A HYDROGEOLOGIC PROCEDURE FOR EVALUATING WETLAND RESTORATION AND CREATION SITES

James J. Miner
Michael V. Miller
Christine S. Fucciolo

Illinois State Geological Survey
Wetlands Geology Section
615 East Peabody Drive
Champaign, IL 61820-6964
Open-File Series 2002-5

Submitted Under Section 319 FAA #3199271
Illinois Environmental Protection Agency
1021 North Grand Avenue East
P.O. Box 19276
Springfield, IL 62794-9276

February 20, 2003

A Division of the Illinois Department of Natural Resources

CONTENTS

PURPOSE

The Illinois State Geological Survey (ISGS) has developed an Initial Site Evaluation (ISE) procedure that can be used to rapidly evaluate the likely hydrogeologic success of wetland restoration or creation at proposed wetland compensation sites. The procedure uses available hydrogeologic information supplemented with field observations and indicators of site hydrogeology. We expect that the ISE procedure will be used to guide the selection of favorable wetland compensation sites from a hydrogeologic perspective. Although this procedure was originally developed using Clean Water Act goals, it can apply equally to creation or restoration of wetlands for other programs and goals, such as water-quality improvement. This report is adapted from a procedure that was previously developed for the Illinois Department of Transportation under contract AE89005 as described in Miller et al. (1998). The creation of this report, containing extended explanation and methods, was funded by the Illinois Environmental Protection Agency under a Section 319 Financial Assistance Agreement. The conclusions and methods of this report do not necessarily reflect the views of the sponsor.

INTRODUCTION

Recent reports conclude that wetland compensation, which encompasses wetland restoration, creation, and enhancement, is often unsuccessful (Gallihugh and Rogner 1998, National Research Council 2001). Sites often fail to maintain saturated conditions required to meet jurisdictional wetland criteria set by the U.S. Army Corps of Engineers Wetland Delineation Manual (Environmental Laboratory 1987). Wetland compensation sites may also fail by creating water levels that are too stable and too deep, making pond-like wetlands that do not perform the functions of the original wetland (Kentula et al. 1992, National Research Council 2001). Improper hydrologic conditions lead to both types of failures, which may lead to possible regional changes in flora and fauna and losses of wetland function (Kentula et al. 1992, Cole and Brooks 2000). Improper hydrologic conditions can result if the wetland compensation site is not favorable, or if the wetland design does not account for the site's hydrogeology.

There are a number of reasons that improper sites are selected and improper designs are used. First, site selection is not made often on the basis of suitability to sustain wetlands, but for other unrelated reasons such as willing sellers or available land. Sites chosen in this manner often require complex designs to overcome the inherent unsuitability of the site, which increases the chance of failure during design, construction, or long-term operation of the site. Second, detailed hydrogeologic data are necessary for the proper design of a wetland, but they are not available for most of Illinois and the rest of the country. Therefore, it often is necessary to perform a detailed hydrogeologic study in order to obtain sufficient data for designing a wetland. This can be a lengthy and expensive process that is often overlooked in favor of best professional judgement and the use of hydrogeologic indicators or proxy data. Third, time and resources that can be spent in collecting hydrogeologic data may be limited, or the number of candidate sites may be large, so that no site can be studied in detail. Fourth, expertise may not be available to collect and interpret hydrogeologic data. Other reasons may also exist.

Given these limitations, decisions regarding site selection and design are often made without proper selection criteria and hydrogeologic data, despite the fact that site selection is a critical step in wetland compensation. Therefore, a procedure is needed to screen and select sites without a large commitment of resources and without detailed hydrogeologic data. If poor sites are removed from consideration through the screening process, then there will be a greater likelihood of success. If the screening procedure favors sites where less complex engineering works are needed, then there will be fewer failures resulting from design, construction, and maintenance aspects.

Since 1992, ISGS has been under contract to the Illinois Department of Transportation (IDOT) to provide hydrogeologic data and interpretation regarding IDOT's wetland compensation activities. During this period, ISGS examined the hydrogeology of more than 50 candidate wetland compensation sites to evaluate their potential and to propose options for restoring or creating wetlands. Based on this experience and on principles from hydrogeology and wetland science, ISGS developed a procedure to rapidly evaluate the likely hydrogeologic success of candidate wetland compensation sites. The procedure uses available hydrogeologic data (i.e. file data) combined with field observations (i.e. field data) of conditions in the site and nearby areas made during a site visit. The original procedure was developed to evaluate sites used to compensate for wetland losses as required under Section 404 of the Clean Water Act. While the audience for this document may not necessarily have Clean Water Act compliance as a goal, the underlying hydrogeologic principles that result in a successful wetland restoration or creation project apply to a wide range of regulatory and nonregulatory goals.

This report presents the ISE procedure in a user-friendly manner, listing the steps that are made and the science and reasoning behind each decision. The report is intended to make users aware of hydrogeologic principles and techniques that will assist them in selecting proper sites for wetland compensation activities. This procedure does not rank sites quantitatively. Instead, sites are broadly categorized using a qualitative classification system.

The users of this procedure may assign differing importance to the various characteristics and functions of wetlands. Therefore, the principles on which the procedure is based are stated in the following section so that the user can customize the procedure to account for programmatic and individual differences. It also should be noted that each site has a unique combination of conditions that caused it to exist, so that differences in success potential may occur even if those sites are classified the same using this procedure. Therefore, some level of best professional judgement may be needed for final site selection, which is not addressed in this report. We recommend involvement of a hydrogeologist or other appropriately trained individual.

We anticipate that potential users of the procedure will have differing levels of experience and knowledge. Some users will not be able to make all observations or interpret all data as suggested in this report, but we expect that every user will benefit from consideration of the issues raised by this procedure, even if the entire procedure is not fully performed. This procedure uses guidelines and indicators that are expected to assist with site selection and design, but it is not a substitute for a complete hydrogeologic characterization of the selected compensation site. Characterization specifically measures the hydrogeologic conditions in sufficient detail and duration for design purposes. The ISGS does not assume any liability for the use of this procedure.

For the purposes of this report, we define a wetland restoration as the reestablishment of preexisting hydrologic conditions in a former wetland that previously was drained, filled, or otherwise altered. Wetland creation is the establishment of wetland conditions in an area where wetlands did not exist previously, or in a location where wetlands previously existed but the original hydroperiod is not being reestablished. A hydroperiod is the depth, duration, and extent of inundation or saturation at a site.

GUIDING PRINCIPLES

The ISE procedure was developed from principles of hydrogeology, wetland-science literature, and experience in examining the hydrogeology of wetlands and candidate wetland compensation sites. These guiding principles are listed here explicitly. If a candidate site has unique goals or circumstances that conflict with these guiding principles, then adjustments in classification should be made using best professional judgement.

1. **Wetland restoration has a greater chance of success than wetland creation** (Hammer 1992, Admiraal et al.1997). Wetlands exist in the landscape due to a combination of hydrologic, geologic, topographic, biotic, and climatic conditions. If wetlands existed on a site prior to alteration, then the right combination of these controlling conditions was present prior to alteration. Therefore, restoring wetlands may be as simple as identifying the alteration and reversing it. Restoration also is the preferred approach of the National Research Council (2001). Creating a wetland where one previously did not exist is more difficult, because the right combination of conditions to support wetlands never existed on site, thus requiring that some conditions be altered to achieve a combination that forms and sustains wetlands. Unfortunately, some of these controlling conditions often are difficult to measure accurately, so it is difficult to identify which conditions to alter and to what extent. The conditions also can be interdependent, so it may be difficult to predict how the others will respond if one is changed. Therefore, the outcome of a wetland creation is often uncertain. Restoration is also preferred because estimates can be made of the size and location of drained wetlands using soil surveys and other historical documents, reducing uncertainty about the extent of impacts from the restoration. The former plant community and expected hydrology may also be estimated by examining sediments and adjacent wetlands. Restoring wetlands reduces uncertainty about all of these issues and therefore has a greater chance for success. For the purposes of this report, "success" is defined as meeting the U.S. Army Corps of Engineers (USACE) 3-parameter criteria (hydrology, soils, and vegetation) for delineating wetlands as outlined in the 1987 Wetland Delineation Manual (Environmental Laboratory 1987). Other definitions may be appropriate if the procedure is being used for other regulatory programs or for non-regulatory purposes.

2. **A restored wetland is likely to function at a higher level than a created wetland**. It may be possible, with enough effort and expense, to make almost any parcel of land wet enough to satisfy the wetland definition referred to above. However, creating all the functions of a particular type of natural wetland (e.g., flood storage, wildlife habitat, etc.) is very difficult and seldom achieved. Similar to the discussion above, less manipulation, expense, and risk of failure are generally associated with restoring lost functions rather than creating them where they did not exist in the past. One example is the function of providing habitat for native flora and fauna, which thrive because they are adapted to specific environmental conditions, some of which are likely to be poorly understood. If that habitat occurred on site prior to alteration, then all the conditions needed by those species were present in the past, and it may be possible to restore them by reestablishing the preexisting hydrogeologic conditions. If it were necessary to create habitat for certain native species in places where they never existed in the past, then we would have to understand each condition that each species requires, and alter the site to create those conditions. Because it is a difficult task to alter the landscape to create even one controlling condition as noted above, it would be nearly impossible to create every controlling condition for each of the many species. It is unreasonable to expect that all conditions needed to restore every function of a lost wetland would be created successfully, so that a created wetland is not expected to function as fully as a restored one.

3. **Wetland restoration involves restoring the original hydroperiod by removing or reversing hydrogeologic alterations (e.g., drainage structures, fill)**. If the original hydroperiod of a drained wetland is not restored, then we consider it to be wetland creation rather than restoration, with the attendant risks of increased failures and decreased functions due to the need to predict and design for all of the controlling conditions for each function.

4. **Created wetlands are easier to design when there is a nearby natural wetland that can be used as a model**. Given the problems mentioned above regarding creating wetlands, natural wetlands nearby that occupy similar geologic and topographic settings and use similar water sources may be used to as models to create wetland areas at a compensation site (Holman and Childres 1995). The controlling conditions and the types of alterations needed to create a wetland may be estimated by comparison to the model wetland, including information such as geology, water sources and availability, expected hydroperiod, flora and fauna, and other characteristics.

5. **Wetlands cannot be created where they already exist**. If a site already satisfies the USACE definition of wetland, then it generally cannot be used for wetland compensation (other than for preservation or enhancement credits) under Section 404 of the Clean Water Act, since the "no-net-loss" of wetlands goal would be violated. Therefore, a site that is already entirely wetland will be ranked as LOW according to the ISE procedure. Similarly, sites where no hydrogeologic alterations have been made, but vegetation has been altered

(e.g., farming or logging) will also not qualify as having HIGH potential, because the hydrologic functions cannot be increased without wetland creation activities such as excavation. However, from nonregulatory and certain regulatory perspectives, there may be good reasons to enhance the functions of a degraded wetland. In those cases, the hydrogeologic principles enumerated in this procedure will help in designing these types of sites and evaluating their hydrologic potential. Again, customizing the procedure is encouraged if the user's programmatic needs differ from the principles listed above.

DATA TYPES USED IN THE ISE PROCEDURE

As noted earlier, the ISE procedure uses a combination of existing information that is available from various sources (labeled "file" data) along with observations that will be made during a site visit (labeled "field" data). This section discusses the data that are normally used for the ISE procedure, and introduces data sheets that are used to ensure that the procedure is performed in a uniform manner. The data collected on the sheets will be consulted in the ISE procedure.

File Data

The file data sheets shown in Appendix 1 are used to summarize the information available for a site. Many categories on the sheets refer to publications listed in the bibliography that contain information about Illinois, including topography, geology, geomorphology, soils, wetlands, and more. This information can be synthesized to provide a hydrogeologic picture of a site and its relationship to the surrounding landscape, and will assist in answering the questions that arise during field visits and during classification. Additional discussion is listed adjacent to many questions in Appendix 2.

It should be noted that many of the data sources listed are of small scale (e.g., 1:100,000 or smaller). Maps and other data products lose their accuracy when examined at a scale much different than they were originally prepared. While these sources often represent the best available data and therefore should be consulted, they will not be accurate if enlarged and viewed at a site-level scale. The user should be aware of the need to confirm those data with field observations, or by examining the original data from which the products were prepared and making a judgement about interpretations made from the source data.

Field Data

The field data sheets are shown in Appendix 2. These consist of a list of questions that is structured to prompt the user to collect basic information while in the field, and to think of that information in a hydrogeologic context. For example, the questions center around inputs and outputs of water, status and locations of wetlands and former wetlands on and near a site, and alterations that may have been made that have affected the hydrogeology of a site.

Other Data

While data sheets are provided to prompt users to collect certain types of data, any other information about a candidate site should be included in this procedure. Information may be available from other sources, such as newspaper articles, government reports, drainage contractors, farm groups, government agencies such as the Natural Resources Conservation Service and state departments of natural resources, neighbors, and most importantly from the landowners. Many landowners are quite knowledgeable about hydrologic alterations such as ditching and field tile, and they have observed the hydrologic behavior of the site for many years. They often know the location, importance, and regularity of each water source, the location and duration of saturation during each season, and other useful information. This information should be sought and included in the classification process, and may in fact be the key to understanding the hydrologic behavior of the site without extensive field work.

CLASSIFICATION OF SITES

The ISE procedure classifies candidate sites into three broad categories: HIGH, MODERATE, and LOW potential for success of the wetland compensation. Based on the guiding principles listed above, a flow chart is used to guide how sites are classified using this procedure. In each step on the flow chart, basic questions are answered using hydrogeologic and other data that have been gathered and interpreted. The flow chart is shown in Figure 1, and each step is listed below with explanation of the methods, data, and reasoning used for the step. In addition to using the chart for the final classification step according to this procedure, the chart can be consulted throughout the data gathering procedure to determine what data are missing and to guide additional work.

Some caveats of the classification procedure are as follows.

- Sites are classified according to their potential for success at meeting regulatory USACE requirements and the successful development of wetland functions, when viewed using hydrogeologic procedures and data.
- We anticipate that different users may classify a site differently due to varying levels of experience, emphasis on particular features, and programmatic needs.
- Users should anticipate that sites ranked identically may have somewhat differing potentials for success due to the individual combination of factors that allow wetland formation at each site, especially when comparing different types of wetlands.
- We fully expect that it may be possible to create a wetland even in sites ranked "LOW", but the effort, expense, and failure rates are likely to be greater, and the site is likely to exhibit fewer wetland functions than higher-ranked sites.
- We expect that circumstances will be encountered when a lower-ranked site may be preferable to a higher-ranked site, due to intangible or unusual site characteristics.

Best professional judgement needs to be applied in classification and final site selection. Some characteristics of each category used in this procedure are listed below.

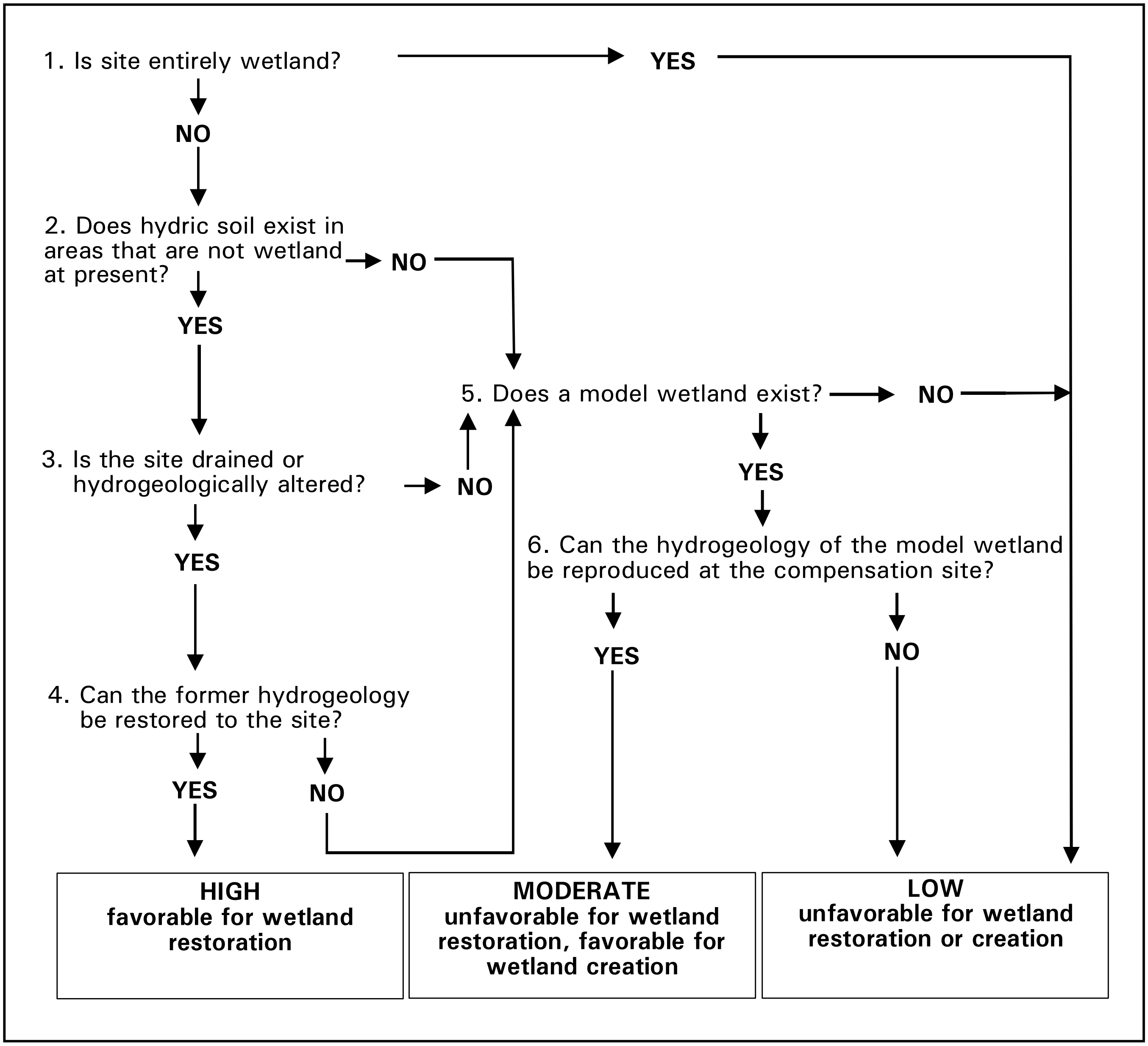

Figure 1. Decision-making flow chart used for classifying the potential of sites using the ISE procedure

HIGH potential: The site will contain hydric soils and former wetlands that have been drained, filled, or otherwise hydrogeologically altered so that they no longer perform the functions of a wetland. The alterations likely will be apparent and reversible, and the water sources likely will be apparent. Restoring wetlands is feasible.

MODERATE potential: The site may have been wetland in the past; if so, the original hydroperiod is not restorable. A model wetland exists nearby that will assist in determining design criteria for wetland creation at the site. Water sources and alterations to any previously existing wetland may not be apparent or reversible.

LOW potential: If the site is entirely wetland, then little compensation potential generally exists under Section 404 and the site is ranked LOW, although preservation and enhancement activities may still be possible. If the site has no hydric soils, then wetlands never existed on the parcel and wetland creation is required. There will generally be no model nearby on which to base wetland creation designs. Water sources and/or alterations are generally not identifiable or restorable.

Step 1. **Determine if the site is entirely wetland**. Because sites are often identified for reasons other than suitability, the first step is to determine if they are already entirely wetland. If no, then some potential may exist for wetland compensation, and proceed to Step 2. If yes, then there is generally no opportunity for wetland compensation. Therefore, the site should be classified as having LOW potential. If nonregulatory activities are being considered, or if it is desirable to preserve a wetland or enhance the functions of an impaired wetland, then it may be useful to proceed to Step 2 to continue with classification regardless if the site is entirely wetland. Resources to examine for this step include National Wetland Inventory (NWI) maps, Natural Resources Conservation Service (NRCS) mapping for agricultural areas or guidance from personnel, assistance from the nearest U.S. Army Corps of Engineers office, plus a site visit. If professional guidance is needed to answer this question, then a professional wetland scientist can be consulted for a wetland delineation.

Step 2. Determine if hydric soils exist in areas that are not wetlands at present. If hydric soils exist in areas that are not wetlands at present, then wetlands existed in the past that have been removed by drainage or other alteration. Proceed to Step 3 to continue classifying and to determine if wetland restoration is possible. If hydric soils are only found in existing wetlands, then no drained wetlands exist and restoration is not an option. Therefore, the site cannot be ranked as having HIGH potential using this classification system. Proceed to Step 5 to determine if the site should be classified as MODERATE or LOW. One important item to note is that hydric soils may be preserved as relics of prehistoric hydrogeologic conditions that have changed naturally through time. Later, it may be necessary to consider how the wetlands were removed (e.g., naturally or anthropogenically), which may impact the restoration potential of the site. Resources to examine for Step 2 include soil surveys for the area in question, as well as examination of any soil borings for redoximorphic features (U.S. Department of Agriculture, Natural Resources Conservation Service 1998) and other hydric soil indicators (Environmental Laboratory 1987).

Step 3. Determine if the site is hydrogeologically altered (i.e. drained or filled). A site visit is required to make observations of alterations, although topographic maps and air photographs may show some features, such as levees, ditches, and field tile. If significant drainage or alteration is observed, proceed to Step 4. If not, proceed to Step 5. The field data sheet contains a number of types of alterations common in Illinois, but any change in the hydrogeologic conditions should be noted, such as topographic change (e.g., fill), loss of water input (e.g., levees, pumping), or increase in water output (e.g., drainage tile, ditches). It is also useful to note if any of the drainage features and other alterations are functioning, and to estimate the magnitude of the impact that they have on the site.

Step 4. Determine if the former hydrogeology can be restored to the site. This step requires some analysis and conclusions based on the data collected about the site. The complexity of the site and the experience of the user will determine if professional assistance is needed. We expect that all users of the procedure, even those with less experience in wetlands, will benefit from considering the issues discussed in the procedure even if all steps are not possible for a specific individual to perform. In general, if the water sources are constant and the drainage structures are apparent and reversible, then there will be less need for assistance. If the water sources are unclear or intermittent, the causes of site alteration are unclear, and the effects of alteration reversal are unknown, then additional analysis or assistance may be needed. A list of questions and situations are presented here to suggest items that may need to be considered before deciding if the previous hydrogeology can be reestablished. However, any number of different situations can be encountered. After considering the following points, if the former hydrogeology is determined to be restorable, then the site is classified as having a HIGH probability of success. If the prior hydrogeology is determined not to be restorable, then proceed to Step 5 for further classification.

A) *What alterations to the site exist?* Alterations can involve changing one or more of the controlling factors, such as topography and water sources. Wetlands are commonly altered by increasing water outputs using ditches and field tiles, or decreasing water inputs by using levees, fill, and ditches. Estimate the feasibility of reversing any alterations.

B) *How long and how often do the drainage features function, and what volume of water (relative to site size) is diverted or drained from the site?* This is best determined from long-term observations or site-specific knowledge, such as from the landowner. If ditches or field tile flow for long durations (several weeks or months), and in a significant volume, then it is likely that those alterations are having an impact and wetland conditions may become reestablished if the alterations are reversed. If a more specific determination is needed, then a water budget can be calculated by measuring water inputs, outputs, and storage. If a water budget cannot be calculated for the site due to limited resources or experience, then water sources can be evaluated in a "time-on-target" approach, i.e., how often and for what duration do the water sources reach a sufficient elevation to saturate the site? According to the 1987 USACE Wetland Delineation Manual (Environmental Laboratory 1987), areas that are saturated or inundated for greater than 12.5% of the growing season conclusively satisfy the "wetland hydrology" parameter of the 3-parameter wetland definition, herein referred to as "satisfying wetland hydrology criteria". In Illinois, this corresponds to approximately 22 to 27 days depending on latitude. If the other two parameters are also met (hydric soils and hydrophytic vegetation), areas that are inundated or saturated for at least 5% of the growing season (approximately 9 to 11 days in Illinois) also may satisfy wetland hydrology criteria.

C) *Are the water sources reliable?* Groundwater input is the most constant source of water, because it responds more slowly to climatic factors than other water sources, and may inundate or saturate a wetland for weeks or months. Runoff and other surface-water sources may be less constant because they respond to precipitation more rapidly, but flood events may differ in duration from hours to weeks depending on the stream. Alternatively, surface water can be advantageous because recurrence intervals for flooding have been or can be calculated in many places. Precipitation is the least dependable source of water, because it is variable and subject to drought. In Illinois, there is a large evapotranspiration deficit in the summer (Hensel 1992), so that wetlands that are supplied mainly by precipitation are less easily established and maintained because climatic variation may reduce the water supply for lengthy periods. Having multiple water sources may help alleviate shortcomings of any particular water source.

D) *Are there undrained wetlands nearby that would have a similar hydrogeologic setting and use the same water source?* If so, then their presence may suggest that the water source is sufficient to maintain wetland conditions after the alterations are removed, and they may provide a model for designing the compensation site.

E) *Have the site and the water sources changed in a fundamental way since wetlands last existed?* This factor addresses changes that may have occurred that would prevent hydrologic restoration if the alterations were reversed. Drainage of a wetland may be natural or anthropogenic, and the cause may be local or regional. Regional-scale drainages are likely to be more difficult to reverse in an individual compensation site. Because natural alterations tend to be regional in scale, they are often difficult to reverse and sustain through time. Other examples of regional hydrologic changes that may be difficult to reverse include regional ditching, natural and anthropogenic river downcutting, development of a network of streams as the landscape matures, artificial control of river levels, climate change, and others. It may not be possible to fully evaluate these items, but it is useful to be aware of them. The wetland may also have drained if the water source has been altered. For example, in many parts of the country, regional water tables have declined due to pumping (Stromberg et al. 1996), thus draining wetlands in a manner that is difficult to reverse in an individual wetland compensation project. Sources of data that may be useful in determining if wetlands existed immediately prior to drainage include old topographic maps, which may show marshy areas and other features that formerly existed, historic air photographs, land survey notes from the 1800s, and historic information about an area including gazetteers, newspaper articles, drainage district documents, and journals or other historic accounts of pioneers settling in an area.

F) *Will adjacent landowners be affected by reversing alterations?* Often, field tile systems, ditches, levees, and other alterations have impacts that may extend off site if removed, so that it may not be feasible to remove all the alterations. Impacts to adjacent land need to be considered.

G) *Will future changes in the watershed impact the site?* In rapidly developing watersheds, alterations to water sources can be expected. These changes can be either advantageous or detrimental. If continuing urbanization is planned, streams may become more flashy, and may contain more contaminants. It may be wise to consult zoning maps and other planning documents to estimate future changes.

Step 5. Determine if an appropriate model wetland exists. This step is reached when sites do not have hydric soils, obvious drainages or alterations, and/or the potential to restore the original hydrogeology. These sites cannot be classified as HIGH according to the ISE procedure, but they may still have MODERATE potential for wetland creation if the following condition applies. The presence of a nearby wetland that has the same hydrogeology will help reduce the uncertainties of wetland creation if the existing wetland can be used as a model for designing the proposed wetland (Holman and Childres 1995), as discussed above. If a model wetland exists, then proceed to Step 6. If a model wetland does not exist, then the site should be classified as having LOW potential, even if some favorable factor exists such as an obvious water source. The reason for the LOW classification is that if a wetland needs to be created without using a model, then every aspect and function of the wetland must be produced by that design, which is unlikely. For example, regarding the function of providing habitat for native plants, a plant community needs to be established that can compete in the long term against invasive species. However, a native plant community may not exist to match the hydroperiod that was created, so that the site may not meet the vegetation success criteria and may be dominated by weedy species. This is only one example of the many functions of a wetland that would have to be created individually. A LOW rating does not mean that the site cannot be made into wetland. However, the cost and the risk of the site failing to maintain wetland conditions and meet permit requirements is likely to be higher, and the site is likely to manifest fewer wetland functions. Model wetlands can be found in the field or by examining nearby topographic, geologic, and NWI maps, soil surveys, and other documents mentioned above. Also, discussions with local NRCS, Corps of Engineers, and natural resources personnel may find nearby model wetlands.

Step 6. Determine if the hydrogeology of the model wetland can be reproduced at the compensation site. This step requires that file and field data be collected from the model wetland similar to the information collected at the compensation site, and analyzed as in Step 4. If the model wetland has the same or similar water sources, topography, geology, and climate as the compensation site, and it is feasible to mimic the model wetland at the compensation site, then the site can be classified as having MODERATE potential for success. If not, then the site should be classified as having a LOW potential for success. Some factors to consider are listed below, but this should not be considered a complete list.
A) *Compare the surface geologic units in the compensation site and the model wetland*. *Do they have similar character?* Surface sediments can also be used to infer water sources and hydrologic performance. For example, clay-rich units suggest that the site could perch runoff and precipitation. Sand and/or gravel substrates suggest groundwater may discharge, or alternatively that infiltration may be too high to sustain wetlands. In Illinois, peat or muck deposits also suggest groundwater discharge, because sustained saturation is needed to preserve the organic material (Miner 2001). Near-surface materials are shown in a variety of geologic maps and are also listed as parent materials in soil surveys.

B) *Compare the geomorphic setting of the model wetland to the compensation site*. *Do they occupy the same landscape position (e.g., floodplain, base of bluff, upland, etc)?* Landscape position may help determine the source of water (e.g., groundwater input is most likely in lower landscape positions and at the base of a slope, precipitation likely dominates in upland or flat areas, runoff likely dominates in riverine settings).

C) *Does the compensation site have similar elevation and shape as the model wetland?* Will they hold similar volumes of water relative to the size of the site? Are the two sites of similar elevation relative to a water source?

D) *Does the compensation site have the same or similar water source as the model wetland?* The water sources for the model wetland should be identified, and comparisons made to the compensation site. Sharing a water source is one suggested method for wetland compensation (Pierce 1993), although it is necessary to estimate if enough water is available to support wetland on both sites. Also, the construction activities on the compensation site must not drain or disrupt the model wetland, such as penetrating any geologic layer that is causing perching of water.

E) *What alterations occurred on the compensation site, and if they are reversed will the site's hydrogeology function similar to the model site?* Changes to water sources and causes of alterations should be evaluated.

SUMMARY

Wetland compensation sites often fail to maintain appropriate hydrology. Sites may be too dry, or alternatively inundation may be too deep and too constant. Poor site selection and improper design are often the cause of wetland compensation failures. Compensation sites are often selected for convenience rather than suitability. Wetland design is complicated by lack of available hydrogeologic data and by poor site selection that often necessitates a complex engineered solution. Therefore, the Initial Site Evaluation (ISE) procedure was developed to evaluate candidate wetland compensation sites rapidly using available data and principles of hydrogeology and wetland science. This procedure promotes successful wetland compensation by screening out poor sites and concentrating efforts toward sites where simpler and more reliable techniques can be used, and where fewest alterations are required. The procedure is flexible enough to be performed by people with various levels of experience, and therefore has wide application and utility.

This procedure ranks sites HIGH where wetlands can be restored, because restoration requires fewest alterations and thus minimizes the potential for errors in design and construction. Sites where restoration is not an option require nearby model wetlands on which to base design decisions in order to receive a MODERATE ranking. All other wetland creation sites are ranked LOW due to the number of parameters that would need to be estimated and altered, with an attendant increase in failure rates and likely decrease in wetland functions.

Examining a wetland compensation site from a hydrogeologic perspective provides another set of tools that can be used to select sites and compensation designs that are more likely to be successful. Because this procedure examines water inputs and outputs, alterations, geology, topography, and setting, it will not only help determine if the site is suitable for wetland compensation, but it will also likely suggest strategies to restore or create wetlands on the parcel.

ACKNOWLEDGMENTS

Many individuals in the Wetlands Geology Section at the Illinois State Geological Survey contributed to the refining of this procedure through its use over the last 8 years, including Steven Benton, Keith Carr, Paul Hilchen, D. Bradley Ketterling, Marshall Lake, Alison Meanor, Geoffrey Pociask, Bonnie Robinson, Nancy Rorick, Paula Sabatini, Blaine Watson, and Kelli Weaver. The writing of this report was funded by a grant from the Illinois Environmental Protection Agency (#3199271). This procedure was originally developed with major support by the Illinois Department of Transportation under contract AE89005 and others. Publication of this document is authorized by the Chief, Illinois State Geological Survey.

REFERENCES

Admiraal, A.N., M.J. Morris, T.C. Brooks, J.W. Olson, and M.V. Miller, 1997, Illinois Wetland Restoration and Creation Guide: Illinois Natural History Special Publication 19, Champaign, Illinois, 188 p.

Cole, C.A., and R.P. Brooks, 2000, Patterns of wetland hydrology in the Ridge and Valley province, Pennsylvania, USA: Wetlands 20:3, p. 438-447.

Environmental Laboratory 1987, Corps of Engineers Wetlands Delineation Manual: U. S. Army Corps of Engineers Technical Report Y-87-1, Washington, D.C., 100 p.

Gallihugh, J.L., and J.D. Rogner, 1998, Wetland Mitigation and 404 Permit Compliance Study, Barrington, Illinois. U.S. Fish and Wildlife Service, 161 p.

Hammer, D. A., 1992, Creating Freshwater Wetlands: Lewis Publishers, Boca Raton, FL, 298 p.

Hensel, B., 1992, Natural Recharge of Groundwater in Illinois: Illinois State Geological Survey Environmental Geology 143, Champaign, Illinois, 33 p.

Holman, R.E., and W.S. Childres, 1995, Wetland Restoration and Creation: Covering Six Coastal Wetland Types: Water Resources Research Institute Report 289, University of North Carolina, Raleigh, North Carolina, 117.

Kentula, M. E., R.P. Brooks, S.E. Gwinn, C.C. Holland, A.D. Sherman, and J.C. Sifenos, 1992, An Approach to Improving Decision Making in Wetland Restoration and Creation: U.S. Environmental Protection Agency, Environmental Research Laboratory, Corvallis, Oregon, 151 p.

Miller, M.V., C.S. Fucciolo, and J.J. Miner, 1998, Using Hydrogeology to Site Wetland Compensation: Engineering Approaches to Ecosystem Restoration, American Society of Civil Engineers Wetlands Engineering and River Restoration Conference 1998, March 22-27, 1998, Denver, Colorado.

Miner, J.J., 2001, Finding favorable wetland mitigation sites in the glaciated Midwest using organic soils: Abstracts, 22nd Annual Society of Wetland Scientists meeting, May 27-June 1, 2001, Chicago, Illinois, p. 45.

National Research Council, 2001, Compensating for Wetland Losses Under the Clean Water Act: Academy Press, Washington, D.C., 322 p.

Pierce, G.J., 1993, Planning Hydrology for Constructed Wetlands: Wetland Training Institute, Poolesville, Maryland. WTI 93-2, 49 p.

Stromberg, J.C., R. Tiller, and B. Richter, 1996, Effects of groundwater decline on riparian vegetation of semiarid regions: the San Pedro, Arizona: Ecological Applications 6(1): p. 113-131.

U.S. Department of Agriculture, Natural Resources Conservation Service, 1998: Field Indicators of Hydric Soils in the United States, Version 4.0. USDA, NRCS, Fort Worth, Texas. 30 p.

APPENDIX 1. File Data Sheets

FILE DATA *References for many data sources are listed in the bibliography.*		
General location		
¼ ¼ Section, Township, Range		
County		
7.5-minute quadrangle (USGS)		
Recent weather trends and averages *(Precipitation, evapotranspiration)* (Midwestern Climate Center, National Water and Climate Center)		
Geomorphic setting *(upland, slope, floodplain, etc.)*		
Topography *(total relief, relation to water sources, etc.)*		
Bedrock geology		
Uppermost Unit (Willman et al. 1967)		
Depth to bedrock (Piskin and Bergstrom 1975)		
Bedrock topography (Herzog et al. 1994)		
Unconsolidated sediments		
Drift thickness (Piskin and Bergstrom 1975)		
Surface sediments (Lineback 1979)		
Stack-unit sequence to 15 m depth on the site (Berg and Kempton 1988)		
Wetlands present on site and nearby (from National Wetlands Inventory, US Fish and Wildlife Service)		
name	map code	description
Susceptibility of site to flooding (FEMA)		
area	map code	description

FILE DATA *References for many data sources are listed in the bibliography.*

Gauging station(s) in vicinity (USGS)

Station name and number
Nearest gauging station from which surface-water levels can be obtained.

Distance from site

Soils mapped on the site (from county soil survey)

Map Unit Number	Soil Series	Hydric List		Drainage Class	Landscape Position and Parent Material	Occurrence on Site
		State	County			

Historical aerial photographs (available from libraries, NRCS offices, and other sources)

Date	Description

APPENDIX 2. Field Data Sheets

FIELD DATA		**NOTES**
Date, personnel		
Hydrogeologic alterations observed *Record any changes to the hydrology, geology, topography, or climate observed. Observed alterations combined with drained hydric soils suggest that restoration is possible.*		
levees	Yes/No	
spillways	Yes/No	
locks	Yes/No	
dams	Yes/ No	
drainage tile	Yes/ No	
drainage ditches	Yes/No	
pumps	Yes/No	
drains	Yes/No	
elevated roadbeds	Yes/No	
culverts	Yes/No	
grading/filling	Yes/No	
incised river or creek	Yes/No	
excavation	Yes/No	
others (list and describe)	Yes/No	
Present Hydrogeologic Conditions		
Geology *Describe thickness, extent, and character of deposits if borings or field observations were made*.		

FIELD DATA	
Surface-water inputs *This list is not comprehensive, but is a reminder of major sources while in the field*.	
River(s)	Yes/No
Creek(s)	Yes/No
overland flow from uplands	Yes/No
direct precipitation	Yes/No
runoff	Yes/No
others (list)	Yes/No
Surface-water outputs *describe*	
Groundwater inputs *describe*, *identify source*	
Groundwater	
likely direction of unconfined flow	
major aquifers *(file or field data)*	
major aquitards *(file or field data)*	
depth to saturated sediments *(if boring made)*	
depth to water in borehole	
discharge evident?	
confined aquifer evident?	
perched water-table evident?	
other comments	
Elevation surveying *Important elevations (e.g., height of site above adjacent stream, height of levees) should be measured and recorded*.	

FIELD DATA		
Is site entirely wetland? *If the entire site is wetland, then no compensation is typically possible in a Section 404 regulatory sense. Other programs may allow or desire enhancement of wetland areas.*	Yes/No	
Are hydric soils mapped on the site? *Refer to soil surveys or take soil cores.*	Yes/No	
Do hydric soils occur where wetlands do not exist at present? *If so, then hydrogeologic alteration may have occurred.*	Yes/No	
Is site drained or hydrogeologically altered?	Yes/No	
Likely water source(s) that supported past hydrology		
Apparent water source(s) supplying current wetlands on the site		
Differences between wetland and nonwetland areas of site (e.g., topographic, geologic, hydrologic, biotic)		
Can the former hydrology be restored to the site?		
Model wetlands		
Present on the site?	Yes/No	
Present near or adjacent to site?	Yes/No	
Possible alterations to produce wetland hydrology on the site		
Potential negative effects of above alterations		

BIBLIOGRAPHY OF DATA SOURCES

Many references listed below are generalized from a recent report, so that specific quadrangles or counties are removed. Many are also available as GIS coverages on line at the Illinois State Geological Survey (www.isgs.uiuc.edu) and other listed addresses.

Berg, R. C., and Kempton, J. P., 1988, Stack Unit Mapping of Geologic Materials in Illinois to a Depth of 15 Meters: Illinois State Geological Survey Circular 542, Champaign, Illinois, 23 p.

Federal Emergency Management Agency, Flood Insurance Rate Map, County of XXXX, Illinois, Panel XXX of XXX, Community-Panel Number XXXXXX XXXXB, map scale 1:24,000, 1 sheet.

Herzog, B., B. Stiff, C. Chenoweth, K. Warner, J. Sieverling, and C. Avery, 1994, Buried Bedrock Surface of Illinois: Illinois State Geological Survey, Illinois Map 5, Champaign, Illinois, map scale 1:500,000, 1 sheet.

Leighton, M. M., G. E. Ekblaw, and L. Horberg, 1948, Physiographic Divisions of Illinois: Illinois State Geological Survey Report of Investigations 129, Champaign, Illinois, 19 p.

Lineback, J. A. (map compiler), 1979, Quaternary Deposits of Illinois: Illinois State Geological Survey, Champaign Illinois, map scale 1:500,000, 1 sheet.

Midwestern Climate Center, Midwestern Climate Information System: Illinois State Water Survey, Champaign, Illinois, available on line at www.mcc.sws.uiuc.edu.

National Water and Climate Center, National Resource Conservation Service, Climate Analysis for Wetlands by County, available online at http://www.wcc.nrcs.usda.gov/ water/wetlands.html.

Piskin, K., and R. Bergstrom, 1975, Thickness of Glacial Drift in Illinois: Illinois State Geological Survey Circular 490, Champaign, Illinois, 34 p.

U.S. Department of Agriculture, Soil Conservation Service, 1991, Hydric soils of Illinois (rev. January 31, 1992), *in* Hydric Soils of the United States: Miscellaneous Publication No. 1491, Washington, D.C.

U.S. Department of Agriculture, Soil Survey of XXXX County, Illinois: Soil Conservation Service, Washington, D.C., p., maps.

U.S. Fish and Wildlife Service, National Wetlands Inventory Map, XXXX Quadrangle, Illinois, map scale 1:24,000, 1 sheet.

U.S. Geological Survey, XXXX Quadrangle, Illinois, 7.5-Minute Series (Topographic): U.S. Department of the Interior, Geological Survey, Reston, Virginia, map scale 1:24,000, 1 sheet.

Willman, H., J. Frye, J. Simon, K. Clegg, D. Swann, E. Atherton, C. Collinson, J. Lineback, and T. Buschbach, 1967, Geologic map of Illinois: Illinois State Geological Survey, Champaign, Illinois, map scale 1:500,000, 1 sheet.