoi River subbasin in Vermont, where Program staff will conduct ground truthing of data. NWIPlus is an enhanced NWI product with hydrogeomorphic-type descriptors that can facilitate predicting wetland functions. The enhanced attributes describe wetland landform, water flow path and water body type. The updated mapping will serve as a pilot project for how the VDEC Wetlands Program can improve mapping throughout the State, will be utilized by developers and landowners to avoid wetland impacts, and will be incorporated into several state models which identify potential wetland restoration projects and conservation priorities. Finalized mapping will be made available through Vermont's Open Data Portal and applications like ANR's Natural Resource Atlas and submitted to the US Fish and Wildlife Service for addition to the National Wetlands Inventory.

The VDEC Wetlands Program is completing this work as part of a Landscape Level 1 wetlands assessment. This work fits into Vermont's Wetland Program Plan ("The Plan") and its goal of providing greater projection of wetlands and aquatic resources statewide. This work is overseen and is supported by the Vermont Wetland Program, within the Watershed Management Division of the Department of Environmental Conservation of the Agency of Natural Resources. The Program's Mission is:

> *"To identify, inventory, monitor, and protect wetlands that provide significant functions and values; to encourage the restoration and enhancement of degraded wetlands; and to provide the citizens of Vermont with information and assistance to allow them to be fully informed of wetland issues and to practice sound wetland stewardship."*

The Missisquoi River Subbasin contains some of the headwaters to Lake Champlain. Lake Champlain is an important multi-national lake with water quality issues related to nutrient-loading (e.g., phosphorus), stormwater pollution and bank erosion risks. Lake Champlain also is still affected by the historic flood of 2011, and is at risk to similar, more intensive precipitation events predicted into the future.

Currently, legacy NWI digital vector data is available for the project area, however, it represents a mix of data creation dates. Some of these data were created circa 1977 from small scale aerial imagery using analog geo-referencing and orthorectification processes. Other areas were created from 1992-1993 image sources and still other areas are based on 2003 aerial imagery. All of these data in the project area, regardless of vintage, were updated by the USFWS to include linear stream and river features from the National Hydrography Dataset (NHD). These features were buffered and NWI Cowardin classification was added to represent riverine wetland features. As a result, wetland features are sometimes under-represented and spatially displaced from their true geographic location. Also, in the process of converted NHD data to NWI wetland polygons, there are some issues in terms of spatial alignment with available imagery and how it works with the original polygonal data (e.g., slivers and gaps).

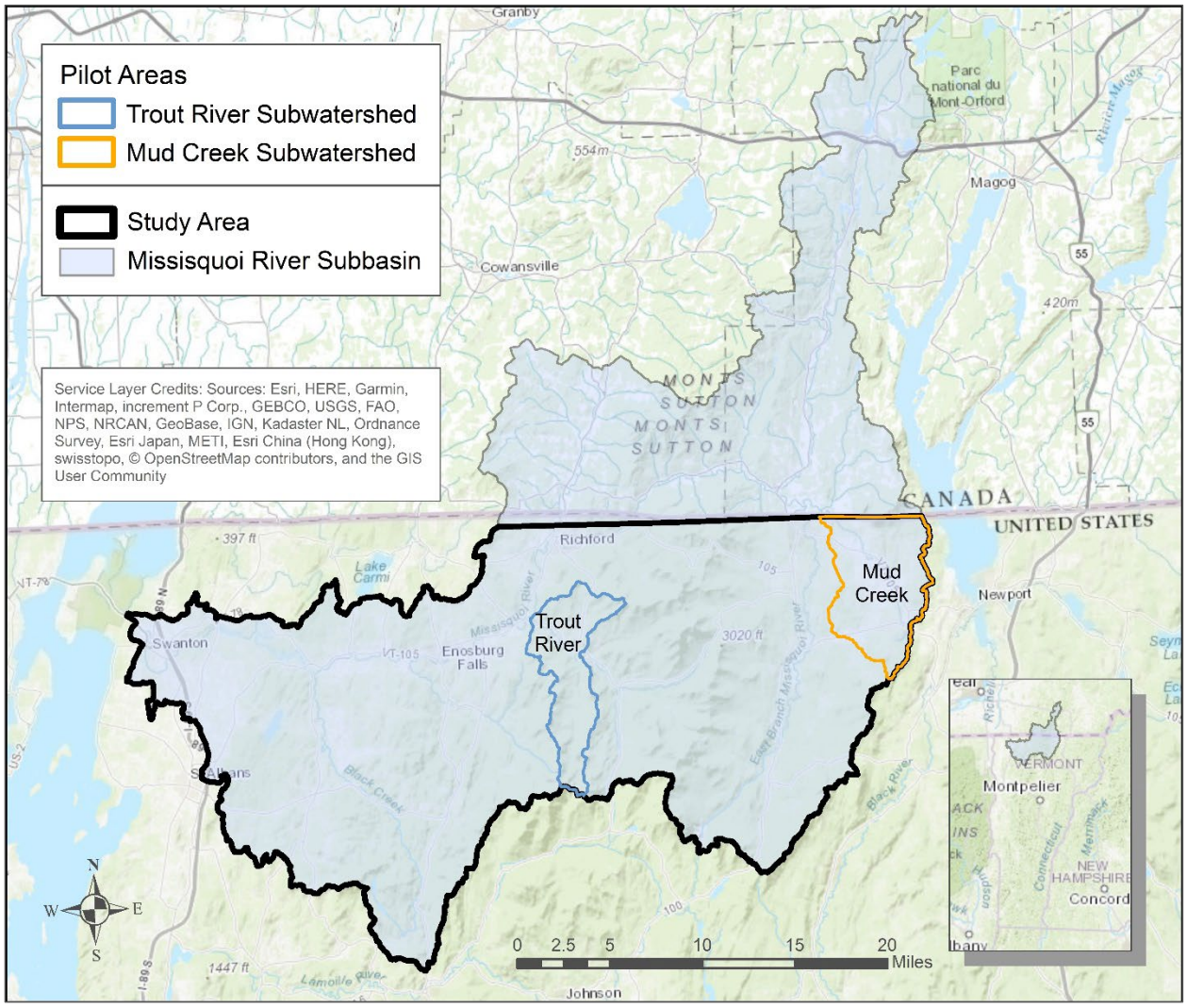

Figure 1. Wetlands Mapping and Classification Missisquoi Subbasin. This QAPP covers the Missisquoi River Subbasin (HUC 8) in northern Vermont. Two pilot areas (Mud Creek and Trout River sub watersheds) act as a sample area mapping units for VDEC to field verify and inform the rest of the mapping in the Study Area (thick black outline). Note: work is not to extend into the portion of the Missisquoi River subbasin that extends into Canada.

1.4 Project/Task Description

The scope of this project is to map and classify wetlands according to Federal Geographic Data Committee (FGDC) standards in the Missisquoi River Subbasin of Vermont (Figure 1) as part of a Landscape Level 1 wetlands assessment strategy.

Project tasks include acquiring imagery and collateral data and assembling a geodatabase, pilot mapping, pilot mapping review, performing remaining wetland mapping, and assigning NWI and LLWW classifications.

Project timelines, including completion dates for each task, are specified in **Appendix 3** and approved project workplans will be completed in the order listed in Table 2 of this QAPP. Workplan timelines will be adhered to for each of the four projects. Semi-annual progress reports from VDEC to EPA for each project will be used track progress.

Table 2. Mapping Tasks and Products

Task	Products
Preliminary meeting and image acquisition	Meeting completed, sub watersheds designated as 2 pilot draft areas, images acquired, collateral GIS data obtained
Complete QAPP	Complete Project Quality Assurance Project Plan ensuring measures are in place to collect quality data
Pilot Area (Trout Creek & Mud Creek Sub watersheds) - mapping field review and mapping classification	Pilot Area-mapping completed and delivered to VDEC, field review completed, and field data and notes delivered to Contractor. This information will aid offsite (Contractor) image interpretation and mapping convention building. This will help the Contractor to develop image interpretation signature conventions based on the VDEC's field review of the pilot sub watersheds and apply it to the Pilot Area and larger project area (Missisquoi River Subbasin within Vermont).
Mapping and wetlands interpretation	Preliminary and final classified wetland GIS dataset
Final version of map, report on methodology	Final data from Contractor to VDEC Wetlands Program. Report from VDEC Wetlands Program to EPA.

Project products include classified wetland maps (digital vector data) covering the project areas specified in the project workplan: Trout River and Mud Creek sub watersheds are identified as pilot areas, and the remaining Missisquoi River subbasin as the complete project area. The final wetland geodatabase will also include LLWW information for all features. The projects will use geospatial techniques and image interpretation processes to remotely map and classify wetlands and riparian areas including narrow polygons representing features typically captured as lines (mainly streams). This aligns with the new NWI mapping standard. These techniques and procedures are outlined in Section 2 (Data Generation and Acquisition) and **Appendix 1**

Tasks that will be completed for each project area include:

- NWI mapping using the Cowardin System (USFWS, 1992) for classifying wetlands and the System for Mapping Riparian Areas in the Western United States (USFWS, 2009a)
- classification of wetlands using the LLWW classification system which considers landscape position, landform, water flow path and water body types (Tiner, 2014 – Ver. 3)

- image analysis from a variety of input image and collateral data sources; and field verification.

All mapping will be completed with at least 1:12,000 resolution with a Target Mapping Unit (TMU) of 0.25 acres, (NOTE: the FGDC standard uses a 0.5 acre TMU for this. For this project the Contractor aims for a 0.25-acre TMU given the resolution of the available imagery) and will comply with the National Wetlands Mapping Standard of the FGDC. The final product to VDEC Wetlands Program will be compatible with our schema and will match the projection of the base imagery, NAD 1983 State Plane Vermont FIPS 4400.

1.5 Quality Objectives and Acceptance and Performance Criteria

The purpose of this section is to specify the level of quality needed to make a decision regarding the success of the project and to document the acceptance and performance criteria used to generate Vermont wetland maps and classifications.

1.5.1 Type of data needed to support intended uses

Wetland mapping and classification relies on the subjective interpretation of wetland boundaries and wetland classification characteristics from a primary aerial image source supported by consultation with collateral spatial data. The primary image source from which all wetland boundaries will be derived is one half meter, spring 2016, leaf-off 24bit orthophotography of the area, in natural color and color infrared emulsion. This imagery, taken by Fugro Earth Data Inc., will be used as the base imagery to inform mapping decisions, however additional, one-meter resolution National Agricultural Imagery Program (NAIP) natural color imagery from earlier years (e.g. 2011, 2013, and 2014) will be consulted for decision support and wetland classification. NAIP imagery taken during the growing season in continental temperate climates can be particularly helpful in determining water regimes of wetlands especially riverine features.

Elevation data is also critical for interpreting wetlands. For this project hillshade and contours derived from a 2016 hydro-flattened 0.7-meter LiDAR DEM created by the VT LiDAR Initiative will be used to interpret wetland location on-screen. Additional data such as soils data and Google Earth will be used in an onscreen (computer) environment to make classification decisions.

All mapping and classification of wetland boundaries that are derived for the intention of populating the wetlands spatial data layer of the National Spatial Data Infrastructure (NSDI) are governed by the specifications of the FGDC Wetlands Mapping Standard (FGDC, 2009). The objective of the FGDC Wetlands Mapping Standard is to support the accurate mapping and classification of wetlands while ensuring mechanisms for their revision and update as directed under Office of Management and Budget Circular A-16 (Revised). If Federal funding is used in support of wetlands inventory mapping activities, then use of this standard is mandatory. The minimum standard for the completeness of the wetland classification is: ecological system, subsystem (with the exception of Palustrine), class, subclass (only required for forested, scrub-shrub, and emergent classes), water regime, and special

modifiers (only required where applicable). The minimum standard for deepwater habitat classification is: system, subsystem, class, and water regime.

The application of the LLWW classification version 3 can act as a demonstration of its use in Vermont. The LLWW classification is intended to bridge the gap between hydrogeomorphic (HGM) and the NWI Cowardin et al. Classification systems.

1.5.2 Conditions under which the data will be collected

Pilot mapping and the field review of these data will provide the image analyst an opportunity to become familiar with wetland communities and land use patterns. Pilot-mapping ground-truthing check sites will be identified in the project area based on typical and atypical signatures for verification of mapping units. The number of check sites used in the pilot sub watersheds will be determined by VDEC Wetlands Program staff. Data that will be collected at all check sites will include GPS (global positioning system) location and photographs. Additional data (i.e. soil descriptions, hydrologic condition descriptions, weather, vegetation, wildlife, and current land use practices) may be collected in the field review, however the field review teams for VDEC Wetlands Program will determine, based on professional judgement, what verification is needed.

1.5.3 Specify tolerable limits

Data quality indicators for wetlands mapping and classification are described in Table 3. Accuracy is a measure of both errors of omission and commission. For this wetland mapping project, accuracy may depend upon several factors affecting identification including:

- Scale of imagery
- Mapping scale or base map scale
- Quality of imagery
- Season of imagery (leaf-off or leaf-on)
- Type of imagery or emulsion of imagery
- Environmental conditions when imagery was captured
- Difficulty of identifying particular types of wetlands (e.g., forested seeps)
- Availability and quality of ancillary or collateral data sources

Accuracy is also a function of data quality and technology as well as proper training of the image interpreter. The FGDC classification accuracy of the final map product should be measured by the TMU (0.5 acres or better) and Producer's Accuracy (PA) (98%) metrics. For this project the Contractor is looking for a 0.25 acre TMU. The FGDC Wetlands Mapping Standard presents no requirement for User's Accuracy (UA).

Wetlands data that meet or exceed the minimum TMU and PA requirements will be accepted for submission to the NSDI. Ninety-eight percent of all wetlands visible on an image, at the size of the TMU or larger shall be mapped regardless of the origin (natural, farmed, or artificial). Features that are at least 0.25 acres will be mapped with a demonstrated PA of 98% for feature accuracy and 85% for attribute accuracy, or higher, across each project map (or the project area if the project area is

smaller than an individual map), as documented through external quality assessment of samples. Habitat changes that have occurred between the date of the base imagery and the date of field observation or ground-truthing are not considered errors because the wetland was correctly classified on the base imagery. The actual TMU and PA for the project area shall be documented in the metadata, along with an associated justification and description of the quality assurance process used.

The quality of the information used for this assessment will be ensured by the following data quality indicator requirements described below in Table 3. Additionally, data integrity procedures employed by GSS are outlined in Appendix 1. These procedures are used as a checklist to insure project data integrity.

Table 3. Data Quality Indicators

Data Quality Indicator	Description	Data Acquisition
Precision	The degree to which a set of observations or measurements of the same property, obtained under similar conditions, conform to themselves	The basis for determining precision will be the comparison of photo-interpreted wetlands against a set of reference wetlands distributed across the project study area. Characteristics of reference wetlands will be collected through field data collection during the project ground-truthing exercise as well as through the expert assessments of members of the VDEC project team.
Accuracy	Degree of agreement between an observed value and accepted reference value	The basis for determining accuracy will be the comparison of image analyzed wetlands against a set of reference wetlands distributed across the project study area. Characteristics of reference wetlands will be collected through field data collection during the project ground-truthing exercise as well as through the expert assessments of members of the VDEC project team.
Bias	The systematic or persistent distortion of a measurement process that causes errors in one direction	Bias will be reduced by using professional and experienced staff to collect and analyze data
Representativeness	The degree to which data accurately and precisely represents a characteristic of an environmental condition	Sites selected as part of the reference data set will be field-verified. Sample selection is representative of the entire sample unit.
Comparability	The measure of confidence that one data set can be compared to another	This project will collect new data where no data is available for comparison. However, methods for data collection are standardized and reproducible.
Completeness	A measure of the amount of valid data needed for project	All representative sites based on typical signatures and atypical signatures within the mapping area will be identified for ground-truthing and represent wetlands and riparian areas of the entire mapping area. On-site ground-truthing will be employed to verify imagery data.
Sensitivity	The capability of a method to discriminate between measurement	All wetlands and riparian areas within TMU will be mapped. The actual TMU and PA for the project area shall be declared in the metadata, along with an

Data Quality Indicator	Description	Data Acquisition
	responses representing different levels of the variable of interest	associated justification and description of the quality assurance process used which is compliant with the "National Wetland Mapping Standard" of the Federal Geospatial Data Committee (FGDC)

1.6 Special Training/Certification

VDEC Wetlands Program has qualified and experienced wetlands and GIS (geographic information systems) staff that have the applicable skills and scientific background to help carry out and administer this project. In addition, the VDEC Wetlands Program will use a qualified and experienced Contractor (GeoSpatial Services, Saint Mary's University of Minnesota) to concurrently carry out this project. The Contractor will utilize skilled image analysts in wetland delineation and classification across various landscapes in the United States. Contractor qualifications are documented through resume and professional references.

The qualifications of key personnel for this project are described below. Each individual's name is followed by their role in this project.

Andrew Robertson is the *Contractor/Director*.

Mr. Robertson has over 25 years of experience in the implementation of a wide range of wetland mapping, spatial data development and natural resource management projects. He is responsible for supervision and development of technical staff including Wetland Biologists and GIS Analysts. Mr. Robertson specializes in the implementation of appropriate GIS applications and other information technologies, such as GPS; image analysis, and field computing, to facilitate information gathering and analysis for decision support. He is a Registered Professional Forest Technologist in Alberta, Canada and a member of the Canadian Institute of Forestry and the Society of American Foresters.

David Rokus is the *Contractor/Senior Wetland Image Analyst*.

Mr. Rokus is responsible for the management of project resources and GIS analysts for a wide range of spatial data development and natural resources projects. Focused mainly on-air image analysis, wetland delineation, and land use/landcover mapping, his responsibilities range from project estimation, establishing mapping standards and conventions, developing and implementing QAQC techniques, providing technical assistance to peers, and writing documentation reports and metadata.

Kevin Stark is the *Contractor/Project Manager*.

Mr. Stark is responsible for supervision and development of permanent technical staff including Wetland Biologists, GIS Analysts, GIS Technicians, and part-time student technicians. Mr. Stark has over 10 years of experience in on-screen wetland mapping and field reconnaissance and field verification of wetland data. He has also been engaged in wetland functional assessment projects for over 5 years for tribal, state and county clients. These project utilize completed wetland data, correlate the data to predicted wetland functions, and then begin to utilize this information into

planning preservation, enhancement, and restoration of wetlands at watershed-scales. Mr. Stark is responsible for project management, communication, QAPP development, oversight of quality control and supervision of project team members.

John Anderson is the *Contractor/ Wetland Image Analyst and QA/QC Specialist*.

Mr. Anderson has more than 30 years of experience in the delineation and classification of wetlands from digital image and hardcopy photo interpretation. He specializes in inventories of existing wetland, restorable wetlands, wetland functions, and land use/landcover. Mr. Anderson has provided technical and managerial services for wetland inventory projects covering more than 300,000 square miles in 24 states. Mr. Anderson has also delineated jurisdictional wetland across Minnesota per the 1987 Corps of Engineers Jurisdictional Wetland Delineation Manual and developed 404 and MN Wetland Conservation Act Permits. He also maintains the following professional certifications: Professional Wetland Scientist (#0001065) from the Society of Wetland Scientists and Certified Mapping Scientist (RS#127), American Society of Photogrammetry and Remote Sensing.

Laura Lapierre is the *VDEC/Wetlands Project Manager*.

Ms. Lapierre is the Wetlands Program Manager at VDEC. She has Wetlands Delineation Training and experienced in wetlands monitoring, in verifying the completion of on-the-ground restoration work, and in contract oversight. For this project she is assign the VDEC Wetlands Project Manager role and will manage the progress of the project, distribute the QAPP, assist in ground-truthing site selection, data transfer, distribution activities, and preparation of final project report to EPA.

Brock Freyer is the *VDEC/Wetlands Officer #1*.

Mr. Freyer is a Wetland Ecologist for the VDEC Wetlands Program. Mr. Freyer is a Professional Wetland Scientist (SWS). He has experience in wetland delineations, environmental impact assessments, water quality sampling, and in studying geomorphology and hydrology. He has ACOE Wetlands Delineation Training and has been performing routine wetlands delineations, and wetlands hydrology, soils and plant identification since for several years. For this project he is assigned the Project Officer #1 role. For this role he will assist in ground-truthing site selection, field data compilation and transfer, onscreen/remote meetings, and preparation of final project report to EPA.

Charlie Hohn is the *VDEC/Wetlands Officer #2*.

Mr. Hohn is a Wetland Scientist for the State of Vermont. He is a member of the VDEC's Wetland Program, specifically focused on wetland Bioassessment. For this project he is assigned Wetlands Officer #2 role and will assist in ground-truthing site selection, field data compilation and transfer, onscreen/remote meetings, and preparation of final project report to EPA

1.7 Documents and Records

Copies of this QAPP and any subsequent revisions will be provided to all individuals included on the distribution list by the VDEC Wetlands Program Project Officer. The Wetlands Program Project Officer and the Contractor Project Manager will also distribute all applicable protocol documents and

subsequent revisions used throughout the project to the appropriate personnel. The QAPP, protocol document and field review monitoring reports will be maintained in the central project file at VDEC. These documents will also be made available to EPA Region 1 Wetlands Program files as requested.

Final digital spatial data (i.e. wetland delineation and classification and all collateral data) will be delivered to VDEC in ArcGIS ver. 10.5 file geodatabase format (or the latest version compatible with software used by VDEC). The delivery version will be specified by VDEC prior to the contract termination date. Quality assurance reports resulting from final examination of the digital spatial data will also be included in the project geodatabase. These reports will include the spatial location of wetlands that have been examined; the results of runs of the United States Fish and Wildlife Service (USFWS) NWI verification tool against the project geodatabase; and summaries of internal testing performed by Contractor error checking routines. The final data will be copied to a portable external hard drive for delivery, or will be transferred through the Contractor's file transfer protocol (FTP) website.

The pilot area-mapping field review and post-mapping ground-truthing exercises will result in data being collected from a series of field validation points as determined by the Program. A GPS coordinate will be recorded to document the spatial location of each sample point and one or more photographs will be taken to document site conditions. GPS data will be delivered as part of the final spatial geodatabase (see above); any field sheets used will be scanned by the Contractor into digital PDF format for transfer to VDEC; and, site photographs will be delivered in digital format along with other project documents. If VDEC collects data independently of the Contractor, then data will be shared with the Contractor electronically and stored on the Wetlands Program Project Officer's computer and in the Wetlands Program central project files.

2.0 Data Generation and Acquisition

2.1 Sampling Process Design

For wetland mapping and classification projects at the landscape level, field reviews are used to address questions regarding image interpretation, land use practices, classification of wetland type and verification of hydrogeomorphic or physical aspects of the wetland such as landscape position, landform, water body type, and primary surface water flow path. Pilot sub watersheds (Trout River and Mud Creek, 12-digit HUCs) will be mapped by the Contractor and reviewed in the field by VDEC staff. This quality control process will be collaborative and require some remote, on-screen review of the field investigations to inform any edits to the pilot sub watershed mapping and to inform the rest of the project area mapping by the Contractor. After the pilot sub watersheds are completed, field investigation completed, and feedback given to the Contractor, the remaining area in the project will be mapped by the Contractor. Then, the final draft data of the entire project area will be reviewed by VDEC and feedback will be given to the Contractor to make final edits to the entire seamless dataset.

The exact procedures for pilot field review will be determined by VDEC as all field investigations for this project will be completed by VDEC and not the Contractor. The following information provides a guide to this process. Pilot-mapping field reviews provide an opportunity for image analysts to become familiar with wetland communities and land use patterns. Any post-mapping field review (ground-truthing) that VDEC can incorporate into the timeline of this project would provide additional assurance on accurate and consistent interpretation of imagery over the larger project area. Information gained from field reviews in combination with the analyst's skills and experience in image interpretation and the use of ancillary data will contribute to successful wetland mapping and classification.

Accurate and consistent interpretations of imagery will be ensured by conducting a pilot-mapping field review for each project area to correlate image signatures with observed wetland and upland types. Viewing digital data on a laptop computer or other portable device will facilitate the review of wetlands map data in the field. Field reviews may include identification of hydric soils or hydric soil characteristics (using standard practices for Munsell soil color chart), information about common regional wetland plants and their distribution, dominant land use, drainage practices, agricultural crops and some preliminary image analysis of sites to be reviewed. Participants in the field reviews may include the Wetlands Project Manager and one or more of the Wetland Project Officers.

Field reviews will involve visits to a cross section of wetland types as well as to sites that may be mapped using different image types, scales, and dates. Check sites for field reviews in each project area will be chosen based on commonly occurring image signatures or habitats characterizing an area, unusual but important imagery signatures (some which may be difficult to identify), borderline signatures (those features that might be wetland or upland) and specific signature problems based on

the date of imagery (recent burning, extreme high or low water conditions). All sites will be accessible via road. Analysts will select field sites near roads or public lands if access is limited.

After each field review, a field trip report will be prepared by the VDEC. Field trip reports will discuss the details of the field review efforts (including participants, dates, and location), ancillary data sources and uses, general descriptions of wetlands and uplands in the area, description of water conditions, details about the quality and interpretation of the imagery, identifiable metrics of wetland function and any special problems, findings or conventions.

The exact number of check sites will be determined by the participants, per defined project specifications, weather conditions, access to sites, and trip objectives. Good quality digital photographs will be provided for field sites.

2.2 Sampling and Image Acquisition Methods

The primary image source from which all wetland boundaries will be derived is the one half meter, Color Infrared (CIR) Orthophotography. This represents tiled ortho imagery in TIFF format from Fugro Earth Data that is published by the Vermont Center for Geographic Information Inc.

Additional or "collateral" imagery that will be consulted by the image analyst (interpreter) will be most recent NAIP from the U.S. Department of Agriculture for Vermont. The specifications for this imagery are documented on the internet at the following location:

https://catalog.data.gov/dataset/the-national-agriculture-imagery-program-naip-information-sheet.

Collateral data used to derive wetland boundaries include data such as USGS digital raster graphics (DRG), NHD streams, and historical aerial imagery.

While in the field, photographs of land use and wetland characteristics will be obtained for reference purposes. The exact location of the site locations referred to in notes and other information will be captured digitally through GPS. Any handwritten field notes on maps regarding changes observed will be clear and understandable. Examples of notations are: 'extend or add this wetland;' 'delete wetland:' or 'refine delineation.'

Field trip reports will provide documentation of the field verification efforts including, general descriptions of wetlands and uplands in an area, descriptions of surface water conditions both on the imagery and at the time of field work, details about the quality of the source materials used, and clarification regarding sites in question to the Contractor.

2.3 Sampling Handling and Custody

GPS data and digital photography will be collected during field reviews for the VDEC to retain custody of all original data NWI Field Data Forms, GPS data, digital photography, and draft hard copy, maps during the field reviews. These data will later be submitted to the Contractor in accordance with the project workplan and will be used to inform the contractors mapping decisions.

2.4 Analytical Methods

The delineation of wetlands and deepwater habitat features through image analysis forms the foundation for deriving all subsequent products and data results. Consequently, a great deal of emphasis is placed on the quality of the image interpretation. Standard image analysis methodology will be used for landscape level wetland assessment and habitat characterization.

Wetland delineation will be conducted on-screen using ESRI ArcGIS ArcMap on a digital image backdrop composed of color infrared leaf off imagery provided to the Contractor by VDEC Wetlands Program. Other imagery will also be consulted in the on-screen mapping process. For example, true color, summer aerial photography from the National Resources Conservation Service (NRCS) NAIP imagery covering years 2011, 2012, and 2011 are available in the project area. This program collects aerial imagery during the agricultural growing seasons in the continental U.S. The default spectral resolution is natural color (Red, Green and Blue, or RGB) but beginning in 2005, some states were delivered with four bands of data: RGB and Near Infrared. NAIP imagery is acquired at a one-meter ground sample distance (GSD) with a horizontal accuracy that matches within five meters of photo-identifiable ground control points, which are used during image inspection. This is compliant with the "National Wetland Mapping Standard" of the FGDC.

Wetland mapping and classification in Vermont relies on the subjective interpretation of wetland boundaries and wetland classification characteristics from a primary aerial image source supported by consultation with collateral spatial data. The image analyst will make use of the following “basic elements” to make decisions about ecological habitat boundaries, wetland types and visible functional characteristics. These same elements are used in the quality control review of delineated information to check for accuracy and completeness.

Tone (also called Hue or Color) -- Tone refers to the relative brightness or color of elements on an image. It is, perhaps, the most basic of the interpretive elements because without tonal differences none of the other elements could be discerned.

Size -- The size of objects must be considered in the context of the scale of an image. The scale will help you determine if an object is a stock pond or large lake or reservoir.

Shape -- Refers to the general outline of objects. Regular geometric shapes are usually indicators of human presence and use.

Texture -- The impression of "smoothness" or "roughness" of image features is caused by the frequency of change of tone in images. It is produced by a set of features too small to identify individually. Grass, cement, and water generally appear "smooth," while a forest canopy may appear "rough".

Pattern (spatial arrangement) -- The patterns formed by objects in an image can be diagnostic. Consider the difference between (1) the random pattern formed by a natural grove of trees and (2) the evenly spaced rows formed by an orchard or planted forest.

Shadow -- Shadows may aid interpreters in determining the height of objects on aerial imagery. However, they can also obscure objects within them.

Geographic Location -- This characteristic of imagery is especially important in identifying vegetation types and landforms. For example, large oval depressions in the ground are readily identified as Carolina Bays in the coastal regions of southeast.

Association -- Some objects are always found in association with other objects. The context of an object can provide insight into what it is. For instance, a nuclear power plant is not (generally) going to be found in the midst of single-family housing.

The on-screen method is the most feasible for identifying and delineating wetlands using digital imagery and supporting tools. The on-screen method involves viewing digital map data that overlays digital imagery on a personal computer screen (monitor). Changes to the map data to make it current with the digital imagery can be made on-screen and the digital data file checked and saved or exported.

The Contractor/Image Analyst using the on-screen method will be experienced in the identification and classification of wetlands. Using the on-screen method, image analysts will ensure the ecological integrity of the mapping process as well as most of the cartographic accuracy. The identification, delineation and attribution of features will be completed within the digital data files.

An ESRI geodatabase will be the format for viewing, editing and storing map data. This greatly improves the administration, access, management and integration of spatial data. The ArcMap interface provides access to a suite of editing tools which create smaller more efficient files and permits map editors to “drag and drop” polygons which prove to be a very important capability in updating wetland map files. The heads-up method has several distinct advantages:

- Uses digital imagery (DOQs or other digital data)
- Eliminates manual cartographic transfer work
- Provides seamless coverage of work areas
- Easily transportable to ArcSDE or other platforms
- Digital Raster Graphics (DRGs), or other digital data layers (historic imagery, Soil Survey Digital Geographic Database (SSURGO), digital elevation model (DEM) etc.) provide a direct backdrop for image interpretation and validation
- Hydric soils can be imported and viewed as ancillary information
- Linear feature files can be eliminated
- Automated verification routines can incorporate GIS capability

To support a streamlined quality assurance/quality control (QA/QC) process, customized scripts will be created by the Contractor/GIS Analyst to allow quicker attribution of map features using wetland and deepwater codes as well as other descriptive codes or information. A standardized verification tool is also available from the NWI Program to provide quality control or logic checks of the digital data. This tool can be accessed at: http://www.fws.gov/wetlands/Data/Tools-Forms.html

Editing and updating wetland digital map data using the heads-up process implies the following:

- Digital imagery will be used as the base imagery to update the wetlands information.
- The existing wetland map digital data will overlay and register to a USGS DRG topographic base map or rectified imagery where available.
- ArcGIS software (latest version) will be used in a Windows environment to edit existing digital data
- Customized software tools from the NWI Program will be used to assist the updating, editing and data verification processes

2.5 Quality Control (Contractor)

In addition to the feedback and field data given to the Contractor by VDEC, the Contractor will conduct onscreen reviews and various tools run to ensure the quality of the wetland GIS data being created for this project.

Quality control of interpreted map products (both boundary delineation and classification) is typically performed on 100% of the project area by a qualified image analyst other than the person performing the original work. To accomplish this, the review analyst will perform an incremental screen by screen (working west to east or north to south) qualitative review of the project area at no less than 1:12,000 scale. Following completion of row or column on-screen views, edits will be saved in the personal geodatabase.

Quality control review of interpreted images will include a comparison of contours, hydrographic symbols, and hillshade appearance to wetland delineations and vegetation signatures. There is considerable latitude allowed in conducting qualitative reviews. However, a complete review of the project area with the backdrop of the standardized base visible at a scale not smaller than 1:12,000 must be completed. All work will adhere to published NWI National Standards, quality requirements and data collection methods. In addition, customized editing scripts will be used in this step to: validate topological accuracy; search for null polygons and slivers; identify adjacent polygons with the same classification; and verify coding to national standards.

Customized data verification tools have been constructed to automate (to the extent possible) the quality control functions necessary to ensure the geodatabase is accurate. This suite of functions has been designed to address geo-positional errors, digital anomalies, and some logic checks that make use of the power of the geographic information system. These tools are extensions to the ArcMap desktop geographic information system product.

Cartographic accuracy - For digital data to be accepted into the USFWS National Wetland Geodatabase, they must first pass verification. A number of geospatial quality control checks are mandatory for the digital data to pass verification. The pass/fail function on the customized tool will automatically execute those verification tools. Other potential problems identified with the verification tool will provide the image analyst the option of editing or ignoring the feature.

Logic checking - The geodatabase verification process also uses the analytical ability of GIS to build in enhancements to the quality control process. Items such as wetland classification accuracy will be checked along with cartographic precision.

Edge matching - Edge-matching of wetland interpretation is required for a seamless wetland database. Two types of edge-matching will be used: 1) internal ties along the borders of source images and 2) external ties to pre-existing wetland data immediately adjacent to the project area. The USFWS requires that in all cases, internal edge-matching be performed.

Wetland mapping units lying along the outer borders of source images within a project area, whenever practical, will be edge-matched with interpretations on all adjacent images within the project area. All polygon features shall be edited to ensure an identical or coincident transition across images in the entire project area. At a minimum, features located on the outer edge of the project area will be closed exactly at the border of the project area. Because some maps have been updated, there may be some temporal differences in the data. Edge matching of data adjacent to the project area will be facilitated by referencing on-line data available from the USFWS.

Attribute table review is the next stage of the quality control process. During this assessment, the analyst will access the geodatabase attribute table and review it for errors. Sorting various data fields in ascending order can easily isolate null attributes, empty attributes, improper attributes and very small, or "sliver" polygons. Where multiple classification schemes have been sued to characterize wetland features (e.g. Cowardin and LLWW), additional attribute reviews are required to ensure that combinations of codes are logically consistent. This is achieved by developing a series of cross reference tables and having a skilled image analyst visually review the tables for inconsistencies.

The production of draft map products is an optional quality control process. In this step, plots of the new/updated wetlands data may be made to review in the field or to provide visual inspection of mapped features at various smaller scales than is practical to view on-screen. There are no specifications for draft products since they are considered interim work products - not for distribution. However, since the production of draft maps is usually accompanied by a field verification trip, consideration should be given to plotting at a manageable size and scale for field interpretation.

Finally, all NWI wetland mapping and classification projects will be coordinated, to the extent possible, with NWI Regional Wetlands Coordinators and project personnel for data reviews and quality assurance steps prior to submission to the National Wetlands Geodatabase. This ensures that incoming data will be of sufficient quality and integrity for national distribution. It also ensures that project cooperators have access to the latest tools and techniques endorsed by the NWI Program for data collection.

2.6 Instrument/Equipment Testing, Inspection, and Maintenance (VDEC)

The equipment used to collect physical measurements for this project will include the following:

- GPS Navigator
- Laptop Computer
- GPS Receiver
- Digital Camera
- Vegetation Field Guides

All field equipment will be inspected each morning prior to commencing data collection. All instruments and equipment will be tested, inspected and maintained in accordance with the manufacturer's specifications as included in the associated instrument/equipment manual.

Contractor staff will use their own equipment. Results of equipment inspections will be noted in the maintenance log and/or project file. Any deficiencies in equipment will be noted and reported immediately. If condition of equipment is in doubt, it will not be used. In the event of equipment failure, the VDEC Wetlands Program Project Officer will be notified and the Contractor will correct the problem, rejecting the resultant data or accepting the data with notations.

2.7 Data Acquisition (Nondirect Measurements)

For this project, the primary image source from which all wetland boundaries will be derived is a 2016 set of spring, leaf-off CRI orthophotos of the area provided to the Contractor by the State of Vermont. The specifications for this imagery are documented on the internet at the following location:

http://maps.vcgi.vermont.gov/gisdata/metadata/VTORTHO_0_5M_CLRIR_2013.htm

Additional imagery that will be consulted in interpreting wetlands on –screen are multiple years of the NRCS's NAIP. The specifications for this imagery are documented on the internet at the following location:

https://catalog.data.gov/dataset/the-national-agriculture-imagery-program-naip-information-sheet.

They include:

- imagery is acquired from aircraft using film or digital cameras that meet rigid calibration specifications
- 1-meter ground sample distance (GSD) or resolution
- 3-band natural color, or Red, Green, Blue (RGB) imagery
- match within 5-meters to existing DOQQs
- 95% of well-defined points tested shall fall within 6 meters of true ground location

The following is an excerpt from the 2011 NAIP metadata:

This data set contains imagery from the National Agriculture Imagery Program (NAIP). The NAIP acquires digital ortho imagery during the agricultural growing seasons in the continental U.S. A primary goal of the NAIP program is to enable availability of ortho imagery within one year of acquisition. The NAIP provides two main products: 1 meter ground sample distance (GSD) ortho

imagery rectified to a horizontal accuracy within +/- 5 meters of reference digital ortho quarter quads (DOQQ's) from the National Digital Ortho Program (NDOP) or from the

National Agriculture Imagery Program (NAIP); 1 meter GSD ortho imagery rectified within +/- 6 meters to true ground. The tiling format of NAIP imagery is based on a 3.75' x 3.75' quarter quadrangle with a 300 meter buffer on all four sides. The NAIP imagery is formatted to the UTM coordinate system using the North American Datum of 1983 (NAD83). The NAIP imagery may contain as much as 10% cloud cover per tile. This file was generated by compressing NAIP imagery that covers the county extent. Two types of compression may be used for NAIP imagery: MrSID and JPEG 2000. Target value for the compression ratio is (15:1).

In addition, other collateral data sources (e.g. USGS DRG, NHD streams, SSURGO soils data) will only be consulted to support decision making on the primary imagery so their accuracy specifications have no bearing on the final map products.

2.8 Data Management

Data obtained for this project are maintained in GIS electronic files and digitized NWI Field Data Forms. All field-level data (photos, notes, field datasheets, GPS points, etc.) will be delivered by to the Contractor by the Wetland Program Officer. Likewise, the Contractor will deliver all GIS data to the Wetlands Program Project Officer as soon as practical following data creation events. Once delivered, these data are to be maintained on VDEC hard drive in the Wetlands Program files that are maintained by the Wetlands Program Project Officer for the project. Contractors will provide a summary report to the Wetlands Program Project Officer. All data and summary reports will be compiled into the semi-annual and final project report and provided to U.S. EPA.

3.0 Assessment/Oversight Elements

3.1 Acquisition and Response Actions

The VDEC Wetlands Program Project Manager provides project oversight by reviewing data collection efforts.

Any problems encountered during the course of this project will be immediately reported to the VDEC Wetlands Program Project Manager who will consult with appropriate individuals to determine appropriate action. Should the corrective action impact the project or data quality, the VDEC Wetlands Project Manager will alert the Contractor Project Manager and the Contractor Director. All problems will be documented for inclusion in the project file, and final report. The VDEC Wetlands Project Manager will assess project progress to ensure the QAPP is being implemented.

3.2 Reports to Management

Semi-annual reports are submitted by the Wetlands Program to US EPA and include progress of project implementation and any available data. Status reports or special reports for VDEC Wetlands Program or US EPA will be prepared on request. A report detailing the findings will be provided in the final project report. Any deviations from what is specified in the work plan for this project will be documented and reported to Wetlands Program Project Manager.

4.0 Data Validation and Usability

4.1 Data Review, Validation, and Verification

Data review and verification are key steps for ensuring the integrity, suitability and usability of the data. Validation and verification will be conducted during the course of this project.

4.2 Validation and Verification Methods

The VDEC Wetlands Program Project Officer and the Contractor will be responsible to ensure that valid and representative wetland data will be delineated and classified for this project.

Wetland delineation will be conducted on-screen in ArcGIS on a digital image backdrop composed of CIR, spring leaf-off aerial photography from the VDEC. However, color infrared true color, summer aerial photography from the NRCS NAIP imagery will be consulted for mapping decisions, especially those related to water regime of the Cowardin Classification. This program collects aerial imagery during the agricultural growing seasons in the continental US. The default spectral resolution is natural color (Red, Green and Blue, or RGB) but beginning in 2005, some states were delivered with four bands of data: RGB and Near Infrared. NAIP imagery is acquired at a one-meter GSD with a horizontal accuracy that matches within five meters of photo-identifiable ground control points, which are used during image inspection. This is compliant with the "National Wetland Mapping Standard" of the FGDC.

The "National Wetland Mapping Standard" of the FGDC also specifies that compliant wetland data must meet both a TMU size and a level of PA. The TMU is an estimate of the size class of the smallest wetland that can be consistently mapped and classified at a particular scale of imagery, and that the image-interpreter attempts to map consistently. TMU allows for mapping below a specified threshold, but does not subject that finer detailed mapping to the accuracy requirements of the Standard. The TMU for the mapping and classification projects is 0.5 acres which is consistent with the "National Wetland Mapping Standard." For this project we are expecting a 0.25 acre TMU given the imagery resolution.

PA measures the percentage of wetland features that are correctly identified and correctly classified on the imagery. PA is measured by both feature and attribute accuracy. Feature accuracy is the correctness of the identification of wetland vs. non-wetland. Attribute accuracy is the correctness of the classification of the wetlands using the FGDC Wetlands Classification Standard. The PA for this project is 98% for feature accuracy and 85% for classification accuracy which is consistent with the "National Wetland Mapping Standard."

The USFWS NWI Program has primary responsibility for ensuring that any federally funded wetland data that is to be submitted to the Wetlands Spatial Data Layer of the NSDI meets the specifications of the FGDC "National Wetland Mapping Standard." As a result, the VDEC Wetlands Program Project Officer and USFWS Regional Wetland Coordinator for Vermont will ensure that data from this project is compliant with the standard. Data validation and verification will include: on-going

informal reviews of completed wetland delineation and classification throughout the active mapping portion of this project; a comprehensive field review of mapped wetlands upon completion of the draft delineation and classification (Draft Map Review); Contractor revisions of the wetland data based on feedback from the field review; and, a complete quality assurance review of the final wetland data, including both manual and automated assessment techniques, prior to submission to the NSDI.

4.3 Reconciliation with Data Quality Objectives

Data quality objectives are agreed upon by the VDEC Wetlands Program Project Officer, Contractor, USFWS Regional Wetland Coordinator and a multi-agency project advisory committee. These groups will work cooperatively throughout the entire project timeframe to answer questions, address issues, review data quality and provide feedback. These reviews will be conducted within the context of federal wetland mapping guidance from three primary documents: the FGDC "Federal Wetland Mapping Standard"; the "Classification of Wetlands and Deepwater Habitats of the United States"; and the "Fish and Wildlife Service National Standards and Quality Components for Wetlands, Deepwater and Related Habitat Mapping". Where variation from data quality objectives is identified by these review processes, the Contractor will make every effort to address issues in a timely and comprehensive manner.

5.0 References

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USFWS 2009b, “Data Collection Requirements and Procedures for Mapping Wetland, Deepwater and Related Habitats of the United States”, USFWS Division of Habitat and Resource Conservation Branch of Resource and Mapping Support, Arlington VA, 22203.

USDA 2016, National Agriculture Imagery Program (NAIP) Information Sheet, March 2016**.**

Accessed at: https://catalog.data.gov/dataset/the-national-agriculture-imagery-program-naip-information-sheet.

6.0 Appendices

Appendix 1 Standard Data Integrity Procedures for GeoSpatial Services Wetland Mapping and Classification Projects

I. Project Initialization

A. Assemble contact information
   1. Request data checkout from project coordinator
   2. Request names of field experts for fieldwork
   3. Host conference call verifying timelines and processes

B. Data Acquisition
   1. Download collateral data
      a. landscape – topography and soils
      b. imagery – historic and stereo pairs
         i. build pyramids
         ii. calculate statistics
         iii. mosaic individual photos
      c. vector – historic wetlands, soils, land use, etc.
         i. join tabular data
   2. Build project to ensure complete coverage of all data
      a. Establish datum, coordinate system, and projections
   3. Perform sample updates and edits
      a. Submit to partners for primary review
      b. Host conference call to document editing and schedule fieldwork

II. Initial Fieldwork

A. Pre-fieldwork
   1. Make travel arrangements
      b. Acquire all necessary equipment (e.g., Soil probe or spade, Clipboard and field data sheets, GPS with car adapter and batteries, Laptop with removable hard drive and project data, camera, field bags for vegetation samples
   2. Create field check site file
      a. Choose points based on typical signatures
      b. Choose additional points based on atypical signatures
      c. Points are randomly distributed and accessible by land
      d. Upload points to GPS unit
   3. Print maps
      a. Several overview maps with streets layer and all points
      b. Large scale navigation and points check list
      c. Individual field site maps with polygons and imagery
   4. Upload data to removable hard drive and prepare ArcMap project

B. In the Field

1. Navigate between check sites using GPS and overview maps
2. Check site record data
    a. Soil probe or pit (if access granted by landowner)
    b. Record hydrologic conditions
    c. Document vegetation, wildlife, and weather conditions
    d. Take a photograph and record direction facing
    e. Talk with local landowners
    f. Note current land use practices
3. Address specific questions posed by Contractor such as on-site water regime classification.

C. Post-field Data Dump
1. Compile all GPS points into a single file
    a. Add photo file field
    b. Add mapped attribute field
    c. Add photo direction field
    d. Record mapped attribute and other notable features into field
2. Develop signature conventions
    a. List all prominent and outlying image signatures
        i. cross referenced with appropriate attribute or code
        ii. signature includes: color, tone, texture, etc.

III. On-screen Digitizing

A. Perform updates and edits
1. Perform self QA/QC often
2. Restart computer daily to flush edits
3. Compact database daily to remove bugs

B. Inform QA/QC as units or milestones are completed
1. Discuss problem areas and issues
2. Revisions as needed

IV. Quality Assurance / Quality Control (QA/QC)

A. Self QA/QC
1. Run daily to weekly by analyst or interpreter
    a. Explode all polygons
    b. Look for Null geometry or polygons below TMU (size of the smallest feature that is being reliably mapped)
    c. Find erroneous attributes and fix codes
2. Save a back-up copy to the server

B. Internal QA/QC
1. Data Preparation
    a. Explode all polygons
    b. Select by attribute based on unique value

i. Remove all erroneous attributes

c. Review all polygons < the TMU (0.25 acres)
   i. Pan / zoom to each polygon to verify its appearance
   ii. Delete, merge, or accept polygon

d. Repair geometry and delete Null geometry

2. Signature Matching
   a. Pan through entire dataset at scale of 1:10,000
      i. Scale of interpretation
      ii. Ensures polygons within each complex are categorized accurately and consistently
      iii. Verifies complexes are hydrologically connected throughout drainage systems
      iv. Verifies complexes are disjunctive across roads and other human influences
   b. Select all of one attribute
      i. Pan / zoom to approximately 5% to ensure similar signature conditions
      ii. Repeat for all other abundant attributes
3. Linework Review
   a. Pan through entire dataset at scale of 1:5,000
      i. Scale of delineation
      ii. Ensures polygon structure is appropriately pieced together
   b. Pan through entire dataset at scale of 1:1,000
      iii. Look for micro errors that affect polygon smoothness and negatively affect fitting appearance
         - Jags
         - Spikes
         - Intersections
         - Corners
4. Same Adjacent Attributes (SAA) Tool
   a. Identifies multiple polygons with identical attributes in contact with each other
   b. Pan / zoom to each of these SAA
   c. Merge, delete, or fix polygons
5. Topology
   a. Overlaps
      i. Pan / zoom and fix
   b. Gaps
      i. Pan / zoom and fix
      ii. Large upland gaps are acceptable
      iii. Run Gap Checker Tool to verify acceptable gaps
   c. Must be covered by each other
      i. Mapped features must be contained within study area
      ii. Study area must have mapped features throughout

6. NWI Verification Tool 2.5.1_9.3
    a. Repeats many of the above QA/QC checks
    b. All-inclusive tool that double checks according to NWI specifics
    c. Pan / zoom and fix
7. Repeat steps 1, 4, 5, and 6
8. Database Finalization
    a. Save multiple copies of database
        i. Make changes according to entity – DNR, USFWS, ACOE.
            - Removal of uplands or unwanted codes (DWL in WIDNR) (U in NWI)
            - Project to desired coordinate system or datum
9. External QA/QC
    a. Submit data to client
        i. Allow time for review
        ii. Host conference call for feedback
    b. Make revisions according to review
    c. Re-run internal QA/QC process excluding step 2 and 3

Appendix 2 Acknowledgement Form

Vermont Department of Environmental Conservation

Mapping and Classification of Missisquoi River Subbasin in Vermont

Quality Assurance Project Plan Cooperator Acknowledgement Statement

This is to acknowledge that I have received a copy of the
Mapping and Classification of Wetlands in Vermont's Missisquoi River Subbasin Project Area - Quality Assurance Project Plan.

As indicated by my signature below, I understand and acknowledge that it is my responsibility to read, understand, become familiar with and comply with the information provided in the document to the best of my ability.

_____
Signature

_____
Name (Please Print)

_____
Date

Appendix 3 Project Deliverables Table

Performance Measure	Deliverable	Timeframe
#1 Develop mapping methodology for QAPP	Mapping section of QAPP	June 4, 2018
#2 Complete NWIPLUS mapping on a sub-watershed of the Missisquoi Basin for QA review by Program	File Geodatabase (10.3.1 release) containing feature class of mapped wetlands	
#3 Meet with the VDEC Wetlands Program to receive feedback on the sub-watershed of data	Summary Memo of meeting	July 15, 2018
#4 Provide draft mapping of the whole Basin.	50% of the subbasin Complete as a 10.5 File Geodatabase containing the wetland polygons	September 1st, 2018
	Remaining half completed delivered as a 10.5 file geodatabase containing the wetland polygons.	November 1st, 2018
#5 Provide finalized NWIPLUS mapping of the Basin based on feedback by the Program	File Geodatabase (10.3.1 release) containing feature class of mapped wetlands meeting federal standards and verified through the Wetlands Data Verification Toolset provided by USFWS	March 1st, 2019