SECTION

3 Site Assessment and Evaluation

All wetland restorations depend on a suitable site to meet intended project goals. Successful projects take advantage of unique project characteristics while overcoming identified drawbacks or obstacles. The collection and assessment of site information is important to understanding both the available opportunities, as well as potential limitations for restoration.

This section of the Minnesota Wetland Restoration Guide discusses the process to assess and evaluate potential wetland restoration projects. It includes discussion on the methods and procedures used to investigate and collect important site information and describe the importance of this information to the over-

Figure 3.1 *Drained Wetland Landscape*

all project evaluation. Included are considerations of varying program policies, project goals, scope, legal considerations, and restoration complexity and their effect on the assessment and evaluation process.

Each potential restoration site is unique. Not every component discussed in this section of the Guide needs to be assessed and evaluated at each project site. Conversely, the assessment of additional components not discussed in the Guide may be warranted depending on the project and specific site conditions. Nonetheless, the design and implementation of the pending restoration will rely on the thoroughness of the site assessment and data collection effort. Expending the time and effort to conduct a thorough site assessment will provide for identification of all restoration opportunities and increases the chances for project success. More importantly perhaps, it allows impractical or costly sites to be avoided or at the very least, allows the project manager or owner to proceed with a full understanding of restoration challenges and potential costs.

Appendixes for Section 3

3-A Wetland Hydrology Classification

3-1 Defining the Project Scope

Figure 3.2 *Aerial View of Drained Wetland Landscape*

This chapter discusses the following project components that influence project scope.

- **Program Policies, Options and Requirements**
- **Project Status**
- **Project Goals**
- **Project Size/Boundaries**
- **Project Complexity**

Once a potential project has been identified, a comprehensive assessment and evaluation is needed to determine the extent of wetland restoration that can be accomplished. Before that occurs, however, every potential project should undergo some type of preliminary site assessment or screening. This includes reviewing available maps, current and historic aerial photos, LiDAR data, and when possible discussions with landowners and others knowledgeable of the project site including its drainage history.

The purpose of a preliminary site assessment is to determine the restoration potential of a project at an early stage in its development. The interest in completing, accepting, or acquiring a project may depend on the outcomes of the preliminary site assessment work. Good judgment at this preliminary stage will limit the extent of information to be collected in order to determine a project's potential; minimizing landowner or program expenses; and recognizes that a more comprehensive assessment can occur later, upon final project acceptance or approval.

A comprehensive site assessment includes further research and review of maps, photos, and other reference materials along with gathering site specific on-site information relating to soils, hydrology, geology, drainage, vegetation, topography, and identification of land uses within the surrounding landscape. It also includes review and understanding of property ownership and associated possible legal constraints in completing the project.

The assessment and extent of data collected when performing a comprehensive site assessment should be reasonably adjusted to the scope of and complexity of the planned project. Therefore, it is important to have some understanding of the project scope before commencing the on-site assessment and evaluation. Important elements of a project's scope include its purpose, goals, size, and its complexity in terms of the design and construction features necessary to achieve the stated objectives. A well-defined scope will make clear the quantity and quality of the evaluation and assessment data to be collected as well as the resources and expertise required to perform the work.

Figure 3.3 *Restored Wetland*

Program Policies, Options and Requirements

Numerous agencies, local governments, conservation organizations, and others are involved in restoring wetlands across Minnesota's diverse, drained and altered landscape, on both public and private lands.

For wetland restoration on private lands, various programs and opportunities exist. Conservation programs that address restoration needs on private lands generally provide financial and technical assistance to landowners to complete the work. These programs all differ to some extent in their restoration goals, enrollment and acquisition procedures, eligibility criteria, terms, policies, standards, approach to restoration, maintenance, and management.

Enrollment or participation in a private lands program or through direct land purchases for the public often results in the project purpose being defined by program or agency requirements. This will influence the scope of the project and the approach taken to restore it. For example, most restoration efforts will have a primary goal of improving habitat conditions for wildlife whereas targeted restorations conducted by local governmental units may be seeking specific outcomes related to water quality or flood control. Private lands restoration work is also conducted for regulatory purposes to address wetland mitigation needs in the state. Restorations done for these more specific purposes will often include defined outcomes that must be met with regard to wetland functions and project performance. This often warrants more intensive site assessment work to ensure that all specific project requirements can be met.

Figure 3.4 *Landowner Discussion*

A commitment to a specific program or project purpose is usually made prior to any site assessment work being performed. It is important, therefore, that everyone involved in the project assessment be aware of applicable program policies, criteria, or requirements that could affect the project scope and extent of site assessment work needed.

Project Status

The status of a project in terms of its readiness for completion can influence the scope and timing of the site assessment activities. Where a landowner commitment or project acceptance is still tentative or when the project acquisition is still in process, it may not be practical to investing the time and resources necessary to complete all aspects of a comprehensive site assessment.

However, the results of such effort can help better define necessary project boundaries and full realization of potential restoration outcomes. Balancing the needs of both project and program funding decisions along with requirements for identifying necessary acquisition areas to ensure a successful restoration becomes a necessary case by case decision of when, or in what stages, to conduct the comprehensive site assessment.

Project Goals

Project goals will also affect the project scope. Program expectations or required project outcomes along with landowner expectations for final appearance and management are critical to project success and will help define the project scope. Examples of such could include:

- Targeted wildlife use of the wetland (such as waterfowl)
- Improved water quality for downstream resources
- Flood control benefits
- Groundwater protection
- Increased landscape diversity
- Targeted plant communities or wetland types
- Specific management objectives (such as the ability to manage wetland water levels)

Figure 3.5 *Waterfowl Use in Restored Wetland*

Specific functional goals will usually require a more comprehensive site assessment and more expertise to interpret the data to ensure that the goals are attainable.

Project Size/Boundaries

Understanding the project boundaries will help to define the project scope and control the extent of site assessment work to be performed. To determine the project boundaries, answer the following questions:

- Are the physical boundaries of the project already defined?
- If project boundaries are not defined, what are the limitations to establishing them?
- Are there any program limitations that may affect the size of the project?
- Are there identified construction or other implementation needs that might affect required project boundaries?
- Are adjacent properties needed to allow the wetland restoration to occur?
- If adjacent properties are being considered for the project, what is their status?

Everyone involved in the site assessment process needs to understand whether the project boundaries are already defined or if their work in assessing and evaluating the site will be used to define them. Where flexibility exists or boundaries have yet to be established, it is likely that more work will be needed to assess and evaluate the site. If not already determined, project boundaries will need to be defined through the site assessment and evaluation process, taking into account project needs, goals and objectives, landowner desires, and program requirements.

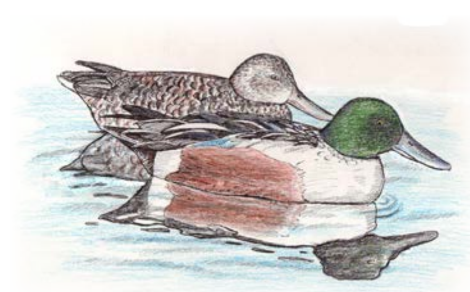
Project Complexity

Project complexity is a function of project size, project type, current site conditions, adjacent land uses, project setting, project issues and constraints, and project objectives. The project complexity directly affects the project scope.

Project Size - Larger projects tend to be more complicated and time consuming to assess because there are often more variables to consider. Larger projects are also likely to have multiple or larger wetlands to restore, more complex drainage systems, plant communities, and soil conditions to assess.

Project Type – Restoration complexity can vary considerably depending on type of project or wetland setting. For example, a project involving restoration of an isolated wetland basin that is altered by a ditch may be less complex than restoring a sloped wetland drained by subsurface tile. Restoring specific or targeted wetland communities can create additional project complexities.

Current Site Conditions – Existing drainage and land use are two key aspects of current site conditions that can affect complexity. Sites that are in agricultural production may be less complex in terms of vegetative restoration as compared to a restoration site with existing invasive species cover, due to the extra effort involved in their eradication. Projects that are extensively drained through a series of subsurface drain tiles that also benefit neighboring properties will be much more complicated to assess than a simple isolated wetland basin that is altered by a ditch or single tile line.



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Adjacent Land Uses – Intensive land uses in areas adjacent to the project such as row cropping or pasturing can make a restoration project more complex because of the need to account for long-term degrading influences that might include excessive inputs from nutrients, sediment, and other chemicals. In contrast, natural areas adjacent to the restoration site will tend to decrease the complexity of the project because of the lack of degrading influences to deal with in the design and management of the project.

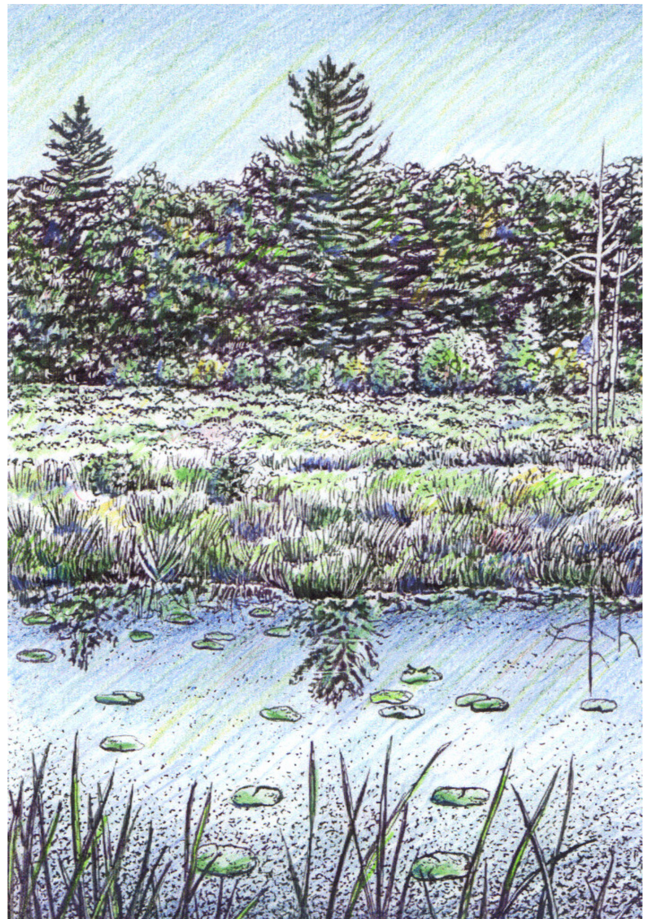
Project Location – Location within the watershed and urban or rural differences can also affect complexity. For example, a project located in the lower portion of a watershed may have significant hydrologic influences to consider compared to projects located in upper areas of a watershed. In addition, projects located in urban settings compared to rural settings will often have more complex issues and project requirements to overcome.

Project Issues/Constraints – Specific issues or constraints that are identified for a project will also affect complexity. Examples include sites that contain utilities such as overhead power lines or underground gas lines.

The cost of completing a project, or certain aspects of it, may also be a constraint depending upon availability of project funding. It will be important to understand the project's budget or cost limits throughout the planning, design, and construction phases.

Project Objectives – Projects with general objectives tend to be less complex than those with more specific objectives. For example, a project with an objective of improving wildlife habitat can be achieved rather easily compared to a project where specific restoration standards or outcomes are required, such as quantifying hydrologic changes or achieving a certain type of vegetation community. In these cases a more thorough examination of existing conditions in comparison to restoration results would be needed.

Understanding the project scope will help to define the extent of site assessment work that is needed for a project. The remaining chapters in this section of the Guide provide discussion on specific site assessment parameters that should be considered for every wetland restoration project.



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3-2 Ownership, Land Use and Legal Issues

Figure 3.6 *Public Drainage Ditch*

This chapter provides discussion on the ownership, legal issues, and land use information that should be assessed for a project and how that information should be used to influence the project evaluation.

- Landowner Discussions
- Land Use and Site History
- Ownership
- Legal Issues
- Utilities, Right-of-Ways and Other Property Issues
- Cultural Resources

Assessing information related to land ownership, land uses, and legal issues is necessary for most wetland restorations. It involves reviewing available information and discussing specific site issues with landowners and others who are familiar with the project. The assessment of these items should occur concurrent with or prior to performing any detailed on-site project work.

The extent of data collected should be adjusted to the scope of the proposed project. For example, a landowner-initiated restoration project that is tied to a conservation program that purchases easements will require a thorough assessment of ownership issues as part of the project evaluation. In contrast, a restoration project done through less formal means of acquisition such as agreements or contracts would not.

Landowner Discussions

Before visiting the site and conducting any field work, gather ownership and land use information. This information is often collected as landowners are applying for enrollment into certain programs or during negotiations for land purchase. Additional information can be gathered through discussions with past owners of the property, neighbors, or anyone else, including renters, who may have some knowledge of the site and its history. These discussions are an important part of the project assessment as critical information about the site is often learned.

Figure 3.7 *Project Meeting with Area Landowners*

Ask questions regarding property ownership, site conditions, land uses, drainage, site history, etc. During these discussions, the goals and objectives of the project should be reviewed with the landowner and others associated with the project. It is important to document information obtained from these discussions via notes or recordings.

Figure 3.8 *Historic Wetland Drainage*

Land Use and Site History

Current, recent, and past land uses of a potential restoration site and the area that surrounds it can affect project assessment and design decisions. Some examples include:

- The current land use may affect the ability to perform on-site assessment work. For example, the presence of a crop can limit site access for topographic surveys and soil borings.
- The type of crop that might have been planted and the chemicals used over the past several years could affect both the site preparation requirements as well as the type of vegetative plantings to be made.
- The length of time a wetland has been drained can impact the presence and reliability of any remnant native wetland plant seedbank that may exist.
- Past land uses (i.e. crop history) may also have an effect on eligibility for certain conservation programs.

Information on current and past land uses as well as general historical site information is important to the site assessment process. The best information about the recent and historic land uses will come from the current or past property owner or renter. Additional site information can also be obtained from a number of different resources including the following:

- The **United States Geological Survey (USGS) quadrangle maps** are broadly available in both paper and electronic formats. These maps are useful in providing a general overview of the project and its surrounding landscape. Older versions of these maps can provide historical information. Topography is included, usually at intervals of ten feet. These maps are available in either a 15 minute map with a scale of 1:62500 (1 in. = 5208 ft., 1 cm = 625 meters) or a 7.5 minute map with a scale of 1:24000 (1 in. = 2000 ft., 1 cm = 240 meters). For smaller projects, the information may be of limited value due to the scale and contour interval provided.
- **LIDAR data** is available for the majority of the state and has become an important site assessment resource. LIDAR data is available through some local governments and through the state at the Minnesota Geospatial Information Office's (MNGEO) interactive website. The data can be viewed or downloaded in several formats depending on project scope and user/software constraints.
- **Aerial photos and Orthophotos** are readily available for all areas of the State in a variety of formats. Aerial photos, in particular historic photos, are an invaluable tool when assessing prior and current land uses, wetland conditions, and drainage extents.
- **Soil surveys** produced by the Natural Resources Conservation Service, provide descriptive information of the site's geology and soil characteristics, which can be necessary during the assessment, planning, and design of the wetland project. Soil survey data is currently available through the NRCS Web Soil Survey.

Other maps, photos, and reference materials may exist for a particular area and should be collected as needed to thoroughly assess the site and project. Copies of all relevant data should be saved to the project file as they may be valuable references during the project design and development stages. Many of these resources are available in both electronic and paper formats.

A recommended reference resource is the Minnesota Department of Natural Resource's GIS Data Deli. This web-based site contains data files on many maps, photos, and other useful materials. It contains spatial data that can be downloaded for use in Geographic Information System (GIS), image processing systems. A wide range of useful reference information is available for download from the Data Deli including:

- Current and historic maps and photos
- LIDAR and other elevation based maps
- Wetland Maps
- Land cover classification maps

- Historic vegetation maps
- County biological surveys

Wetland based resource information in Minnesota frequently changes and improves. Users are encouraged to reference and utilize this information to its fullest extent for efficient and effective planning and design of wetland projects.

Ownership Issues

For projects that involve easements or fee title acquisitions, consider early in the assessment and evaluation process the status of the acquisition and the potential for ownership issues to exist that could affect the acquisition. These projects require a thorough review and understanding of property ownership, drainage rights, flowage rights, and prior property interests.

When purchasing a property through free-title easement acquisition, the purchaser should require that the property is free and clear of any ownership issues or objectionable encumbrances. The presence of any title claims or other ownership issues may affect the ability to secure the necessary property rights for the project. A review by a qualified person, such as a title agent or an attorney, of the ownership records, property deed, and abstract, will clarify the true legal ownership of the property along with any encumbrances or other legal issues that can impact or prevent completion of the project. Examples of potential encumbrances and legal issues that could affect a restoration project include the following:

> It will be important to identify and understand all ownership and legal encumbrances associated with the property as they can affect acquisition or restoration outcomes

- Mortgages
- Liens
- Covenants
- Subsurface (mineral) rights
- Delinquent property taxes owed
- Drainage agreements/easements
- Rights-of-ways or utility easements

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Consents, subordinations, releases, and satisfactions are all possible legal actions that will be needed to address identified property encumbrances as a part of easement conveyance or land acquisition. For most fee-title or easement acquisition projects, the legal work associated with reviewing ownership and property records occurs after the site assessment and evaluation process has been completed. This is because the assessment is usually needed to justify the acquisition and to identify the necessary acquisition boundaries for the project. A negative result is the completion of an extensive site assessment for a project that later turns out not to be viable due to ownership or other legal issues. Therefore, a preliminary evaluation of the potential ownership and legal issues associated with a project should be conducted prior to or concurrent with site assessment process. This preliminary evaluation should involve a courthouse search of property records. More specifically, property records should be researched to uncover the existence of any liens, judgments, mortgages, encumbrances, or recorded land rights, easements, or agreements. Knowing about a property issue ahead of time provides an opportunity to avoid these difficult sites or, at the very least, allow the owner or project manager to proceed with a full understanding of those identified issues.

Legal Issues

Legal issues related to access, drainage, and flooding are commonly associated with wetland restoration projects. One of the biggest challenges that is often encountered when restoring wetlands is dealing with drainage rights and potential adverse impacts to adjoining properties. If potential direct or indirect impacts to adjoining properties are identified, then an assessment of the legal rights related to the potential impact should be completed. This may involve consultation with individuals familiar with applicable Minnesota laws.

Drainage rights are probably the most common land rights issue that needs to be understood as restoration projects often involve the manipulation of existing drainage systems.

The evaluation of legal rights associated with potential impacts on adjoining properties may require an expansion of the site assessment. This may require that investigations extend beyond the project boundary and onto neighboring properties. This must be done with the cooperation of the neighboring property owners. These investigations can lead to an expansion of the project size, depending upon what is discovered and the willingness of the landowners to cooperate. If negative impacts will occur on neighboring properties where legal rights for protection exist and the neighbor has no interest in participating or cooperating, the project either needs to be scaled back, planned and designed to avoid those impacts, or terminated, if necessary.

> A basic understanding of drainage related laws and regulations is necessary to effectively restore drained wetlands

Additional drainage rights information and the process to amend legally protected drainage systems can be found in **Section 4-9 Construction Related Laws, Regulations and Permits**.

Utilities, Rights-of-Way, and Other Property Issues

The presence of utilities such as natural gas, petroleum, water, sewer, telephone, and electric on a property can prevent or limit a wetland restoration project. The restrictions associated with these utilities may limit or preclude certain project components from occurring within their designated easement or right-of-way boundaries. Information about utilities can be collected during the landowner discussion, on-site assessment, courthouse search, and title review work. Examples of potential restrictions associated with utility easements and right-of-ways include:

- Flooding within road right-of-ways
- Flooding areas over gas and oil pipelines
- Flooding areas around power or transmission poles and under transmission lines
- Impairing access for routine utility maintenance

In most situations, through negotiations and creative planning, solutions can be found to allow the project to be completed in a manner that is agreeable to the owner of the utility. **Section 4-7 Engineering Design and Construction, Other Design Strategies** of the Guide provides information on how to comply with existing utilities as part of the project design.

Cultural Resources

Cultural resources are evidence of past human activity. They may include pioneer homes, buildings or old roads; structures with unique architecture; historic villages, battle sites, artifacts, or objects; rock inscriptions; burial sites; and earthworks, such as battle entrenchments or mounds. These are important, nonrenewable

Figure 3.9 *Gas Pipeline Utility*

resources and although many locations are known and currently protected, there are numerous forgotten, undiscovered, or unprotected cultural resources remaining in Minnesota. Federal, state, and local laws have been enacted to preserve cultural resources. These include the National Historic Preservation Act of 1966 and the Minnesota Field Archeology Act. Cultural resource sites can be encountered when performing construction work in upland areas that surround larger, more significant wetland restoration sites. A preliminary assessment for these cultural resources needs to be part of every project. If a high potential for a cultural resource occurrence is identified, an archaeological field investigation may be needed. More information on laws and procedures enacted to protect our cultural resources is available from the Minnesota State Historic Preservation Office.

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Checklist

Data Collection Needs – Ownership, Land Use and Legal issues

The following is a checklist of items to review and consider when assessing ownership, land use and legal issues associated with wetland restoration projects:

- ❑ Type of ownership of the property.
- ❑ Information about any liens, encumbrances or mortgages on the property.
- ❑ Current and past land uses on the property.
- ❑ Recent cropping history and specific chemical uses.
- ❑ Information about site drainage and any drainage agreements that may exist.
- ❑ Site hydrology, flooding frequency and duration.
- ❑ Information about springs or wells that may exist in or near the site.
- ❑ Information about utilities, septic systems, garbage, hazardous materials or chemicals etc. that may exists in or near the site.
- ❑ The expected goals or outcomes of the project.
- ❑ Type of relationship with any neighbors that could be impacted by the project. Is it an amicable relationship or have there been past disputes?
- ❑ Conduct a courthouse search reviewing property information specific to liens, judgements, mortgages, encumbrances, or recorded easements or agreements.
- ❑ Make copies of any recorded land rights, agreements, or easements that may be important to the project (i.e. utility easements, drainage agreements, mineral rights or leases, etc.)
- ❑ Review current and historical photos.
- ❑ Review historic land survey notes.

3-3 Site Soils

Figure 3.10 *Soil Profile*

The topics covered in this chapter include assessing site soils both for their suitability as a medium for plant growth and for their use in construction.

- **General Considerations**
- **Using Soil Survey Data**
- **Soil Characteristics for Vegetation Establishment**
- **Soil Mechanics and Construction Issues**
  - *Topsoil Conditions*
  - *Sediment Deposition*
  - *Foundation Conditions*
  - *Borrow Areas*
  - *Wetland Creations/Excavation*

Soils are an important but often overlooked component of many wetland restorations. Soils are an integral part of every wetland ecosystem and the foundation for project design components from the selection of plant communities to the design of earthen structures and other soil-related project components.

General Considerations

For most wetland projects, the soils assessment is straightforward. It includes a review of the published soil survey and separate on-site soil investigations to support both the engineering and vegetation design components of the project. Soil attributes such as texture, organic matter content, and pH influence the selection of plant species that will be best suited for specific areas or hydrologic regimes within a project. Physical or geotechnical soil properties such as permeability, compressibility, and strength can affect the design and construction of the project. The extent or presence of sediment in the wetland, or other soil disturbances, must also be considered.

It may also be necessary to determine if on-site soils are compatible with the goals and objectives of the project, specifically, their suitability with the intended type of wetland and associated wetland plant communities. Investigations may reveal that existing substrate soils are not suitable and an alternate source, if available, would serve as a more suitable medium for plant growth. Engineering features may also need a detailed assessment of site soils, including a comprehensive analysis of soil permeabilities for planned retention areas.

Using Soil Survey Data

All wetland restoration projects should include a review of the NRCS Web Soil Survey as part of the site assessment. The soil survey describes the geology and characteristics of identified soils. It also provides information about soil texture, chemical properties, physical properties, hydric soil designations, and construction material suitability that is useful in the planning and design of any wetland project.

> The published soils information should be viewed as general in nature and should not be used in place of more detailed on-site soil data collection

The soil survey can be used to identify the presence and size of existing or drained wetlands on a project site. The displayed hydric and non-hydric soil map units can be used to estimate the extent and type of former wetland areas including hydrologic regime and identify those sites which may have the greatest opportunity

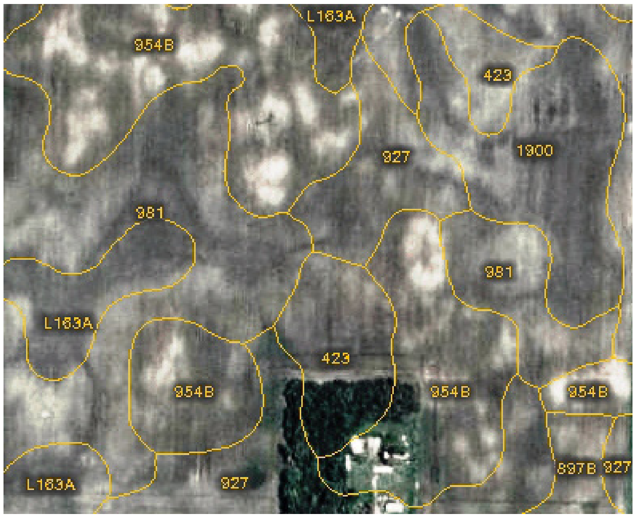


Figure 3.11 *Sample Soil Map from Web Soil Survey*

for restoration of both wetland hydrology and wetland plant communities.

The soil survey information can have some limitations, however. Reliance on it should take into consideration whether recent disturbances have occurred since the survey was completed. An example of this would be within the corporate boundaries of a city or where extensive land alteration or wetland impacts through prior draining, filling, or grading have occurred.


Figure 3.12 *Soil Assessment*

Soil Characteristics for Vegetation Establishment

The ability to establish vegetation in restored wetlands and surrounding upland buffer areas can be influenced by soil characteristics such as texture, structure, organic matter content, bulk density, fertility, compaction, pH, and sediment deposition. The influence of each characteristic varies depending on the type of project, landscape setting, land use, and extent that the soil has been disturbed.

With respect to vegetation establishment in uplands, soil texture and organic content will have the greatest influence on the success of the planned vegetative plantings. For example, dry prairie species typically require sandy soils with a low organic content while mesic prairie species require moist soils with a higher organic content. Increased moisture from a high water table in sandy soils may require the selection of species adapted to more moist conditions. If forest species will be planted, soil texture and organic content should guide the selection of individual tree and shrub species.

When assessing and evaluating site soils, the anticipated soil moisture conditions for a project should direct the selection of seed mixes to be used . Seed mixes are selected based on the level of planned saturation in the soil or planned water levels. If a diverse seed mix is used for a project, soil characteristics will influence the success of certain species and result in a plant community that matches site conditions. If a less diverse seed mix is used, it is more important to match species to specific soil conditions.

In undisturbed soil conditions, basic soil characteristics such as texture, structure, bulk density, and organic matter content can reasonably be deduced from soil survey information and shallow, hand-augered samples (**Figure 3.13**). Establishing the general character of a soil such as "sandy loam" for texture or "muck" with regard to organic soils is adequate for most sampling work. For soils that have been disturbed, watch particularly for sedimentation and compaction, both of which can affect plans for restoration.

For created wetlands, a more comprehensive assessment of soil characterization is important because, unlike restored sites, the soil has not previously supported wetland vegetation. Soil characteristics related to vegetation establishment such as compaction, nutrient content, and organic matter content will need to be examined in more detail. It may be useful or even necessary to examine soils in nearby reference wetlands. This could provide useful information regarding appropriate soils for different vegetative communities. An assessment of potential soil substrates for wetland creation sites will reveal limitations in regard to moisture-holding capacity, plant nutrient availability, degree of compaction, and other factors influencing vegetation establishment. Informed decisions can then be made regarding the choice of soil substrate and any possible soil amendments.

Assessing soils with respect to vegetation establishment should involve a review of the soil survey information and on-site investigations using hand augers or other equipment. These on-site investigations are typically confined to the upper one to two feet of the soil or the effective rooting zone of wetland and upland plants. For disturbed or highly variable soils, a more extensive assessment utilizing mechanized boring equipment may be warranted.

Figure 3.13 *Hand Augered Soil Sample*

Soil Mechanics and Construction Issues

Excavations or earthfills are often associated with planned wetland restorations. Their design should take into account the expected site conditions that will develop over the life of the project. The design of these features will depend upon the characteristics of the soils used in their construction. Detailed geotechnical explorations as well as sampling and testing of specific soil characteristics such as density, compressibility, and permeability are often required when evaluating soils.

During an initial assessment, it is not likely that detailed geotechnical explorations will be needed. Detailed geotechnical evaluations are often conducted later in the design of the project, as more specific engineering design features are identified. In consideration of this, soils investigations as part of the initial site assessment should be consistent with the scope of the project. Items that should be considered for investigation include:

- Topsoil Conditions
- Sediment Deposition
- Foundation Conditions
- Borrow Areas

Topsoil Conditions

Accurate measurement of topsoil depths is most critical when the planned construction at a project site includes excavations; borrow sites, or embankment construction. Topsoil present in construction areas usually is removed and then replaced as part of the final grading process (**Figure 3.14**). The amount of topsoil that will be stripped and re-used can have a significant effect on design, construction sequencing, and project budget. Therefore, it is recommended that accurate topsoil depth measurements be obtained during the site assessment phase. It may be necessary to locate alternative sources of topsoil if suitable amounts are not readily available to support stabilization and the establishment of vegetation in construction areas.

Sediment Deposition

Sediment accumulation is common in both existing and drained wetlands, whether through natural or

Figure 3.14 *Topsoil Stripping*

accelerated erosion of watershed soils. Conditions of the surrounding watershed, such as soil types, land use, topography, and hydrologic conveyance systems such as ditches, tile, and storm sewers, will have a direct impact on sediment inputs. The depth of sediment resulting from these inputs can be up to three feet in some wetlands. Over time, sediment accumulation can cover the original wetland soils and any remnant native wetland plant seedbank that may exist.

Removing accumulated sediment aids in the restoration of historic hydrology and, if done correctly as part of the planned construction activities, can release and allow the germination of remnant vegetation from the seedbank. Because the cost to remove sediment can be quite high, an accurate assessment of sediment depths is important. The location, extent and depth of sediment deposits vary throughout most wetlands, requiring that measurements be made at multiple locations when assessing sediment depths (**Figure 3.16**).

There are three methods commonly used to determine the presence and depth of sediment. They include assessing soil color, texture, and performing a hydrochloric acid test. It should be noted that even with these assessment methods, it can be difficult in many situations to distinguish the sediment layer from the original wetland soil surface. This is particularly true in wetlands that are drained and have a long history of agricultural site disturbances where sediment and wetland soils are tilled and mixed together. It is recommended that an experienced soil scientist or wetland ecologist be involved in the assessment process to help properly identify sediment depths when its removal is critical to the success of the project.

Determining sediment depths through an assessment of soil color is often the easiest and most obvious means of diagnosis. Lighter soil colors being present above darker soil colors (i.e. lighter tan colored soils on top of black organic soils) is usually an obvious indication of sediment.

Figure 3.15 *Sediment Accumulation due to Field Erosion*

Figure 3.16 *Assessing Sediment Depths*

Assessment of soil texture is another method to help determine the boundary between sediment and the original wetland soil surface. Possible evidence of this boundary includes changes in soil texture, organic content, and the presence of dead plant material or crustacean shells, such as snails, within the underlying soil profile. Sediment will generally be a denser, course or fined grained soil material containing little to no organic material. Organic soils original to the wetland will feel very smooth, almost greasy but not sticky. These soils may leave a slight stain on your hand when sampling. Perform texture samples every two inches or so by rubbing a small soil sample between your thumb and forefinger until a boundary layer can be distinguished.

> Sediment removal should be an important design consideration for most restoration projects

The third method of assessment is testing for effervescence using hydrochloric acid (HCL). The HCL test is very diagnostic and easy to perform. Soils effervesce if they contain calcium carbonate and a dilute acid solution is applied. Carbonates in the soil react with the dilute acid and carbon dioxide gas is given off. The gas will be seen as frothy bubbles and produces a fizzling sound. In general, wetland soils will not effervesce whereas upland soils will. When effervescent soil layers are found over non- effervescent layers it can be assumed that the effervescent soils physically washed in from surround calcareous upland soils. When using this test method test the soil profile with one drop of acid every two-inches or so in depth where the sediment boundary is suspected.

Additional discussion on strategies and considerations for sediment removal occurs in **Section 4-6 Engineering Design and Construction, Sediment Removal, Scrapes, and Other Excavations.**

Foundation Conditions

For many wetland restoration projects, earthwork activities include the construction of simple, low-head earthen embankment structures. To design and construct these structures, a basic assessment of the underlying foundation soils will be necessary. Evaluating foundation conditions for simple structures can be as easy as taking a few borings with a hand auger or soil probe (**Figure 3.17**). This basic assessment includes estimating topsoil and sediment depths at planned structure locations and exploring for suitable borrow sources.

More complex projects could include embankment or other construction in areas where more permeable or poor strength underlying soils exist. Foundation treatments may be necessary to address these soil conditions. If so, a comprehensive investigation and analysis of the site soils is needed.

Having good information on foundation soils can be critical to the design process. Geotechnical investigations should include a well-defined approach to assessing the physical characteristics of the site soils through explorations, sampling, and analysis (**Figure 3.18**). This could include a full soils analysis providing information on permeability, compressibility, and strength of underlying soils. This work would be specific to the design and construction needs of the proposed engineering plan. Additional discussion on the requirements and purpose for foundation soils exploration

> The design of certain embankments and other structures may require a detailed assessment and analysis of foundation soils

Figure 3.17 *Soils Assessment with Probe*

and investigation occurs in **Section 4-4 Engineering Design and Construction, Earthen Embankments.**

The geotechnical needs of some projects can be addressed as part of the initial site assessment, usually completed as part of the project survey. This is only possible if structure locations are easily identified from the initial project layout and topography. The extent and locations of planned earthwork activities may not be known until a full site assessment and preliminary design is made. In such situations, it is possible that additional soil investigation may be needed after a preliminary engineering plan for the project is prepared.

When deemed necessary, geotechnical investigations of embankment foundation soils are performed along the alignment of the planned embankment at varying intervals anywhere from 50 to 200 feet apart. Variability in topography and subsurface soil conditions will dictate the spacing interval needed for proper assessment. The depth of investigations will be dependent on the project scope but also on equipment used, site conditions, and characteristics of the foundation soils encountered. At minimum, the investigation should include an evaluation of the soil stratification, which is essentially an examination and classification of soil types, depths, and layers along with identifying the depth to water table, if present. In limited situations, other tests may be necessary, including the evaluation of grain properties (soil texture, particle size, organic content, and water content) and soil behavior properties (permeability, density, and compressibility). It will be important that an experienced engineer, geologist, or soil scientist be involved when determining the requirements for evaluation and when performing the geotechnical investigations.

Figure 3.18 *Soils Assessment with Drill Rig*

Borrow Areas

Earthen embankments and other earthfills require suitable soil "borrow" material for their construction. The physical requirements for borrow material will vary depending on the height and scope of the earthen embankment or other planned earthfills. In many situations, suitable borrow areas can be preliminarily identified through a review of the published soil survey. Final evaluations are then made as a result of on-site explorations done at the time of construction. In other situations, the suitability and characteristics of borrow soils will be important for the design of the project. Examples of when this might occur include evaluating large scope projects where the design and functionality of an embankment will be critical to the project's success, when downstream hazards from an embankment might exist, or when embankment or foundation related seepage or stability will be of concern. In these situations, borings will need to be taken as a part of the design to determine the suitability and characteristics of soil materials for their intended purpose. Additional discussion on the suitability of borrow materials in the design of the earthfills occurs in **Section 4-4 Engineering Design and Construction, Earthen Embankments.**

The objective should be to find suitable borrow material as close as possible to potential construction areas. This will minimize construction costs without compromising the integrity of the project or any of its structural components. Many wetland soils are suitable for use as fill in low-head earthen structures and are often preferred over upland borrow areas, as their use provides an opportunity to enhance wetland depths and diversity. Excavations within the bed of any existing or drained wetland need careful evaluation of the soil substrate; excavations in some locations might penetrate through an impermeable substrate layer into a pervious sediment substrate or sand lens, impacting the ability of the site to retain water. To avoid this problem, the wetland site assessment should always include borings when excavations within it are planned.

Figure 3.19 *Recently Constructed Wetland Excavation*

For wetlands that are created through excavation and removal of the site soils, the geologic evaluation may be the most critical site assessment function that needs to be performed. The success of these creations depends largely on achieving the desired hydrologic regime. There are generally two approaches or strategies used when attempting to create wetlands via excavating down to the existing water table or excavating into a pervious substrate with a compacted, impervious clay liner to retain water. Both conditions require a detailed assessment of the texture and permeability in the soil profile as well as the hydrologic regime of the planned wetland and its relationship to groundwater conditions. This will typically involve deeper soil borings and professional interpretation by a qualified engineer or soil scientist.

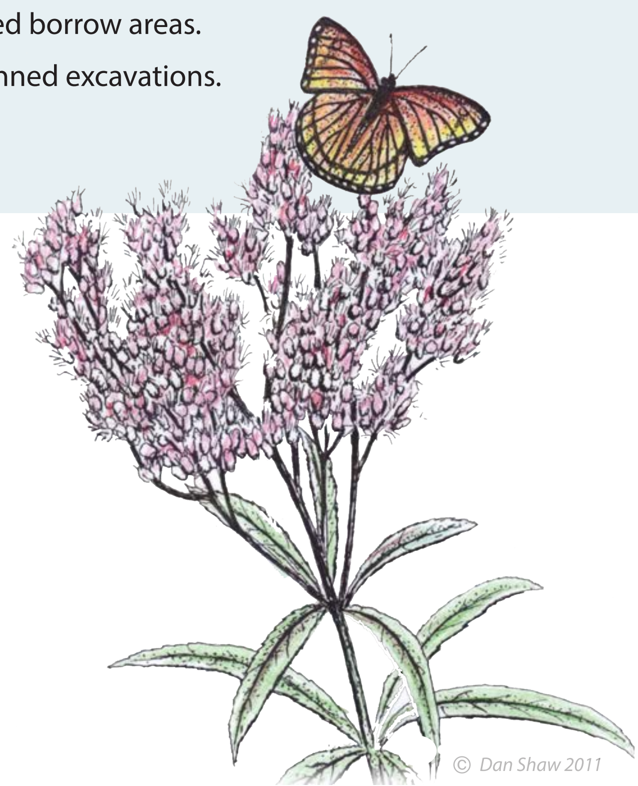
Checklist

Data Collection Needs – Soils

Most initial on-site soils investigations are shallow in depth and will occur within the first few feet of the soil surface. This investigation, if properly planned, can take place as other site assessment work is being completed. Shallow geologic investigations can be completed with a shovel, hand auger, or soils probe. Deeper explorations may be needed for which specialized equipment, capable of taking deeper core samples, should be considered. The test locations and information collected should be noted on a photo, map, or included in the specific site survey data. When appropriate, soils information from any boring(s) should be properly noted, logged, and sampled for future analysis.

The following checklist includes soils information that should be collected and on-site soils investigations that should be completed, when and where deemed appropriate:

- ❑ Review the NRCS Web Soil Survey and make copies of appropriate information for the file.
- ❑ Review the extent of hydric soils, verify on-site as necessary.
- ❑ Identify soil textures at identified areas.
- ❑ Investigate topsoil depths at identified areas .
- ❑ Investigate sediment depths when its removal is being considered.
- ❑ Investigate foundation conditions at identified structure locations.
- ❑ Investigate suitable locations for any planned borrow areas.
- ❑ Investigate substrate conditions for any planned excavations.



3-4 Site Hydrology

Figure 3.20 *Restored Wetland*

This chapter provides an overview of site factors that can affect wetland hydrology and discusses what information needs to be collected during the site assessment to allow for a hydrologic evaluation of a wetland restoration site.

- General Considerations
- Hydrology Sources
- Landscape Setting
- Watershed Assessment
- Assessment of Hydrologic Disturbances
- Assessment Ground Water Conditions

The success of any wetland restoration will fundamentally depend on the ability of the site to provide and maintain the desired hydrologic regime. Hydrology affects the size and type of wetland, the plant communities that develop, and, ultimately, the function of the wetland project itself.

General Considerations

The approach taken to assessing hydrology will vary depending upon the type of wetland that is being planned and the geographic location and hydrologic setting of the site. Ultimately, the site assessment process will determine if the available hydrology will meet goals established for the project. Adjustments to the project goals may be needed if information gathered suggests that the amount of anticipated hydrology is not attainable.

When restoring drained wetlands, attempts to manipulate the natural hydrology for a specific project purpose or restoration goal that is different from the pre-drainage condition of the wetland often leads to failure. The best probability of success for a restoration project will be achieved by allowing the available, natural hydrology along with other relevant site conditions to control the wetland type and plant communities that are to be restored. This approach will help ensure that soils and other site functions are matched with the historic hydrologic conditions, improving the chance for a successful restoration. The goal, then, of any true wetland restoration should be to restore the site hydrology as close as possible to its pre-drainage condition. The project assessment should attempt to determine historic hydrologic conditions and if those conditions can be reestablished. Considering the landscape changes that have been made in most watersheds with respect to land uses and drainage, this can be a challenging task. Where significant landscape changes have occurred, it

Figure 3.21 *Outlet Structure on Restored Wetland*

may not be possible to restore hydrology to historic conditions. Ownership, drainage patterns, land use changes, and site constraints may require that some other hydrologic condition be considered.

With wetland creations, more flexibility exists in achieving a planned or "target hydrology" condition. Creations are most often the result of excavation. With proper assessment of existing site conditions and control over the planned excavation work, a desired hydrologic condition can often be achieved. Then, specific wetland soil and plant communities can be established to match the created hydrologic condition.

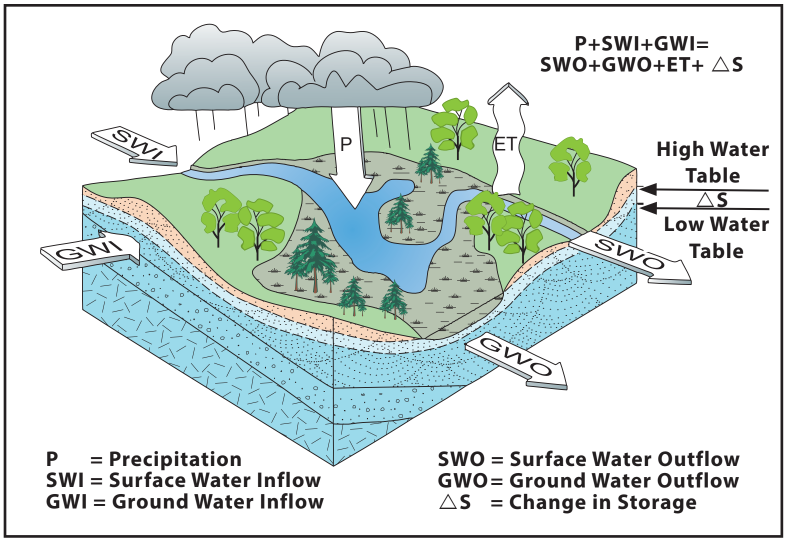


Figure 3.22 *Components of a Wetland Water Budget*

Hydrology Sources

The extent that hydrology is available may be the single most important factor affecting a wetland's potential to achieve desired project goals. The hydrologic condition not only affects potential water levels of the proposed wetland, it interacts with and affects chemical and physical soil properties, the basis for the diversity and productivity of plant and animal species that will become part of the finished project.

The movement of water through air, land, plants, and water bodies is referred to collectively as the **hydrologic cycle**. Its components include **precipitation, infiltration, surface water flow, ground water flow,** and **evapotranspiration**. The interrelationships of these components are often described as a water budget (**Figure 3.22**). Wetlands continuously receive and lose water through these natural processes in exchange with the atmosphere, surface water bodies, and the soil. This discussion of hydrologic inputs and outputs should not give the impression that water moves through the hydrologic cycle at a steady or constant rate. Water movement through the cycle is, in fact, quite erratic and often unpredictable. These inputs and outputs include:

> While precipitation is important, all potential hydrologic inputs and outputs need consideration as part of the site assessment and design

Precipitation - Moisture that falls from the atmosphere and reaches the ground is the primary source of water to most wetlands. It can be in the form of rain, mist, snow, sleet, or hail. It provides water directly to a wetland when it falls within the wetland boundaries. Precipitation that falls outside of a wetland and then flows into it is called watershed runoff and is part of the surface water inflow process.

Surface Water - Overland flow or runoff from precipitation events within a wetland's watershed, stream flow, flooding from lakes and rivers, and groundwater discharge are all potential sources of surface water inputs to wetlands. For most wetlands, watershed runoff will be the predominant source of surface water inputs. The amount provided is directly related to the characteristics of the contributing watershed including its size, shape, soil permeabilities, land uses, topography, and the extent and type of any hydrologic alterations such as drainage.

Surface water outflow from wetlands also occurs and will be greatest during wet seasons and after large rainfall or flood events. Surface water outflows will be managed and controlled by natural or constructed outlets. Surface water outflow will typically be more uniform and consistent in wetlands with a strong groundwater component than in wetlands supplied mostly by precipitation and surface water runoff.

Riparian flows – Riparian sources are a form of a surface water input that can include hydrologic contributions from rivers, streams, creeks, and sometimes drainage ditch systems. Relying on riparian sources for hydrology can be risky. Carefully assess all potential riparian sources for flooding frequency, duration, levels, flow rates, and potential sediment deposition. Account for possible transport of undesirable seed and animals such as fish to the project wetlands when riparian flooding occurs.

Drainage/Stormwater - Drainage and storm water conveyance systems can be beneficial or detrimental to a planned site depending on the situation and the intended goals of the project. Discharge rates, volumes and issues with water quality from these conveyance systems all need consideration.

Ground Water - Ground water is subsurface water that exists in pore spaces and fractures in rock and sediment beneath the earth's surface. It originates as precipitation or seepage from surface water bodies.

Ground water recharge is the movement of water that infiltrates through unsaturated soil materials until it reaches the saturated zone.

Ground water discharge occurs when ground water moves to the surface as seeps and springs or when the water table rises above or is close to the ground surface. Wetlands often exist in landscape settings where ground water discharge occurs.

In some cases, sites with high water tables that have been effectively lowered through drainage provide good opportunities for successful restoration. Less often, excavation may be done to intercept existing ground water levels.

Evapotranspiration - Evapotranspiration is the combined loss of water by evaporation from open water surfaces and transpiration from the soil by plants. The rate of evapotranspiration is governed by temperature, solar radiation, wind speed, relative humidity, soil moisture, and vegetative cover. Evapotranspiration rates for a given site vary both seasonally and daily. Deeper, open water wetlands typically have higher loss rates than shallower, vegetated wetlands. Evapotranspiration rates also vary based on geographic location within the state due to temperature differences and other weather related phenomenon.

Direct measurement of evapotranspiration is difficult. Estimates are usually obtained indirectly from measured meteorological or other variables. The State Climatology Office has additional information on evapotranspiration estimates for all areas of the state.

Comprehensive hydrologic analyses that assess long-term hydrologic function and sustainability will require an estimation or calculation of evapotranspiration over the analysis period. Evapotranspiration may be a significant long-term hydrologic component for open water wetlands or wetlands with large areas of saturated soils. Evapotranspiration is of particular importance for excavated, created wetlands as the degree or rate of evapotranspiration losses may exceed available inputs.

Landscape Setting

In addition to identifying and understanding the potential sources of hydrology to a planned wetland, the overall hydrologic assessment must place the wetland in context of its landscape setting. The landscape or hydrologic setting describes the type of wetland in relation to its geographical location, topography, interaction with groundwater, and other general hydrologic parameters. Drained or altered wetlands can then be categorized hydrologically with respect to landscape position and potential hydrology sources, which will aide in evaluating their design needs.

Minnesota's wetland ecosystems include wetlands in closed depressions such as "prairie potholes", wetlands at the fringes of lakes and along streams and rivers, wetlands on sloped surfaces, as well as the many large forested wetlands, wet meadows, fens and bogs, that appear to be nearly flat. In terms of hydrologic setting, these wetlands can be summarized into one of three general categories, **depressional wetlands, sloped wetlands,** and **extensive wetland flats**. Within these categories, three primary interdependent hydro-

logic factors exist and are used to define and describe the differences among these wetland categories:

- Geomorphic or Landscape Setting (depressional, sloped, or extensive flats)
- Water Source (groundwater, precipitation, and runoff)
- Water Movement (unidirectional flow, reversing flow)

The interaction with surface and ground water together with landscape position (location on a slope, depression, or extensive flat setting) accounts for the major hydrologic differences in wetlands. The variability of these interdependent hydrologic factors contributes to the diversity of wetland types and hydrologic settings across Minnesota. Based on this principle, six basic wetland hydrology classes have been developed for Minnesota's wetlands (**Figure 3.23**). While classifica-

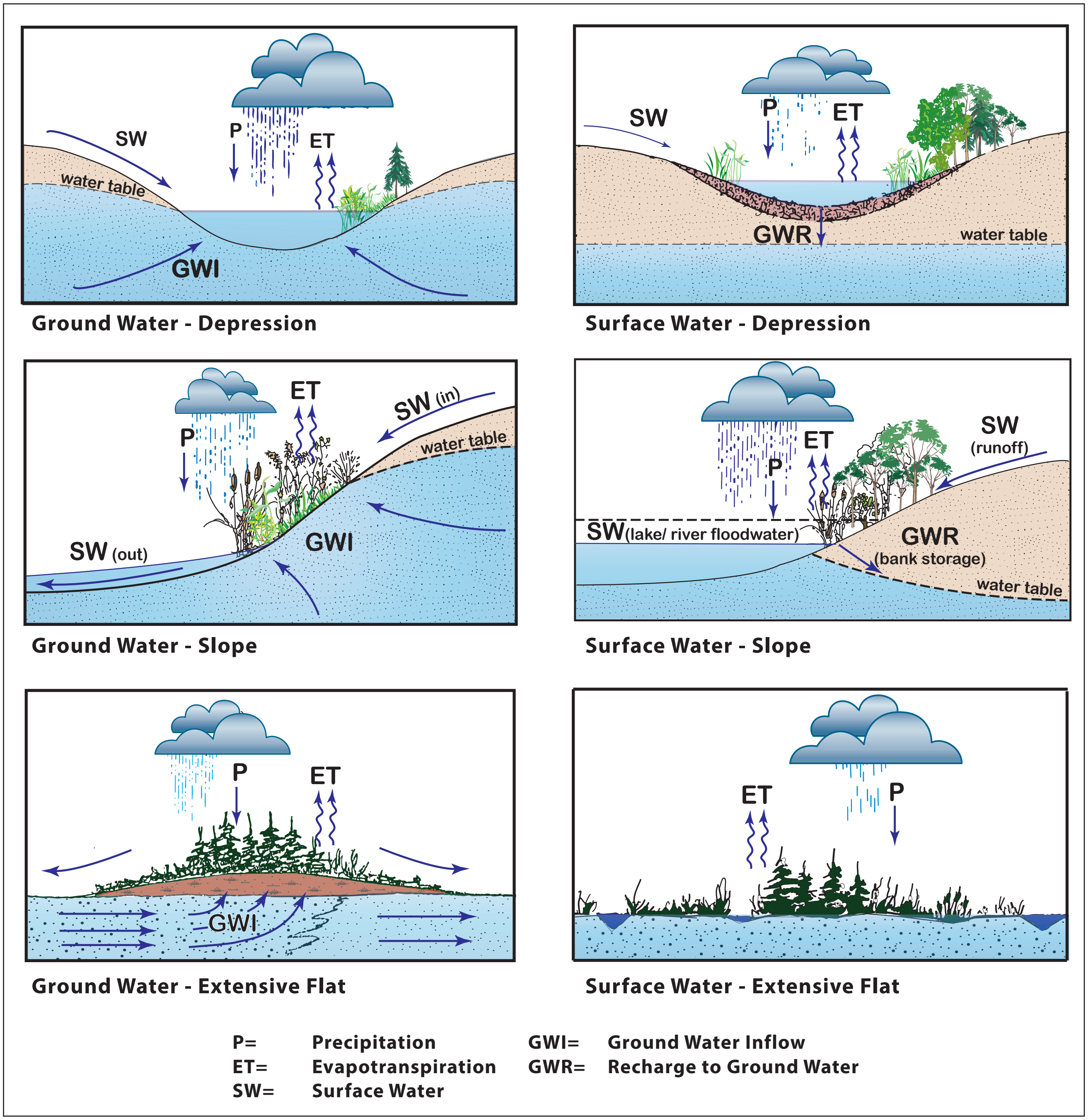


Figure 3.23 *Basic Wetland Hydrology Classes for Minnesota's Wetlands (Novitzki 1982 and 1998)*

Figure 3.24 *Drained Wetland Complex*

tion is useful to frame a hydrologic assessment, actual wetlands may exhibit properties of more than one class. **Appendix 3-A** presents the characteristics of these six wetland hydrology classes in more detail together with strategies that are used to restore these wetlands when drained and altered.

Watershed Assessment

Watershed hydrology includes drainage or runoff from adjacent, upstream areas that contribute water to the wetland from a storm or runoff event. Runoff can be delivered through a variety of means including overland flow, channelized flow, and subsurface drainage. Hydrologic inputs from surface runoff can be measured in terms of runoff rates and volumes and can be predicted from climatic data and watershed characteristics. Watershed features that affect runoff rates and volumes include:

- Drainage area of watershed
- Topography
- Land use and cover
- Soil types
- Gradients of channels or flow paths
- The extent of temporary storage areas

In most instances, the watershed size will be the limiting hydrologic factor influencing runoff volumes to a wetland. A preliminary assessment to determine the project's watershed is done by reviewing existing topographic maps, LIDAR (light detection and ranging) data, and air photos of the project site. Most watershed boundaries can be determined through this map review process. An on-site verification of the delineated watershed may be necessary and should be completed during the site assessment. This field review will help confirm the watershed boundary and verify or correct areas of uncertainty. Prior to performing the field assessment, transfer the preliminary estimated watershed boundary onto an air photo, as scale and orientation of an air photo will improve the field verification process.

If multiple project wetlands will exist in close proximity to each other, assess the hydrologic relationship between them. Obtain and review detailed ground elevations of the various wetlands and buffer areas. With good topographic information, the hydrologic relationship of these wetland areas can accurately be defined.

An assessment of drainage patterns including waterways, ditches, creeks, and streams, should be made within the upstream watershed as well as areas immediately downstream of the project site. Note any surface drainage patterns that are bisected by existing roads, driveways, or field approaches. When performing field verification work, investigate these locations; they may influence site hydrology and design requirements for the project. Note the size, type, and condition of culverts or other restrictions, along with a general assessment of the size of the storage area upstream of the road. Culverts and other restrictions that are in close proximity to the project wetlands should be noted on the topographic survey. Their elevations may be important in the project evaluation and design. Take photographs to show the condition of the restriction as well conditions both upstream and downstream of it.

> The presence of culverts through roads within the watershed can influence peak runoff rates and affect the project design

Note and verify the presence of any depressional areas within the watershed. Depressional areas may exist as other drained wetlands within the landscape but can also include existing wetlands, lakes, or other waterbodies. Depressional areas will temporarily store runoff water, affecting how or even if that stored water

Figure 3.25 *Shallow Drainage Ditch*

becomes available to the project wetland. Where depressional storage exists, make a determination of the approximate size and volume of the storage area. If the depression area is a drained wetland, note the type of drainage system, its size, and if possible the direction of flow and outlet source. If possible, include these areas within the scope of the topographic information obtained for the site.

In addition to the above watershed features that must be assessed, the quality of the source water may need to be considered, as well as conditions for potential future sediment transport and loading. The scope of the project should dictate the importance of all of these watershed features to the project's assessment.

Assessment of Hydrologic Disturbances

Land use disturbances associated with drainage, agriculture, forestry, mining, and urbanization can all impact the amount of hydrology that is currently available to a site when compared to historic conditions. These disturbances must be documented and evaluated as part of the site assessment process. For example, consider the long-term effects caused by existing drainage systems within the project area. Can wetland hydrology be fully restored through successful manipulation of these drainage systems? A drainage system that remains functioning and is adjacent or in close proximity to a restored wetland can starve the wetland of hydrology by diverting surface runoff, groundwater contributions, or modifying water table conditions.

Figure 3.26 *Installation of Drainage Tile*

The type and extent of existing drainage along with the landscape setting will provide clues to historic site conditions and sources of wetland hydrology. For example, a sloped wetland that is extensively tiled and shows evidence of having springs or seeps will indicate that the wetland is likely influenced by ground water.

Drainage and stormwater conveyance systems are often diverted into planned wetland projects to provide supplemental hydrology. This can be beneficial to a project, or not, depending on the project's goals. The merits of these proposed diversions require a detailed and accurate assessment of the conveyance system and its potential impact on the planned wetland. There are potential concerns with water quality, quantity, and sediment loading. For example, pollution-tolerant plant species such as narrow leaf and hybrid cattail and reed canary grass can thrive in nutrient-rich conditions and may out-compete more desirable plant species. In addition, too much water can be diverted into a wetland, adversely affecting vegetation development due to frequent and erratic water level fluctuations.

Assessment of Ground Water Conditions

When restoring drained wetlands that are ground water influenced, it can be difficult to assess the contributions that ground water will have and its impact on the project design. The current water table is likely to be affected by the site's drainage and may not be a true reflection of the past or potential future conditions. Evaluate the potential impacts to surrounding areas when attempting to understand and restore ground water influenced wetlands. A review of soils, landscape setting, historic photos,

For some sites, ground water will be a major contributor of wetland hydrology.

topography, extent of the wetland's drainage, and landowner discussions can all provide valuable information about the pre-drainage ground water conditions of a site.

Most wetland creations rely on excavating down to existing ground water to achieve the desired hydrologic regime. This requires a comprehensive understanding of the site's geology and pre-construction monitoring of ground water conditions. Water table levels can fluctuate throughout the year and are affected by annual precipitation amounts. Unstable water table conditions can affect the presence or extent of hydrology and associated success for many excavated wetlands.

Monitoring of pre-project ground water conditions may be important or necessary when attempting to restore certain types of drained or altered wetlands. Ground water levels and flows are typically measured with observation wells (**Figure 3.27**) or test pits (**Figure 3.28**) that are strategically located to provide the most beneficial data. Through manual observations or the use of automated measuring devices, the water level surfaces can be measured to provide an indication of water table elevations and flow direction. Measurements taken over a period of time, at time intervals that are appropriate for the scope of the project, will contribute to sound design decisions and provide information that can be used to define the expected change to groundwater conditions and wetland hydrology as a result of the restoration. The frequency or time intervals of observations made will be dependent on the complexity of the site and its geology. For a year with normal precipitation, it is possible that one year of monitoring data will be needed to provide an accurate assessment of groundwater levels. When water supply is limited or when water table levels vary throughout the site, ground water flow modeling may be necessary.

For certain mitigation projects, discussions to define individual project monitoring needs should occur with the regulatory agencies and should include input from professional hydrologists or hydrogeologists. These discussions should occur early in the assessment process so as to define the number of observation wells, frequency of observations, and duration of monitoring that may be needed for a project. These requirements vary for each project depending on its location and its planned goals for wetland hydrology and associated plant communities.

It is often valuable to observe, assess, and monitor nearby reference wetland areas to understand groundwater conditions in the project area. Consult with local government staff who observe or monitor local environmental conditions; they can often provide valuable information on groundwater conditions in a particular project area.

Regardless of the reason, an inability to accurately predict or measure water table conditions will add some uncertainty and therefore risk to projects that will rely

Figure 3.27 *Measuring Water Levels in Observation Well*

Figure 3.28 *Measuring Water Levels in Test Pit*

on ground water as their primary source of hydrology.

Checklist

Data Collection Needs – Site Hydrology

The following checklist includes information pertaining to site hydrology that should be collected, as necessary, during the assessment process:

- ❑ Determine preliminary watershed boundary (through review of USGS quad map or other available map/photo resources).
- ❑ Perform on-site review of the project (to verify and adjust watershed boundary).
- ❑ Note general watershed characteristics, land uses, slopes and flow paths/patterns .
- ❑ Identify restrictions within the watershed (culverts, bridges, etc.).
- ❑ Identify depressional storage areas within the watershed.
- ❑ Identify existing drainage/stormwater conveyance systems within the watershed.
- ❑ Identify springs or seepages within the project area.
- ❑ Determine quality of water sources (if applicable).
- ❑ Determine potential for sediment loading and transport from upstream sources.
- ❑ Install monitoring wells and collect information for appropriate timeframe.

3-5 Site Drainage

Figure 3.29 *Wetland Drainage*

This chapter describes details of the assessment methods and data collection needs of the various types of on-site drainage systems.

Artificial drainage has been occurring across much of Minnesota's landscape since the mid-1850's, largely through the construction of surface ditches, subsurface tile, and lift stations or pumps. Consequently, the majority of wetland restoration opportunities in Minnesota will involve, to some degree, the manipulation of existing drainage systems. Because the presence of artificial drainage will affect the restoration or creation of wetlands, a thorough evaluation of drainage systems within or adjacent to every potential project site is a necessary part of the site assessment process.

Various strategies can be used to manipulate drainage systems for restoration. Each requires specific information to be gathered in the site assessment process. These strategies are discussed later in the Guide in **Section 4-3 Engineering Design and Construction, Drainage System Modifications.**

General Considerations

Prior to performing any on-site assessment work involving a drained or partially-drained wetland, identify and understand the type of drainage system that exists and its history. This can be accomplished through discussions with the property owner and through a review of available map and photo resources.

Figure 3.30 *Drainage Ditch Along Property Line*

Before conducting the assessment of a drained wetland, review what is proposed to restore the site's hydrology. This information can influence the scope of assessment work needed for the drainage system. The assessment may need to include drainage systems on adjoining properties and, perhaps, of the entire drainage system affecting the site.

One of the first objectives of the assessment will be to determine whether or not the drainage system can legally be abandoned or otherwise manipulated to allow for the restoration of hydrology while protecting the drainage rights of neighboring properties. Drainage systems that originate or exist entirely on the project property are more straightforward to evaluate as long as good drainage records are available. However, many drainage systems are shared systems that exist along or extend across property lines (**Figure 3.30**). Shared systems can provide drainage benefits to several properties. Manipulating those drainage systems can be a challenging task that requires an extensive site evaluation and knowledge of available restoration design strategies.

> Existing drainage systems need to be thoroughly evaluated

Shared drainage systems can exist as private systems or as public systems that are administered by a governing body, typically a county board or watershed district, as per Minnesota law. A project manager must consider existing drainage rights and take appropriate actions with respect to required administrative and legal processes when a project involves the modification of a shared drainage system. While the drainage rights of property owners do not necessarily change with respect to whether the drainage system is private or public, the process that one needs to go through to manipulate the drainage system for the purpose of restoring wetlands does. For example, a plan to modify or partially abandon a public drainage system requires a petition and approval from the administrative authority for that system. These legal and administrative processes are discussed later in the Guide in **Section 4-9 Engineering Design and Construction, Construction Related Laws, Regulations and Permits.**

As a general rule, neighboring lands that share a drainage system have a right to continued unimpeded drainage. Proper legal and administrative actions can be taken to manipulate a shared drainage system as long as it can be demonstrated through analysis and design that drainage benefits will not be negatively impacted, either upstream or downstream of the project site. Demonstrating this requires a thorough assessment and evaluation of the drainage system.

Available Resources

Drainage information obtained from a landowner or from other sources is important to the assessment process. The source and amount of the information available will depend largely on the age of the system and also if the drainage system is public or private. The on-site assessment work will be easier and more complete if this information is obtained and reviewed prior to conducting field work. This is discussed in more detail in **Section 3-2 Ownership, Land Use, and Legal Issues.** As part of this review, the landowner or others closely associated with the project should be asked several questions that relate specifically to the drainage of the site and surrounding area. A list of these questions is provided at the end of this chapter.

Public Drainage Systems

Public drainage systems are, for the most part, well mapped and documented for both surface ditches and subsurface tile. Maps of these drainage systems will show their locations, sizes, and the drainage areas that contribute to them (**Figure 3.31**. Stationed profiles of public drainage systems are usually available providing information on system sizes, depths, and grades (**Figure 3.32**). Public ditch administrative and maintenance records are found at the county courthouse, township hall, or other units of government as appropriate. Public drainage records are considered public information and, therefore, are available for viewing and photocopying.

Private Drainage Systems

Most landowners keep fairly good records and maps of their private drainage systems and can readily provide copies of what information they have (**Figure 3.33**). Although sometimes difficult to decipher, these maps contain valuable details such as size, type, location, and sometimes even grade of the system.

Private drainage records for some properties may be found at the local NRCS/SWCD office. It is possible that the drainage contractor who did the work has information, possibly even as electronic GPS data. Previous landowners and land renters can be good sources of information. Discussions with adjacent landowners about shared or neighboring drainage systems may be necessary.

> If there are no maps, the landowner may be able to sketch on an air photo where their drainage tile exists or, at the very least, identify the locations out in the field

If the information provided indicates that a private drainage easement or agreement exists on the property, obtain copies of those legal documents. If not available directly from the landowner, these recorded documents will usually be on file at the county record-

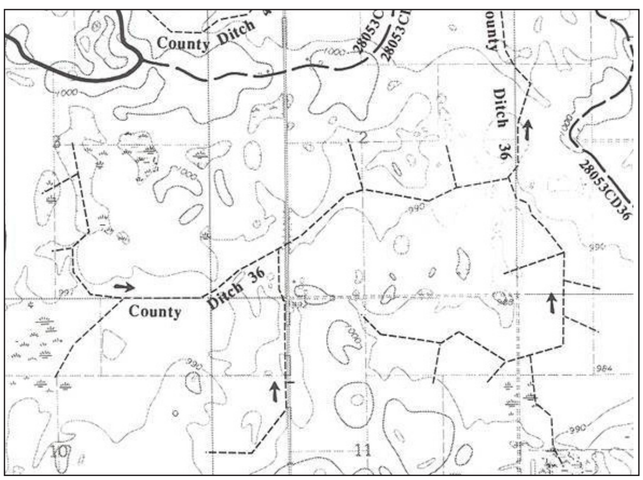


Figure 3.31 *Map of Public Drainage System*

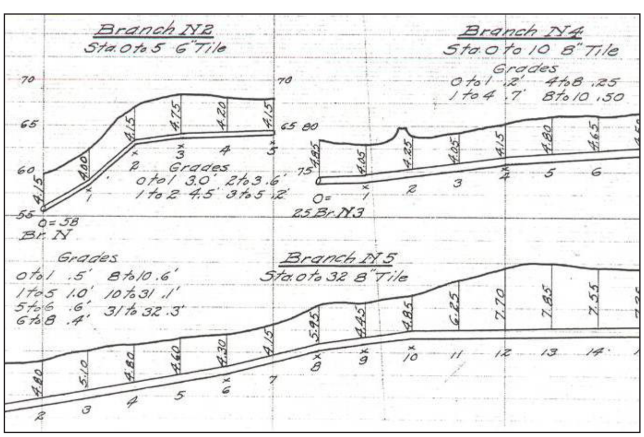


Figure 3.32 *Profile of Public Drainage Tile System*

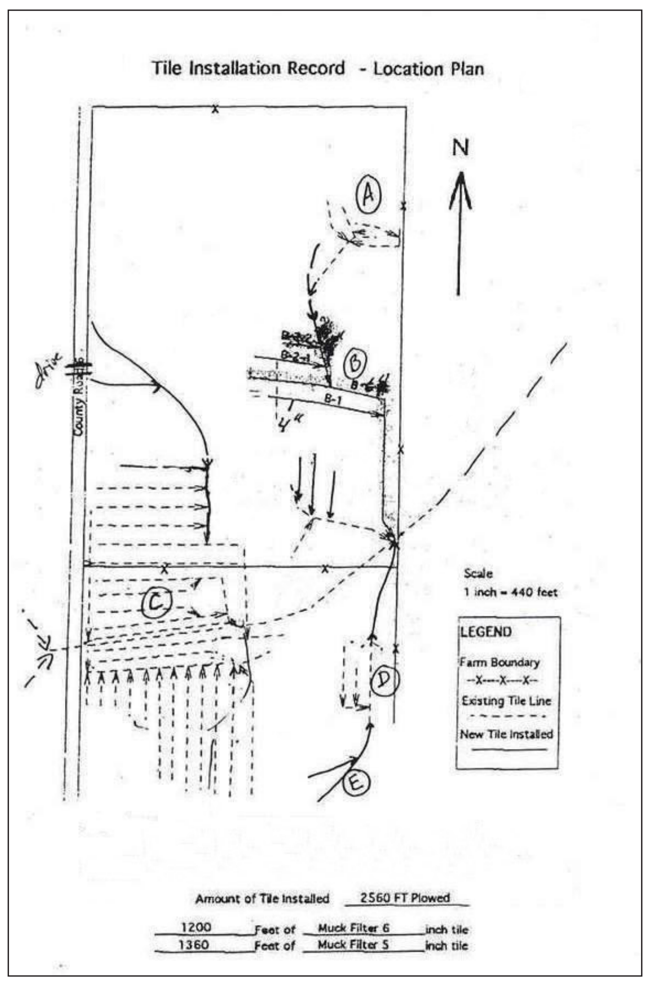


Figure 3.33 *Map of Private Drainage Tile System*

er's office. A routine courthouse search of property records may be another means of determining if drainage easements or agreements exist. Specific details about the private drainage system such as size and location are often included in those recorded drainage agreements. This information is important as the easement or agreement document often needs to be amended as part of any efforts to modify or abandon the shared drainage system.

Other Types of Information

As part of the map and photo review work discussed in **Section 3-2 Ownership, Land Use, and Legal Issues**, a specific review of current and past aerial photos or slides should be conducted to help evaluate current and past drainage conditions of the site. The extent of this historical assessment may depend on whether any current maps of the drainage system are available. If drainage system maps are not available or are difficult to evaluate, the historical photos and slides become very important to the review process. Photo and slide reviews can create a historical summary of the site's drainage, possibly identifying ditch systems that have since been replaced with tile. The effectiveness of the site's drainage system can also be evaluated through this review process. In many instances, the locations of subsurface drainage can be determined when reviewing aerial photos and slides, as tile drainage signatures will occasionally be evident as lighter lines through darker, wetter soils (**Figure 3-34**).

> The review of historic photos and slides can be important when evaluating drainage extents and history of a property

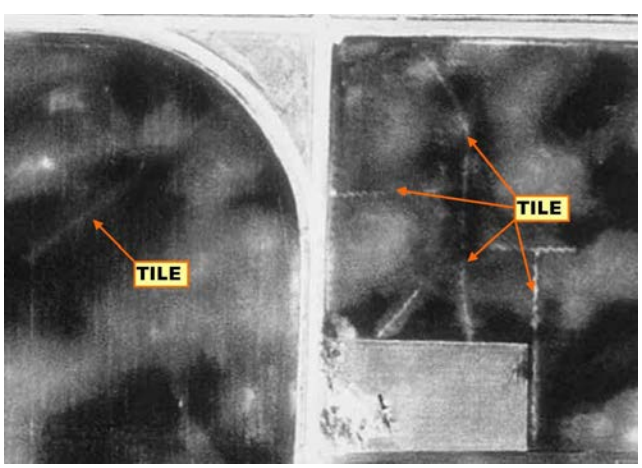


Figure 3.34 *Tile Line Signatures on Air Photo*

Through discussion and review of available resources, all available drainage system information should be collected. That information, along with the system's location within and adjacent to the project, should be identified and transferred to a site map or photo. This can become a base map for reference when in the field performing on-site assessment work and later as site maps are being prepared.

Assessment of Surface Drainage Ditches

For surface drainage ditches that exist entirely within the wetland or project area, it is likely that the restoration will include blocking or filling the ditch. To determine if a standard ditch plug will be effective at restoring hydrology, an assessment of the site will be needed. This includes the collection of topographic data and even a geotechnical assessment of the area where the plug is to be constructed, depending upon the scope of the project. If collected, this information will enable the design and construction of an effective ditch plug.

With many depressional wetlands, particularly those with deeper ditch systems, the ditch excavation through the wetland may have penetrated through an impervious bottom substrate into a more pervious soil layer. In landscape settings where ground water does not influence the wetland's hydrology, this pervious soil layer can provide additional wetland drainage. When this situation occurs, plugging the ditch at the wetland's outlet may not be fully effective at restoring hydrology. A complete filling of the ditch system may be needed to prevent hydrologic losses into the underlying soil layer. An assessment of both site soils and ground water conditions can assist in evaluating for this condition. Additional discussion on this topic occurs in **Section 4-3 Engineering Design and Construction, Drainage System Modifications**.

For ditches that extend upstream and off of the project, it will be necessary to determine if the planned restoration can be completed without causing negative impacts to the upstream, non-project areas. This will require that detailed elevations be obtained for both the wetland and the ditch system, particularly at upstream boundaries where the ditch enters the project area.

Figure 3.35 *Surface Drainage Ditch*

Assessment of Subsurface Drainage Tile

Assessing and collecting field data on subsurface tile drainage systems can be challenging. Tile system maps are not always available or completely accurate. There may be additional tile on the property that was never mapped or that was reinstalled several times over in an attempt to improve the drainage or repair older, failing systems. Tile systems and their locations are often forgotten over time as properties are passed down from one generation to the next or through ownership changes. Experience and judgment will play a part in being able to determine whether additional, unmapped tile is likely to exist within the project area.

Even with good tile maps, locating tile systems in the field and understanding their impact on wetland hydrology can be difficult. In tilled cropland, tile line locations might be located by simple field observations. The existence of tile intakes is an obvious clue as to their presence and location. Areas where tile are located may be the first to show dry soil conditions after spring snowmelt or saturating rain storms. As discussed earlier, a review of historic air photos and slides will occasionally show tile drainage signatures as lighter lines through darker, wetter soils. These observations, in conjunction with available tile maps, can help to identify locations of tile lines and improve the on-site drainage assessment.

Where shared drainage systems with neighboring properties exist, extend the collection of tile information

Figure 3.36 *Subsurface Drainage Tile Intake*

beyond the immediate project area. Make arrangements with the neighboring property owners to allow for a complete assessment of the drainage system.

> Tile locations, sizes, flow directions, and even flow line elevations can often be determined through the use of a tile probe

The assessment of subsurface drainage systems should provide information on tile alignments, flow directions, elevations and sizes of the tile, tile intakes, and tile outlets, and general topography of the area where these features are located (**Figure 3.37**).

Figure 3.37 *Probing for Drainage Tile*

In some situations, it may be necessary to utilize a backhoe to investigate and gather tile information. Using a backhoe can be an efficient way to locate tile, especially when tile locations are uncertain or when tile is too deep to be located by probing. When locating with a backhoe, the size , elevation, and condition of tile can also be more easily determined. This information could be critical to determining restoration feasibility or preparing the design for some projects.

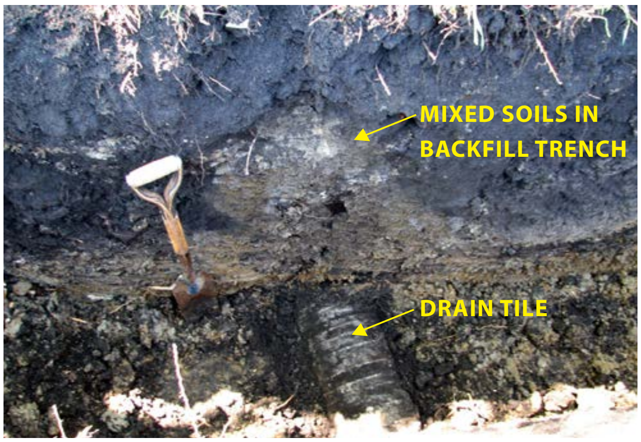


Figure 3.38 *Tile Investigation Trench*

When investigating for tile with a backhoe, for many soil conditions it is usually only necessary to excavate a trench that is about 3 feet in depth or just above where tile might be expected. At this depth, you can usually see a vertical "streak" where darker A horizon soils are mixed with lighter B horizon soils. This mixing of soil horizons resulted as part of the tile installation and backfill process (**Figure 3.38)**. Once a streak is identified, a tile probe can be used to verify if a tile is present and its exact location. Additional excavation and shovel work can then expose the tile with minimal risk of damaging or breaking it.

Section 3-7 Site Topography provides additional information on the process of collecting information on subsurface tile drainage systems as part of the site survey.

Assessing Other Types of Drainage

Other types of wetland drainage will require fieldwork and data collection commensurate with the planned restoration activity. Examples could include sites drained by lift stations or sites located in urbanized areas with stormwater drains.

Checklist

Data Collection Needs – Drainage Assessment

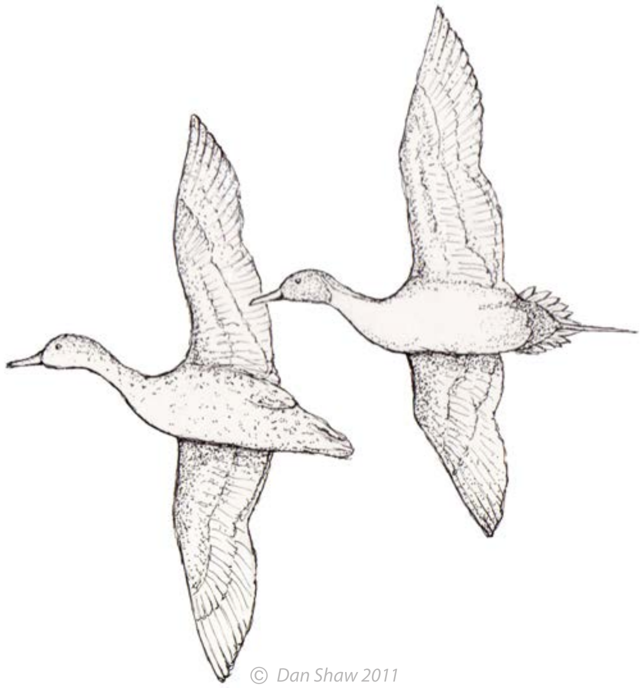
The field data and on-site information to be collected for a drainage system will depend on the project goals, restoration desires/requirements, and the scope of the drainage system. Most of the on-site drainage system information will be collected as part of the project survey and geological assessment work.

The following checklist includes items and questions to be reviewed with the landowner(s) and others (i.e. drainage contractors), when appropriate for the given site conditions:

- ❑ What is the extent of the drainage on the property?
- ❑ When was the drainage system installed?
- ❑ What modifications or repairs have been performed to the system and when?
- ❑ If tiled, what materials were used, what are the tile sizes, what direction does the tile drain, and where is the outlet?
- ❑ Is the drainage system public or private?
- ❑ If the drainage system is public, who is the drainage authority and what are their requirements for manipulating the system?
- ❑ What maps are available of the drainage system?
- ❑ Are there tile intakes or gravel inlets on the property?
- ❑ What is the current condition of the drainage system?
- ❑ Does any drainage (tile) from neighboring properties flow into the property?
- ❑ Are there any formal or informal drainage easements or agreements in place?

The following checklist includes other drainage system related site assessment functions to be performed, when deemed appropriate:

- ❑ Collect from county records any available information on public drainage systems (i.e. maps, photos, engineering plans, profiles, etc.).
- ❑ Collect any available information on private drainage systems (maps, photos, profiles, agreements/easements).
- ❑ Review current and historical aerial photos/slides for drainage history, location, and effectiveness of the drainage system.
- ❑ Survey and geotechnical evaluations as needed.
- ❑ Tile searches as needed with tile probe or backhoe.



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3-6 Conditions for Vegetation Establishment

Figure 3.39 *Wetland Vegetation*

This chapter provides discussion on the assessment of project components that can influence the scope of the vegetation plan.

- Assessment of Existing and Historic Vegetation
- Assessment of Soil Characteristics
- Assessment of Recent Land Uses

When evaluating a potential wetland site for restoration, assess the site and gather information that will allow for the development of a comprehensive vegetation establishment plan that can meet the expected goals, objectives, and, where necessary, the performance standards for the project. An assessment of existing vegetation conditions within and adjacent to the project area and within its contributing watershed highlights potential seed sources, both for desired plants and undesired weeds and invasive species. An assessment of the site soils will reveal characteristics that will affect plant growth and development. An assessment of recent land uses can influence site preparation and vegetation establishment strategies.

Assessment of Existing and Historic Vegetation

Re-establishing vegetative species that historically existed at a site helps ensure that plant communities will be adapted to the site's climate and soil conditions and that appropriate habitat will be created for wildlife species native to the area. Vegetation communities that currently exist within a project area can influence project outcomes. Record the location, types, and condition of any existing plant species and communities that are found.

The success of restoring remnant native plant species and communities will be influenced by potential sources of seed from the seedbank and existing plant communities within or nearby the project site. **Section 5-5** of the Guide provides more information about the use of native seedbanks, and **Appendix 5E** provides protocol for seedbank testing procedures. Plant communities that exist in the surrounding area, particularly within the project's watershed, should be evaluated. Seeds from plant communities in these areas could easily be transported to the project site by wind, animals, and during runoff

Figure 3.40 *Invasive Species*

Figure 3.41 *Remnant Wetland Plants*

events. Depending on the project's scope, consider removing some or all of any identified undesired species as part of the vegetation establishment plan. Conversely, wetland vegetation in a high quality nearby wetland may indicate appropriate species to consider in the proposed project and might also act as a valuable source of locally adapted seed.

Special effort should be made to identify the extent of invasive plant species and noxious weeds

Any remnant native plant species that are found may provide an indication of the communities that existed before disturbance or drainage of the site. Even sites that have been in agricultural use for many years may have native upland and wetland species still surviving in nearby undisturbed areas, drainage ditches, or depressional areas too wet to farm. Observations of these plant species can be used to determine what species to plant and possibly even the type of wetland system that existed prior to drainage.

Figure 3.42 *Woody Vegetation*

The presence of undesired woody vegetation within close proximity to a project may also be a concern. Past land disturbances have allowed undesired woody vegetation to establish in many areas of the state, with many wetlands becoming dominated by tree and shrub species after hydrology was removed by drainage. Examples of these species includes; quaking aspen, sandbar willow, American elm, cottonwood, common buckthorn and glossy buckthorn. This is most true in the prairie regions where woody species historically were suppressed by fire and grazing. The presence of certain trees and shrubs within the project area may be undesirable and their removal may need consideration. For example, prairie wetland projects with a primary goal of waterfowl production should typically not have trees in or near the project wetlands, as they can serve as perches for avian predators.

In many areas of the state, woody vegetation historically was part of the natural landscape. In these areas, remnant woody species on or near the project site may give some indication of what species to consider if their restoration is a goal for the project.

If desirable woody species exist within a project site, document and map their locations

Assessment of Soil Characteristics

Soil types and their characteristics can help determine the plant communities that are appropriate for a site. Soil texture and moisture content influence what species will grow and will help determine the appropriate seed mixes for different sections of a site. Soil survey maps act as a general guide for determining soil types. Field investigations should be conducted to verify the soil survey information and, at a minimum, to categorize specific restoration areas as becoming dry, mesic (medium), wet, or aquatic to help determine the suitability for establishment of different plant communities.

Additional discussion on the assessment of site soils in terms of vegetation establishment occurs in **Section 3-3 Site Soils, Soil Characteristics for Vegetation Establishment.**

Assessment of Recent Land Uses

The research and review of historical information pertaining to land use, original hydrology, drainage, and vegetation at the site is important to the vegetation assessment process. Landowner discussion and review of aerial photographs may provide much of this information. Additional discussion on this occurs in **Section 3-2 Ownership, Land Use and Legal Issues**.

The amount of time since the site was drained or disturbed can influence the methods used to re-establish native plant communities. The viability of a wetland's native seedbank begins to decline immediately after drainage of the wetland occurs. Poorly drained wetland areas that historically were left fallow when too wet to farm may periodically have supported wetland plants that produced seeds, increasing the chances that a viable seedbank may exist. If repeated disturbance or other factors have not led to the loss of native seedbank, it can be a source of seed; however, consider additional seeding to supplement any remnant seedbank sources.

Wetlands that have been drained and in agricultural use for an extensive length of time are less likely to contain a viable source of native seed bank. Tillage activities and sediment inputs can affect the viability and germination of the dormant native seed bank. In addition, residues from chemicals such as Atrazine, Treflan, and Avadex, if recently applied, could inhibit germination and growth of plantings. Sites where glyphosate-based herbicides have been used are typically not considered a problem for germinating seeds.

In urban areas, wetlands may have been receiving stormwater and have accumulated sediment and other pollutants.

Following are questions to ask in relation to the land use history of the site. Answers may provide important information that will be used in the development of the vegetation establishment plan:

- Are there swales or other low-lying areas on the site that were not disturbed and may have native seedbank or native plants?
- Are there stormwater inlets coming into the wetland or outlets exiting the wetland?
- How many years has the site been in agricultural production or otherwise disturbed?
- If the site was previously in agricultural production, was it farmed continuously or allowed to lie fallow occasionally?
- If the site was in agricultural production, what types of crops were produced and what type of agricultural chemicals were used?

The surrounding landscape, particularly the immediate watershed, should be evaluated for its potential to contribute pollutants and invasive species to planned wetlands. While areas closest to the restoration site will have the greatest impact on the wetland, the entire watershed and region can influence the restoration outcome. Inputs such as nutrients can adversely impact wetland plant species richness and enhance their susceptibility to colonization and dominance by invasive species. Restorations that have the potential for inflows of nutrients, pesticides, or invasive plant seeds would benefit from wide buffer areas. The implementation of

Figure 3.43

conservation practices such as grassed waterways, no-till agriculture, and the use of stormwater filtering and infiltration systems in the watershed can be beneficial. In some cases, there may be a direct source of inputs from the surrounding landscape, such as a stormwater outlet. In these situations, it may be difficult to control the quality and potential impacts of water entering the restoration site.

In summary, each drained or altered wetland is unique and has a varied history of drainage and site disturbance. These, along with other factors such as watershed condition, need to be studied and evaluated in order to develop a successful vegetation establishment plan.

A variety of vegetation-based reference materials and map resources exist and should be reviewed to provide the necessary base maps and reference materials for the project file.

Checklist

Data Collection Needs – Vegetation Assessment

The field data and on-site information to be collected for the assessment of vegetation and plant communities depends largely on project goals, objectives, and program requirements. The extent and locations of vegetative plant communities that are found should be noted on a map, photo, or included in the specific site survey data. The following checklist includes vegetation information to be collected during the site assessment process:

- ❑ Existing wetland vegetation within proposed wetland areas.
- ❑ Existing vegetation in adjoining upland areas.
- ❑ Viability and diversity of remnant wetland seed bank.
- ❑ Plant communities in adjoining areas.
- ❑ Were any attempts made in the past to introduce a plant community to the area and, if so, what was its success?

3-7 Site Topography

Figure 3.44 *Drained Wetland Landscape*

This chapter discusses the use of topographic data and provides information and guidance on conducting a topographic survey.

- General Considerations
- Preliminary Assessments
- Topographic Surveys
- Equipment and Survey Methods
- Project Control
  - *Vertical Control*
  - *Horizontal Control*
  - *Benchmarks*
- Survey Operations
- Topographic Map Development

Most wetland projects require detailed topographic data for the planned wetlands and surrounding upland buffers. Detailed topographic information allows for an evaluation of each planned wetland and its elevation relationships among other project wetlands, uplands, and surrounding properties or infrastructure. Having detailed topography is important when assessing the feasibility and potential of any wetland restoration.

Topographic information is critical when evaluating, designing, and implementing the various components of a project. It is also an important aspect of the many maps or plans that will be prepared and used to support a project. This includes background information for concept, construction, and vegetation establishment plans.

General Considerations

Topographic maps are a two-dimensional elevation representation of the land. They convey information about the land surface through the use of elevation-based contour lines. Contour lines can depict depressional areas, valleys, waterways, hills, drainage features, and other land forms. In addition to contours, topographic maps can also show roads, structures, buildings, field edges, and other physical boundaries.

Initially, topography can be best observed or obtained by using high-resolution elevation data that has been collected for the State of Minnesota using LiDAR technology. This data can be viewed and retrieved from either the MnTOPO web application that is managed by the Minnesota Department of Natural Resources or the MN-GEO interactive website managed by the Minnesota Geospatial Information Office. Practitioners are encouraged to be familiar with the content and use of each of these web sites as they are invaluable when assessing wetland restoration projects.

> LIDAR data is available for the majority of the state and has become an important resource tool when restoring and creating wetlands and associated upland habitats

The MnTOPO web based application is of particular value as elevation data can be observed or printed without having to download data or use specialized desktop mapping software. It also allows uses to develop elevation profiles across an area or to view specific point elevations at selected point locations. A digital elevation model (DEM) can also be downloaded for advanced analysis and use with specialized mapping software such as CAD or GIS.

While elevation information from existing data sources such as LIDAR is invaluable, it cannot replace the need for specific on-site surveys. The on-site survey is needed to more accurately define and collect critical project information that will be unavailable from LIDAR or other sources of data. For example, elevation information of culverts, tile drainage systems, ditch systems, etc., can only be determined from a specific, on-site survey. On-site survey work also allows for the establishment of accurate horizontal and vertical control that is needed for construction. In addition, users must consider the reliability of any existing topographic data, the date on which it was collected, landscape changes since the data collection, and the precision or accuracy of the information. For example, LIDAR data does have discrepancies and does not always provide accurate information in areas containing trees or other heavy vegetation.

The process to collect and process topographic data from on-site surveys should not be confused with the process to perform a legal survey. Legal surveys are performed to determine or establish property or acquisition boundaries. Minnesota state law requires that legal surveys only be performed by registered, licensed land surveyors. Conversely, surveys to collect elevation data and other site information can be performed by anyone with sufficient knowledge and experience.

Preliminary Assessment

Due to the many uncertainties associated with projects while in their early planning stages, it may prove advantageous to perform a preliminary assessment of a project before scheduling a detailed topographic survey of the site features. This includes obtaining and reviewing available LIDAR or other elevation data to help determine the restoration or creation potential of a project. This may also include conducting a preliminary on-site survey to collect precise elevation information at select locations in and around the project site. The combination of these items can provide an accurate means to evaluate the restoration or creation potential and feasibility of planned projects. Good judgment will be needed to identify what and how much on-site preliminary survey information needs to be collected to supplement available information and allow an accurate assessment of a site.

This approach to project planning and investigation can save time and money, avoiding the need to prepare for and then conduct a detailed on-site topographic survey on projects that have minimal or no potential for success. For example, if the preliminary assessment identifies a neighboring property that will be impacted by a planned wetland restoration and that landowner has no interest in or is unwilling to cooperate with the project, then the project can be stopped prior to investing significant time and resources into it.

Topographic Surveys

A comprehensive topographic survey should allow for the preparation of a detailed topographic map that will locate and provide accurate elevations and detailed information of select project features. The size, scope, and type of the project should dictate the survey method and amount of survey data that should be collected.

Where LIDAR data is available and can be used, on-site topographic survey work can sometimes be limited to areas where more precise elevation data and site information is needed. This includes areas where specific construction activities may be occurring or where more accurate elevation information is needed for the project's evaluation and design. In such situations, the on-site topographic data

> The collection of on-site topographic data should be considered for all but the smallest and most limited scope wetland projects

Figure 3.45 *Site Survey*

can be merged with LIDAR data to efficiently create comprehensive topographic maps of larger project sites.

Sufficient topographic data should be collected to create one-foot contour intervals of the project area. In areas with little relief, or extensive micro-topography, one-foot contours may be too broad; in these cases contour intervals should be reduced to one-half (1/2) foot.

The topographic information collected for a site should identify all lands potentially impacted by the proposed project and therefore necessary for enrollment, acquisition, and/or protection to facilitate completion of the project. The survey data should provide, at a minimum, enough relevant information to determine the feasibility of the project and provide information to calculate quantities, design, and implement the project. The extent and detail of the topographic survey data, as with other site assessment functions, must be commensurate with the scope, complexity, and intended project goals. For example, a project in an area with very flat topography may require very detailed analysis in order to detect subtle elevation differences that may be important in the design of the project. In addition, complex projects that will involve a large amount of construction will tend to require more detailed topographic information compared to projects with minimal construction activities.

It is often beneficial to obtain more survey data than may seem initially necessary. Limited site information may lead to uncertainties, a conservative design, or a design based on poor information, all of which could limit restoration potential or increase the overall cost of the project. Having to collect additional survey data later in the project design phase because limited data was collected during the initial survey results in increased project costs and project delays.

A topographic survey can provide detailed elevation information for any of the following site features:

- Micro-topography for the site that helps define potential wetland areas, water depths, wetland types, and water storage volumes
- Control areas for watershed flows into and out of the project wetlands
- Existing drainage systems or features
- External areas that could be affected by the project
- Existing wetland areas for regulatory purposes
- Creation of an accurate and detailed concept plan for landowner review, planning, and project design purposes
- Construction areas to allow accurate estimates of cuts, fills, and other construction quantities
- Specific zones for wetland and upland plantings based on elevations

Equipment and Survey Methods

A detailed topographic survey can be performed by any of several different methods. The method used will be more related to the survey equipment available and experience of the surveyor than the type or function of the intended project. The methods available include:

- **Electronic total stations** or **survey grade global positioning systems (GPS)**. When coupled with ATV's or other motorized vehicles, portable communication radios, and current computer-aided survey/civil software, these survey systems can efficiently collect, record, and process numerous survey points (**Figures 3.46**). This allows for more extensive data collection over a broader area.
- **Stadia-azimuth surveys** performed with a level or transit; **grid surveys** performed with a laser or survey level; or **low-grade GPS surveys** performed with

Figure 3.46 *Equipment Setup for GPS Topographic Survey*

a hand held or backpack GPS system and a laser or other level. These are less efficient survey methods that should be considered only for the smallest projects.

- **Aerial surveys** or data from an existing **DEM**. On-site ground control work and additional data collection will be needed.

Regardless of the survey method or equipment used, data should be collected in sufficient detail to visualize site topography, effectively evaluate the project and determine its feasibility, perform the necessary design work, and prepare construction plans with accurate quantities.

Have a general idea of the intended goals of the project and what amount and type of construction and project implementation work is anticipated before the survey operations begin. Knowing what survey information to collect and where to collect it requires some amount of survey and project experience. The quality of the survey data collected can influence the design and implementation processes.

Project Control

Depending on the project scope, establishing and maintaining horizontal and vertical control throughout the life of the project can improve project implementation, monitoring, management, and maintenance. Horizontal control can be defined as the spatial reference of the survey data collected. Vertical control is the referenced datum for elevation and is an essential component of every survey. For a new project, establishing control is one of the first survey functions to be performed. The ability to establish and maintain a high level of accuracy for both horizontal and vertical control throughout the life of a project is often dependent on the equipment and method used to conduct the survey and process the data.

Horizontal Control

The level or accuracy of horizontal control for project surveys can vary and will be dependent on the project scope and the method and equipment used to conduct the survey. Establishing an accurate and precise horizontal control system can provide multiple project benefits including:

- Improved efficiencies in collecting and processing survey data
- Improved mapping capabilities that can enhance the site assessment, evaluation, and planning
- The ability to precisely layout and stake the project, leading to more accurate construction efforts and quantities

When possible, reference and utilize an existing horizontal coordinate system

The use of GPS survey technologies easily allows a project to be correlated to the Universal Transverse Mercator Projection (UTM) or other acceptable coordinate systems. This allows a project's survey data to be used with other high resolution digital photos, maps, and even digital elevation models where they exist. Planning and developing a site is much easier if its survey data is in a known coordinate projection allowing it to be spatially referenced with digital photos and other mapping tools.

In order to establish and maintain horizontal control for a project, one or more project control points will be needed. This is typically accomplished by driving a steel rod into the ground at the location of the survey instrument or base station (**Figure 3.47**). The rod should be long enough to be driven below frost depth and should be located where it will not be disturbed. Future project surveys can use this same reference point for setting up the survey equipment. To allow for efficient reestablishment of project controls, the location, coordinates, description, and elevation of the base station control point should be included in the survey notes

Figure 3.47 *Base Station Setup*

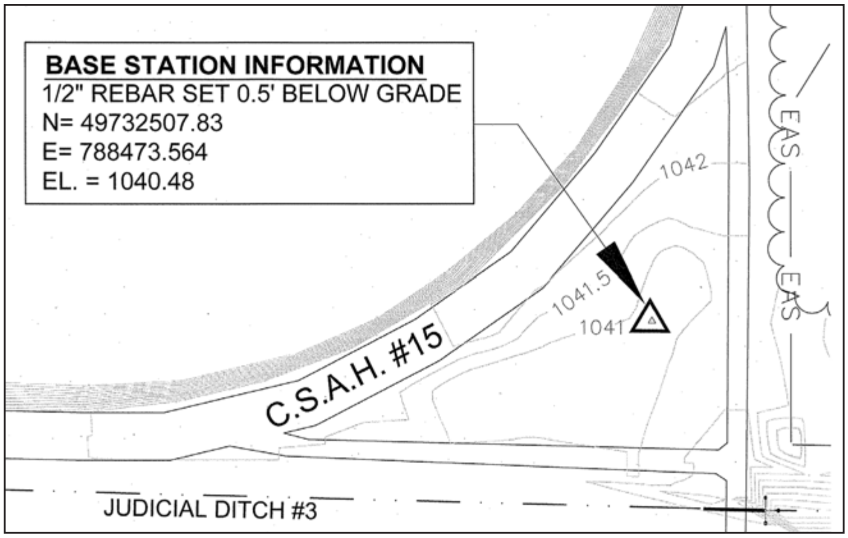

Figure 3.48 *Base Station Information*

and also on any maps or plans prepared for the project (**Figure 3.48**).

> Project elevations that are referenced to a MSL datum can always be re-established, regardless of the project's status or age

Vertical Control

With few exceptions, wetland restoration projects will rely on site elevations to depict what is needed for planning, design, implementation, and future project monitoring. Elevations are established and maintained through the use of common reference points called benchmarks. Benchmarks are durable, physical control points that can be precisely described and maintained. Maintaining vertical control throughout the life of the project is accomplished by referencing or establishing one or more project benchmarks during the course of the project survey. Elevations used to define vertical control can either be referenced to a local datum or a datum that correlates to a Mean Sea Level reference elevation.

Figure 3.49
MSL Benchmark

A **local datum** is project specific and is only as good as the local benchmark(s) set to establish it. An example would be a local project benchmark on a culvert top at elevation 100.00. Local datums should only be used for small projects where simple construction work will be needed and where there would be no need for reestablishing the vertical datum after construction is completed.

A **mean sea level (MSL) datum** is a vertical reference established for common control points that are set throughout the state. MSL vertical control points/benchmarks are typically a geodetic disk set in exposed bedrock, on a steel rod driven into the ground, on a building, bridge, culvert headwall or a concrete monument. There is a large network of MSL vertical control benchmarks available for reference. These control points are owned and maintained by a variety of governmental entities including the United States Geological Survey (USGS), the National Geodetic Survey (NGS), the Minnesota Department of Transportation (MnDOT), and county highway and survey departments. The vertical datum of these common control points will either be referenced to a National Geodetic Vertical Datum (NGVD) of 1929 or a North American Vertical Datum (NAVD) of 1988. These datum elevations are slightly different, which makes it important to identify and note which datum is used for the referenced vertical control point (**Figure 3.49**).

The MnDOT Geodetic Unit keeps and maintains a geodetic database containing information on most permanent geodetic control points located in Minnesota. Their database is a good reference source for locating MSL benchmarks and is accessible through MnDOT's land management web site.

Correlating a survey to an MSL datum is recommended whenever possible, regardless of the project scope. Situations that may require a reference to a MSL datum can include:

- Wetland mitigation projects
- Projects that will affect or modify public drainage systems
- Projects that will affect any public infrastructure (roads or utilities)

- Projects with large water control structures or complex restoration plans
- Projects located within incorporated urban areas
- Projects requiring zoning or other local permits

Benchmarks

Project surveys that lead to the development of designs will require the establishment of unique project benchmarks. The description, elevation, datum, location, etc. of all serviceable bench marks should be clearly conveyed on the construction plans prepared for the project. Project benchmarks should be durable and available for easy reference during project establishment and for years to follow as routine inspections and monitoring work is performed. A project benchmark that is established during the course of a site survey is referred to as a temporary benchmark (TBM). Correlating TBM project elevations to a mean sea level datum is recommended.

TBMs should be set for every project and located as near as possible to any construction areas but where they will not be disturbed during any of the construction activity. Have at least two TBMs to help verify accuracy of the project's vertical control or to maintain control should one of the TBMs be damaged or lost. The number of TBMs necessary depends on the project scope. TBMs and other control points should be well noted and described, with their elevations and descriptions shown both in the survey field book and on any maps or plans developed for the project.
Some of the more common types of TBMs include:

- **Metal rods** – These are driven into the ground at select, protected locations and marked or otherwise described where they can easily be located in the future. Drive the rod so its top is at least six inches below the ground surface to minimize the chance that the rod will be disturbed by future surface activities. The length of rod used should be sufficient to allow it to be driven below frost depth. A metal rod is often used as a TBM when establishing a base station for horizontal control. The TBM information can be written on a well-marked (flagged or painted) wood lathe that is set next to the metal rod (**Figure 3.50**).
- **Culverts** – The top edge of culverts are often utilized for TBMs. Culverts through roads are most stable when several feet of road fill exists above the pipe. Road culverts with limited cover can be subject to frost heaving. Sectional pipes such as RCP culverts may not be stable if the pipe sections are not tied together. The description of a culvert TBM should be well documented along with its elevation. Spray-

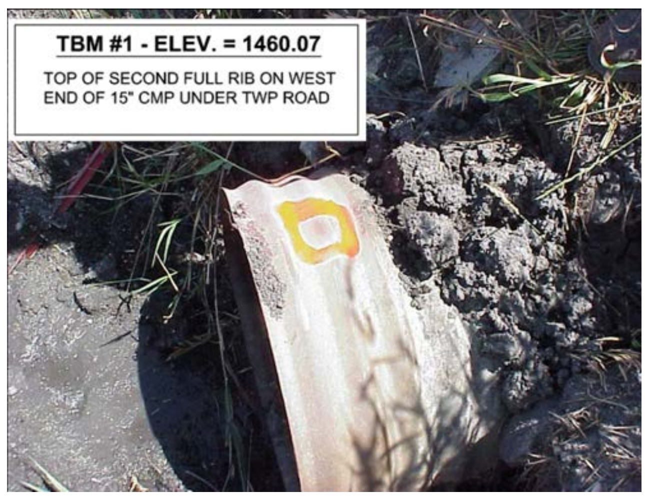

Figure 3.51 *CMP Culvert used as a TBM*

Figure 3.50 *Metal Rod used as a TBM*

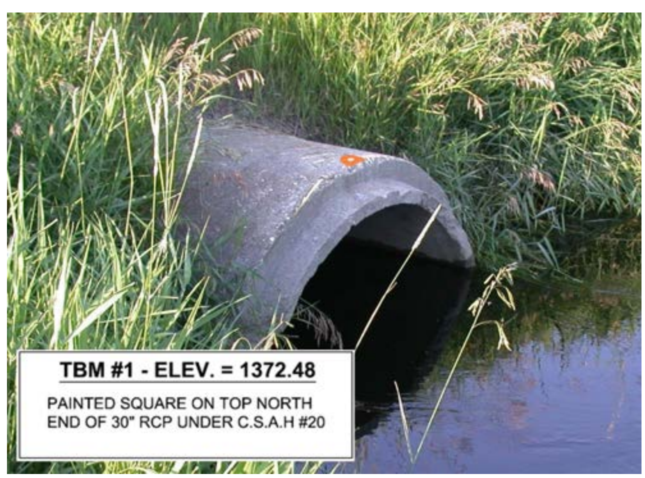

Figure 3.52 *RCP Culvert used as a TBM*

painting or chiseling a spot or square on the culvert at the TBM location is recommended (**Figures 3.51 and 3.52**).

- **Spikes or Nails** – Metal spikes or large nails can be driven into the base of trees, power poles, fence posts, timber bridges, etc., and used as TBMs. Use 50D or larger nails for durability and drive the nail to a sufficient depth to avoid problems with bending if tampered with. Typically, only one to two inches of the nail is left exposed. If setting a TBM in a tree, double spiking may be necessary to increase the durability and longevity of the TBM. Locate spikes in trees within one to two feet of the ground or in a root if the tree is large enough (**Figures 3.53 and 3.54**).

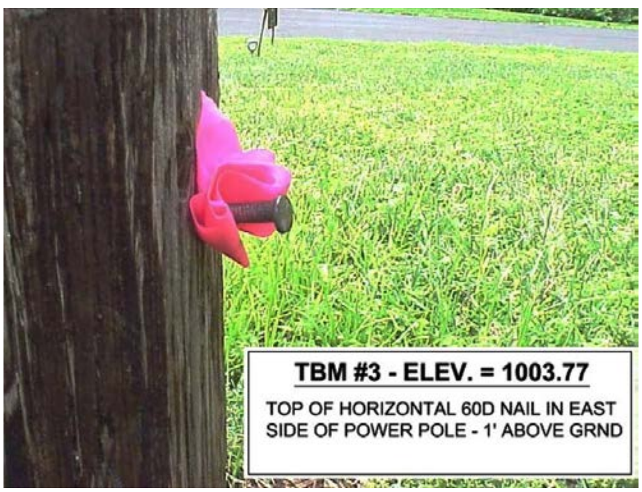

Figure 3.53 *Spike in Power Pole used a TBM*

Figure 3.54 *Double Spike in Tree used a TBM*

- **Hubs** – Wood hubs with tapered ends that are driven into the ground may be used as temporary construction benchmarks. They are short in length (one to two feet) and, when set, will not be driven below frost depth. They should be considered only as very temporary control points and should not be relied upon if established in a previous year. If their continued use is required, the elevation of each hub should be rechecked at least once each spring and elevations adjusted as necessary. The elevation of the wood hub can be written on a well-marked (flagged or painted) wood lathe that is set next to the hub (**Figure 3.55**).

Figure 3.55 *Wood Hub used as Construction TBM*

Survey Operations

Upon establishing vertical and horizontal controls for the project, the process of collecting topographic survey data can begin. When applicable to the project site and scope of work, the following features should be surveyed using the guidelines provided. The information collected can be critical for the evaluation and design of the project:

- **General survey points** should be taken to help define the topography of the site. The exent and spacing of collected survey points "shots" should be relative to the site conditions and project goals. Broad, relatively flat areas with limited elevation relief should have survey points at approximate 100-foot spacings. Areas with more variable elevation relief or with subtle but critical elevation changes should have closer shot spacings. In addition, it may be necessary to have more dense shot spacing where elevations could be critical to the evaluation and design of the project. The survey should include all wetlands and surrounding upland areas to the extent necessary to determine the project impacts and to facilitate the design of both vegetative and construction practices.

- **Property lines/corners, fence lines/corners, field edges/corners, and other physical features**, when surveyed and mapped, provide reference for the project and in many cases are used to help define the project boundaries.

- **Plant and wetland communities, vegetation changes, boundaries, etc.** should be surveyed as appropriate for the project scope. These mapped boundaries provide information necessary for developing vegetative plans and site preparation needs for the site. With coordination, any required wetland delineations could be performed just prior to the topographic survey work being conducted. The delineated wetland boundaries can then be included in the survey and graphically displayed with the survey results. Delineation boundaries can also be integrated with the survey data if the delineated boundary information is shot and recorded at another time and uses the same horizontal control and coordinate system as the site survey (**Figure 3.56**).

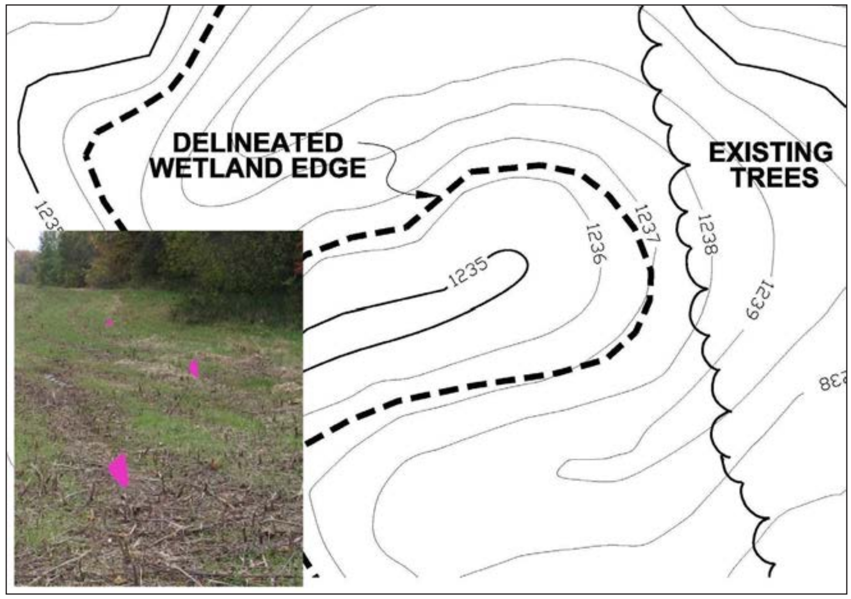

Figure 3.56 *Wetland Delineation Boundary*

- **Roads, driveways, field roads, etc.** can help define the project boundary and site conditions. This data is useful for locating and defining the project and its boundaries and should be obtained regardless of the distance from the site. If a road might be impacted by restoration, detailed survey information of the entire road section and its right-of-way will allow for the creation of cross sections and profiles for analysis and design purposes.

- **Utilities** that are near or located within the project area should be surveyed and shown on the project plan. Utilities may include power-transmission lines and poles, telephone and communication boxes, underground cables, electrical vaults, and gas and oil transmission lines. The design of the wetland project may be affected by the location, elevation, or type of utility found and detailed information of them may be critical. If there are utilities on site that may be impacted by the planned restoration or construction work, coordination with the appropriate authorities will be required.

- **Culvert and bridge** information is often needed in the assessment of potential hydrologic impacts. All culverts and bridges within the immediate project area should be surveyed. For large, complex projects, it may be necessary as part of a hydrologic assessment or analysis to collect information on all culverts and bridges within the project's entire watershed. It is recommended to collect this information during the project survey. Both upstream and downstream inverts (flow lines) and tops as appropriate should be

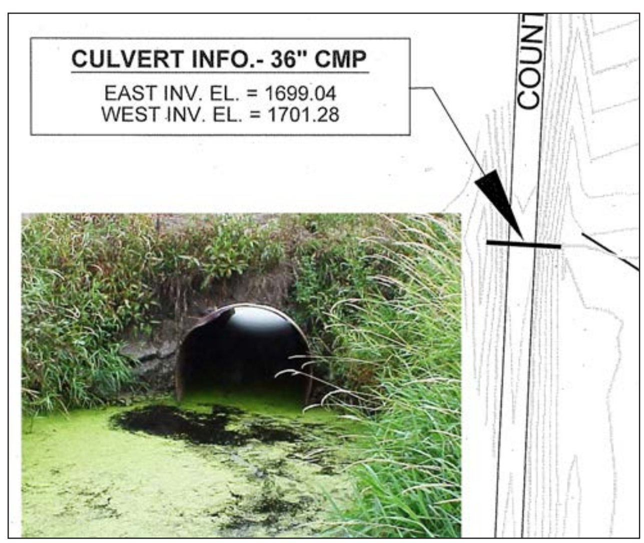

Figure 3.57 *Culvert Information from Survey*

surveyed (**Figure 3.57**). A description of the culvert or bridge should also be noted, including its size and material. If sediment exists on the bottom of the culvert or bridge, it should be clearly noted, particularly if elevations are obtained on the top of sediment. Culverts and bridge tops can make good temporary benchmarks for the project and should be considered for such as they are being surveyed.

- Information on any **subsurface drainage tile** within the project area may be needed for the assessment and design of the project. Sometimes only limited information is available for tile drainage systems. Perform thorough field observations to locate and survey all tile information that is available. This includes survey information on intakes, outlets, and where tile lines are broken or blowouts have occurred. Tile drainage assessments should not be limited to just one property if it appears that a shared tile drainage system exists. Information on both upstream and downstream tile systems can dictate the extent of restoration possible for a site. Any tile information that can be obtained may be important in the evaluation and design of the project.

- When collecting information on **tile intakes**, the elevation of the top of the intake along with the ground adjacent to the intake should be recorded along with the diameter and type of tile intake material. The elevation of the flowline (invert) of the tile down in the intake should be recorded when tile elevation information may be necessary for evaluation and design purposes. (**Figure 3.58**). If water is flowing in the tile, observe and note the direction of flow. If the tile has sediment deposits, that should also be noted. The elevation of the tile should be clearly differentiated from the elevation of sediment. When direction of flow and size of the underground tile may be important, a tile probe can be used to help gather this information. Locate the underground tile with the tile probe several feet from the intake. Survey the top (handle) of the probe while it is at rest on top of the tile (**Figure 3.59**). The length of the probe (usually five feet) should be added to the height of the rod or staff as part of recording the survey point. For an accurate assessment of flow direction, location, and tile size, at least two and preferably more locations both upstream and downstream of any existing tile intakes should be surveyed using this method.

> Where tile probing is not possible, run a metal sewer tape down the intake and try locating it with a metal detector

- When **tile location, grade, or tile size** is needed at other project locations, a tile probe can be used in the same way as described above. When probing plastic tile and in some cases with clay or concrete tile, the tile probe can be pushed through the top of the tile to allow for information to be collected on the tile flowline as well. Along with a suitable description for these survey points, this method of collecting

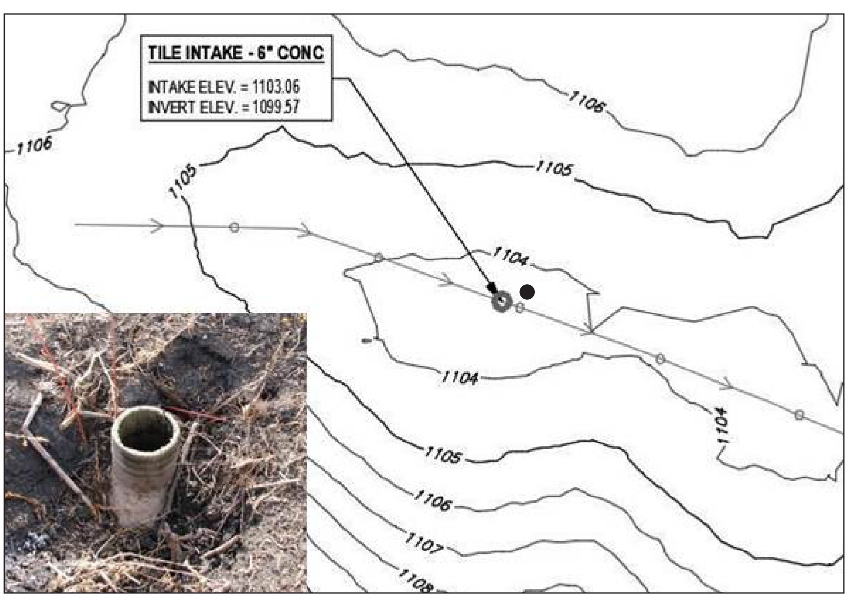

Figure 3.58 *Tile Intake Information from Survey*

Figure 3.59 *Surveying Underground Drain Tile*

information can help define the tile location, size, grade, and flow direction when the survey information is plotted. In some situations, it may be necessary to locate and expose tile lines with a backhoe prior to or during the survey to allow the collection of critical tile information.

- When collecting data on **tile outlets**, the elevation of the flowline (invert) and top of the outlet pipe should be recorded along with the size and material of the outlet pipe (**Figure 3.60**). Most tile outlets are constructed with a section of corrugated metal pipe (CMP) for protection and stability purposes. As such, the size of the CMP sleeve will often be a different diameter from the tile itself; usually larger to fit over the tile. Recording that the tile outlet survey point was taken on a CMP sleeve can avoid later confusion and uncertainty if the size of the tile is important for the evaluation and design of the project.

- The survey information collected on any **surface ditches** will vary depending on project scope and location within the project. In general, random survey points on ditch bottoms and ditch bank tops will be necessary. Ditch bottom shots and ditch cross sections should be taken as needed to define potential upstream impacts, existing ditch grade, downstream conditions, and hydraulic capacity of the ditch. Survey information of the ditch banks can be important and should be obtained as needed. At potential structure sites or other critical locations along the ditch, survey a full cross section of the ditch (**Figure 3.61**). Additional cross sections should be taken a short distance both upstream and downstream to help better define the design needs and quantities of the potential structure. It can be critical to obtain water level measurements in the ditch at the time of the survey. For some projects, these water level readings at certain times of the year (early spring, after heavy rainfall events, etc.) can provide valuable information regarding site hydrology.

Figure 3.61 *Surveying a Ditch Cross Section*

- When **lift or pump stations** are encountered, survey and gather information about the lift station and how it operates. Use extreme caution due to the obvious hazards associated with these structures. The type of sump, its size, top and bottom elevations, and material should be surveyed and recorded whenever possible. Survey and record size and elevation information on any pipes or tile that flow into or out of the sump. It may be necessary to operate the pump and dewater the sump in order to collect this information. Take photographs of the lift station, as they can be useful for reference, particularly when the project involves the pump's manipulation, relocation, or removal.

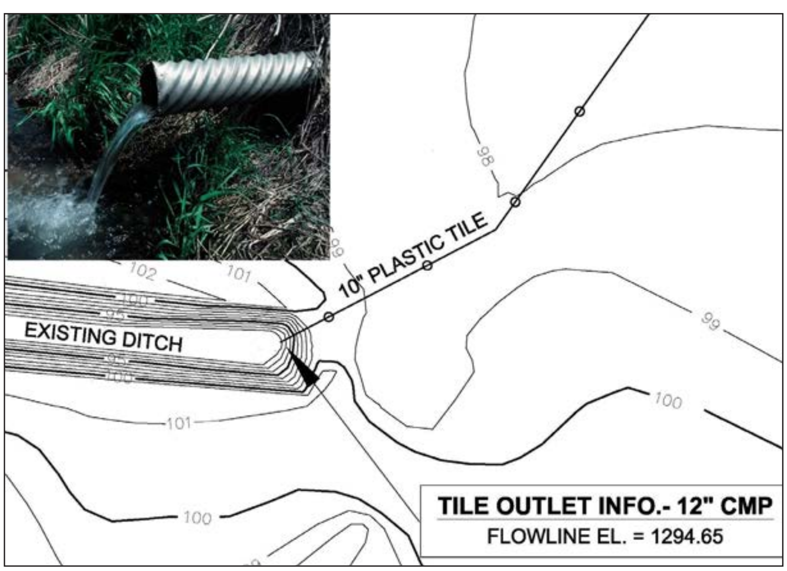

Figure 3.60 *Tile Outlet Information from Survey*

Photographs taken throughout the course of the survey can provide additional, important information when referenced and referred to as the design and construction plans are being prepared for the site

Topographic Map Development

The final step in the site survey process is to prepare a comprehensive topographic map that spatially and graphically represents the terrain and physical features of the project site. When completed, this map will become an invaluable asset to the remaining planning, design, and construction phases of a project. It is essential that attention be given to quality and detail as the map is being prepared. When computer generated, great flexibility exists in scale, appearance, and format of the prepared maps. The quality of the topographic map can have a great impact on impending decisions that need to be made in regard to design, construction, and perhaps even the landowner's decision whether to undertake the project at all.

The ability to produce a high quality comprehensive topographic map is a direct function of the quantity and quality of survey and other site data collected. Communication regarding the project scope and needs becomes an important project function that should be understood by all of the project team members, planners, surveyors, drafters, and the project engineer/manager, before the site assessment and evaluation processes begin.

Because the topographic map usually becomes the base or plan map for concept, design, and construction plans, consider the size and scale of the map carefully as it is being prepared. The size of the project, extent of design detail, and construction requirements all should influence the map size and scale.

A well-prepared topographic map will include, but not be limited to, the following information:

- Title block indicating project name, survey date, name of surveyor, datum reference, and project location
- Map scale of 1 in. = 100 feet or smaller is recommended (large projects may need to be split into multiple zones to avoid larger map scales)
- Contour lines at appropriate elevation intervals for project (typically 0.5 to 1.0 foot)
- Location, description, and elevation of project benchmarks (at least two are recommended)
- Indication of drawing scale (bar scale recommended)
- North orientation
- Depiction of roads, fence lines, buildings, properties, property lines, project boundaries, pipelines, power lines/poles, and other utilities within and adjacent to project area
- Locations and information of rivers, streams, bridges, culverts, ditches, tile lines, tile intakes, tile outlets and pump stations
- Existing vegetation, as appropriate for scope of project

If LIDAR data is used in the preparation of topographic maps for all or portions of a project, it should be clearly noted on the map. This is for the benefit of those who review or may later attempt to use the elevation information for other purposes.

Figure 3.62 *Creating a Topographic Map*

For many projects, the topographic map becomes the foundation or base map for many of the remaining project mapping needs

Checklist

Data Collection Needs – Site Topography

The following checklist includes survey related information that should be collected, when and where deemed appropriate:

- ❑ Obtain for review information from Digital Elevation Model (DEM) (if available).
- ❑ Perform a preliminary survey and collect and review relevant site information (if deemed necessary).
- ❑ Establish both horizontal and vertical control as appropriate for the scope of the project.
- ❑ Establish temporary benchmarks.
- ❑ Collect survey points appropriate for the scope of the project.
- ❑ Take photographs of surveyed features.

3-8 Surrounding Landscape & Reference Wetlands

The land uses adjacent to the project or within the project's watershed can influence the success of a wetland restoration or creation project. Land uses and sources of potential pollutants, nutrients, and sediments within the project's watershed can affect viability and quality. While it may not be possible to change surrounding land uses outside of the immediate project area, it is important to understand the potential impact those land uses may have.

The topics covered in this chapter include information on assessing surrounding land uses and evaluating their impact on a potential project site.

- Surrounding Land Uses
- Point and Non-Point Pollutants
- Hazardous Waste and Materials
- Environmental Corridors
- Reference Wetlands

Surrounding Land Uses

Land uses adjacent to a project or that occur within the project's watershed need careful consideration in terms of their potential influences to the project wetlands. Land use considerations will vary with every project. **Table 3.1** summarizes the potential consequences and effects of some of the more common, potentially harmful land uses that may exist in a wetland's watershed.

Figure 3.63 *Cropped Landscape*

Table 3.1 *Surrounding Landuses and their Influence on Wetlands*

Land Use	Potential Consequences	Potential Restoration Project Effects
Artifical Drainage	■ Increased runoff rates from drained area ■ Increased hydrologic connections throughout the watershed ■ Enhanced transport mechanism for nutrients, pollutants, and sediments ■ Increased restoration costs	■ More water to control and manage ■ Greater water level fluctuations ■ Plant stress from fluctuating water levels ■ Inhibited growth and survival of target information ■ More suitable conditions for invasive species ■ Habitat created for undesirable animal populations (e.g. Fathead Minnow, Carp)
Agriculture/ Urbanization	■ Increased runoff volumes ■ Soil disturbances/ compaction ■ Increased erosion/ sedimentation ■ Increased nutrient loading ■ Herbicides, pesticides, toxins, and pollutants found in runoff water	■ Improved growth conditions for invasive species ■ Increased growth of filamentous algae and duckweeds in open water ■ Loss of sensitive native plant species ■ Decreased plant species diversity
Commercial Forestry	■ Increased runoff volumes ■ Soil compaction ■ Increased erosion/ sedimentation	■ Improved growth conditions for invasive species ■ Decreased plant species diversity ■ More water to control and manage ■ Greater water level fluctuations
Mining	■ Changes in watershed hydrology (drainage, diversion of water, water table lowering) ■ Soil compaction ■ Increased erosion/ sedimentation	■ Uncertain long-term hydrology conditions ■ Unsuitable substrate for wetland vegetation establishment

Point and Non-Point Pollutants

Certain point and non-point pollution discharges may be present in the project's watershed and should be identified. This can include any of the following:

- Untreated runoff from storm sewer systems
- Uncontrolled runoff from feedlots
- Improper disposal of livestock waste on crop fields
- Septic systems or dairy system milk house drains that are connected to subsurface drainage systems or that are surface outletted

These types of pollution discharges may have negative effects on the project depending on the identified goals and objectives. For example, projects that have a goal of establishing diverse native plant communities would be negatively impacted by untreated runoff from an adjacent feedlot. Explore opportunities to implement conservation practices to mitigate the potential negative effects of pollutant discharges. In this case, implementation of a livestock nutrient management plan would reduce the negative effects of untreated livestock waste water.

Figure 3.64 *Storm Sewer Outlet*

Figure 3.65 *Small Dumpsite*

Hazardous Waste and Materials

As part of the site assessment, identify any potentially hazardous wastes or materials on or near the project site. Observations of any of the following conditions may indicate a potential environmental hazard:

- Discolored and/or unusual smelling soil conditions
- Discolored and/or unusual smelling surface or tile water
- Dumps
- Drums or containers (full or empty)
- Solid Waste

> The presence of environmentally hazardous materials or situations can create a significant liability risk and may affect eligibility for certain programs

Potential hazards should be further investigated to determine if they will prevent the project from moving forward. Interviews with past and present landowners and local government officials may reveal the nature and source of the observed conditions. In some cases, a detailed environmental hazard assessment by a certified inspector may be necessary where the nature of the potential hazard is undetermined or the material is a threat to human health and safety.

Environmental Corridors

Environmental corridors are areas of natural vegetation that can act as passageways for wildlife between isolated habitat units. One example is a tree-lined stream corridor that connects two wetlands that are otherwise separated by a developed area. Another example is a field row of tall herbaceous vegetation, shrubs, or trees that provides cover and a travel corridor for wildlife.

Depending on the project goals and objectives, it may be desirable to establish, connect to, or enhance an existing environmental corridor to increase the usefulness of the wetland project for wildlife species. Environmental corridors when they exist or are planned should be identified and mapped during the assessment process. Encourage opportunities to increase landscape diversity when connecting to or establishing environmental corridors.

Reference Wetlands

Reference wetlands can be a valuable source of information for some wetland restoration projects. Examining characteristics of existing wetlands in the proximity of the restoration project can provide information on vegetation types, soil conditions, hydrologic conditions, and other features important to the project.

When evaluating reference wetlands, make comparisons and take notes of site characteristics that may be similar to your project site. For example, if the reference wetlands are degraded and of poor quality, what were the environmental factors that might have caused this condition? Could this condition have been avoided through the implementation of conservation practices in the watershed or more intensive management of the wetland? How could these factors affect the goals and objectives of the proposed project and what level of future management can be expected for it?

For a comparison with high quality wetlands, consider visiting state natural areas or other publically-owned high quality wetlands in the project vicinity. The Minnesota Department of Natural Resources can provide information on state natural area locations and characteristics. Local soil and water conservation districts, watershed districts, and watershed management organizations may have information on local high quality wetlands in the project area. In addition, the Minnesota Pollution Control Agency has established reference wetlands around the state.

Figure 3.66 *Reference Wetland*


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Checklist

Data Collection Needs – Assessment of Surrounding Land Uses and Reference Wetlands Soils

The following is a checklist of items to review and consider when assessing surrounding land uses and reference wetlands:

- ❑ Identify any surrounding land uses that could influence the ability to achieve project goals.
- ❑ Investigate and identify all point and non-point pollutant sources.
- ❑ Investigate and identify any potential hazardous wastes that may be near the project site.
- ❑ Identify where environmental corridors could be established, connected to, or enhanced.
- ❑ Visit reference wetlands and make project comparisons.

3-9 Analysis & Interpretation of Site Assessment Data

Figure 3.67 *Evaluating Site Assessment Information*

The information in this chapter provides discussion on the process used to review and evaluate the site information collected for a project.

- General Considerations
- Concept Plan
- Feasibility Analysis
- Setting/Redefining Project Boundaries
- Identify Project Constraints
- Project Review
- Redefining Goals and Objectives and Establishing Performance Standards

The final step in evaluating a potential wetland restoration project is to analyze and interpret the data gathered for the site. This involves evaluating the collected information and identifying opportunities as well as limitations to restoring identified project wetlands. This is best accomplished by developing a plan for the project which portrays the locations of all planned wetlands and associated restoration strategies that will be used for others to see and review. Those involved in the project can utilize this information to determine feasibility, and set or redefine project boundaries, goals, objectives, and performance standards.

General Considerations

This final step in the site assessment process requires the project designer to weigh all of the available information and make an evaluation of what can reasonably be accomplished at a project site. This needs to be done with respect to the available budget and the previously defined goals and objectives for the project. A determination must be made as to what site factors are most limiting and which limitations can be overcome through negotiations or design adjustments.

Many factors will influence what can and cannot be accomplished on a potential project site. This requires a thorough understanding of both the existing and historic project conditions. The evaluation process should consider physical, biological, and economic factors associated with the project. This evaluation process can be quite simple or extremely comprehensive depending on the scope and project complexity.

An effective evaluation will incorporate reputable design concepts and procedures that are associated with restoring or creating wetland and upland habitats. Prior to developing design concepts, review both **Section 4 - Engineering Design** and Construction and **Section 5 - Vegetation Establishment.** Both sections provide discussion on specific design strategies for the restoration and creation of wetland and upland habitats.

Concept Plan

For most wetland restoration or creation projects, a concept plan of some type will be needed to facilitate review and input before detailed project designs are prepared. The exception to this may be simple projects that are being completed for conservation purposes. The development of a concept plan sets the stage for possible further data collection, analysis, and refinement of the project design details. It also provides an opportunity for the landowner, sponsor, agency, or other individuals that are involved or have an interest in the project to review and comment on the proposed plan at an early stage in its development.

> The scope of the concept plan relates directly to the project's complexity and purpose

A well-prepared concept plan will summarize existing site conditions and show anticipated project improvements and activities. It may help determine the eligibility or priority of a proposed project and possibly allow for infeasible projects to be eliminated; it may also be just what is needed to convince a landowner (or group of landowners) to participate in a proposed project or include the amount of land necessary to maximize the site's restoration potential.

The topographic map developed for the project usually serves as a base map for the plan. Concept plans are typically developed electronically but in some cases are drawn by hand. A written narrative may also accompany the concept plan to further support and describe the plan.

A concept plan should be prepared with the appropriate amount of detail as required by the reviewing audience. For example, if the project involves work that will impact a public road, the details of project activities that will affect the road should be emphasized and clearly conveyed in the plan and associated narrative, allowing for preliminary discussions with the corresponding road authority. Another example might be projects that are being implemented for mitigation reasons where a comprehensive concept plan is a required part of the regulatory process. It can be extremely beneficial to contact those who will be reviewing the plan to find out their concerns, requirements, and issues prior to finalizing the plan.

A concept plan should include, but not be limited to, the following items:

- Describe existing site conditions including drainage features, areas of existing vegetation (both desired and undesired) and connection to or presence of habitat corridors
- Clearly define the existing or proposed boundaries of the project
- Review the project goals and objectives and how the project will achieve them
- Provide an overview of the proposed project wetlands and uplands including a depiction of wetland areas, elevations, and associated plant communities
- Provide a summary of proposed project activities such as vegetation manipulation and establishment, grading activities, tile breaks, etc.
- Provide a summary of expected and available hydrology for the site
- Identify any site constraints that need to be resolved
- Discuss any potential regulatory issues
- Discuss preliminary project costs and project feasibility

Feasibility Analysis

The feasibility and cost effectiveness of a project includes determining if the project will achieve program goals and requirements and can be completed within expected timeframes and financial constraints. Depending on the purpose and program for which a project is being considered, funding limitations, program requirements, and certain expectations for project outcomes may limit the merits and the feasibility of some projects.

The feasibility analysis is usually conducted in conjunction with the development of a project's concept plan. The concept plan should identify proposed improvements and site changes providing for an estimate of labor and material quantities, which can then be translated into costs. For example, a project that involves importing or exporting significant amounts of soil may require a concept grading plan to quantify the amount of material to be moved and the associated transportation costs.

Figure 3.68 *Installation of Diversion Pipe*

The project manager or engineer must be aware of financial constraints and timing limitations when assessing feasibility. In addition, there must be an awareness of how flexible project goals and objectives can be. Projects with broader goals and objectives tend to be more flexible when it comes to adjusting implementation strategies to overcome identified constraints. Projects with narrower goals and objectives (such as those dictated by some conservation program eligibility requirements) tend to be less flexible in regard to project modifications.

Project managers making a determination of project feasibility should clearly articulate the reasons for their decision. This would include a summary of relevant project constraints and an explanation as to why each one can or cannot be overcome through project modifications. If the project is determined to be feasible, acquisitions can be finalized and detailed design work can begin.

Setting/Redefining Project Boundaries

Evaluate the proposed project boundaries as the concept plan is being developed. Boundaries are usually defined by ownership and landowner desires but must also consider the project requirements for protecting or securing the necessary land rights to impacted areas. Boundaries are typically defined as the area that will be secured under easement, purchased for fee title acquisition, or defined under some type of agreement or contract.

If project boundaries are already defined and are not adjustable, the concept plan needs to be developed to work within the constraints of this boundary. Where boundaries have not been defined, they should be determined or confirmed at this stage in a project's development. Several factors should be considered when establishing or determining boundaries for a project. They include but are not limited to:

- Land ownership and landowner desires.
- Program limits or criteria. Some programs may have minimum or maximum enrollment sizes or possibly even enrollment limits on upland to wetland ratios.
- Amount or width of desired or required vegetative buffer area adjacent to project wetlands. The lateral width of upland buffer areas can affect wetland water quality, wildlife use, and other ecological factors.
- The extent of wetland areas to be restored along with adjacent land areas that may occasionally be flooded during large runoff events. The full extent of impacts to these adjacent areas will likely not be known at this stage of a project; use good judgement in this determination. As a general rule, impacted adjacent areas should be defined to include, at minimum, all lands within two vertical feet from any planned wetland water surface. That will include the entire wetland area and any adjacent land areas potentially impacted by the project. Exceptions to this rule exist and can include areas where roads, embankments, ditch banks, or other physical structures exist or are planned. Adjustments to this general rule may be necessary in areas with very flat topography or where the expected flood bounce and duration may be a factor.
- Straight lines should be used whenever possible to define project boundaries. Straight lines are easier to define, establish, maintain, and enforce.

> A preliminary hydrologic analysis may be necessary to determine the extent of flooding or "bounce" expected from a potential wetland project as boundaries are being determined

Figure 3.69 *Easement Boundary Sign*

Figure 3.70 *Utility Near a Project Site*

Each project is different and a constraint for one project may not be a constraint for another. Some identified constraints can be overcome through additional on-site investigations, modification of project goals, scope, boundaries, or through negotiations or properly applied design and implementation strategies; others cannot. After an initial determination of project constraints, the project manager should follow up with others involved in the project to determine if the constraints can be overcome within the context of project goals and objectives. For example, if the constraint is an adverse effect on a neighboring landowner, this landowner should be contacted and a determination made as to whether they have interest in joining or cooperating with the project. If they are not interested, the project will need to be re-evaluated to see if the plan can be modified to avoid impacts to that neighboring property.

It is important to identify the project constraints early in the planning stages of a project so they can be investigated and addressed as needed prior to proceeding to design. Projects that are adapted to fit the site conditions and work within identified limitations often end up being more successful than those that attempt to manipulate or exceed the limitations in an attempt to achieve a pre-determined project goal.

Identifying Project Constraints

Constraints to implementing a project that are identified through the planning and site assessment processes are best conveyed through the concept plan. Items identified as constraints have the potential to affect the desired project goals and objectives, or possibly even prevent the project from being completed. Through the site assessment process, factors such as ownership, soils, hydrology, drainage, topography, vegetation, and project boundaries should have been thoroughly reviewed, allowing for an understanding of what can be accomplished on the site and, perhaps more importantly, what cannot.

Examples of project constraints include:

- An identified impact on a neighboring property
- An identified utility within the project boundaries
- A drainage system shared with an upstream neighbor
- Invasive species in the upstream watershed, etc.

Make a determination for each site assessment element (legal issues, drainage, topography, etc.) as to whether or not it is a constraint or limitation for the proposed project. This decision can only be made if the project manager has a clear understanding of the project goals and objectives as well as realistic understanding of logistical limitations such as timing and costs.

Project Review

One of the purposes of the concept plan is to seek review, input, and, when necessary, permission to proceed with a proposed project. Depending on the project scope, this review process could be quite simple or very detailed with many interested parties involved. For example, a simple wetland restoration being completed as part of a conservation project may only require landowner review and input to the project proposal. In contrast, a project being completed for mitigation purposes will involve the review and input by many individuals, regulators, and concerned parties. They all have an interest in ensuring that the mitigation policies and requirements are being met. Project complexity and proposed impacts to varying utilities, transportation, and drainage infrastructures can also influence the required review process. Seeking input and preliminary approval from authorities who administer these infrastructures is recommended and will often be necessary.

Figure 3.71 *Concept Plan Review with Landowner*

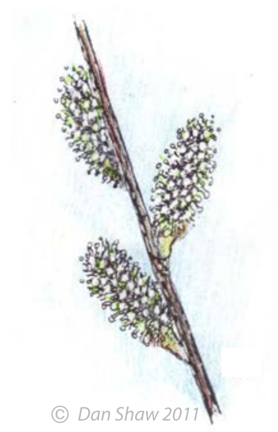
Prepare concept plans with a clear definition of what is proposed for the project to allow for this review by interested parties. From a cost standpoint, it is more practical and economical to negotiate plan ideas and possible project outcomes through the use of a concept plan than it is using a detailed design plan. Changes made to a completed design plan that relate to general restoration concepts (i.e. wetland depths, elevations, structure types, locations, etc.) can be extensive, costly, and time consuming.

> An unclear or incomplete concept plan can result in confusion and potential rejection of the project proposal

Anyone with an interest or responsibility in the proposed wetland restoration should be provided an opportunity to review and comment on the project. Carefully consider any comments and concerns that are provided before the project progresses to its design phase. It is possible, as a result of this review process, that significant changes to the project proposal will need to be made. It is often beneficial to provide a summary of comments from plan reviewers with an accompanying explanation as to if and how each comment will be addressed. This is particularly important if the plan will require final approval by a particular government entity. Proceeding to the design phase of a project without addressing substantive comments on the concept plan can result in wasted effort to develop a project design that will not ultimately be approved.

Developing Specific Project Goals and Objectives

A final step in the site evaluation and project planning process is to develop or redefine, as necessary, goals and objectives for a project. While the results of the site assessment and evaluation process may not have changed the initial goals that were originally envisioned for the project, it is likely that the objectives to accomplish those goals have changed. At this point in the planning process, goals should be re-evaluated and fairly specific project objectives should be identified. These objectives should support the concept plan that has been prepared for the site. Additional discussion on developing project goals and objectives along with developing meaningful, measurable outcomes or performance standards occurs in **Section 2 Planning**.



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Checklist

Site Evaluation Checklist

Through the final evaluation and concept planning process, project constraints are likely to be identified. Evaluate and address these project constraints prior to proceeding to design. The following checklist provides an organized approach to identifying and evaluating project constraints. The information listed is a summary of items discussed throughout the Site Assessment and Evaluation Section of the Guide. The project manager or engineer should review each listed item, determine whether or not it is a significant issue or constraint for the project, and, if so, decide whether it can be overcome through negotiation, design, or project modification.

Section 3-2 Ownership, Land Use and Legal Issues

- ❑ Will ownership issues affect the purchase of the property for fee title or easement?
- ❑ Will existing agreements or easements for the property affect program enrollment and the ability to achieve desired project goals?
- ❑ Are cultural resources at the project site a potential concern?

Section 3-3 Site Soils

- ❑ Will existing soil conditions affect the ability to establish planned or desired hydrology and vegetation communities?
- ❑ Will existing soil conditions limit the construction possibilities for the project?

Section 3-4 Site Hydrology

- ❑ Is adequate hydrology available to support the intended project goals?
- ❑ Can hydrology be restored without adverse impacts to adjoining properties?

Section 3-5 Site Drainage

- ❑ Will modifications to a private or public drainage system be needed for restoration of drained wetlands?
- ❑ Can these modifications be made without adversely affecting drainage rights of adjoining properties?

Section 3-7 Site Topography

- ❑ Is the topography of the site conducive to achieving identified restoration goals?

Section 3-8 Surrounding Landscape and Reference Wetlands

- ❑ Are surrounding land uses of concern?
- ❑ Could existing vegetative communities affect the ability to achieve desired project goals?
- ❑ Do point or non-point pollutant discharges need to be considered?
- ❑ Will hazardous wastes or other materials in the surrounding landscape be a potential problem?

Section 3-9 Analysis and Interpretation of Site Assessment Data

- ❑ Do funding limitations exist?
- ❑ Is the restoration of wetlands on the project feasible to consider?
- ❑ Is the project area adequate in size to facilitate the restoration of wetlands?