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A Comparative Review of Wetland Mitigation Practices: Monitoring, Maintaining, and Funding Mitigated Wetlands

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A COMPARATIVE REVIEW OF WETLAND MITIGATION PRACTICES:

MONITORING, MAINTAINING, AND FUNDING MITIGATED WETLANDS

by Giselle Marie Groshart

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ABSTRACT

A Comparative Review of Wetland Mitigation Practices:

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by

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The objective of this project was to examine alternatives for monitoring, maintaining and funding of mitigated wetlands, as part of a larger project on wetland mitigation strategies. Research methods included a literature review, questionnaire, and telephone survey to determine current wetland mitigation practices. A variety of methods and techniques are presented, each with varying application for incorporation into a specific wetland mitigation strategy. Key components that came out of this study are the importance of maintaining flexibility, referring to project objectives, and planning throughout the process.

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Giselle M. Groshart

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CHAPTER I

INTRODUCTION

BACKGROUND

Wetland mitigation is becoming more common as wetland losses to development increase and the regulation of these losses becomes more stringent. The destruction of wetlands is less acceptable as we realize the inherent value of the wetlands for both humans and the environment. For instance, Mitsch and Grosselink (1993) note that wetlands provide a substantial amount of required habitat for commercially and biologically important species. Wetlands also mitigate flood impacts, remove pollution and sediment from water to improve water quality, and recharge aquifers (Mitsch and Gosselink 1993). As the general public gains more understanding of the value of wetlands, demands for preservation and protection increase.

Wetland destruction and alterations impact the functional values of wetlands. To reduce these impacts, federal and state legislation seeks to protect wetlands from destruction by dredging and filling. Though other pieces of legislation protect wetlands to a certain extent, Section 404 of the Clean Water Act currently provides the most comprehensive protection (ibid). The wetland permitting process is the primary means of protection in Section 404, requiring the acquisition of a permit before a group or individual can alter a wetland. Guidelines developed by the United States Army Corps of Engineers (Army Corps) and the Environmental Protection Agency (EPA) determine permit requirements, and the Army Corps acts as the wetland permit-regulating agency

(Kruczynski 1990). In the 1970's, the Army Corp began to issue conditional permits allowing landowners to destroy or alter a wetland if the party agreed to replace or enhance the impacted wetland (ibid). The practice of conditional permitting allowed the alteration of a wetland for a non-wetland use based on a "no net loss" requirement, and initiated the practice of constructing mitigation wetlands (ibid). Conditional permitting is a standard practice today, resulting in numerous wetland construction projects. As legislation continues to develop, affording more protection for wetlands, questions arise about what constitutes an acceptable replacement and whether permit requirements result in the construction of mitigation wetlands which function at an acceptable level in the long term.

Highway construction projects often require wetland mitigation, because the construction of linear corridor systems often seriously damage or destroy large areas of wetlands. Mitsch and Gosselink (1993) state that highway impacts mainly occur through changes in the hydrologic conditions of the wetland, alteration in vegetative structure, an increase in pollution and sedimentation levels, or complete destruction of the entire wetland. Wetland mitigation is a substantial part of highway construction, due to the scale of wetland alteration and impacts both during and after construction. Because of their involvement with highway construction, state departments of transportation (DOT's) have become heavily involved with wetland mitigation and the permitting process.

The Utah Department of Transportation (UDOT) contracted with the Department of Landscape Architecture and Environmental Planning at Utah State University to research procedures and practices for mitigating wetland impacts. UDOT requested research on wetland mitigation procedures because of the challenges they face in numerous projects involving mitigated wetlands and Army Corps permits. In a recent example in Provo Canyon, the Army Corps fined UDOT for violating permit requirements (May 1998). Not only did the permit violation result in a large fine, UDOT must also demolish and realign a completed portion of the highway (ibid). UDOT (2000) notes that in the near future, the Legacy Highway poses a serious challenge in terms of mitigated wetlands. In the permit application for the preferred alternative of the Legacy Highway, the construction is expected to impact 114 acres of wetlands (UDOT 2000). UDOT proposes to replace the impacted wetlands with a greater area of mitigated and improved wetland, approximately three acres of replacement wetland for every acre lost (ibid). In the past, many of UDOT's wetland mitigation projects failed to meet permit requirements or perform anticipated wetland functions (Johnson 2000). Because of wetland mitigation challenges, UDOT sought a review of alternative wetland mitigation strategies to guide the development of their own wetland mitigation program.

Specifically, UDOT expressed interest in guidelines for evaluating, monitoring, inventorying, maintaining, funding, and staffing of wetland mitigation sites and planning activities. Kusler and Kentula (1990) find that these considerations often determine failure or success of wetland projects, with proper evaluation and monitoring techniques playing a key role in successful mitigation projects. Public agencies, organizations, and wetland scientists have developed numerous approaches to the planning, design, construction, and management of mitigated wetlands. These approaches provide valuable information for wetland mitigation, and UDOT sought an evaluation of these procedures to determine which programs are applicable for their wetland mitigation program. From this information, UDOT can develop an effective wetland mitigation procedure to achieve higher levels of mitigation success, in terms of permit compliance or fulfilling wetland mitigation goals.

RESEARCH OBJECTIVES

As part of a larger research project of wetland mitigation strategies for UDOT, the research presented in this thesis will focus on procedures for monitoring, maintaining, and funding of mitigated wetland sites. The objective is to evaluate appropriate procedural guidelines, techniques, important characteristics, and required resources for each category. The information evaluated during this project comes from several sources including current literature, state DOT's, regulatory agencies, environmental consultants, and contractors. With this evaluation, UDOT will be able to review their current monitoring and maintenance procedures and funding levels. In addition, they will have relevant data to use in exploring alternative methods to improve their mitigation strategy.

RESEARCH METHODS

The research undertaken to investigate monitoring, maintenance, and funding strategies for wetland mitigation included the following activities:

- Completion of a standard literature review: This provides valuable information on existing and theoretical techniques for monitoring, maintaining, and funding mitigated wetland projects.
- Preparation of abstracts from literature with significant information in the focus subject areas: This provides UDOT with summary information relevant to their wetland mitigation program.
- Analyzation of questionnaires sent to state DOT's: This provides information about monitoring, maintenance, and funding procedures in different states. The focus of the questionnaire analysis is to elucidate the similarities and differences between individual state DOT procedures, and how their procedures relate with their rate of wetland mitigation success.
- Completion of telephone interviews with regulatory agencies, environmental consultants, and wetland contractors: This provides additional information on alternative strategies for wetland mitigation and information pertaining to monitoring, maintenance, and funding.
- Summarization of the information compiled in the literature review, questionnaire, and interviews: This provides UDOT with information they need to evaluate their current procedures and make decisions for necessary changes.

SUMMARY

Since state DOT's often work with wetland mitigation, they require effective wetland programs to comply with Army Corps' wetland permit requirements.

Information on effective wetland mitigation strategies is available through a variety of sources including the scientific community, state and federal agencies, and practitioners. This research project investigates various wetland mitigation strategies from these sources to provide UDOT with options to evaluate and improve their wetland mitigation program in the areas of monitoring, maintaining, and funding.

CHAPTER II

RESEARCH METHODS

LITERATURE REVIEW

A standard literature review provided valuable information on existing and theoretical techniques for monitoring, maintaining, and funding mitigated wetland projects. Applicable research literature includes many alternative wetland monitoring and maintenance techniques developed by public agencies, wetland researchers, and wetland managers. Some sources also suggest various funding alternatives to properly perform the wetland mitigation tasks. The literature research provided information on mitigation guidelines and standards for UDOT.

ABSTRACTS

Abstracts of important methods and protocols from the literature review will provide UDOT with summary information to allow them to decide which methods are applicable to their situation. From these abstracts, shown in Appendix A, UDOT can choose which references to examine in further detail.

QUESTIONNAIRE ANALYSIS

The questionnaire analysis involved examining questionnaires, designed by Craig Johnson in conjunction with UDOT and sent to the DOT's in all 50 states. In the questionnaire, the state DOT's responded to questions about their mitigation strategies.

See Appendix B for a copy of the questionnaire. The responses that are relevant to monitoring, maintenance, and funding were evaluated based on the similarities between the individual state DOT procedures, and how their procedures relate with their rate of wetland mitigation success.

The results from the 50-question DOT questionnaire were coded by ratings, percentage estimates, and positive/negative responses according to recommendations from the Utah State University Statistical Consulting Center. The data was entered into an Excel spread sheet file. This organization allowed for the use of descriptive statistics and the completion of a statistical analysis in SAS. Appendix B also contains the coding for the questionnaire.

Descriptive statistics used in this study allowed "[the organization of] data…for illustrative purposes" (Gauch 2000). The determination of the distribution of responses for each question allows classification of the data, and the results of this classification are displayed in charts and graphs. Determining distributions is an appropriate way to organize data, and involves "listing…all the elements in a data set that are classified/ assigned to specific categories" (ibid). The distribution of data is obtained by a simple count of the frequency, or "how frequent a characteristic occurs", of data falling within a specific category or range (ibid).

Through a cross tabulation between rate of success and each individual question, frequencies and row percentages express the relationship between a mitigation practice and success. Cross tabulation involves setting up two variables in a table to show a relationship between the two variables (ibid). Cross tabulation allowed further organization of the data and organized the data for statistical analysis.

Statistical analysis allowed identification of significant relationships between variables, such as the relationship between wetland mitigation practices and success rate. Fisher's Exact Test was used to statistically analyze the data. This test measures "exact distributions rather than large-sample approximations", which is appropriate in this study because of the small sample size (Agresti 1990). Fisher's Exact Test of the relationship of two variables allows the determination of a P-value. The P-value, or probability value, is the probability that two variables are related. An acceptable P-value to represent statistical significance is .05 or less (ibid).

In addition to data organization and analysis, narrative responses in the questionnaire that are relevant to the thesis topics were summarized and organized. Narrative responses provide additional insight to the statistical organization and analysis and the information collected in the study.

TELEPHONE INTERVIEWS ANALYSIS

Telephone interviews to regulatory agencies, environmental consultants, and wetland contractors provided additional information on alternative strategies for wetland mitigation. An effort was made to contact representatives from professional societies with wetland related interests, but no contacts were made. The interview questions are generally based on the questionnaire, with applicable questions selected for each group. See Appendix C for specific telephone interview questions. From the interviews, information and findings pertaining to monitoring, maintenance, and funding were evaluated and summarized.

SUMMARY

A summary of the information compiled in the literature review, questionnaire, and interview will provide UDOT with information they need to evaluate their current procedures and make decisions for necessary changes. To allow them to easily access the information, charts, graphs, and tables of summary wetland monitoring, maintaining, and funding information were produced.

CHAPTER III

LITERATURE REVIEW

INTRODUCTION

Wetland mitigation is a complicated process that requires careful planning to avoid overlooking necessary elements and to complete mitigation activities with appropriate timing. Since wetland mitigation can be a relatively small part of the overall road design process, elements can easily be overlooked in the planning and design stages of a roadway project. The flow chart in Figure 3.1 shows a typical wetland mitigation and permitting process. This flow chart provides perspective for the wetland mitigation activities discussed in the following sections, outlining appropriate timing and sequence of typical events. Appendix D contains the UDOT Design Process, showing how the permitting process fits into their overall road design process.

Several literature sources suggest guidelines for monitoring, maintaining, and funding of mitigation wetlands. Some sources address all of the focus areas in a general sense, while other sources limit their scope to address one subject more thoroughly. Due to the variability and the merits of each individual research effort, no single wetland mitigation method exists that addresses all components in a complete mitigation program. Each literature source addresses specific interests, and several sources may offer valuable guidelines to use in a combination that applies to the needs of a specific wetland program.

Figure 3.1. Wetland Mitigation and Permitting Process
(Developed from IMTF 1994 and Raming and Gross 1997)

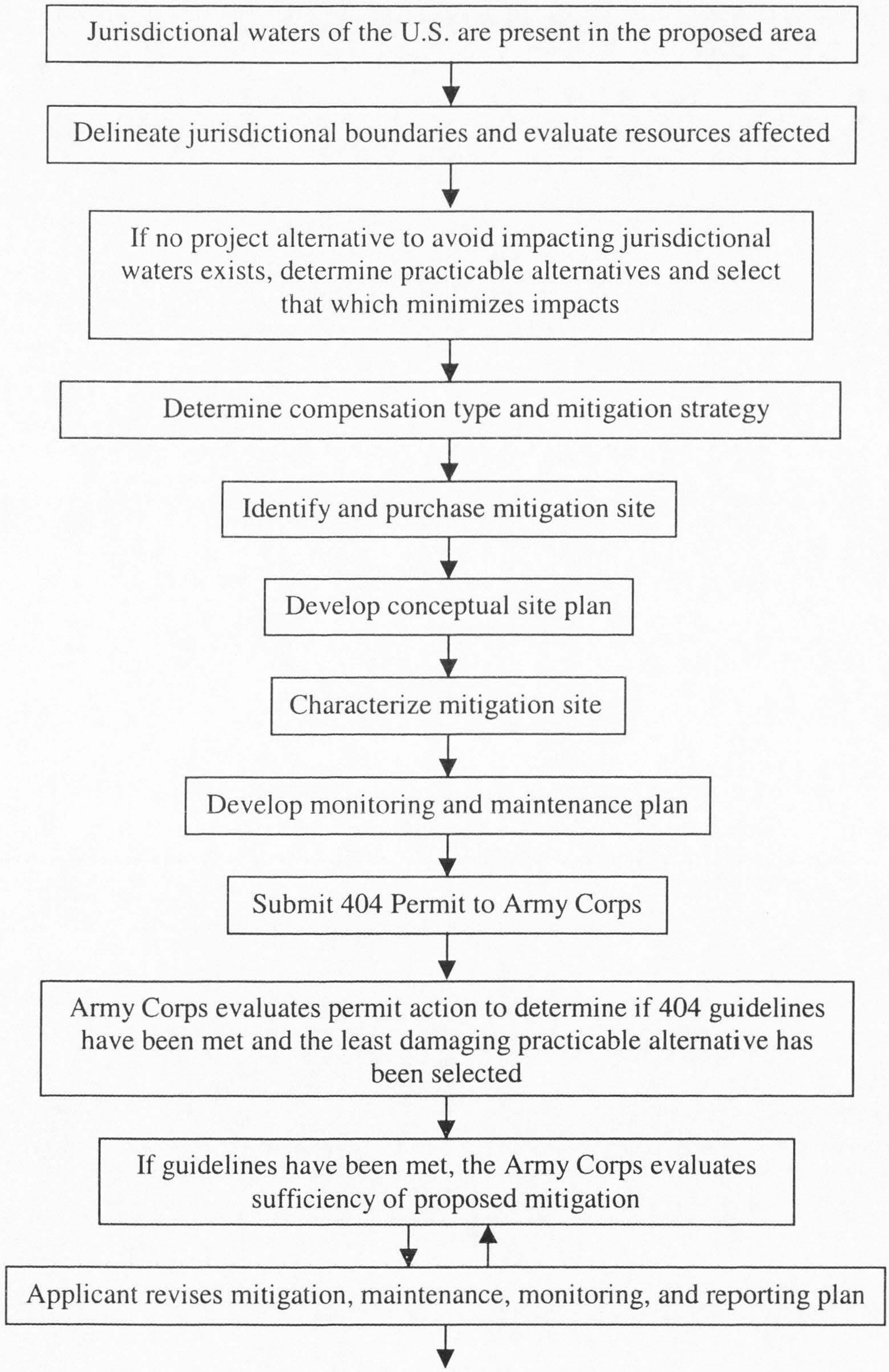
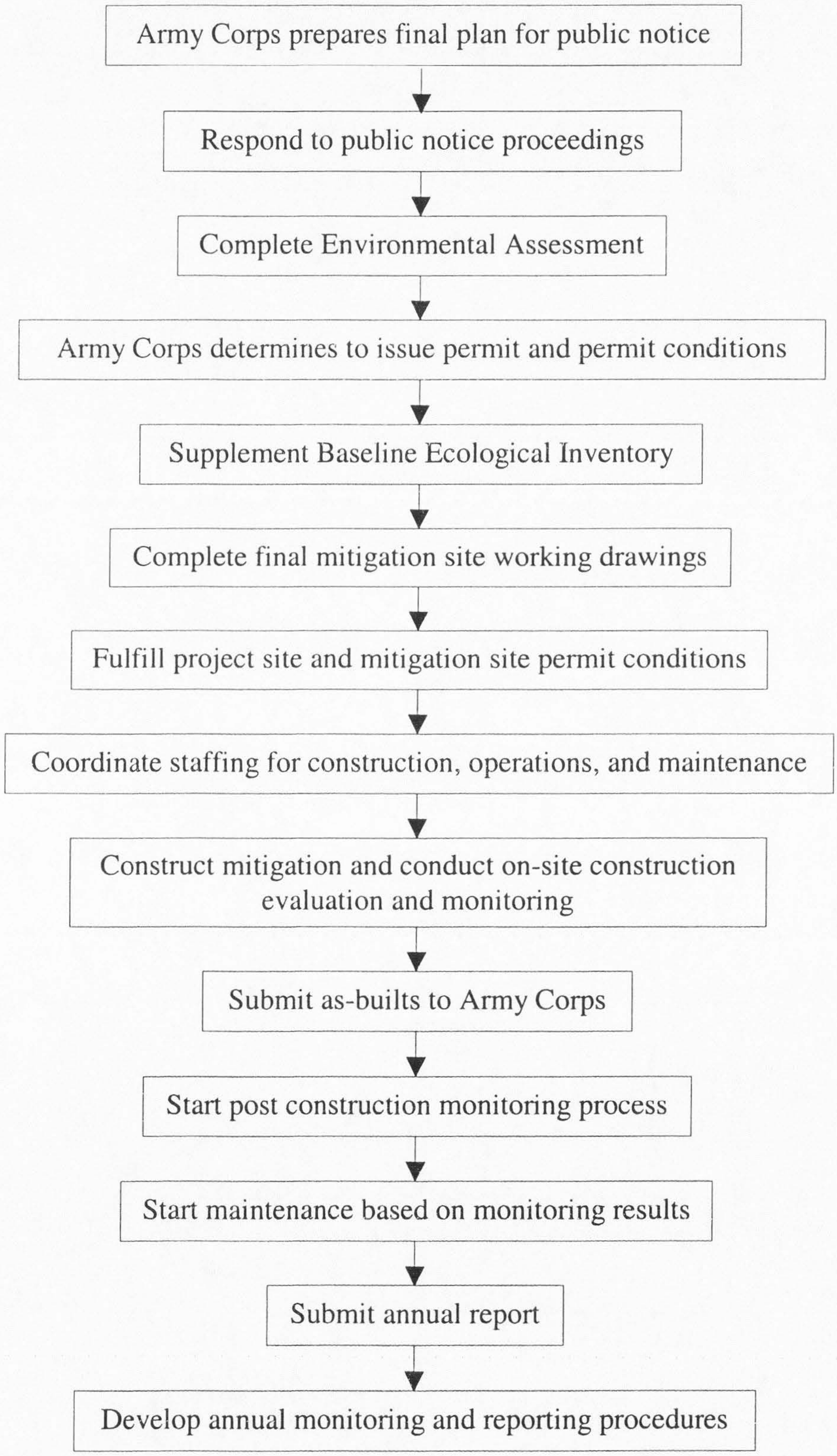


Figure 3.1 Continued.



MONITORING

MONITORING GUIDELINES

Alternative methods for wetland mitigation monitoring programs vary depending on project focus and requirements. Consequently, choosing an appropriate method requires the determination of appropriate evaluation criteria based upon desired functional replacement. The mitigation team can determine which wetland functions to monitor from the evaluation criteria, as well as the number of measurements and level of data detail necessary to accurately assess wetland function (Erwin 1990). For example, some procedures require site specific, quantitative monitoring by a trained professional, while others call for a more qualitative, standardized program to allow for staffing flexibility. One complication involved with choosing a specific monitoring protocol is that the appropriate monitoring plan may change from project to project, depending on size, type, and other specific conditions of the mitigated wetland. Therefore, certain groups may find that a monitoring guideline containing a significant amount of flexibility may suit their program better than one with rigid protocols. Table 3.1 shows literature sources reviewed for monitoring protocols and a brief description of each. Specific protocols are discussed in more detail in the following sections. Since the standard monitoring protocols have inherent advantages and disadvantages, a comparison between each method provides UDOT with a better idea of monitoring procedures that are applicable for various mitigation situations and scales.

Table 3.1. Literature sources reviewed for monitoring guidelines.

Wetland Research Plan, Kentula, *et al.* 1993 Offers a basic framework for wetland management specifically geared towards decision-making for public agencies. Discusses evaluation procedures and offers a flexible program for monitoring that relates to goals set in the initial phases of the plan.
Hydrogeomorphic Approach, Smith 1995 Evaluates wetlands based on hydrogeomorphic characteristics of geomorphic setting, water source, and hydrodynamics. From this, a series of regional assessment models are developed. Monitoring is based on standards of comparison for regional models and measuring functional capacity, or performance of a functional wetland.
Habitat Evaluation Procedure, USFWS 1980 Evaluates quality of habitat for wildlife species through development of habitat suitability indices. Researchers can monitor wetlands by recording changes in habitat suitability indices over time.
Habitat Assessment Technique, Cable, *et al.* 1989 Uses avian species composition and wetland size to determine faunal index value. Monitoring can occur through recording changes in faunal index over time.
Wetland Functional Assessment- Adamus and Stockwell 1983 Evaluates and monitors wetlands based on a standardized set of wetland functions. Very intensive and complete data gathering.
Bureau of Land Management Inventory and Monitoring Process- Cooperrider, *et al.* 1986 Inventories and monitors wildlife habitat to increase efficiency. The focus is on the planning process, with monitoring identifying changes in form, structure, and wildlife use.
Biomonitoring- Adamus and Brandt 1990, Danielson 1998 Focuses on biological systems at organism and population level as they react to wetland conditions. Monitoring focus stems from project objectives, and a series of biological indicators are used to determine if project meets objectives.

Table 3.1 Continued.

Environmental Monitoring and Assessment Program- Leibowitz and Brown 1990 Uses response indicators to measure the general health of a wetland. Changes in wetland are identified using exposure and habitat indicators, "associated with change over time".
Illinois Wetland Restoration and Creation Guide- Admiraal, *et al.* 1997 Discusses all stages of wetland mitigation, including planning and implementation, design, and management. Specifically for Illinois wetlands but parts could successfully be adapted in another region.
Maryland Compensatory Mitigation Guidance- IMTF 1994 Briefly discusses monitoring related to mitigation wetlands. Also discusses specific monitoring procedures.
Pennsylvania Wetland Resources Handbook- PennDOT 1997 Serves as a guideline for managing mitigation wetlands in transportation projects. Discusses all phases of wetland mitigation and contains a comprehensive section on monitoring, with suggestions for data collection and corresponding forms.
Iowa Mitigation Monitoring Protocol- Iowa DOT 2000 Uses the PennDOT procedure as a guideline. Describes a work flow sequence with specified products and procedures for each wetland monitoring activity.

Wetland Research Plan Approach

General Description

The Wetland Research Plan (WRP) approach, developed by Kentula, *et al.* 1993, is specifically geared toward dealing with wetland mitigation in public agencies. This approach provides a basic framework for agencies to make decisions regarding wetland management. It addresses wetland evaluation and how public agencies use information gathered from specific sites for decision-making. Like others, the method is based on scientific literature and research, but this method tries to bridge the gap between the practitioners and the scientific community.

The definition of success is based on comparing project goals to measured conditions. Kentula, *et al.* (1993) state that these goals are "what is acceptable for a particular project in a specific locale...[leaving] the definition of the project objectives and the associated success to those planning or regulating the project". Their method is broad enough to be applicable in different locations, allowing agencies to "tailor resource management to meet specific local and regional needs" (Kentula, *et al.* 1993).

Another aspect that sets this method apart from others is its definition of success. In choosing a reference wetland as a standard of comparison, the authors consider how adjacent land activity will affect the functioning of the wetland (ibid). In contrast, many other methods suggest choosing a reference wetland in an undisturbed area, unaffected by possible anthropogenic stress that will likely affect the constructed wetland.
"Comparison of projects with natural wetlands occupying similar landscapes, and, therefore, having potentially similar ecological conditions, ensures that what is expected of a wetland project is within the bounds of possible performance given the setting" (ibid).

Monitoring Guidelines

The authors discuss monitoring at great length, emphasizing the need for planning early in the wetland mitigation process to set up an effective monitoring plan (ibid). The monitoring plans are adapted to the priorities and objectives developed in the initial phases of the project (ibid). The monitoring requirements change from project to project, depending on the "environmental significance of the project, the compliance requirements, the age of the project, and the probability of successfully achieving targeted wetland functions" (ibid). This approach minimizes irrelevant data acquisition, because the data needs relate to the objectives of a particular project. The monitoring plan includes "proposed assessment procedures, timing, and frequency" and staffing (ibid).

Like other methods, the WRP approach uses indicators to monitor the function of the constructed wetlands. The authors advocate limiting the number of indicators to those that are easily determined and representative of ecological function for economic reasons (ibid). The indicators chosen must be "sensitive enough to determine functional performance in a reasonable amount of time at a reasonable cost both in dollars and in damage to the wetland. Measures of wetland structure, e.g. site morphology or species present, are readily available and more often meet the requirements of expediency and economy than do direct measures of function" (ibid). The general indicators, which indicate a minimum level of wetland function, include "one variable measuring each of the three parameters (wetland hydrology, hydrophytes and hydric soils) that indicate the presence of a wetland" (ibid). The indicators that measure the structure of the wetland should be related to the function desired (ibid). This provides the basic level for monitoring the wetland, and, depending on project objectives, wetland managers can add other indicators to the monitoring set.

The monitoring plan occurs in three possible levels to track the condition of the wetland project over time (ibid). In all steps of the monitoring plan, the data collected "reflect[s] project objectives" and varies "on a project-by-project basis" (ibid).

The first step of the monitoring plan is the *documentation of as-built conditions* (ibid). The researchers record the initial conditions of the newly constructed wetland, including "project location, morphometry, hydrology, substrate, and vegetation" (ibid). This allows an assessment of needed corrections to the design, and provides conditions for comparison with the next stages of the monitoring plan, "providing a baseline for future evaluation of project development and performance" (ibid).

The next step of the monitoring program is *routine assessments*, which are "'simple site examinations' or 'spot checks' used to monitor and record wetland development" (ibid). This involves "visual assessments of wetland conditions [in comparison] to maps and photographs from prior visits" (ibid). The procedure allows a rapid assessment of general site conditions during the first years of the study, to determine if the development is occurring as expected, or if changes need to occur. This is a low cost method and "potentially less damaging to the site than more comprehensive assessments because data collection is less intensive and many observations can be made without entering the interior of the wetland" (ibid). The frequency of the routine assessments is "annually, or until... the project is developing as expected [or is] replaced by more comprehensive monitoring procedures" (ibid).

Based on indications from these routine assessments, the researcher may need to undertake *comprehensive assessments* (ibid). Comprehensive assessments "generate more complete and quantitative information on the wetland's performance than do routine assessments" (ibid). The researchers generally perform these assessments several years after construction, because the data collection may disturb the site (ibid). The comprehensive assessment "[identifies] modifications to the site that are required to meet project objectives, [provides] a basis for evaluating project design and establishing performance criteria, [helps] explain why a wetland project was or was not successful, and [supports] long-term research efforts" (ibid). The greater reliance on intensive data collection makes this step more expensive.

The data gathered from the monitoring activities generates a performance curve for the constructed wetland, allowing evaluation of whether the project is meeting desired levels of function in a timely manner (ibid). The "performance curve documents the development of the ecological function of projects over time relative to levels of function for similar natural wetlands" (ibid).

The three-tiered monitoring process in the WRP approach allows agencies to adjust their monitoring procedure based on project objectives and regional characteristics. While a large commitment of time is required in the planning stages of this approach, the method allows rapid assessments once the project objectives are clear and procedures are defined. This leads to a more realistic data set, allowing agencies to choose comparison standards that are relevant for the location and type of wetland. The approach's flexibility and efficiency results in a cost-effective method for long-term monitoring of wetlands.

Hydrogeomorphic Approach

General Description

Smith (1995) describes the hydrogeomorphic (HGM) approach to wetland evaluation, which involves classifying wetlands based on their hydrogeomorphic characteristics in terms of geomorphic setting, water source, and hydrodynamics. After setting up the basic classification system, regional ecosystem characteristics further divide the wetland types into subclasses (Smith 1995). Reference wetlands from each regional subclass are chosen and the characteristics of each are studied to develop standards of comparison (ibid). The standards are called a "functional profile that describes physical, chemical and biological characteristics of the regional subclass" (ibid). The process of developing functional profiles for each regional subclass "identifies which functions are most likely to be performed, and discusses different ecosystem and landscape attributes that influence each function" (ibid).

Monitoring Guidelines

The HGM method suggests monitoring constructed wetlands based on the standards developed for each regional subclass (ibid). This allows a standardized set of functional characteristics to compare against constructed wetlands, allowing efficiency once the characteristics are determined. Assessment models are developed from reference wetlands, and the constructed wetlands are then compared to this model based on functional capacity (ibid). Functional capacity, which is measured during the monitoring process, is the "degree to which an area of wetland performs a specific function" (ibid). The capacity is either "qualitatively measured (interval or ratio scale data) or quantitatively measured (nominal or ordinal scale data)" (ibid). The selected measurement of capacity is recorded on a standardized form or database and allows evaluation of the wetland performance (ibid). The functional capacity can then be aggregated into a functional capacity index, which is a ratio of the project's functional capacity to the reference wetland's functional capacity (ibid).

The initial assessment requires a description of the project area and a site inventory. The data collected includes "narratives, maps and figures" (ibid). The description includes the following information:

- "Name and location, nature of the project, assessment objectives
- Hydrogeomorphic and National Wetlands Inventory classification
- Description of climate, land form, geomorphic setting, hydrology, vegetation, soils, land use, ground water characteristics, surficial geology, urban areas, potential impacts, red flag features, and other relevant characteristics"
- Base map showing site features (ibid).

The subclasses allow regional variations in the monitoring process. Indicators irrelevant to the regional subclass are not monitored, saving time and money. "By narrowing the focus to a regional subclass, it is possible to identify the functions that are most likely to be performed and of the greatest benefit to the public interest" (ibid). The scientific rigor applied to creating the assessment models combined with the regional subclasses allows an "acceptable level of accuracy and precision with minimal data collection and analysis requirements" (ibid). Since the HGM method monitors systems using their pre-defined subclass assessment model, a wider variety of personnel can utilize the approach. The method does not require a wetland scientist for every monitoring project, rather the personnel only need to understand the pre-defined assessment models and appropriate monitoring techniques.

Habitat Evaluation Procedure

General Description

The U. S. Fish and Wildlife Service established the Habitat Evaluation Procedure (HEP) to evaluate the quality of habitats for specific wildlife species. Though not specifically for wetland evaluation, this method is applicable because wildlife function is a major part of wetland systems and often a function that is to be accommodated in the mitigation wetland. The presence of wildlife habitat often indicates that the structures of the wetland, such as vegetation and hydrology, are functioning properly. The HEP "documents the quality and quantity of available habitat for selected wildlife species" and is a method for assessing a wetland in terms of wildlife suitability (USFWS 1980).

Monitoring Applications

The HEP allows a researcher to monitor changes of wetland characteristics, in terms of changes in the wildlife quality of the wetland (ibid). The habitat quality is quantified as a Habitat Suitability Index, which is a ratio of the value of study to the value of an optimal reference standard (ibid). The reference standard is determined using habitat models for species of interest, which can include game animals, threatened and endangered species, indicator species, or other species of ecological importance (ibid). The habitat value of the study area is determined by looking at vegetative cover and other habitat requirements of the area in relation to the habitat model (ibid). Over time, the Habitat Suitability Index can be used to monitor a mitigated site by determining if the area's habitat value is changing.

Habitat Assessment Technique

General Description

Cable, *et al.* (1989) developed the Habitat Assessment Technique (HAT) as a wetland assessment procedure that uses avian species composition and wetland size to determine wetland value. The advantages of this technique are simplicity and efficiency, while requiring few resources and accurately assessing conditions of the wetlands demonstrated in the case studies (Cable, *et al.* 1989). The process is also replicable, allowing comparisons between wetlands or for one wetland over time. Disadvantages of this method include the requirement that the assessor be "competent in bird identification" and the possibility of "[underestimating] the value of [migratory staging] wetlands" (ibid). In addition, this method is not applicable for assessing wetlands with minimal value as wetland habitat, but still requiring mitigation because of other wetland characteristics.

Monitoring Applications

Wetland monitoring with the HAT requires few variables, which greatly simplifies the monitoring procedures. The first variable is a species index, which is a measure of species diversity or rare species ranked using a point system (ibid). This system places a high value on both high species diversity and populations of rare species (ibid). The procedure recommends using only birds as indicators of wetland value, because "they are easy to identify" and studies have shown that they are adequate indicators of wetland health (ibid). The other value is wetland size or area factor, with the basis being an optimum size developed by regional wetland experts (ibid). A faunal index is the result of dividing the species index by the area factor, to provide a numeric value for assessing wetlands (ibid). Monitoring staff can assess the habitat value of the mitigated wetlands over time to determine if the habitat is improving.

Wetland Functional Assessment

General Description

The Wetland Functional Assessment approach incorporates a large number of variables into a standardized method for evaluating and monitoring wetlands. Adamus and Stockwell (1983) focus the procedure on general wetland functions, which includes "groundwater recharge", "groundwater discharge", "flood storage and desynchronization", "shoreline anchoring and dissipation of erosive forces", "sediment trapping", "nutrient retention and removal", "food chain support", "habitat for fisheries", "habitat for wildlife", "active recreation", and "passive recreation and heritage value". The method is set up like a dichotomous key, with qualitative values from low to high measuring the wetland functions (Adamus and Stockwell 1983). Standardized data forms present guidance for personnel using the procedures and allow for replicability.

Monitoring Guidelines

Monitoring involves taking measurements related to the wetland functions as outlined by the authors. The monitoring team inputs data directly to the standardized form, allowing a clear and relatively fast procedure especially during the initial part of study. The form also makes the method more accessible to personnel not trained in wetland science. However, some have found this approach very time consuming because of the large number of variables considered (Cable, *et al.* 1993). In addition, the ranking system of high, medium, and low for each variable does not allow for finer grained differentiation, and may lead to problems when comparing results to other wetlands.

Bureau of Land Management Inventory and Monitoring Process

General Description

The Bureau of Land Management (BLM) developed an inventory and monitoring process to increase efficiency in managing wildlife habitat (Jones 1986). The emphasis of the process is planning the study to appropriately assess the conditions of the study area, making the study more meaningful for decision-makers (ibid). The first step in the process is "problem definition", which involves examining the problem to identify specific areas of concern (ibid). The focus of the study then determines the type of data needed to address the problem (ibid). After data collection and analysis, personnel make a decision on the next course of action, which is then monitored and reviewed as necessary (ibid).

Monitoring Guidelines

Though the general process is useful as a guideline during the planning process for an effective wetland assessment program, the BLM also specifically addresses monitoring and inventory of marsh and riparian ecosystems. The focus is on identifying form and structure, and wildlife use of these ecosystems. This process also provides alternatives for data collection, monitoring wildlife habitat, and techniques for monitoring and evaluating wildlife habitat (Ohmart and Anderson 1986; Weller 1986).

For riparian systems, this method suggests compiling data to assess baseline conditions, for comparison as the system matures. The list is organized based on priority for data collection, and includes "developing vegetation maps" from aerial photos, "classifying plant community and structural types", "determining vertebrate species richness and relative abundance", and "censusing vertebrates" (Ohmart and Anderson 1986). For marsh systems, monitoring includes measuring "water depth and fluctuation", vegetation cover including species type, density, and patterns, and wildlife composition and population (ibid). The monitoring procedures are very basic and geared towards wildlife habitat, with a few focus points that require an intensive study.

Biomonitoring

Another option for monitoring wetlands is to use biological indicators to measure wetland function. Adamus and Brandt (1990) focus on biological systems at the organism and population level as they react to wetland conditions. The method discusses how to choose monitoring categories, which depends on desired focus and policy requirements (Adamus and Brandt 1990). In general, multiple indicators over time give the best indication of the wetland biological condition, with the study design based on project and objectives (ibid).

A standardized sampling procedure is unspecified, but common sampling procedures are discussed with the procedures occurring "randomly, along transects...at ecotones", in chosen habitat types, or in areas chosen by the monitoring personnel (ibid). The sampling must occur at appropriate times of the year to accurately reflect the biological wetland characteristics (ibid). The indicators discussed include microbes, algae, herbaceous vegetation, woody vegetation, invertebrates, fish, amphibians, reptiles, birds, mammals, and biological processes (Adamus and Brandt 1990; Danielson 1998).

The most limiting disadvantage of this method may be cost. "There are numerous situations where alternative indicators... can more cost effectively reflect the ecological conditions, impact causes, and sustainability of a wetland than can community-level biological methods" (Adamus and Brandt 1990). In addition, the direct cause of impacts on the biological community may be hard to identify without further physical or chemical monitoring, and additional methods of wetland assessment are recommended (ibid). Biomonitoring, however, can also "detect impacts of many sources for which chemical [or physical] criteria cannot detect" (Danielson 1998). This approach can also identify "cumulative effects of multiple and episodic stressors", resulting in a more accurate measure of wetland condition (ibid).

Environmental Monitoring and Assessment Program

The EPA developed wetland monitoring guidelines that use indicators as part of an Environmental Monitoring and Assessment Program (EMAP). Leibowitz and Brown (1990) suggest response indicators measured in the monitoring program to indicate the general health of the wetland. These indicators include "organic matter and sediment accretion, ...wetland extent and type diversity, ...abundance, diversity, and species composition of vegetation, ...[and] relative abundance" of animals, especially avian species (Leibowitz and Brown 1990).

The other set of indicators identified by EMAP include exposure and habitat indicators, which "identify and quantify changes in exposure and physical habitat that are associated with changes in response indicators" (ibid). These indicators include "wetland extent and type diversity, ...abundance, diversity, and species composition of vegetation, ...nutrients in water and sediments, ...chemical contaminants in water and sediments, ...hydroperiod, ...linear classification and physical structure of habitat, ...[and] landscape pattern" (ibid). In addition to the indicators listed here, EMAP also identifies lower priority indicators that may be useful in a wetland monitoring program.

State DOT Protocols

The questionnaire requested that states send any of their protocols for mitigated wetlands when they returned the questionnaire. Though many states did not have protocols, a few did and they serve as useful guides. Protocols sent by state DOT's cover a variety of subjects including evaluation, site selection, design, construction and post-construction activities. Monitoring was also addressed in several of the protocols, and the summaries in regards to monitoring are presented below.

Illinois Guide to Wetland Restoration and Creation

This guide discusses all stages of wetland mitigation and is specifically focused for Illinois wetland restoration. Many concepts, however, are applicable for wetland mitigation in other states. Monitoring guidelines are provided to address needs both during and after construction. The authors of the guide, Admiraal, *et al.* (1997), discuss the importance of monitoring during construction, saying "on-site construction monitoring is essential because mistakes, oversights, and potential design problems can be identified and corrected before further difficulties develop." They suggest assigning the wetland designer, manager, or wetland ecologist to monitor site construction and work closely with the contractors to ensure proper completion or make adjustments based on unanticipated site conditions (Admiraal, *et al.* 1997)

Post construction monitoring is also laid out in the guide. Admiraal, *et al.* (1997) discuss outlining, "project goals, objectives and performance standards, [a] list of which wetland components will be monitored, and a description of how each will be monitored." The authors provide a variety of procedures and a couple levels of data acquisition to allow flexibility and meet project objectives (ibid).

Maryland Compensatory Mitigation Guidance

This guideline offers a brief discussion of monitoring related to mitigation wetlands. The guide suggests developing a monitoring report that includes a narrative description of the site, problems, and possible corrective measures (IMTF 1994). Data collection is also discussed in detail, including procedures and data forms for sampling vegetation, soils, and hydrology for different wetland classes.

Pennsylvania Wetland Resources Handbook

This handbook contains a section devoted to a protocol for post-construction wetland monitoring. The monitoring protocol was developed to fulfill permit requirements, "standardize a monitoring process", establish a statewide database, and provide feedback for the design and construction process (PennDOT 1998).

The approach has three levels for monitoring, with different intensities that allow adaptation based on permit requirements and complexity of wetland (ibid). The method also explains purposes for collecting specific data and techniques for data collection (ibid). A flow chart for the monitoring process is also included in the protocol to specify the timing of the process. The handbook contains forms for site monitoring techniques, allowing guidance in data collection and standardized data entry into the PennWET database system for data analysis and tracking (ibid).

Iowa DOT Mitigation Monitoring Protocol

The goals outlined in this monitoring procedure follow those set in the PennDOT monitoring protocol, with the PennDOT procedure serving as a guideline for the Iowa DOT procedure (Iowa DOT 2000). The method contains a workflow process chart with coordinating forms for completion of wetland monitoring activities (ibid). Monitoring activities completed as part of this process include preparing as-built plans, developing aerial photographic records, conducting soil tests, testing and documenting hydrologic conditions, describing vegetative characteristics, delineating wetland boundaries, and producing a comprehensive report from information and data collected (ibid).

MONITORING TECHNIQUES

Several different techniques for monitoring exist, and these continue to evolve as knowledge in wetland science increases and technology becomes more sophisticated. Existing data organizational techniques for monitoring include compiling data records, hand mapping, Geographic Information Systems (GIS) mapping, and a number of other methods to acquire data. These techniques can work successfully on an integrated and flexible basis, depending on the monitoring approach or site maturity. Each of the various techniques requires different levels of personnel, funding, and equipment. Table 3.2 shows resources that provide more information on monitoring techniques. Comparing individual techniques with associated costs and requirements will allow UDOT to determine appropriate monitoring techniques for their projects.

Data Records

One option for obtaining comparative monitoring data is compiling data for various aspects of monitored sites. Monitoring personnel can store collected data in computer databases or filing systems, and data can be collected though a various sampling procedures. Rosen, *et al.* (1995) and Adamus and Brandt (1990) note that monitoring for water quality and microbial wetland communities may require water sampling and sediment sampling. Monitoring for vegetation communities can involve

Table 3-2. Monitoring techniques references.

	Data Records	GIS	Field Data Acquisition	Aerial Photography	Lidar	Satellite Imagery
1	X					
2	X					
3	X					
4		X				
5		X				X
6			X			
7			X			
8						X
9				X		
10				X		
11				X		
12				X		
13				X		X
14				X		
15					X	
16						X
17				X		X
18						X

1. Rosen, *et al.* 1995
2. Adamus and Brandt 1990
3. Ohmart and Anderson 1986
4. Haywood and Cornelius 1993
5. Koeln, *et al.* 1994
6. Ritchie, *et al.* 1988
7. Falkner 1995
8. Goosens, *et al.* 1993
9. Phinn, *et al.* 1996
10. Lo 1986
11. Gurnell, *et al.* 1993
12. Van Zee and Bonner 1981
13. Avery and Berlin 1992
14. Wenderoth and Yost 1969
15. Lefsky, *et al.* 1998
16. Levein, *et al.* 1998
17. Varner, *et al.* 1998
18. Lewis, *et al.* 1998

a number of vegetative sampling techniques. Adamus and Brandt (1990) report that line transects, quadrants, and variable-sized plot sampling can approximate vegetative cover of certain plant species or communities in a wetland system. Rosen, *et al.* (1995) discuss invertebrate and vertebrate species studies, including the determination of the number of species, number of individuals for each species, and biomass. Adamus and Brandt (1990) suggest several methods to conduct species studies, including water sampling, substrate sampling, pit trap or funnel use, direct observation along transects or at random points, audio observation, nest counts, snare traps, and live traps. Ohmart and Anderson (1986) discuss fixed point or panoramic photography as another method to record general wetland changes over time. Remote sensing techniques discussed in later sections may also be useful for compiling data records.

Conventional Mapping

Mapping provides another way to record data, and this method is more spatially meaningful than data records alone. Data gathering can require the same collection techniques as in keeping data records, but surveying techniques or another form of determining spatial location is also required. Alternatives for data acquisition and determining spatial location are discussed in the following sections. Though this method may be more useful than compilation of data records, it may also be less effective than GIS mapping because of the amount of data often required for effective monitoring. Area analysis with hand mapping is difficult because area calculations are manual, rather than an automatic function in a computer system. Analysis across temporal scales is also limited because it requires a series of overlays and the data involved can be difficult to manage, as more data is included in the analysis. This method, however, is accessible to field personnel with limited training in computer applications, and the temporal and spatial analysis can be more efficient if the information compiled in the hand mapping process is input into a GIS system.

Geographic Information Systems

GIS can be an effective way to organize and analyze data gathered in a wetland monitoring program. GIS systems are applicable to monitoring wetland systems for similar reasons that they are also applicable for other environmental monitoring programs such as water quality or radioactive pollution monitoring. Haywood and Cornelius (1993) suggest that the system can "[handle] the large volumes of data generated by monitoring programs at different geographical and temporal scales". This allows production of a usable assembly of data that is meaningful on spatial and temporal scales, rather than a jumble of graphs and forms with data from the monitoring program. The mapping applications of GIS provide an effective way of showing spatial relationships of wetland characteristics such as vegetation, hydrology, and topography. In addition, monitoring staff can easily identify changes in these wetland characteristics from the baseline map to subsequent years of wetland development. However, Koeln, *et al.* (1994) note that acquisition of accurate and relevant data is the most costly and the most critical aspect of effective GIS monitoring.

Data Acquisition

The method of data acquisition chosen depends on a number of factors. Ritchie *et al.* (1988) state that the objectives of the study are generally the most important factor. This decision guides the determination of the scale of the study and resolution required, which in turn guides the choice of method.

Field Data Acquisition

Monitoring personnel can collect the data needed for mapping and analysis through fieldwork. This involves a combination of identifying site features and determining their location. Researchers can determine the location of site features by using traditional surveying methods. Based on a reference point, an electronic device measures distance, a theodolite measures angles and elevation changes, and an electronic tacheometer (total stations) measures angle, elevation, and distance (Falkner 1995; Ritchie, *et al.* 1988). Falkner (1995) discusses modern surveying equipment that integrates the technology of Global Positioning Systems (GPS), using satellite positioning to determine the location of interest on the earth's surface. Koeln, *et al.* (1994) reports that hand-held GPS units allow field personnel to "obtain geographic coordinate position data" for objects of interest relatively easily.

Remote Sensing

Inputs of photographic and satellite imagery are effective in developing data sets of spatial relationships, and offer an alternative to field data acquisition. Remote sensing is an effective way to determine spatial relationships without a large amount of fieldwork. Goosens, *et al.* (1993) discuss how remote sensing is useful in ecological monitoring projects looking at the effects of fire disturbance, noting that "a multi-temporal image classification makes it possible to follow the rate of regeneration [or the amount of change] of the vegetation affected by fire razing". Remote sensing imagery provides an effective way to determine vegetation types because "individual species and assemblages of species may produce unique spectral reflectance characteristics as a function of their structure, condition, and fractional cover" (Phinn, *et al.* 1996).

Aerial Photography

Aerial photography, which includes black and white, color, color infrared, and multispectral, "[provides] information on the distribution, type, and structure" of a landscape feature (Lo 1986). Gurnell, *et al.* (1993) describe "visual interpretation of air photographs or standard false-color composites of digital data from airborne or satellite platforms… [as a] rapid means of defining the boundaries of vegetation classes, once the classes have been established using ground survey". Since aerial photography reduces required labor, it is a cost effective alternative when compared with fieldwork. In a study done on rangeland cover, Van Zee and Bonner (1981) found that cover estimates from color aerial photographs had a high correlation with field surveys and were half the cost of field surveys.

Color photography provides distinction between land covers through reflection of visible wavelengths (Avery and Berlin 1992). Color infrared provides distinction of land covers by recording the reflection of green, red, and near infrared wavelengths (ibid). Color infrared (or false-color) is especially effective in distinguishing vegetation, because vegetation reflects infrared wavelengths.

Multispectral photography "makes use of different spectral bands of the electromagnetic spectrum to differentiate between objects and to determine the physical condition of objects based on the amount of reflectance in each band" (Lo 1986). Wenderoth and Yost (1969) note that this type of photography allows differentiation between types of vegetation that may not be evident in color photography because of similar-looking cover types. Phinn, *et al.* (1996) utilized multi-spectral aerial photography to determine whether a restored wetland provided the objective habitat for the clapper rail bird. They found that the use of "remote sensing and GPS technologies [provided] a relatively low-cost [and non-invasive] solution at the appropriate spatial sale for monitoring wetland restoration efforts" (Phinn, *et al.* 1996).

Lidar

Lidar (Light Detection and Ranging) remote sensing provides a three dimensional analysis of objects on a landscape, such as vegetation. Lidar systems produce a "series of data elevation points with known geographic positions" through an aircraft-mounted laser system that measures reflected light and coordinates with a Global Positioning System (GPS) (Greer 1998). Lefsky, *et al.* (1998) have applied this technology in forests to measure spatial patterns as well as vegetation structure. Because of the three-dimensional capabilities of lidar, it may provide information about vegetation structure that may be necessary in a wetland monitoring system.

Satellite Imagery

Satellite imagery is another option available for inputting data into GIS. Levein, *et al.* 1998 discuss that "while aerial photography can detect change over relatively small areas at reasonable cost, satellite imagery has proven more cost effective for large regions." The resolution of satellite imagery, however, may be too coarse for utilization in monitoring of small wetlands, but the resolution is getting finer grained as technology evolves. Two commonly used satellite imagery sources, Landsat and SPOT, are discussed in the following sections.

Landsat (Land Satellite) imagery provides multispectral images on a temporal scale (Avery and Berlin 1992). Koeln, *et al.* (1994) notes that Landsat MSS (Land Satellite Multi-Spectral Scanner) measures "radiation from four different spectral bands (green, red, and two in the infrared)" and has a resolution of 79m by 56m. Landsat TM (Land Satellite Thematic Mapper) "measures the intensity of reflected radiation in six spectral bands" (blue, green, red, a near infrared, and two short-wave infrared) (Koeln, *et al.* 1994). Landsat TM has a finer resolution than MSS, being 30m by 30m.

SPOT (Systeme Pour l'Observation de la Terre) is another type of satellite imagery that "has 9 times more spatial detail than Landstat TM" (Koeln, *et al.* 1994) and has a resolution of 10m (Avery and Berlin 1992). Koeln, *et al.* (1994) reported that this imagery is positional and that high quality images can be produced by "combining the Landsat's spectral data with the spatial advantages of SPOT's panchromatic data". Gossens, *et al.* (1993) found that SPOT technology could distinguish areas that are larger than 1.2 hectares with areas larger than 3.0 hectares being more reliable for accurate data collection.

Combination of Remote Sensing Methods

In many cases, a combination of imagery alternatives may be an effective and accurate way to acquire data for GIS input. In a noxious weed monitoring program, Varner and Lachowski (1998) began the study using Landstat TM and other GIS data layers to determine areas most susceptible to noxious weed invasion. In these areas, they used aerial photography and found that some weed species showed up with a conventional 70mm aerial camera; another species showed up with a color infrared digital aerial camera, a multispectral aerial camera, and a 35 mm and 70mm conventional aerial camera; and another weed species did not show up with any of the cameras used (Varner and Lachowski 1998). The visual manifestations of the weed are due to a variety of factors including structure, color, and stage in life cycle. Aerial photographs taken at different times of the year may allow better differentiation of some of the weed species from other cover types (ibid).

Another study that used a combination of imagery methods for data input was a wetland mapping and monitoring project in California (Lewis, *et al.* 1998). In a regional study in Central Valley, California, Lewis, *et al.* (1998) looked at inventorying wetlands "to evaluate waterfowl capacity, to target potential areas for wetland restoration, and [eventually] ensure that reliable water sources are available for managed wetlands". They generated a GIS model with a "combination of multi-date satellite imagery, [Landsat TM and SPOT], and existing ancillary datasets [National Wetlands Inventory data, USGS Digital Line Graphs and River Reach data, and California Department of Conservation Farmlands Mapping Program Data]" (ibid). They found that the model provided an adequate "baseline inventory…[but] additional data layers need to be added to improve its utility for wetland conservation purposes" (ibid). The methods used in this study might function as an effective guide for UDOT to put together an inventory of mitigated wetlands in the state, though the scale is too large for individual wetland monitoring.

Combination of Field and Remote Sensing Data Acquisition

In addition, a combination of remote sensing and field sampling is also effective. For example, researchers may find that an aerial photograph shows basin boundaries and general vegetation classes accurately and more cost effectively than field survey. The detailed vegetation cover analysis of the same site, however, may require field vegetative sampling based on the overall spatial arrangement determined from aerial photography. Many of the above examples utilize a combination of methods. An integration of methods and monitoring techniques that are adaptive based on individual site conditions may provide the monitoring team with the most effective data for their monitoring program.

SUMMARY OF MONITORING

The monitoring guidelines discuss a variety of issues in the monitoring process that are important to consider. Planning is essential in the process, including the establishment of an activity schedule, determination of which activities should occur and at what intensity, and utilization of collected data. Many guidelines were flexible, allowing the user to adjust a guideline to a specific project. Incorporating this flexibility, several guidelines discussed tailoring monitoring protocol to project objectives and the use of reference wetlands to set criteria. Overall, the guidelines provide diverse options for monitoring wetland sites and provide some direction in the monitoring process.

A variety of options also exist for collecting and recording monitoring data. These techniques range from traditional data collection and mapping to computer mapping applications and database systems. For many cases, a combination of these procedures may apply to a particular group conducting wetland monitoring. The appropriate techniques depend on the group's data needs and available resources. As the computer and remote sensing technology advances, researchers have increased opportunities for compiling accurate and accessible data records. These techniques are especially applicable for wetland monitoring because of the low impact on the wetland system and the need for accuracy.

MAINTENANCE

Maintenance should be addressed as part of the wetland mitigation plan early in the process, with timetables and responsible parties specified in the plan (Garbisch 1990). Maintenance is necessary for a mitigated wetland that is not performing desired functions due to structural problems. For instance, vegetative overgrowth, external impacts such as debris collection or sedimentation, or minor problems with the initial design may inhibit the proper functioning of a wetland and require maintenance attention. The maintenance plan must fit the site requirements, and, therefore, may change depending on site conditions and goals. Some mitigated wetlands, for instance, require dredging and vegetation removal on a yearly basis, while others may require more minimal maintenance. The maintenance can be a costly part of wetland mitigation, but may also play a large role in successful mitigation for UDOT projects.

MAINTENANCE GUIDELINES

Many literature sources that describe integrated wetland programs do not explicitly establish maintenance guidelines, but a few suggest that maintenance follows the evaluation of monitoring results as a correction to problems discovered in the monitoring process. Literature that discusses wildlife management techniques are the best source for general maintenance guidelines, and the concepts discussed in these sources are useful for a variety of functions besides wildlife habitat.

MAINTENANCE TECHNIQUES

As is the case with most maintenance activities, taking care of a problem when it is small is the most effective way to manage a mitigated wetland. The techniques presented here are a brief overview of activities possible for maintenance of a mitigated wetland. The techniques include weed control, algae control, pest control, erosion and sedimentation control, plant care, revegetation, structure maintenance, and debris removal (Payne 1992; Kent 1994; Galatowitsch and van der Valk 1994).

Weed Control

Weed control is a significant problem with most mitigated wetland sites because the extensive disturbance of these sites leads to rapid colonization by weed species (Zentner 1994). Invasive plant species can also replace newly planted or established wetland plant communities. Examples of problem weed species include Common Reed, *Phragmites australis,* and Purple Loosestrife, *Lythrum salicaria,* which establish dense stands and choke out other species. Weed control methods vary with targeted species and the maintenance group's resource availability.

Physical Removal

Physical removal is an effective method of control for a number of weedy species. Zentner (1994) presents options of weeding plants by hand or cutting the plant back completely. Using this method early in the plants' life cycle is important to prevent spreading seeds produced by mature plants and to make the process less time consuming (ibid). Cutting or weeding is best for small areas where the density of weeds is low compared to other plant species. In other cases, this method is very "labor intensive and costly unless the personnel consist of volunteers" (ibid). Mowing is closely related to cutting individual plants and involves using mowing machinery to cut vegetation in large, dense areas (ibid).

More disruptive methods of physical removal include disking or excavating. Disking involves dragging a plowing disk across an area "to break up stands of sod-forming grasses" (Payne 1992) and "prevent growth of woody vegetation" (Kent 1994). Excavation of an entire stand of plants may be an effective way to control dense vegetation that has completely invaded an area. This method is the most disruptive to the wetland system because it displaces soil through removing root structures and vegetative propagules. Physical removal is often effective in weed control, though effectiveness varies depending on targeted plant species.

Biological Control

Biological control involves using various organisms to control weed species. Insect herbivores can be effective against certain types of plants. For example, Galatowitsch and van der Valk (1994) report that researchers have conducted studies of European insects' control of purple loosestrife. Payne (1992) discusses how seasonal grazing by mammal species, such as cattle, sheep, horses, or muskrat, can "reduce undesirable perennial plants" and break up stands of dense vegetation. Grazing also can stimulate growth of plants valuable for wetland systems. Such biological controls, however, must be closely monitored to prevent problems with excessive herbivory as discussed in the section on pest control.

Water Level Manipulation

In comparison to other methods of weed control, water level manipulation can be one of the least disruptive methods of weed control. Middleton (1999) notes that flood cycles are an important part of the disturbance regime of a natural wetland system, and they can function as a controlling mechanism for many species of invasive weeds. Flooding reduces species not accustomed to anaerobic conditions, and can inhibit seed germination and establishment depending on the targeted species (Payne 1992; Galatowitsch and van der Valk 1994). Flooding is also effective when used in addition to other methods of control. For instance, Kent (1994) states that cutting cattail stems followed by flooding kills cattail by cutting off the necessary supply of oxygen to the cattails rhizomes. Conversely, drawdowns affect species intolerant to drought, and also inhibit seed germination and establishment for certain species (Payne 1992). Payne

(1992) suggests that important considerations for maintenance personnel to consider when manipulating water levels include frequency, season, and duration of flooding and drawdown cycles. Depending on target species and ability to control water levels, water level manipulation can be an effective weed control method that mimics the natural disturbance regime in a wetland system. Personnel who understand flooding and drawdown effects in a wetland system should design water manipulations.

Controlled Burns

Controlled burning can also be an effective tool for vegetation management, mainly in large wetland complexes. As with flooding cycles already discussed, Middleton (1999) discusses how fires are a historical disturbance regime in wetlands, especially in seasonal wetlands. The weed control accomplished by prescribed burns varies depending on burn intensity and weed species. As an example, a "late summer burning [that] kills the root crowns" controls common reed (Middleton 1999 citing Ward 1942). Because of the problem of controlling fire, Payne (1992) notes that prescribed burns should be closely monitored and performed with thoroughly prepared strategies. In limited areas, fire can have a desirable effect on weed species in wetlands. In small wetland systems, however, fire may be undesirable because of the amount of disruption.

Chemical Control

Another method of weed control is the use of herbicides, which can be a cost efficient way to get rid of invasive species (Zentner 1994). Payne (1992) discusses general types of herbicides appropriate for wetlands, including selective or non-selective, foliar or root-absorbed, pre-emergent or post-emergent, or aquatic herbicides. Zentner

(1994) notes that spot spraying of herbicides offers the most control in a wetland system, limiting exposure of the entire system to damage by herbicides. Spot spraying may be a successful method for weed control, especially for woody species when used in conjunction with cutting. Payne (1992) discusses that any sort of chemical control, however, has possible adverse effects on other organisms in the entire wetland system and affects water quality. Since herbicides are potentially damaging to the wetland system, maintenance personnel should limit chemicals to occasional use.

Algae Control

Algae blooms are another problem maintenance personnel may have to address in mitigated wetland sites. Payne (1992) reports that algae increase the turbidity of the water, which causes a decrease in submersed aquatic vegetation that may be desirable in the system. Algae can also create anaerobic conditions in the wetland (Payne 1992).

Maintenance personnel can control algae before it becomes a problem by decreasing the level of nutrients that stimulates algae growth in the water supply. Filtering nutrients out of the water before it enters the wetland complex is one way to prevent algae. Payne (1992) reports that flushing the wetland system with unpolluted water is also an option to reduce the nutrient base for the algae. Chemical control can also be used to reduce nutrient levels through a chemical reaction that precipitate the nutrients out of solution, preventing algae growth. An example of chemical control of algae is using aluminum sulfate to react with phosphorus and remove it from the water column (Payne 1992).

Other methods to control algae include measures that reduce viability of the algae itself. Galatowitsch and van der Valk (1994) report a method of biological control that involves "maintaining large populations of zooplankton that feeds on algae…to control algae growth". Another alternative is the use of an algaecide that is costly and could require repeated application, in addition to problems with polluting the water supply (Galatowitsch and van der Valk 1994). The methods that target algae growth can be effective, but prevention of the problem at the outset can be more efficient in the long run.

Pest Control

An additional threat to the desired plant communities is the impact of pests, which includes many different animal species. In many wetland systems, carp tend to decrease submersed aquatic vegetation because they increase turbidity and disrupt root structures while feeding (Galatowitsch and van der Valk 1994). Payne (1992) notes that carp can be managed by decreasing the water level significantly, which kills fish because of anaerobic conditions or freezing during the winter. Maintenance personnel can also control populations with chemical measures, such as rotenone (Payne 1992). This method is similarly discouraged along with other chemical controls already discussed because of the effect on the rest of the system. Upon successful removal of the carp population from a wetland, barriers can prevent the return of carp (Payne 1992).

Excessive herbivory by animal species such as cattle, deer, muskrat, and beaver can also cause major disturbance to the desired plant community. Maintenance personnel can control some of these animals by fencing off the entire wetland. Zentner (1994) suggests that personnel can also protect plants individually by using screens or tree guards to prevent damage. Individual plant protection is desirable in cases where the management team would like to maintain selected animal species as part of the wetland ecosystem, but prevent the animal species from removing all of the vegetation. For example, the management team may want to allow beaver to be part of the wetland system's dynamics, but they want to protect a portion of the trees from beaver harvest.

If an animal is causing severe damage to the wetland ecosystem, such as a predator species reducing wildlife populations, the wetland managers may resort to extermination of the pest (Payne 1992). Wetland personnel coordinate with local wildlife agencies to execute extermination of wildlife pests. Careful monitoring of the wetland system is a key component for determining the extent that an animal is beneficial or detrimental to the system.

Erosion and Sedimentation Control

Erosion in a wetland system leads to loss of soil, increased water turbidity, increased sedimentation, and vegetation loss. The mitigation plan review process should identify areas with possible erosion problems and identify best management practices that can prevent erosion. Zentner (1994) suggests that a possible solution for erosion problems on a site is to regrade or redesign the site to channel water away from vulnerable areas or to reduce water velocity or wave action as it moves across the site. Another way to control erosion is through revegetation. The vegetation acts to slow water down as it moves through the vegetated area and the plant roots secure the soil in place. By controlling erosion through best management practices, wetland managers can control problems associated with excessive erosion.

Sedimentation control is a management issue closely related to erosion control. Sedimentation is a problem in wetland systems because it fills up pond areas, impedes water movement, and blocks water control structures. Approaches to controlling sedimentation include controlling erosion in the first place, by preventing water from picking up heavy loads of sediment as or before they enter the system. Payne (1992) suggests dredging, which involves the physical removal of sediments, as a method to control sedimentation when excessive sediment deposition occurs in a wetland system. Dredging should only be used as a last resort as it can be a highly disturbing activity for an established wetland, and it becomes costly from the use of heavy machinery and disposal of sediments (Payne 1992).

Plant Care

Plant care is an important management activity to ensure that desired plants establish themselves as quickly as possible. The established vegetation plays a major part in the proper functioning of a wetland, and plant cover is often one of the measured indicators to determine if the wetland is functioning as planned. A quickly established plant community also lessens the chance of weedy colonizers overtaking the desired plant community.

Attending to the plants cultural requirements increases their adjustment to the site. Zentner (1994) notes that fertilizer may be needed if the site has nutrient poor soil, and slow release formulas are often the best method for fertilizing. In addition, the plants may require supplemental irrigation until they develop required root structures (Zentner 1994). Plants may also require structural supports such as tree stakes and cages to ensure that plants maintain a desirable form (Zentner 1994). In case of disease or insect problems, "all infestations should be treated using Integrated Pest Management (IPM) techniques" at the wetland site (Zentner 1994). Attention to proper plant care by maintenance personnel early in the establishment period can greatly reduce other management techniques needed if the vegetation fails to establish.

Revegetation

Revegetation may be another necessary management activity if planted material does not germinate or survive, or if a weed species displaced the desired plant material. Methods for revegetation include the same techniques as those used to plant the site in the first place. Payne (1992) suggests that the common technique of seeding is the most inexpensive, but also is the least successful method. For successful seeding, germination requirements and proper soil preparation are important to consider (Galatowitsch and van der Valk 1994). The use of vegetative propagules, such as cuttings or rhizomes, is more successful for establishing desired plant communities, especially larger plant material such as woody species. Transplanting greenhouse stock is the most expensive, but also generally most successful, especially with plants that have low germination rates

(Galatowitsch and van der Valk 1994). Revegetation success also depends on providing adequate irrigation during establishment of the plant species. The various methods of revegetation can also be combined depending on the budget for revegetation, individual plant requirements, and difficulty in establishing desired vegetative species.

Structure Maintenance

Hydrologic control structures require routine maintenance to keep the systems in working order. Water control structures may require periodic clearing of debris and sediment to ensure that water can flow through with ease. Galatowitsch and van der Valk (1994) report that another important aspect of maintaining water control structures is periodic inspection for structural damage to ensure function during high water flow. If an irrigation system is part of the site, this also requires routine inspection for leakage or plugged system components (Zentner 1994). Maintaining water control structures and irrigation systems are important management activities in systems that rely on these components on a regular basis.

Debris Removal

Debris removal is a commonly required maintenance activity and involves the removal of both trash and excess plant litter that can inhibit vegetation growth (Zentner 1994). Wetland systems require litter removal only when the litter is adversely affecting wetland function, because the litter can be a beneficial part of the wetland system in certain instances. Generally, the necessary litter removal requires hand removal and can be labor intensive. Frequency required for debris removal depends on adjacent human usage and amount of litter.

SUMMARY OF MAINTENANCE

A variety of maintenance activities may be necessary for mitigation wetland sites. Possible wetland maintenance activities include weed control, algae control, pest control, erosion and sedimentation control, plant care, revegetation, structure maintenance, and debris removal. Since these techniques vary from maintenance techniques in an upland system, maintenance personnel must have specific training to deal with these systems. Particularly prone to disturbance, wetland systems may function better if maintenance activities correct problems caused by external sources and problems with site construction.

FUNDING

Funding is a major issue in effective wetland mitigation because the finances available for mitigation can significantly affect the quality of the project. Inadequate sources of funding are a likely reason that many wetland projects fail to function. "Financial incentives in wetland mitigation markets reward low cost, not high quality restoration, and account for the relatively poor performance of many restoration projects" (Kentula, *et al.* 1993 citing King 1991). Many limitations exist for acquiring proper funding for wetland mitigation. Some funding is available through many federal grants and private non-profit organizations, but fewer opportunities exist for public agencies such as UDOT. In addition, the various funding options are seldom discussed in the literature that outlines wetland mitigation programs. Identification of funding sources is a necessary part of a wetland mitigation program, since funding is critical for proper evaluation, monitoring, staffing, and maintenance of mitigated wetlands.

FUNDING SOURCES

Grants

A limited number of grants are available for public agencies for use with wetland programs, and most have strict restrictions on allowable use of funding. Most of the grants require matched funding by a third party, commonly at a one to one ratio. These grants also require a number of different project objectives, which may or may not be applicable for wetland mitigation projects.

The EPA provides Wetland Program Development Grants for qualified state, tribal, and local government applicants. They fund projects that "build and refine comprehensive wetland programs... in five areas: monitoring and assessment, regulation, restoration, water quality, and public-private partnerships" (USEPA 2001). Past projects funded through this grant include "developing [and refining] plans and management tools for wetland resources, [and] advancing scientific and technical tools for protecting wetland health" (ibid). The EPA has two areas of focus that they would like to see in future proposals, which may be directly applicable for UDOT. One area of program focus includes "monitoring and assessing the status and condition of wetlands...[directed towards] developing and ultimately implementing...wetland monitoring programs" (ibid). The other area of focus is "improving the effectiveness of compensatory mitigation...[through] improvement or development of mitigation programs" (ibid). This grant, however, does not provide funding for specific mitigation activities. The matching requirement for this fund is 25% of the project award.

The National Fish and Wildlife Foundation (NFWF) also has grants available, but the grant criteria may go beyond the mitigation requirements in many cases. The NFWF funds programs that "benefit multiple species, achieve a variety of resource management objectives, and/or lead to revised management practices that reduce the causes of habitat degradation" (NFWF 2000). They look for projects that involve partnerships and provide benefit to federal lands (ibid). They require a one to one match of non-federal funds and prefer a two to one match (ibid). The foundation also has several different partnership programs with more specific objectives (ibid).

Federal Funding

The Intermodal Surface Transportation Efficiency Act of 1991 outlines some wetland mitigation practices that can receive federal-aid (FHWA 2000). Eligible projects and programs for federal-aid participation include: "banking of wetlands mitigation concurrent or in advance of project construction; contributions to statewide and regional efforts to conserve, restore, enhance, and create wetlands; and development of statewide and regional wetlands conservation and mitigation plans" (FHWA 2000). This allowance for federal funds to go towards mitigation banks rather than only on-site mitigation efforts allows transportation departments more flexibility within their wetland mitigation program.

Guarantees

Rather than seeking additional funding to fix wetland mitigation problems after construction, a monetary guarantee of quality construction can provide funding for post-construction corrections. These monetary guarantees include "[performance or completion] bonds, trust funds, escrow accounts, or insurance" to ensure that the contractor either properly construct the mitigated wetlands, or pay for necessary amendments (Cylinder, *et al.* 1995 citing Environmental Law Institute 1993).

SUMMARY OF FUNDING

Funding sources for wetland mitigation is limited. Some funding is available through many federal grants and private non-profit organizations, but fewer opportunities exist for public agencies such as UDOT. In addition, the various funding options are seldom discussed in the literature that outlines wetland mitigation programs. Identification of external funding sources, however, is a necessary part of a wetland mitigation program, since funding is critical for proper evaluation, monitoring, staffing, and maintenance of mitigated wetlands.

CHAPTER SUMMARY

Monitoring, maintaining, and funding are important components of a successful wetland mitigation plan. Various options exist for each subject, but how they are incorporated into a comprehensive mitigation plan is far more complex than picking one option and sticking with it. Throughout the literature, creating a high quality mitigated wetland plan and following through with the plan is the most important component. If the mitigation plan is closely related to the project goals and objectives, appropriate activities have a higher application for improving wetland function and guiding future designs on different projects.

Another overriding theme in most the literature was that mitigation plans require flexibility, and must be constantly reevaluated as changes occur. No one set of techniques is successful for every mitigation problem encountered. Protocols that set absolute standards may provide an alternative that is costly and irrelevant. In contrast, flexible plans contribute to the success of a project by providing feedback.

CHAPTER IV

RESULTS AND DISCUSSION

INTRODUCTION

This chapter contains results from the questionnaire and telephone interviews. The questionnaire provided statistical results and narrative responses to wetland mitigation questions, while the telephone interviews only provided narrative responses. Thirty-five states responded to the questionnaire, so the overall response rate was 70% of the 50 states that received the questionnaire. Appendix E contains a list of the states that responded to the questionnaire. Because one state distributed the questionnaire to its DOT districts, a total of 37 responses were received. Of these, two could not be utilized at all, yielding a usable response rate of 94.5% of the number of questionnaires received. Quantitative questions from the usable questionnaires were examined in two different ways.

FREQUENCY ANALYSIS

The frequency of responses for each question was determined to provide a general idea of the different mitigation practices in each state. The frequency analysis for the first question of the questionnaire, which was an overview question of wetland mitigation problems associated with mitigation failure, had a sample size of 35. The maximum sample size for the remaining frequency analysis is 34, or 92% of the total responses received, with variability of sample size due to incomplete survey responses or inapplicability of the question to DOT practices. All the results of the frequency analysis are shown in Appendix F. The frequency analysis shows the more common practices among state DOT's, serving as a guide for possible elements to incorporate into a mitigation strategy.

SUCCESS COMPARISON

In addition to frequency, each question was compared to the state's estimated wetland mitigation success based on Army Corps permit compliance. The maximum sample size for the comparison is 31, yielding a usable response rate of 84% of the total responses received. The variable sample size with some of the comparison analysis is again due to lack of response for several of the questions or inapplicability of the question to a state DOT. Appendix G contains all the results of this comparison, and the distribution of success is shown in Figure 4.1.

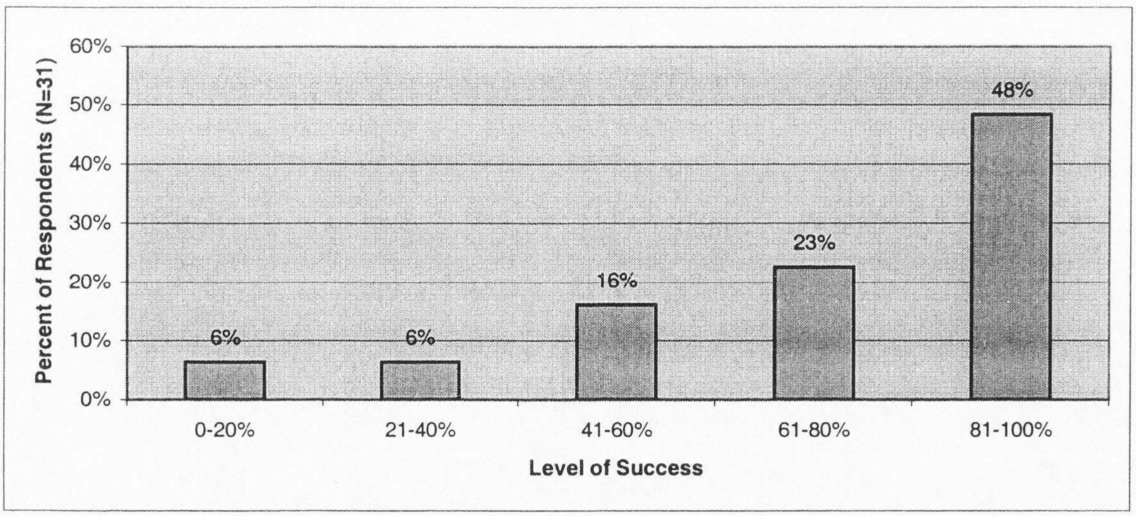


Figure 4.1. Success rates of wetland mitigation.

Success Grouping

As shown in Figure 4.1, the percentages of the highest success rate of 81% to 100% success greatly exceed the lower success rates. Because many states fell under the highest success category, a comparison between the rate of success and mitigation practice was difficult to visualize. To allow a better comparison between success and mitigation practices, the success rates were grouped into two categories of higher and lower success. Since approximately half of the respondents had between 81% and 100% estimated success rates and half the respondents reported less than 80% success, this split provided a more equally distributed grouping than the five categories of success distribution in Figure 4.1. The sample was aggregated to achieve a more equal distribution of respondents in the highest success category and the lowest success category, and does not imply that the states in the lowest success category are unsuccessful. Figure 4.2 shows the grouping of success rates into two categories of 0% to 80% success and 81% to 100% success.

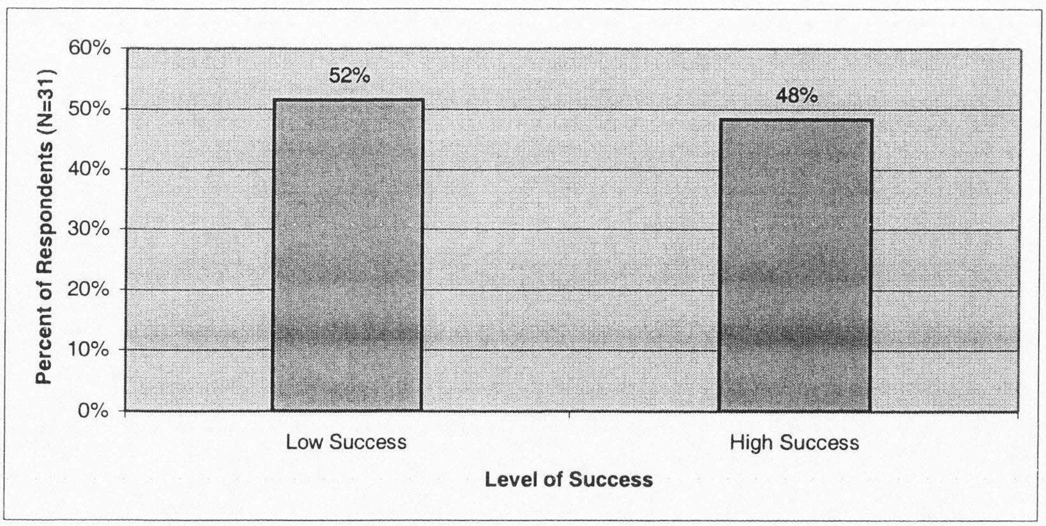


Figure 4.2. Success category distribution for comparison analysis.

This classification allows greater visual difference in characteristics between more successful and less successful DOT's because the sample was equally divided. Of the 15 states in the high success category, two are interior western states. Six of the interior western state respondents returned the questionnaire, and one did not respond to the success question. In the following sections, the category of 0% to 80% success is referred to as low success and the category of 81% to 100% success is referred to as high success.

NARRATIVE RESPONSES

Narrative responses from both the questionnaire and telephone interview that related to the frequency and comparison analysis provide additional insight of common problems and practices. Appendix H shows all narrative responses from the questionnaire, and Appendix I contains all narrative responses from telephone interviews.

RESPONDENTS

The questionnaires were completed by personnel in the environmental divisions of state DOT's. The respondents' educational backgrounds were varied and included five civil engineers, four landscape architects, 22 biologists or ecologists, and eight "others", whose backgrounds include law, forestry, geology, botany, geography, and soil science. Some respondents had educational backgrounds in more than one field. The distribution of years of experience of the respondents dealing with wetland-related issues is depicted in Figure 4.3.

YEARS OF EXPERIENCE	# OF RESPONSES
0 – 5	5
5 – 10	10
10 +	20

Figure 4.3. Distribution and years of experience.

When this distribution was compared to success level, the result suggests a positive relationship between high success and increasing years of experience as seen in Figure 4.4. Kusler and Kentula (1990) support this finding, stating that project success will depend to a considerable extent upon the expertise of the project staff. Comments from questionnaire respondents and interview respondents also frequently refer to the importance of experienced personnel in developing successful mitigation wetland projects.

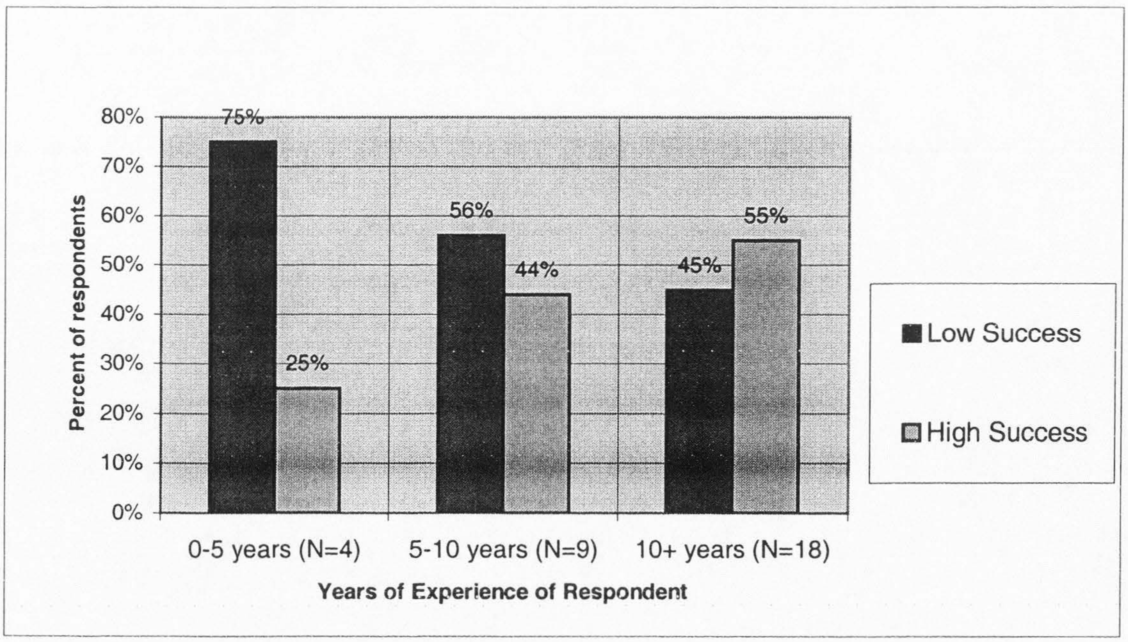


Figure 4.4. Years of experience and level of mitigated wetland success.

OVERVIEW OF PROBLEMS WITH WETLAND MITIGATION

The first question of the questionnaire asked respondents about the relationship of a number of wetland mitigation problems with failure. This provided an overview of the wetland mitigation process and general problems that occur throughout the process. Figure 4.5 shows the top five causes associated with wetland mitigation failure according to the survey results. Other problems relevant to monitoring, maintaining, and funding strategies were addressed in the overview question. Poor maintenance was a common to universal problem for 51% of state DOT's. Inadequate funding for staff to monitor and evaluate mitigated wetland was a problem for 46% of DOT's, and insufficient funding to

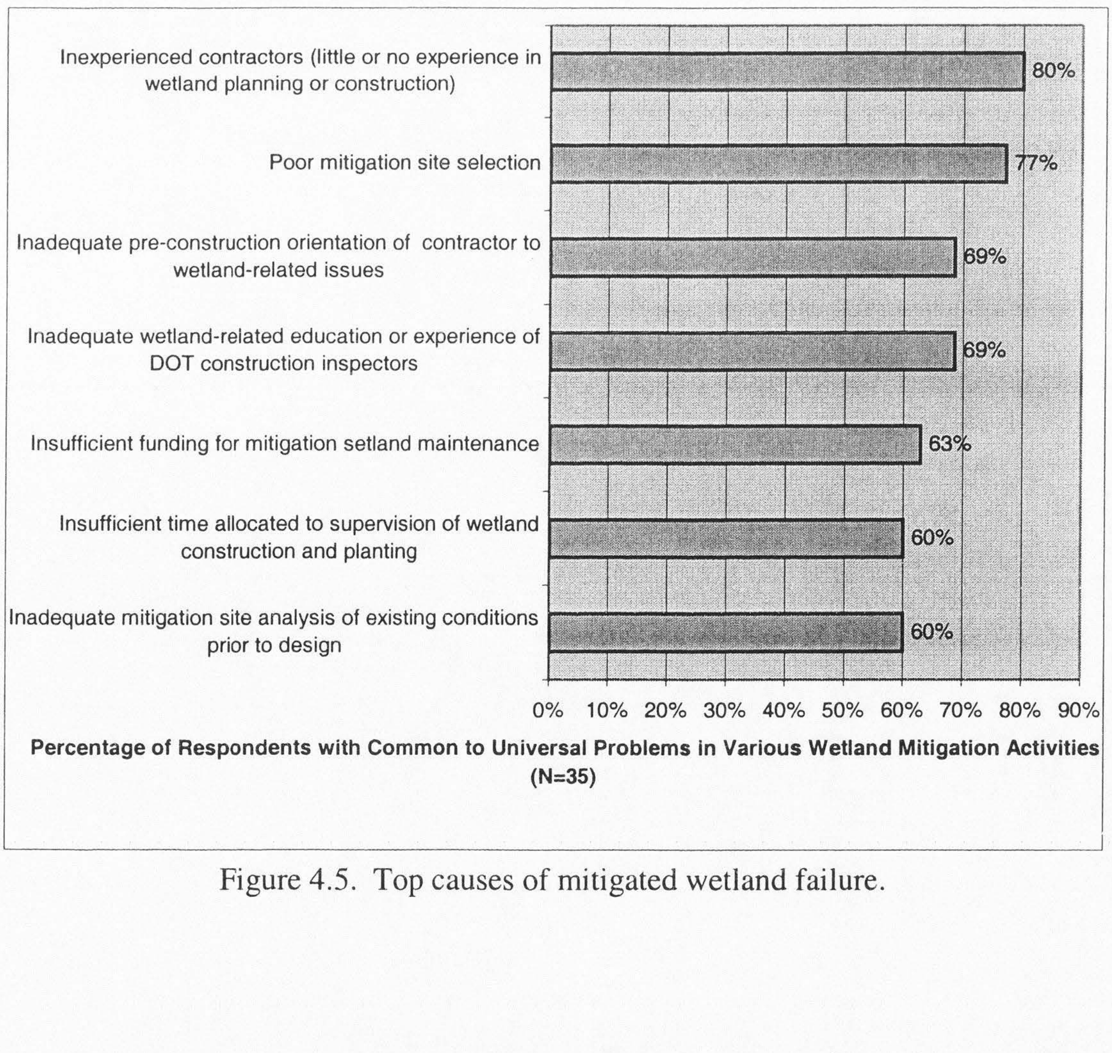


Figure 4.5. Top causes of mitigated wetland failure.

retrofit failures was a cause associated with failure for 43% of DOT's. Insufficient funding for quality wetland construction, however, was a common to universal cause of wetland failure for only 14% of DOT's, indicating that they generally have enough funds to cover the initial costs of wetland construction. The problems in the other areas of wetland mitigation related to monitoring, maintaining, and funding generally occur after construction. Many of these problems also showed up in the remaining results of the questionnaire, as discussed in the following sections.

MONITORING

GENERAL PRACTICES

One of the first areas examined in monitoring was the amount of monitoring that occurs in DOT operations. Questionnaire respondents reported that less than half, or 44% (N=34), have specific personnel to conduct wetland monitoring. Figure 4.6 shows the relationship between success and the presence of specific personnel on staff for wetland monitoring. When compared with success rates, the relationship between success and presence of specific personnel for monitoring is minimal. This result, however, is contrary to information found in the literature review because most of the reviewed monitoring guidelines require personnel with some specialized training to complete monitoring activities. The narrative responses also indicate that assigning qualified personnel to monitor is beneficial for addressing problems early, and having qualified personnel assigned to construction monitoring is especially important.

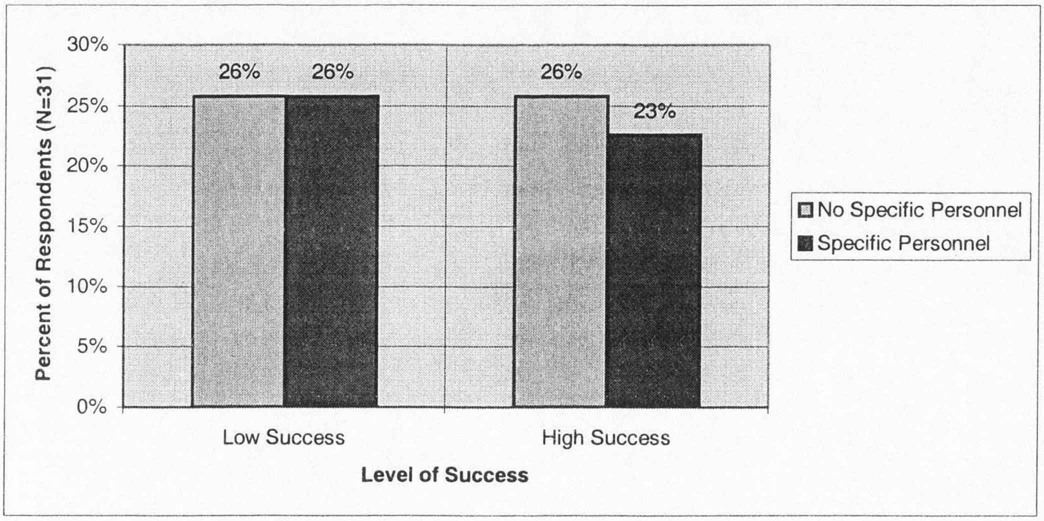


Figure 4.6. Specific monitoring personnel related to success.

Another indication of states' active involvement in a monitoring program was whether or not they had a formal monitoring protocol. In the questionnaire, 50% (N=34) of the state DOT's reported having a monitoring protocol. As with the previous question, those with monitoring protocols have equally distributed success rates as shown in Figure 4.7. This suggests that having a monitoring protocol is not the only component of a successful wetland mitigation program. However, most of the literature suggests that having some sort of guideline ensures direction and efficiency in a monitoring program. For example, Kentula, *et al.* 1993 suggest a procedure for monitoring related to project objectives, which also incorporates flexibility based on these objectives and wetland function over time. Narrative responses indicate a need for wetland mitigation planning, but also stress the need for a "project-specific" approach.

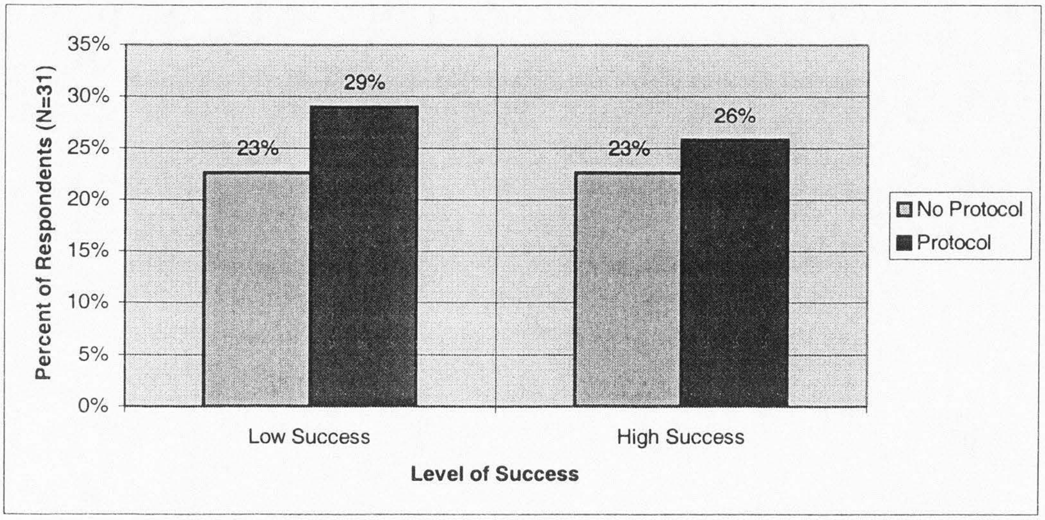


Figure 4.7. DOT's with formal monitoring protocol related to success.

MONITORING PERSONNEL

Personnel who conduct monitoring activities come from a variety of different educational backgrounds. Another question regarding monitoring in the questionnaire addressed the representation of certain professions in a wetland mitigation monitoring plan. Figure 4.8 shows the frequency of professionals participating in monitoring,

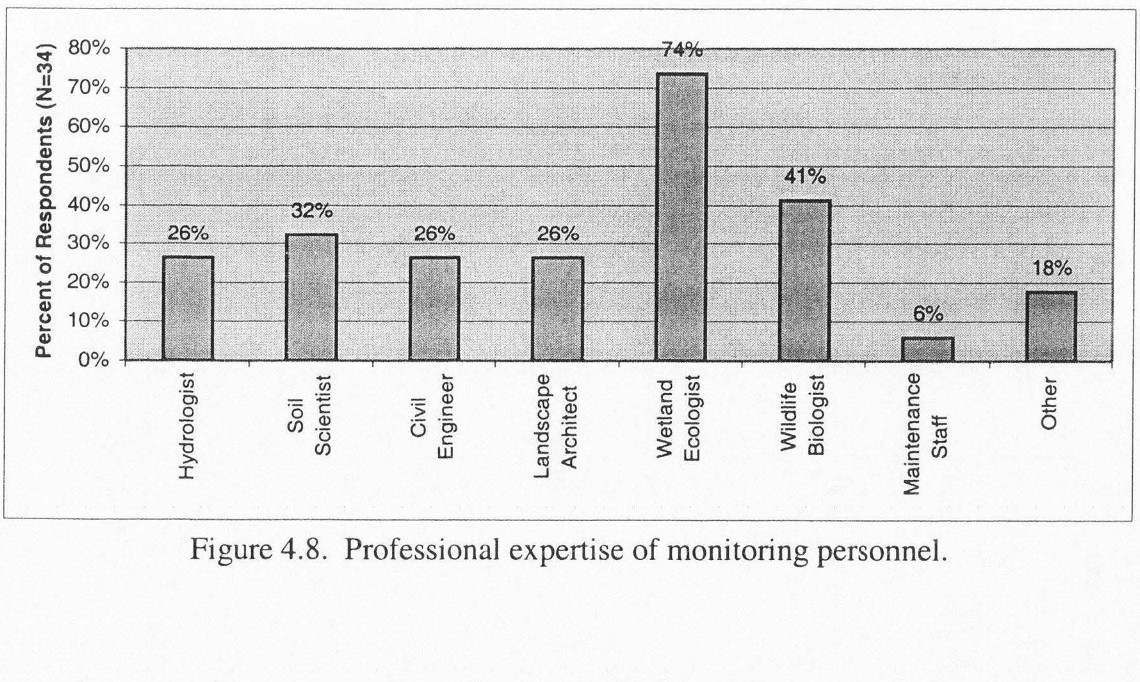


Figure 4.8. Professional expertise of monitoring personnel.

with wetland ecologists being the most common by a large percentage. This result is expected because wetland ecologists have specialized knowledge in the function of wetland systems. When compared with success, however, no significant relationships emerge. Figure 4.9 shows that involvement of a wetland ecologist has no apparent effect on the success rate.

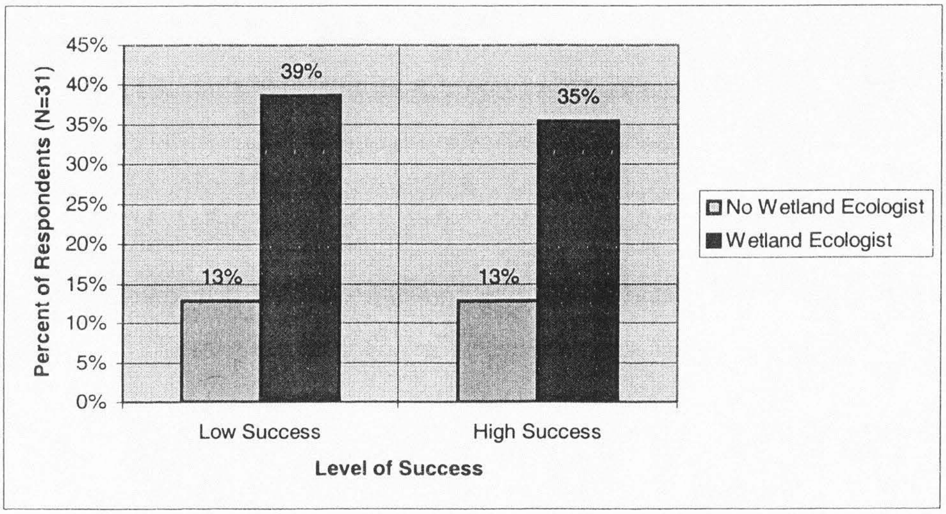


Figure 4.9. Wetland ecologists conducting monitoring related to success.

Personnel who evaluate the monitoring data were another focus of the survey. Figure 4.10 shows the personnel involved in evaluating monitoring data and the frequency of their involvement. Again, the wetland ecologists have the highest frequency of involvement.

Most of the comparisons of this question with success provide similar results as the professions involved in monitoring activities, but one statistically significant relationship shows up in this group of data (p-value = 0.0400). Fewer of the most successful states have wildlife biologists involved with evaluation of monitoring data, while more of the less successful states (0%- 80% success) have wildlife biologists.

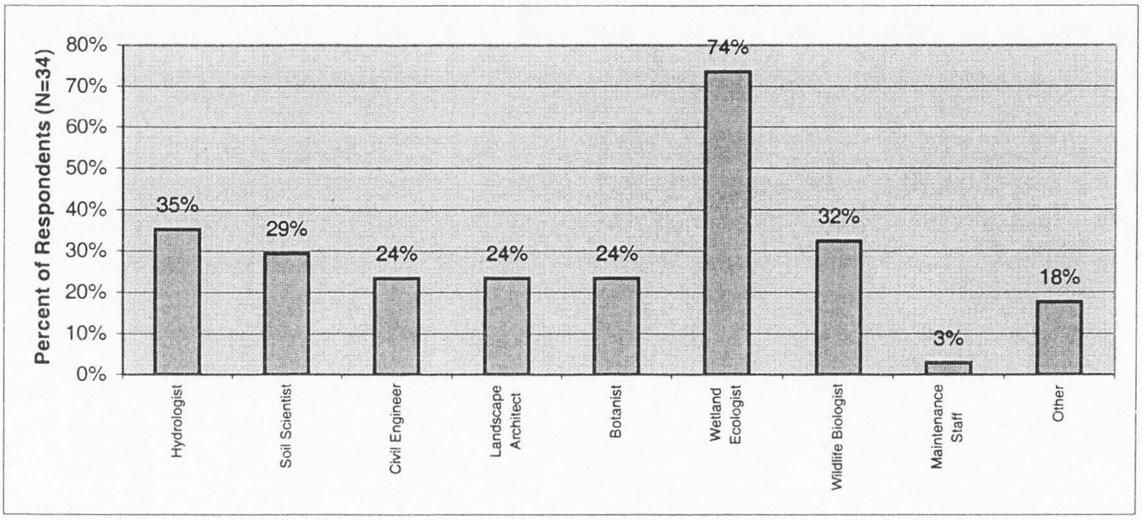


Figure 4.10. Frequency of professional expertise evaluating monitoring data.

Figure 4.11 shows this relationship between wildlife biologists and success. This result may be caused by the low sample size and high frequency of success. In addition, wildlife biologists may have less experience with hydrology on the site, which is a major cause of failure according to several telephone interviewees and information in the literature. Since little or no relationship is evident with the other professions, they may

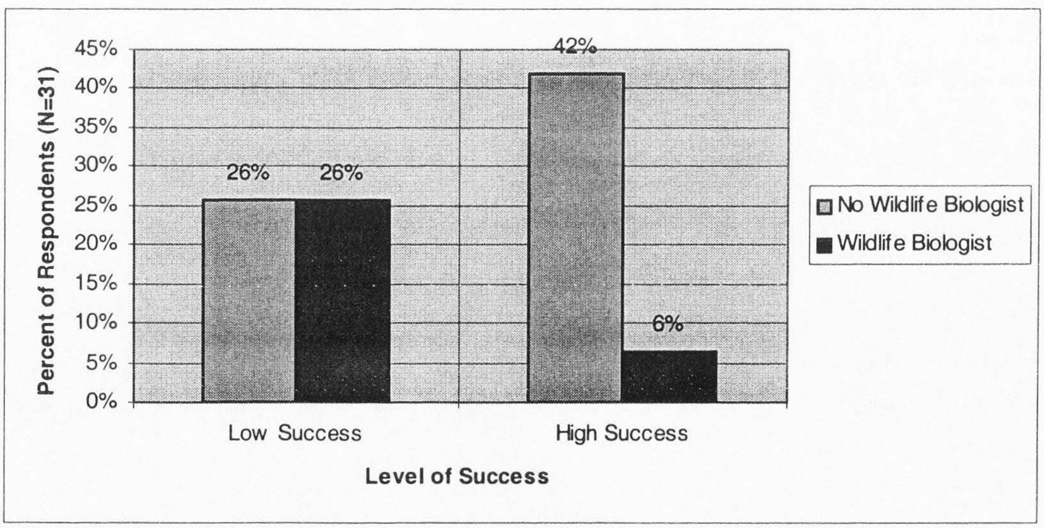


Figure 4.11. Personnel involved in evaluation of monitoring data compared to success.

either have a better background in hydrology or may participate less in the evaluation of monitoring data.

Sufficiency of time and staff for monitoring was another issue in the questionnaire dealing with monitoring personnel. Only 41% (N=34) of the respondents felt that DOT staff and available time was sufficient to monitor wetland plans and specifications. These results show that staffing for monitoring activities could be a problem in wetland mitigation. This estimated sufficiency of staff and available time was not statistically significant, however, when related to success.

CONSULTANTS

The use of consultants for monitoring activities was a fairly common practice, with 62% (N=34) of questionnaire respondents reporting consultant involvement in monitoring. When consultant monitoring was related with success, the p-value was low though not considered statistically significant (p-value=0.0552). Those states utilizing more consultants had lower success than those who did not use consultants, as illustrated in Figure 4.12. This relationship, however, is inconsistent with a comment from one of the telephone interviewees, who stated that consultants should be held on retainer to ensure that the DOT has the necessary staffing at the appropriate time. Other telephone interviews suggested that states could improve their monitoring programs by employing, "outside help from consultants or wetland experts". The variation from expected results may be a problem with the sample size or the high frequency of success. In addition, the problem could be caused by insufficient coordination between the consultants and the

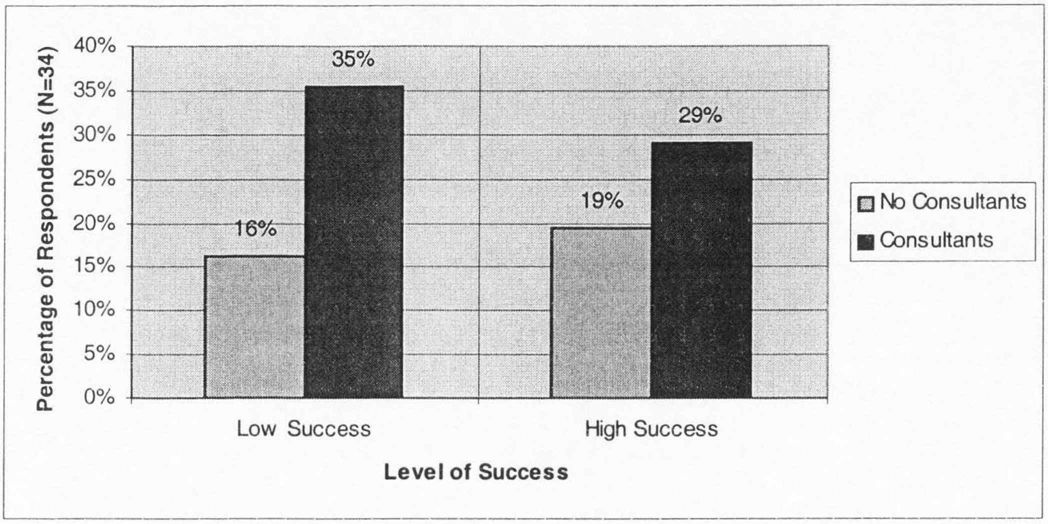


Figure 4.12. Use of consultants to monitor related to success.

DOT's and variability in the qualifications of outside consultants. In contrast to interview responses, several of the narrative responses from the questionnaire emphasized the importance of having trained personnel in-house rather than using consultants.

Only 41% (N=34) of respondents require that their consultants use DOT monitoring protocols, and this may be an additional reason for the above results. If every consultant is performing a variety of monitoring activities on each wetland without coordination, the information gathered may not be useful for the DOT unless related to project goals and the overall mitigation plan. However, no significant relationship exists between the requirement that consultants use monitoring protocol and success.

MONITORING FOCUS

Monitoring focus depends on the function or value replaced by the mitigation wetland. The questionnaire examined which functions or values are most often replaced by mitigation wetlands in each state. The appropriate monitoring program or combination of procedures follows the function or value replaced. Figure 4.13 shows the functions and values often replaced by DOT's, with habitat replacement being the most common.

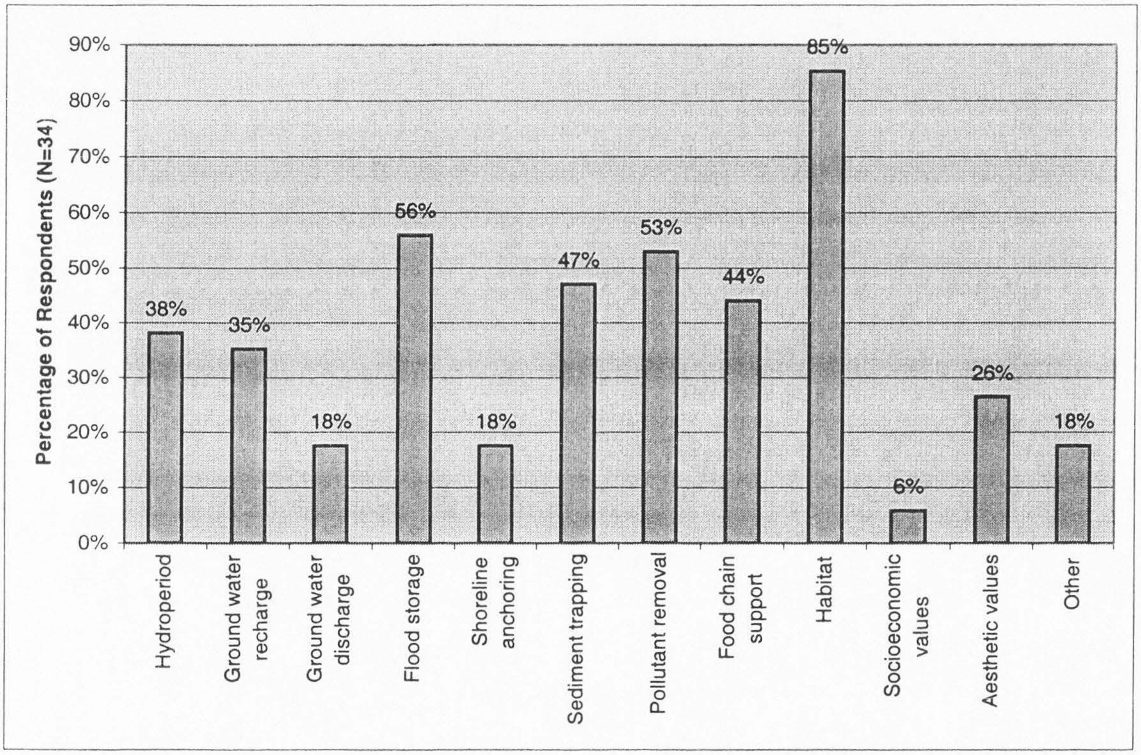


Figure 4.13. Functions or values replaced during wetland mitigation.

When related to success, groundwater recharge replacement (p-value = 0.0635) and groundwater discharge replacement (p-value = 0.0904) had low p-values, though not statistically significant. If states had to mitigate for these two functional values, they had less success than states that did not mitigate for groundwater recharge and discharge. This relationship is expected because groundwater hydrology is often difficult to replicate due to the unpredictable flow and difficulty measuring the flow. See Figure 4.14 for groundwater recharge replacement related to success and Figure 4.15 for groundwater discharge replacement related to success.

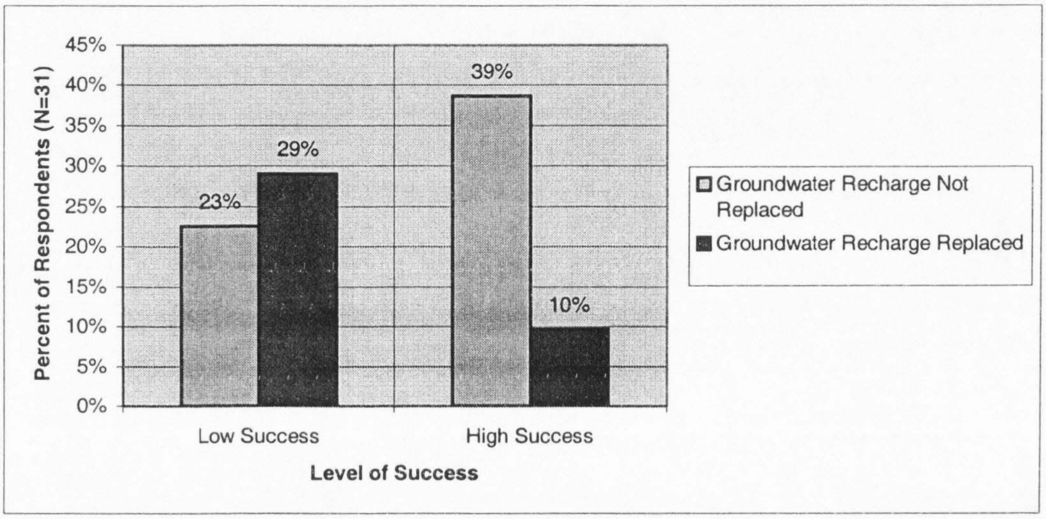


Figure 4.14. Groundwater recharge replacement during mitigation related to success.

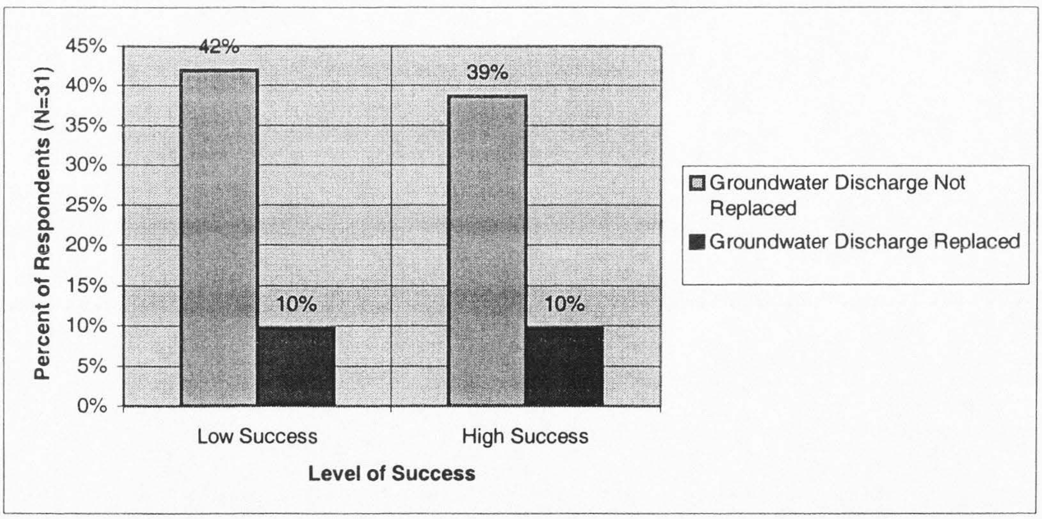


Figure 4.15. Groundwater discharge replacement during mitigation related to success.

Narrative responses from the questionnaire indicate that the researchers typically monitor mitigation efforts based on goals and objectives in their monitoring plan or permit requirements. Very few states indicated that they focus on just one set of function and values, such as groundwater recharge or discharge for each site. Most wetlands require replacement of various functions and values.

MONITORING TECHNIQUES

The questionnaire also requested information about monitoring techniques used in wetland mitigation programs. Figure 4.16 shows the use frequencies of several monitoring techniques from the questionnaire responses, with vegetation sampling being the most frequently used technique.

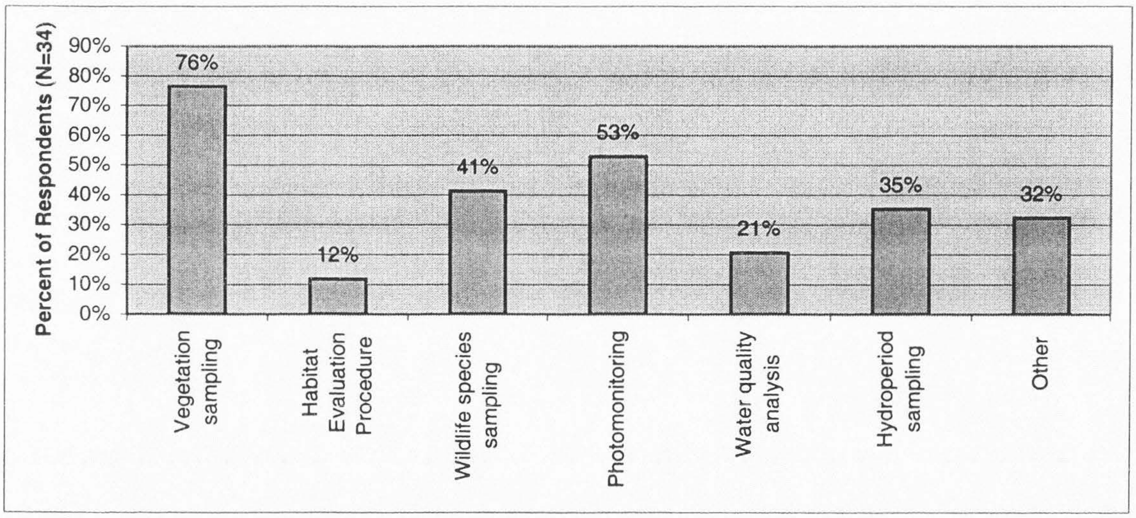


Figure 4.16. Monitoring techniques

When related to success, none of the techniques were statistically significant. They merely followed the general success distribution like many previous examples, with the monitoring technique used reflecting project objectives

Inventory techniques in the questionnaire also are related to possible monitoring techniques that DOT's may use. Figure 4.17 shows inventory techniques that DOT's use to inventory wetlands. The most frequent inventory technique is production of plan maps followed by "other" techniques, defined mostly as a compilation of data reports.

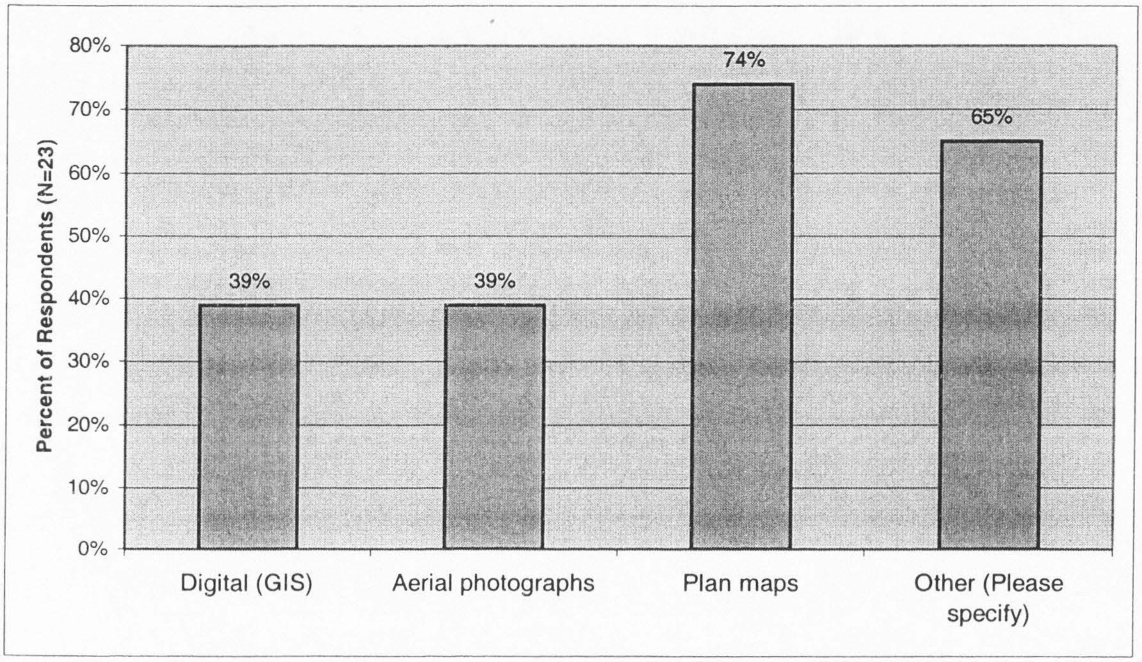


Figure 4.17. Inventory techniques for wetlands.

Figure 4.18 shows the use of digital (GIS) techniques, which has a low p-value though not statistically significant when related to success (p-value = 0.0628). In the high success category, more states do not use digital (GIS) inventory techniques, while those with digital (GIS) techniques have lower success. The states that use GIS have a lower success, and this may be an attribute of the sample success curve, or the relative newness of the technology coupled with scale restrictions and efficiency of acquired data sources. In addition, GIS may allow more accurate acquisition of quantitative data, leading to sites failing permit requirements because of better data. The newer technology leads to more objective data, because the researcher has less bias built into the quantitative data, thus allowing more rigorous evaluation.

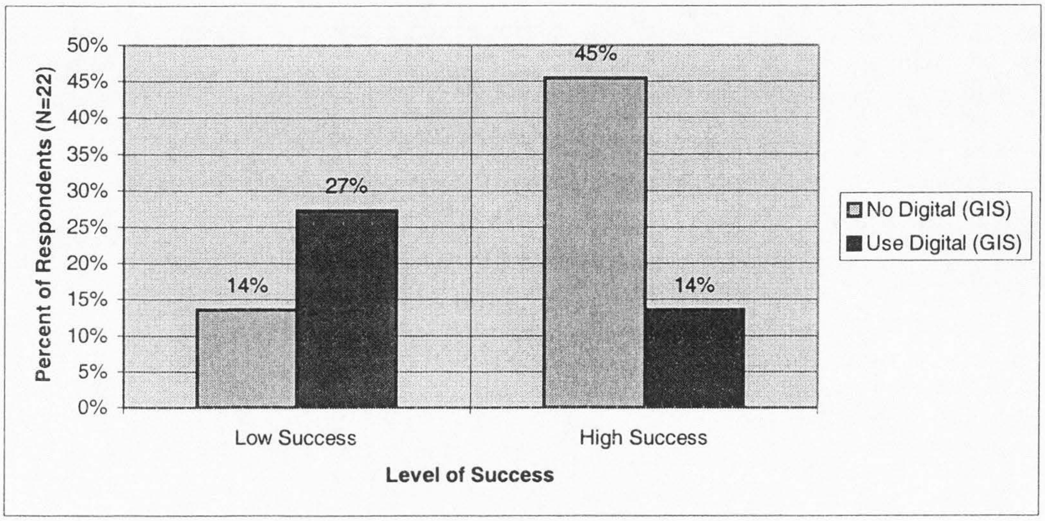


Figure 4.18. Digital (GIS) inventory techniques related to success.

SITE ADJUSTMENT

Effective monitoring requires effective use of monitoring data, applied to correcting problems based on indications from the monitoring program. Many states indicated in the narrative portion that monitoring is a problem because the data is seldom used or staffing limits collection of the required data. One recommendation suggested by several states is the need to "establish better criteria, stop relying on universal and formal procedures, guidelines and policies, and always make adjustments of criteria to reflect site conditions".

MAINTENANCE

GENERAL PRACTICES

One of the questions in the questionnaire addressed active management of wetlands. A low frequency of 26% (N=34) of respondents reported active management of mitigation wetlands after the monitoring period. When related to success, active management is not strongly related as shown in Figure 4.19.

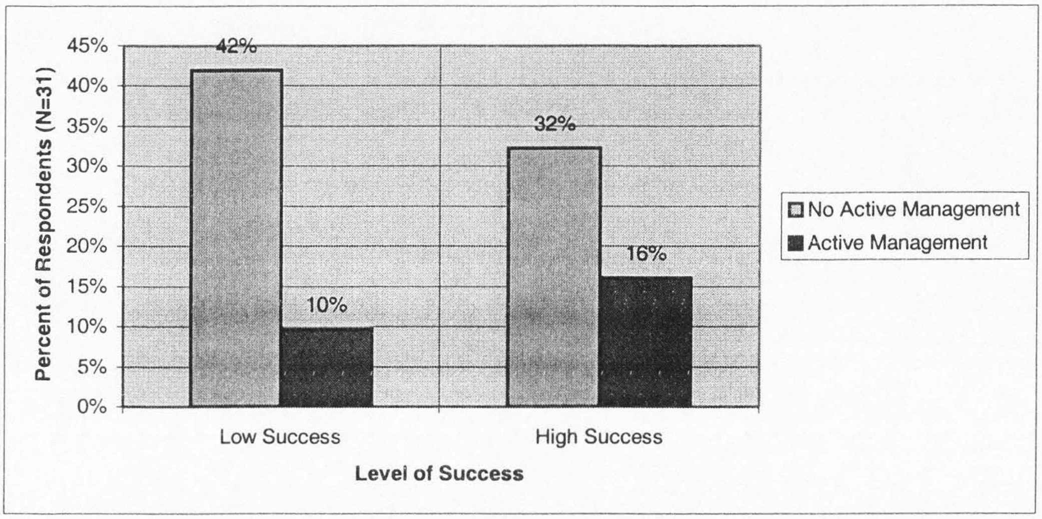


Figure 4.19. Active management of wetlands after monitoring period related to success.

The lack of a relationship is probably a function of sample size, because the graph begins to show an expected relationship of actively managed sites having better success. Garbisch (1990) discusses how maintenance is an important part of a successful mitigation plan, allowing correction of problems that reduce proper wetland function.

Some of the telephone interviewees found maintenance to be a major issue limiting success of operations. Lack of long term planning, funding, and training for maintenance personnel and programs may cause this limitation. Maintenance may become an issue more closely tied to success if more states put energy into active management plans.

MAINTENANCE PERSONNEL

Maintenance personnel involvement in various wetland mitigation activities is minimal. Only 12% (N=34) of respondents have maintenance staff involved in evaluation of site plans and specifications, even though they may be responsible for performing maintenance activities on the site. The frequency of maintenance staff involvement in supervision of wetland construction is 9% (N=34). Without a voice in the entire process, they may have little knowledge of their role and, therefore, may be limited in their ability to suggest necessary changes to improve maintenance once the project is completed.

Different crews may have responsibility for maintaining the mitigated wetlands. Figure 4.20 shows the frequency of crews responsible for wetland maintenance, with general roadside crews performing most of these activities. The responsible crew related to success is statistically insignificant.

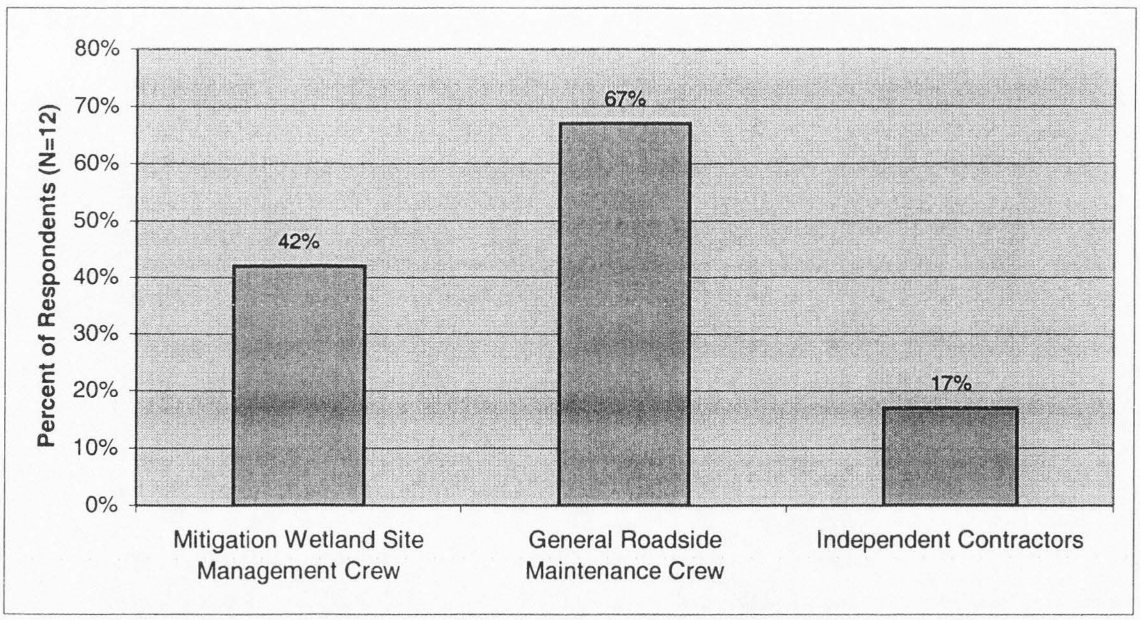


Figure 4.20. Crew responsible for wetland maintenance.

Wetland training for maintenance personnel was also addressed in the questionnaire. Seventy-five percent (N=12) of states that report maintenance activity have training for their maintenance personnel who deal with wetland management. One of the narrative responses addressing the issue of improving wetland maintenance was that "a training course would be great". Lack of training limits the quality of maintenance on a site.

MAINTENANCE ACTIVITIES

A variety of maintenance activities occur on mitigated wetlands, even if the DOT does not actively maintain their mitigated wetlands. Figure 4.21 shows the various maintenance activities and their frequency, with the most frequent maintenance activity

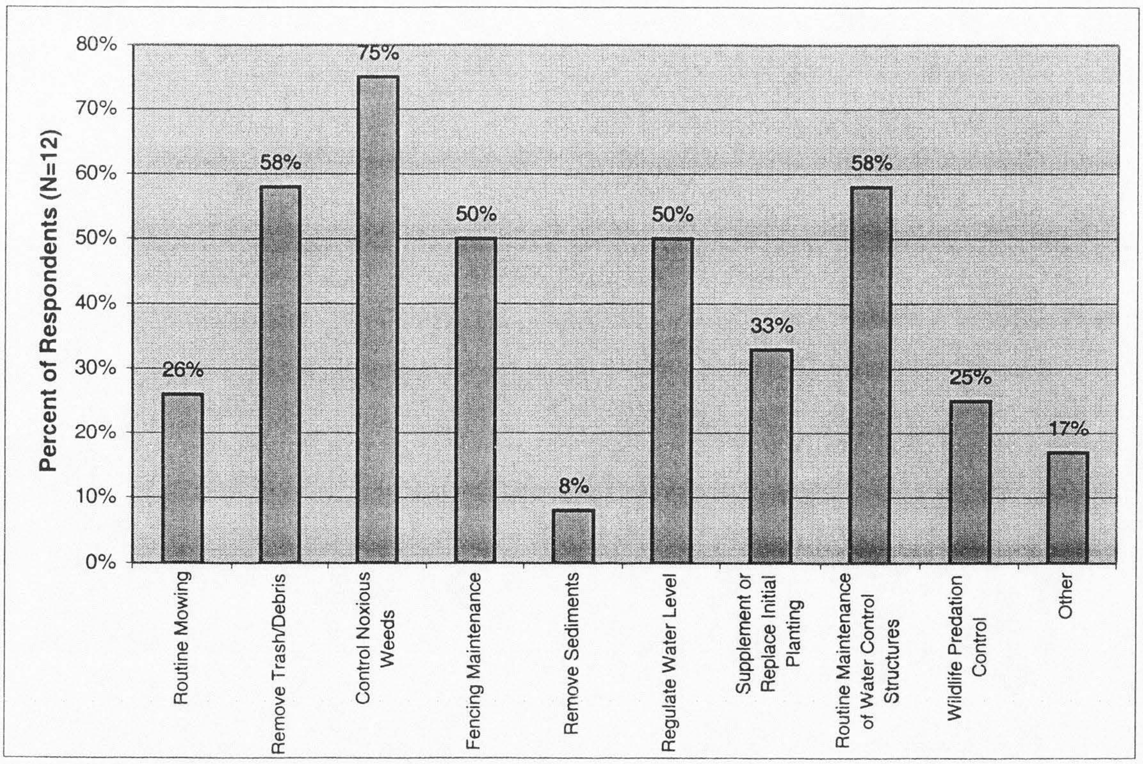


Figure 4.21. Maintenance activities.

being noxious weed control. Weed control is frequently addressed in the literature, because of the importance of the desired plant communities to wetland function and frequent government-mandated weed control. When related to success, none of the management activities are statistically significant.

Figure 4.22 shows a typical relationship of maintenance activity to success, with noxious weed control contributing slightly to the success rating. A larger sample size may have created a more significant relationship because those that practice noxious weed control regularly may experience more success with their wetland mitigation projects.

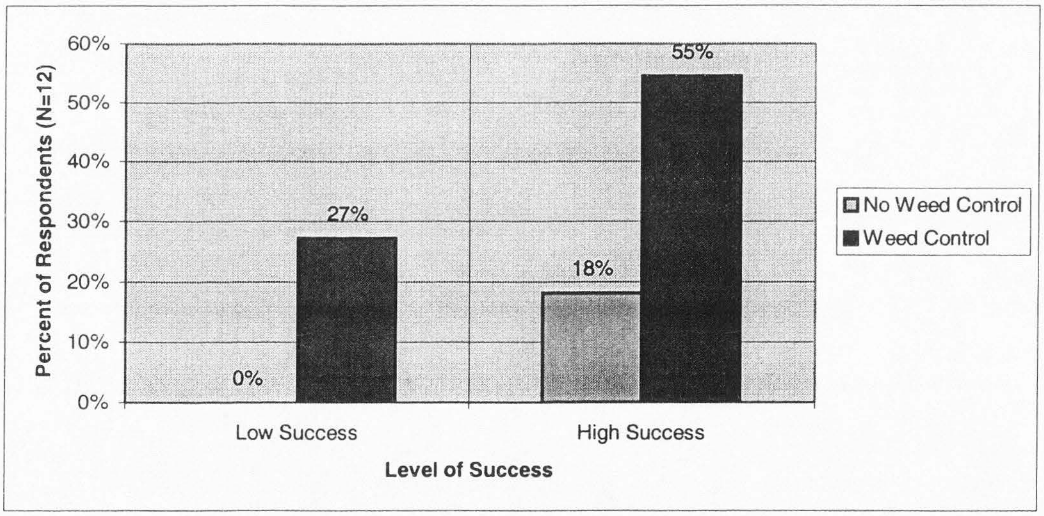


Figure 4.22. Noxious weed control related to success.

TIMING OF MAINTENANCE ACTIVITIES

The questionnaire also looked at how often DOT's perform maintenance activities. The timing for maintenance activities was sporadic, with very few states performing activities on a regular basis. Figure 4.23 shows the frequencies for the timing

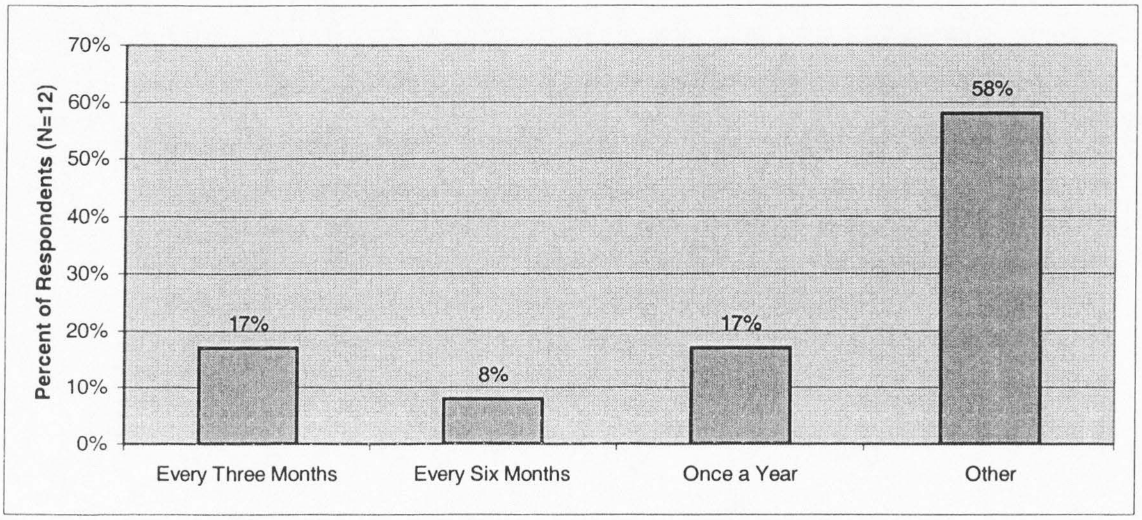


Figure 4.23. Timing of management activities.

of maintenance activities. Other, which was usually defined "as needed" by respondents, was the most frequent maintenance schedule. The timing of maintenance activities related to success showed an insignificant relationship.

FUNDING

GENERAL ISSUES

Funding for staff to monitor and evaluate mitigated wetlands, funding for mitigation wetland maintenance, and funding for retrofitting failures were common to universal problems for a majority of the state DOT's. Responses from the telephone interview suggest that additional funding is important to improve quality. DOT's would benefit by "outlining funding sources for their monitoring and maintenance". Figure 4.24 shows the general sources for wetland mitigation funding, with most of the funding coming directly from project costs. When related to success, no funding source has a significant relationship.

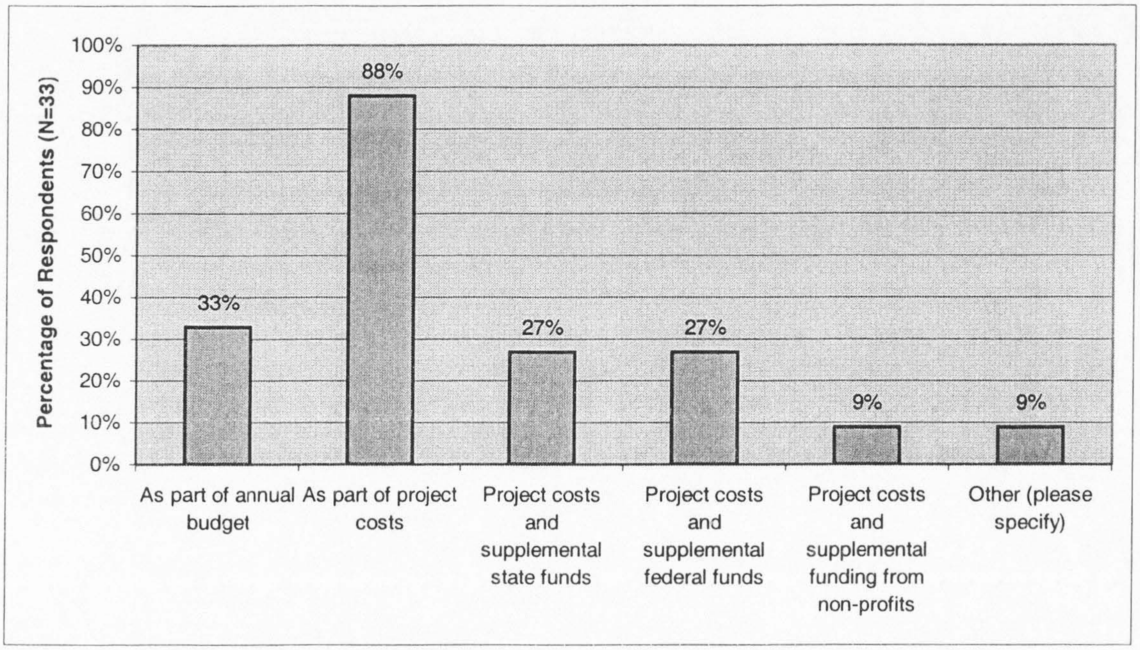


Figure 4.24. Funding sources for wetland related tasks.

ADDITIONAL FUNDING

Whether a state had additional funding for site maintenance activities was another focus of the questionnaire. Since most of the funding comes from project costs, funding availability for maintenance activities can be limited. However, only 26% (N=34) of states have additional funding for wetland maintenance, with no significance when related to success.

An alternative to increasing funding is employing volunteer labor to perform post-construction monitoring and maintenance tasks. State DOT's, however, do not consistently use this option, with only 18% (N=34) using volunteer labor for mitigation activities. In addition, those that use volunteer labor were not significantly related to success, likely because of the low number of DOT's taking advantage of volunteer labor. Narrative responses suggest an interest in exploring the use of volunteer labor, especially in monitoring activities. In addition, Kentula, *et al.* (1993) present an effective volunteer program for wetland monitoring, which shows the staffing and educational benefits of volunteer programs.

FUNDED POSITIONS

Most states have staff devoted specifically to wetland related tasks, with 71% (N=34) having exclusively funded positions. No significant relationship exists between having funded positions and success, as seen in Figure 4.25.

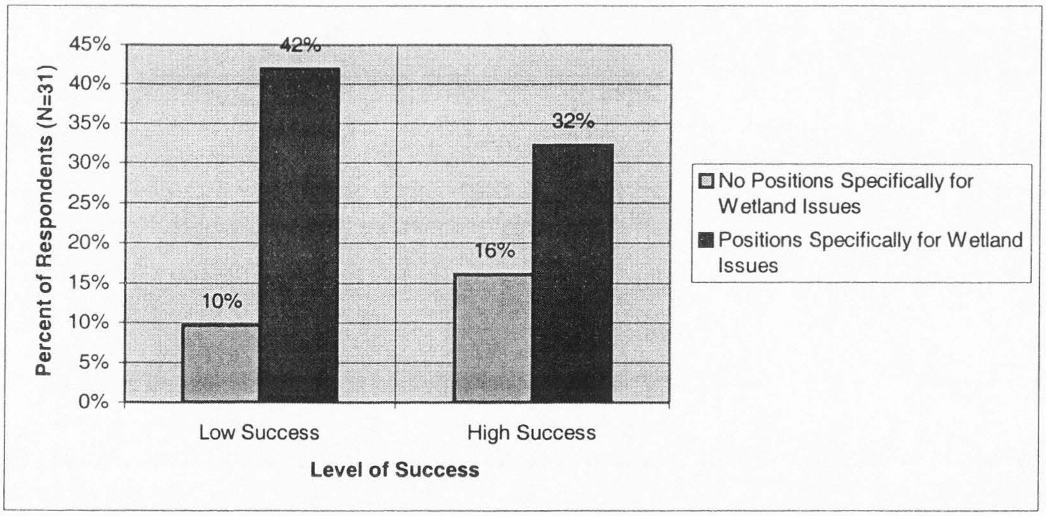


Figure 4.25. Positions specifically funded for wetland issues related to success.

Figure 4.26 shows professions in funded positions, with wetland ecologists being the most frequently funded position. This is expected due to the large percentage of wetland ecologists involved in wetland mitigation activities.

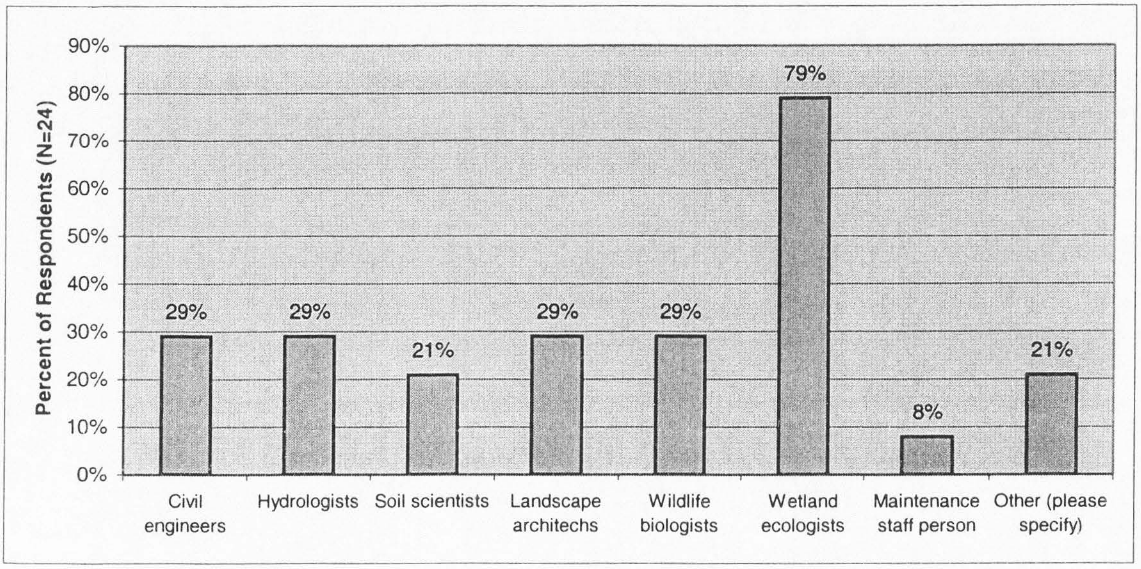


Figure 4.26. Professions in positions funded specifically for wetland issues.

CHAPTER SUMMARY

Very few significant relationships showed up in the analysis of the questionnaire results, and these relationships were occasionally contrary to the expected relationships. The high level of estimated success in addition to the small sample size may be reasons for the limited number of significant relationships when compared to estimated success. Frequency results, however, did provide insight into the common activities of DOT's in relation to their mitigated wetlands. UDOT can use the common practices as a guide for their mitigation plan. The frequency results can also help identify needs in wetland programs. For example, more states may require additional funding for maintenance, but if they are not receiving adequate funds from projects they need to seek external funding sources.

The survey results were slightly disappointing in that they did not highlight specific practices that clearly lead to success. This, however, echoes some responses from the questionnaire and telephone interviews that no one set of standards works for everyone. Some key components, such as having a wetland ecologist on staff to monitor and evaluate wetland sites and the importance of planning, may be useful for most wetland mitigation plans. Using a "cookbook" approach, however, may be detrimental to an effective wetland mitigation strategy. This rejection of completely standardized procedures was apparent in the literature, with most guidelines advocating mitigation strategies tied closely to project objectives. The most frequent attributes of states' mitigation strategies and suggestions in the narrative responses serve as guidelines for reviewing mitigation strategies and making changes to improve the strategy, rather than an exact formula for success.

CHAPTER V

CONCLUSIONS

SECTION CONCLUSIONS

This section contains a summary of information gathered in the literature review, questionnaire, and telephone interviews. Items noted below were generally repeated throughout the sources, identifying them as key areas of focus for improving wetland mitigation processes, procedures, and practices. The process of evaluating or improving current wetland mitigation planning efforts could focus on these areas.

The causes of mitigation wetland failure that appeared on over 50% of the questionnaires returned include:

- "Inexperienced contractors"
- "Poor mitigation site selection"
- "Inadequate pre-construction orientation of contractor to wetland-related issues"
- "Inadequate wetland-related education/experience of DOT construction inspectors"
- "Insufficient funding for mitigation wetland maintenance"
- "Insufficient time allocated to supervision of wetland construction and planting"
- "Inadequate mitigation site analysis of existing conditions prior to design"
- "Poor maintenance"
- "Incompatible mitigation site and objectives"

These findings are consistent with the literature and interview responses previously discussed. The following sections discuss conclusions from each major section of the report including monitoring, maintenance, and funding.

MONITORING

- Monitoring must be tied with project objectives and goals to be relevant and cost efficient. If objective and goal identification are poorly executed, monitoring likely will be unguided and ineffective.
- Effective wetland strategies requires effective use of monitoring data for feedback to determine the intensity of monitoring that needs to continue and to evaluate progress. Effective use requires that the data is compiled in a usable format and that data is used in a timely manner to allow relevant corrections as soon as problems become noticeable. In best case, monitoring data also should be useful for learning which design components work and which do not work for future reference.
- Outlining a specific time schedule for monitoring activities is considered important in literature and narrative responses. Several guidelines suggest appropriate time schedules, which are flexible depending on the complexity of the project.
- Quality monitoring programs require that personnel completing monitoring activities and evaluation of monitoring data have sufficient training and education. Wetland ecologists are key personnel involved in these activities.

Consultants are often also important players in these activities, bringing specialized knowledge when a DOT has personnel with limited wetland expertise.

- Monitoring and evaluation during construction by trained personnel is necessary to identify problems with the design and site conditions immediately in order to eliminate the need to fix avoidable problems during post-construction activities. This requires a monitor or evaluator that is knowledgeable of wetland design and construction practices and capable of maintaining a good working relationship with the contractors.
- Monitoring protocols require built-in flexibility. Rigid standards often do not reflect specific project goals and site conditions, wasting time and resources.
- Suitable monitoring techniques depend on the utilization of data for decision-making, specific project goals and objectives, and staffing and technology available to the DOT's. A combination of techniques is often desirable for monitoring wetlands.

MAINTENANCE

- Maintenance should be closely tied with project objectives and goals.
- Maintenance personnel have little involvement in the rest of the mitigation process. Lack of maintenance personnel involvement throughout planning and implementation may contribute to failure.
- Specific mitigated wetland maintenance is not an activity undertaken by most state DOT's. General roadside crews typically complete wetland maintenance.

- Proper maintenance of wetlands requires specific training since wetlands are considerably different from upland situations and are regulated by the federal government. Both these conditions require maintenance techniques that differ from normal roadside maintenance practices. Currently, only a few states offer training for wetland maintenance personnel.
- Maintenance personnel should respond quickly to wetland problems to minimize the potential for problems reaching an unmanageable size.

FUNDING

- Information on funding is very limited in the literature. Many sources spoke of the need for funding, but did not suggest solutions to the funding problem.
- Funding for wetlands, in most instances, comes from project costs, which limits funding availability for monitoring and post-construction mitigation activities.
- Supplemental funding possibilities include receiving federal and private non-profit grants, or in-kind services from volunteers. States can also implement a fining or guarantee system, ensuring that the contractors' construction of the mitigated wetlands meets specified performance standards.

GENERAL CONCLUSIONS

From the collection of the survey data, information gathered in the literature review, state questionnaire respondent comments, and telephone interview responses, some general conclusions can be made about the elements that contribute to a high level of mitigation wetland success. The elements contributing to a high level of success include the following:

1. Good Communication

"If you don't see water or don't have equipment becoming stuck, call us!" was a comment from one state respondent in reference to communication between contractor and design team. The importance of good communication is mentioned often as a key element of successful project completion. Recognizing problems early in the project can increase the probability for successful corrective action, but only if clear channels or methods of communication exist.

Comments from respondents include: "[We need an] improved transfer of information between phases of planning, design, construction, and operations", and "[we need] good communication between wetland biologist, landscape architect, and hydrologic engineer."

Communication with resource agencies is also important during the wetland mitigation process. Respondents stated that DOT's need "[to receive] more details and input from regulatory agencies approving mitigation", "[to] make and keep contacts with the agencies to allow effective communication", and "[to] involve agencies on site."

2. Involvement of an Interdisciplinary Team Through All Mitigation Phases

An interdisciplinary team is one in which individuals from more than one area of expertise are involved. The word interdisciplinary implies that rather than each profession working individually on their specific area of expertise, professionals share information and cooperate. By working together, team members arrive at a solution or plan that will more likely achieve success.

Although the survey data are inconclusive with respect to the combinations of professions that result in a high level of success, information in the literature, and narrative responses support the involvement of professionals from various disciplines. Some related comments from respondents about the importance of interdisciplinary work include the following: We need to have "a diverse professional evaluation", "a peer review of plans and [specifications]", "a team approach", "an interagency review group", "sharing of information", and we should "bring in specialists."

Some sources suggest that consultants can bring specialized knowledge to the interdisciplinary team. One narrative source noted that employing consultants allows DOT's to bring in experienced staff when needed, rather than having surplus staff during times of little mitigation activity. The respondent stated, "Hire consultants on retainer so that they're not understaffed or overstaffed depending on the amount of work." However, the use of consultants does not override the importance of having a trained interdisciplinary staff within the state DOT. Some DOT's suggested eliminating consultants completely. Because consultants may have little understanding of the DOT process, state DOT's need trained personnel to coordinate the process and ensure that consultants are contributing elements that are necessary in the DOT process.

3. Integration of Activities in Wetland Mitigation

Integrating all wetland mitigation activities allows an immediate identification of problems and avoidance of preventable problems. In addition, integration permits the information gathered in one phase of the mitigation process to influence the next course of action. This eliminates unnecessary activities by coordinating project needs in response to project objectives and progress already made. This integration also includes ensuring that those involved in other elements of the highway project, besides wetland mitigation, have an understanding of wetland issues.

Narrative responses that address the need for integrated activity include the following: "Only conduct monitoring-indicated maintenance", rather than keeping activities independent and "make sure that everyone has a clear understanding of wetland issues in [the] project ahead of time".

4. Proper Mitigation Site Selection

The respondents ranked "improper site selection" as the second most frequent cause of mitigated wetland failure. Very closely tied to improper site selection is "inadequate mitigation site analysis of existing conditions prior to design". This was also ranked in the top five most frequent causes associated with failure. Comments from state respondents, contractors, consultants, and agency personnel indicate that this is a major issue in the wetland mitigation field. The insufficiency of hydrologic systems in a mitigated wetland is the most commonly cited problem of the selected site.

Hydrologists and soil scientists are team members important in the site selection and evaluation process. Hydrologists should be able to determine if proper hydrology is present or if it can be manipulated. Soil scientists should be able to determine the soil type and look for characteristics that would indicate previous inundation and determine water-holding capacity.

Comments from respondents include: Causes of failure are "improper site selection", "lack of stable water, lack of predictable hydrology", "improper design for site selected", and "[inadequate] pre-construction monitoring of site."

Suggestions for improving the process of site selection include the need for more money dedicated to the early stages of the mitigation process so that a proper job of site selection is completed, based on a thorough analysis of the functions and values needing replacement. Proper preparation and decisions made in the early stages are beneficial during a project.

5. Experienced and Trained Individuals Involved in Wetland Mitigation

Experience and training are mentioned often as important elements of a successful wetland mitigation project. Because many unanticipated problems can occur throughout the process, experience can be an advantage. Experience is especially important when it comes to the actual construction phase of the project. "Contactors with little or no wetland related construction or planting experience" was ranked as the number one cause of mitigated wetland failure. Sources suggested that a short list of specialized contractors within an area should be developed for use on projects. The low-bid process does not work well for wetland mitigation projects, unless pre-qualification requirements are stringent.

"Inadequate education or experience of construction inspectors" also ranked highly on the list of causes most frequently associated with failure. Having trained supervisors and inspectors is especially important. Comments from respondents include:

[There is a need for] "more training and education", "formalized instruction", "trained project engineers", and "more experienced professionals."

6. Consistency of Methods and Strategies

Consistency during the wetland mitigation process is important, though few references or respondents felt that wetland mitigation strategies should or could be standardized. However, guidelines and checklists for wetland activities can be beneficial if they are specific enough to maintain regularity, yet flexible enough to adjust to variables. Comments from respondents included that [there is a need for] "a good checklist for all aspects of a plan", "maintenance protocols", and "a format to follow."

7. Flexibility of Methods and Strategies

Though wetland mitigation strategies must maintain consistency, they also must incorporate flexibility. The fact that successful states had varying mitigation practices emphasizes that a variety of approaches lead to success. All activities must respond to specific project needs, and project needs can be diverse. Otherwise, mitigation activities may be irrelevant and waste DOT resources.

Narrative responses that indicate the need for flexible approaches include the following: "Stop relying on universal, formal procedures, guidelines, and procedures"; "always make adjustments or criteria to reflect site conditions"; and deal with problems with a "project specific" approach.

8. Proper Planning and Follow-Through

Planning facilitates the entire wetland process, allowing early identification of possible problems and needed action, resources, and communication. Not only does planning allow a thorough examination of critical elements in the process, it also allows better reaction to unanticipated situations. Narrative responses noted that, "criteria needs to be carefully thought out", and DOT's "need to clarify, in detail, the scope of work."

FOLLOW-UP PHASE

A number of ways exist to enhance the planning and implementation process for wetland mitigation in state DOT's. From the information gathered in this report, UDOT staff can evaluate their process and look at ways to integrate wetland mitigation strategies into the general engineering and scheduling process of highway construction projects. Specific recommendations for changing the UDOT process can be developed from needs and strategies discussed in this report. The following are examples of how UDOT might take findings from this research and develop specific recommendations for their program.

- Research indicated that hiring and retaining experienced and qualified staff in several disciplines is essential. If this is a problem in their program, UDOT could develop a specific recommendation for individual DOT districts to develop a retention program for their wetland staff and to have an interdisciplinary team that includes all essential professions within the state.
- Research indicated that training is essential for various phases of wetland mitigation. After an assessment of their program, UDOT may see shortcomings in the training of their wetland construction supervisors and wetland maintenance staff and develop a specific recommendation to

implement wetland-training courses for these groups. Training for wetland contractors in a number of venues could also improve success.

- Research indicated that communication is essential for successful wetland programs. After examining their program, UDOT may see a communication breakdown between their wetland staff and the engineering design team during various phases of their design process and make specific recommendations to use various techniques to eliminate these communication bottlenecks.
- Research indicated that data accessibility is a problem when attempting to determine changes that need to occur in a project or to learn from success and failure of past projects. If UDOT sees a shortcoming in their program in this area, they may develop a specific recommendation for a statewide database that allows personnel to search project results for past projects that have similar characteristics to a current project.

These are just a few examples of how the information in this report can serve as a starting point for an evaluation of current mitigation wetland policies, programs, procedures, and processes and develop into specific recommendations that are directly applicable to how a DOT executes mitigatory wetland projects. Because of variability with wetland challenges and structure of DOT's, every state or district may need to approach the enhancement of their wetland program differently.

CHAPTER SUMMARY

Quality wetland mitigation strategies require extensive planning and commitment to the plan to ensure that intentions are carried out. The sources express that no exact formula for success exists, and the fact that successful states had varying practices emphasizes that no one approach leads to success. Overall, the research sources suggest that all components of a wetland monitoring strategy should be integrated components that allow feedback and reevaluation. Some states, by nature of their wetland ecosystems, have more challenges with wetland mitigation and must respond accordingly. By keeping mitigation plans focused and proceeding with intention rather than chance, states may have more success in wetland mitigation.

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APPENDIX A

ABSTRACTS

Adamus, P.R. and K.H. Brandt. 1990. *Impacts on the Quality of Inland Wetlands of the United States: A Survey of Indicators, Techniques, and Applications.* EPA/600/3-90/073. United States Environmental Protection Agency. Environmental Research Laboratory: Corvallis, OR.

Focuses on biological systems at organism and population level as they react to wetland conditions. Monitoring focus stems from project objectives, and a series of biological indicators are used to determine if project meets objectives.

Adamus, P.R. and L.T. Stockwell. 1983. *A Method for Wetland Functional Assessment, Volumes I and II. FHWA-IP-82-23.* Federal Highway Administration. Office of Research, Development and Technology: Washington, D.C.

Evaluates and monitors wetlands based on a standardized set of wetland functions. Very intensive and complete data gathering.

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 Survey Special Publication 19.

Discusses all stages of wetland mitigation, including planning and implementation, design, and management. Specifically for Illinois wetlands but parts could successfully be adapted in another region.

Cable, T.T., V. Brack, Jr. and V.R. Holmes. 1989. Simplified Method for Wetland Habitat Assessment. *Environmental Management.* Vol. 13, No. 2, pp. 203-213.

Uses avian species composition and wetland size to determine faunal index value. Monitoring can occur through recording changes in faunal index over time.

Cooperrider A.Y., R.J. Boyd, and H.R. Stuart (Eds.). *Bureau of Land Management Inventory and Monitoring of Wildlife Habitats.* BLM/YA/PT-87/001. United States Department of Interior. Bureau of Land Management: Washington D.C.

Developed to inventory and monitor wildlife habitat to increase efficiency. The focus is on the planning process, with monitoring identifying changes in form, structure, and wildlife use.

Galatowitsch, S.M. and A.G. van der Valk. 1994. *Restoring Prairie Wetlands: An Ecological Approach.* Iowa State University Press: Ames.

Discusses the ecological restoration of prairie wetlands, from design considerations to management. Many suggested maintenance techniques are applicable for other types of wetlands, as well as prairie pothole wetlands.

Interagency Mitigation Task Force (IMTF). 1994. *Maryland Compensatory Mitigation Guidance.*

Briefly discusses monitoring related to mitigation wetlands. Also discusses monitoring procedures.

Iowa DOT. 2000. *Mitigation Monitoring Protocol for Wetlands Investigation and Protection Program.*

Uses the PennDOT procedure as a guideline. Describes a workflow sequence with specified products and procedures for each wetland monitoring activity.

Kentula, M.E., R.P. Brooks, S.E. Gwin, C.C. Holland, A.D. Sherman, and J.C. Sifneos. 1993. *An Approach to Improving Decision Making In Wetland Restoration and Creation.* Edited by A.J. Hairston. U.S. Environmental Protection Agency, Environmental Research Laboratory: Corvallis, OR.

Offers a basic framework for wetland management specifically towards decision-making for public agencies. Discusses evaluation procedures and offers a flexible program for monitoring that relates to goals set in the initial phases of the plan.

Kusler, J.A. and M.E. Kentula (Eds.), 1990.*Wetland Creation and Restoration: The Status of the Science.* Island Press: Washington D.C.

This volume contains a collection of papers representing a preliminary evaluation of the status of the science of wetland creation and restoration in the U.S. General conclusions include:

- *Wetland creation and restoration projects are complex and difficult.*
- *Methods for determining clear, sound goals need to be outlined.*
- *Clear, quantitative methods need to be established for determining if goals have been met.*

Leibowitz and Brown, 1990. In Hunsaker, C.T. and D.E. Carpenter (Eds.) 1990. *Environmental Monitoring and Assessment Program.* EPA/600/3-90/060. Atmospheric Research and Exposure Assessment Laboratory, Office of Research and Development, U.S. Environmental Protection Agency: Research Triangle Park, N.C.

Uses response indicators to measure the general health of a wetland. Changes in wetland are identified using exposure and habitat indicators, "associated with change over time".

Lewis, A.T., R.G. Kempka, R.E. Spell, and F.A. Reid. 1998. "Wetlands Mapping and Monitoring in California". pp.139-145. In J.D. Greer (Ed.). 1998. *Natural Resource Management Using Remote Sensing and GIS: Proceedings of the Seventh Forest Service Remote Sensing Applications Conference.* American Society for Photogrammetry and Remote Sensing: Bethesda, MD.

Discusses wetland monitoring at regional scale by generating a GIS model from a number of data sources, including satellite imagery, and existing databases.

Payne, N.F. 1992. *Techniques for Wildlife Habitat Management of Wetlands.* McGraw-Hill, Inc: New York, NY.

Comprehensive resource for wetland management, especially in area of wildlife habitat. Discusses management of hydrologic, vegetative, and biological resources in wetlands, with corresponding management techniques applicable in many wetlands.

Pennsylvania Department of Transportation (PennDOT). 1997. *The Transportation Development Process: Wetlands Resources Handbook.* Publication No. 325. Pennsylvania Department of Transportation. Bureau of Environmental Quality: Harrisburg, PA.

Serves as a guideline for managing mitigation wetlands in transportation projects. Discusses all phases of wetland mitigation and contains a comprehensive section on monitoring, with suggestions for data collection and corresponding forms.

Phinn S.R., D.A. Stow, and J.B. Zedler. 1996. Monitoring Wetland Habitat Restoration in Southern California Using Airborne Multispectral Video Data. *Restoration Ecology.* Vol. 4, No. 4, pp. 412-422.

Article discusses using remote sensing to differentiate vegetation types, with differing spectral reflection of different types of vegetation picked up by multispectral imagery. The authors used this imagery to monitor habitat in restored wetlands.

Rosen B.H., P. Adamus, and H. Lal. 1995. A Conceptual Model for the Assessment of Depressional Prairie Wetlands in the Prairie Pothole Region. *Wetlands Ecology and Management.* Vol. 3, No. 4, pp.195-208.

Discusses sampling techniques for prairie pothole wetlands based on a model developed for assessment of these wetlands.

Smith, D. R. 1995. *An Approach for Assessing Wetland Function Using Hydrogeomorphic Classification, Reference Wetlands and Functional Indices.* Technical Report WRP-DE-9. U.S. Army Corps of Engineers: Vicksburg, MS.

Evaluates wetlands based on hydrogeomorphic characteristics of geomorphic setting, water source, and hydrodynamics. From this a series of regional assessment models are developed. Monitoring is based on standards of comparison for regional models and measuring functional capacity, or performance of a functional wetland.

United States Fish and Wildlife Service (USFWS). 1980. *Habitat Evaluation Procedure.* ESM 102. Division of Ecological Services. United States Fish and Wildlife Service. Department of the Interior: Washington D.C.

Evaluates quality of habitat for wildlife species through development of habitat suitability indices. Researchers can monitor wetlands by recording changes in habitat suitability index over time.

APPENDIX B

QUESTIONNAIRE

Mitigation Issues Wetland Questionnaire

August 16, 2001

Dear :

Millions of dollars are spent annually by Departments of Transportation (DOT) on wetland mitigation projects, yet success rates remain low. Regulatory and resource management agencies are becoming increasingly concerned about the number of constructed mitigation wetlands that fail to meet the performance specifications and ecological value criteria required in permits. Dealing with failed wetlands is costly, time consuming and often frustrating.

The Utah Department of Transportation (UDOT) is seeking ways of improving the quality of wetlands on mitigation sites. To meet this goal, UDOT has initiated a research project in cooperation with the Department of Landscape Architecture and Environmental Planning at Utah State University. Research will focus on the following wetland mitigation issues:

Evaluation	Inventory
Monitoring	Funding
Maintenance	Staffing

We need your help! As part of the research design, we have prepared this questionnaire which will be sent to DOTs in all 50 states. We believe a synthesis of questionnaire responses will provide insights into why many wetlands on mitigation sites fail. More importantly, we are interested in finding out what DOT policies, programs, and protocols lead to successful mitigation projects.

Please take a few minutes and complete this questionnaire. Your responses will contribute to the broad base of information necessary for UDOT to effectively plan, implement and manage mitigation wetland sites. UDOT will share the research findings with all state DOTs that return this questionnaire. All responses will be kept confidential. Anticipated publication of the final report is June, 2001.

Questionnaire

- The numerical codes used for the statistical analysis are included in this sample of the questionnaire as a reference for the results in Appendix F and Appendix G. These codes are indicated by italics and are placed in the center of the blanks in the sample questionnaire.
- For those questions where a code is not indicated on this questionnaire, the following coding was used:
  - If the respondent marked a blank with a check mark or chose the "YES" option, the result was coded as 1.
  - If the respondent left a blank unmarked or chose the "NO" option, the result was coded as 0.

Mitigation Issues Wetland Questionnaire

Background Questions

State ______________________

A. Your Educational Background

a. _____ Civil engineer

b. _____ Landscape architect

c. _____ Environmental engineer

d. _____ Biologist/Ecologist

e. _____ Other (please specify)

B. Your position within the DOT

____

C. Years of experience in dealing with mitigation wetland-related issues.

_*1*_ 0-5 _*2*_ 5-10 _*3*_ more than 10

Causes of Mitigation Wetland Failure: Overview Questions

1. Based on your experience, rate the frequency with which each cause is associated with failure. Please check appropriate box.

		4 Universal	3 Very Common	2 Common	1 Uncommon	0 NA
a.	Poorly defined mitigation goals					
b.	Poor mitigation site selection					
c.	Incompatible mitigation site and objectives					
d.	Inadequate mitigation site analysis of existing conditions prior to design, particularly soils, and hydrology.					
e.	Unsatisfactory, inadequate, or incorrect mitigation site design					
f.	Poor planting plan and specifications/failure to follow plan					
g.	Poor planting stock					
h.	Proposed plants unavailable					
I.	Inadequate wetland construction documents and specifications					
j.	Inadequate pre-construction orientation of contractor to wetland-related issues					
k.	Inexperienced contractors (little or no experience in wetland construction or planting					
l.	Insufficient time allocated to supervision of wetland construction and planting					
m.	Inadequate wetland-related education/experience of DOT construction inspectors					
n.	Inadequate funding for staff to monitor and evaluate mitigated wetlands					
o.	Insufficient funding for mitigation wetland maintenance					
p.	Poor maintenance					
q.	Lack of as-built documentation of mitigation wetland configuration, i.e. makes remediation planning difficult					
r.	Insufficient funding to retrofit failures					
s.	Insufficient funding for quality wetland construction					

2. Please estimate the percentage of wetland mitigation sites implemented by your DOT over the past five years that have met specified performance criteria after the 3/5-year monitoring period and are approved by the Army Corp.

________% *1= 0-20%, 2= 21-40%, 3= 41-60%, 4= 61-80%, 5= 81-100%*

Evaluation

3. Which of the following professions in your DOT or hired consultants is involve in evaluation of mitigated wetland mitigation site plans and specifications. (Check all answers that apply)

   a. _____ Hydrologist
   b. _____ Soils scientist
   c. _____ Civil engineer
   d. _____ Landscape architect
   e. _____ Wetland ecologist
   f. _____ Wildlife biologist
   g. _____ Maintenance staff
   h. _____ Other (please specify)

4. The person or persons doing the evaluation are

   __1__ DOT employee
   __2__ Consultants
   __3__ Combination of above

5. If more than one profession is involved, how would you rate communication between the professions?

   __4__ Excellent
   __3__ Good
   __2__ Fair
   __1__ Poor
   __0__ NA

6. What means are used to ensure communication?

   a. _____ Meetings
   b. _____ Checklists
   c. _____ Correspondence sign off

7. Does your DOT have a check list or similar guide for reviewing mitigated wetland mitigation site plans and specifications before construction?

_____ Yes

_____ No

If you have a checklist or other type of review guide, would you please send it with your returned questionnaire.

8. Do you believe sufficient staff and time are allocated to review mitigation plans and specifications as part of the entire project review process?

_____ Yes

_____ No

9. Based on your experience, which of the elements of a wetland mitigation plan and specification are most likely to need revision? (Check all answers that apply)

a. _____ Plan hydrology
b. _____ Grading plan
c. _____ Planting plan and schedule
d. _____ Inlet/outlet overflow design
e. _____ Other structural design features
f. _____ Grading specifications
g. _____ Site preparation specifications (for planting)
h. _____ Specifications for planting stock
i. _____ Specifications for structural features
j. _____ Other (please specify)

10. What would you recommend to improve DOT evaluation of mitigation plans and specifications?

11. Who in your DOT or hired consultants is responsible for evaluating the on-site construction of wetlands?

____

Job title (list all titles if more than one individual is involved)

12. What is the educational background of the person or persons typically responsible for supervision of wetland construction? (Check all answers that apply)

a. _____ Hydrologist
b. _____ Soils scientist
c. _____ Civil engineer
d. _____ Landscape architect
e. _____ Wetland ecologist
f. _____ Wildlife biologist
g. _____ Maintenance staff
h. _____ Other (please specify)

13. Have these individuals had any specific training in wetland construction techniques or planting in wetland settings?

_____ Yes
_____ No

14. What would you recommend to improve the quality of supervision of wetland construction?

15. What areas of profession expertise in DOT or hired consultants evaluate the monitoring data? (Check all answers that apply)

a. _____ Hydrologist
b. _____ Soils scientist
c. _____ Civil engineer
d. _____ Landscape architect

e. _____ Vegetation specialist (botanist)
f. _____ Wetland ecologist
g. _____ Wildlife biologist
h. _____ Maintenance staff
i. _____ Other (please specify)

16. What criteria does your DOT use to evaluate the data?

17. If the evaluation indicates that the wetland mitigation sites not meeting goals and the performance specifications of the permit, what, if any, formal procedures do you have to rectify the problem?

18. What would you recommend to improve the way in which monitoring data is evaluated and the evaluation used to remedy wetland problems?

Monitoring

19. Who in your DOT is responsible for post construction monitoring of wetland mitigation sites?

____

Job title (list all titles if more than one individual is involved)

20. Does your DOT have a protocol for post construction mitigation wetland monitoring?

_____ Yes
_____ No

If your answer is yes, would you please send a copy of your monitoring protocol along with your response to this questionnaire.

21. Does your DOT have personnel assigned specifically to conduct wetland monitoring?

_____ Yes
_____ No

22. What areas of professional expertise are represented by monitoring personnel? (Check all answers that apply)

a. _____ Hydrologist
b. _____ Soils scientist
c. _____ Civil engineer
d. _____ Landscape architect
e. _____ Wetland ecologist
f. _____ Wildlife biologist
g. _____ Maintenance staff
h. _____ Other (please specify)

23. Do you believe sufficient DOT staff and time are allocated to monitor mitigated wetland plans and specifications?

_____ Yes
_____ No

24. Do you employ consultants to monitor mitigated wetlands?

_____ Yes
_____ No

25. Are consultants required to use DOT monitoring protocol?

_____ Yes
_____ No

26. Please check those functions or values that your DOT most frequently replaces in its mitigation wetlands.

a. _____ Hydroperiod
b. _____ Ground water recharge
c. _____ Ground water discharge
d. _____ Flood storage and desynchronization
e. _____ Shoreline anchoring
f. _____ Sediment trapping
g. _____ Nutrient and pollutant retention and removal
h. _____ Food chain support
i. _____ Fish and wildlife habitat
j. _____ Socioeconomic values
k. _____ Aesthetic values
l. _____ Other (please specify)

27. What techniques are used to monitor constructed wetland performance with regard to these functional values? (Check all answers that apply)

a. _____ Vegetation sampling (transects, plots, etc.)
b. _____ Habitat evaluation (HEP)
c. _____ Wildlife species sampling (flush counts, call counts, trapping, etc.)
d. _____ Photomonitoring
e. _____ Water quality analysis
f. _____ Hydroperiod sampling (duration and frequency)
g. _____ Other (please specify)

28. In what form do you record monitoring data?

29. What recommendations would you make to improve the quality and efficiency of construction and post construction monitoring of mitigation wetland sites?

Maintenance

30. Does your DOT actively manage mitigation wetlands after the 3-5 year monitoring period?

_____ Yes
_____ No (Proceed to question 36)

31. Which of the following management activities do you conduct? (Check all answers that apply)

a. _____ Routine mowing
b. _____ Remove trash/debris
c. _____ Control noxious weeds
d. _____ Fencing maintenance
e. _____ Remove sediments
f. _____ Regulate water level
g. _____ Supplemental or replacement of initial planting
h. _____ Routine maintenance of inlet/outlet and water control structures
i. _____ Wildlife predation control
j. _____ Other (please specify)

32. How often do you engage in post construction management/support of mitigation wetland sites?

__1__ Every three months
__2__ Every six months
__3__ Once a year
__4__ Other (please specify)

33. Site management is done by

a. _____ A crew specifically assigned to mitigation wetland site management
b. _____ General roadside maintenance crews
c. _____ Independent contractors

34. Do personnel who manage mitigation wetland sites receive any training related specifically to wetland ecology or federal regulations pertaining to wetlands?

_____ Yes

_____ No

35. What recommendations would you make to improve the quality and efficiency of post construction mitigation wetland project management?

Inventory

36. Does your DOT maintain a statewide inventory of all mitigation wetland sites?

_____ Yes

_____ No (Proceed to question 42)

37. In what form is the inventory data recorded?

a. _____ Digital (GIS)
b. _____ Aerial photographs
c. _____ Plan maps
d. _____ Other (please specify)

38. Does the inventory include information about each mitigation wetland and its condition?

_____ Yes

_____ No (Proceed to question 41)

39. Which of the following wetland data items or conditions are included in the inventory? (Check all answers that apply)

a. _____ General description
b. _____ Classification by wetland type
c. _____ Wetland acreage
d. _____ Hydrology
e. _____ Vegetation
f. _____ Wildlife/Fish
g. _____ Sedimentation
h. _____ Water quality
i. _____ Aesthetic characteristics
j. _____ Other (please specify)

40. How often is the inventory updated?

__1__ Annually
__2__ Every 2 years
__3__ Every 5 years
__4__ No specific schedule

41. What suggestions would you have for creating a mitigation wetland inventory that is useful, accurate, easy to access and can be rapidly updated?

Funding/Staffing

42. Does your DOT have line positions (full or in part) for staff specifically responsible for mitigation wetland issues?

_____ Yes, number of positions
_____ No (Proceed to question 44)

43. Which of the following professions are funded specifically (full or in part) to work on wetland issues? (Check appropriate answers.)

a. _____ Civil engineers
b. _____ Hydrologists
c. _____ Soil scientists
d. _____ Landscape architects
e. _____ Wildlife biologists
f. _____ Wetland ecologists
g. _____ Maintenance staff person
h. _____ Other (please specify)

44. How would you rate communications between those working on wetland mitigation issues and those responsible for other roadway design issues?

__4__ Excellent
__3__ Good
__2__ Fair
__1__ Poor

45. Who in your DOT is ultimately responsible for approval of mitigation wetland plans and specifications?

__1__ Project manager (responsible - feasibility through as built)
__2__ Project engineer (responsible - design through as built)
__3__ Head of Environmental Division
__4__ Other (please specify)

46. How are mitigation wetland related tasks funded by your DOT? (Check all answers that apply).

a. _____ As part of annual budget
b. _____ As part of project costs
c. _____ Project cost and supplemental state funds
d. _____ Project cost and supplemental federal funds

e. _____ Project cost and supplemental funding from non-profits (Ducks Unlimited, Pheasants Forever, etc.)

f. _____ Other (please specify)

47. Does your DOT hire consultants for any of the following activities: Plan and specification review, construction supervision, post construction monitoring, inventory, post construction management.

_____ Yes

_____ No

48. Does your DOT allocate additional funding for mitigation wetland site management beyond that allocated to general roadside maintenance?

_____ Yes

_____ No (Proceed to question 50)

49. What would you estimate the additional funding would be on a per acre basis?

50. Does your DOT involve volunteers in maintaining mitigated wetlands?

________ Yes

________ No

Thank you for taking time to fill out this questionnaire. Your response and those from other states will help us better understand how to plan, implement, and maintain mitigation wetlands that perform the functions for which they were constructed.

APPENDIX C

TELEPHONE INTERVIEW

Introduction

Hello I'm (name) with the Department of Landscape Architecture at Utah State University. The Department is conducting a research project for the Utah Department of Transportation. UDOT is seeking ways to improve the quality of its mitigated wetlands. As part of our research design, we are conducting a short telephone interview with professional societies researching wetland issues, wetland consultants, regulatory agencies, and wetland contractors. Would you be willing to answer a few short questions? All responses will be kept confidential. Would you be willing to participate?

<u>Contractors Interview Questions</u>

Introduction

1. In your experience, what are the principle causes of mitigated wetland failure?

2. Do you believe that pre-construction conferences conducted by DOT personnel adequately prepare you for the mitigated wetland portion of highway construction projects?

   A. If your answer is NO, what would you suggest that DOT's do to make the pre-construction conference more effective regarding mitigated wetlands?

3. Rate the quality, clarity, accuracy, and practicibility of the mitigated wetland plans you have to work from?

   Excellent
   Good
   Fair
   Poor

   A. If you answered fair or poor, what do you believe should be done to improve mitigation wetland plans?

4. Do you have any general comments that you believe would help DOT's construct higher quality mitigated wetlands?

Regulatory Agencies Interview Questions

Introduction

1. Based on your experience in assessing mitigated wetlands, what are the principle causes of wetland performance levels below agreed upon standards of wetland failure?

2. Has your agency developed a protocol or check list for evaluating (reviewing) mitigated wetlands plans?

   YES or NO

   If your answer is YES, would you please send a copy to:

   Craig Johnson
   LAEP Dept.
   FAV Bldg.
   Utah State University
   Logan, UT 84321

   A. Do you believe DOT's do an adequate job of evaluating mitigated wetland plans?

      YES or NO

   B. What would you recommend DOT's do to improve the quality of their plan evaluations?

3. Has your agency developed a protocol for evaluating mitigated wetland construction in the field?

   YES
   NO
   WE DON'T EVALUATE WETLANDS UNDER CONSTRUCTION

   If your answer is YES, would you please send a copy to the address previously described?

4. Does your agency have a recommended protocol for monitoring mitigated wetlands or for preparing a monitoring plan?

   YES
   NO
   WE AREN'T INVOLVED IN WETLAND MONITORING

   If your answer is YES, would you please send a copy to the address previously described?

   A. Do you believe DOT's do an adequate job of monitoring mitigated wetlands?

   B. What would you recommend DOT's do to improve the quality of monitoring mitigated wetlands?

5. Briefly describe the interaction between the various agencies that may be involved in plan evaluation, monitoring, and approval of compliance.

6. Do you believe that the DOT's in your state or DOT's in your region are adequately staffed in numbers and areas of expertise to adequately address mitigated wetland projects?

7. What advice would you give DOT's to assist them in meeting your agency's regulations?

<u>Wetland Consultant Interview Questions</u>

Introduction

1. Based on your experience in designing and/or monitoring mitigated wetlands, what do you believe are the principle causes for poor wetland performance or failure?

2. How would you rate the quality of mitigated wetland plan evaluation by DOT's in your state or region?

   Excellent
   Good
   Fair
   Poor

   If you answered fair or poor, what do you believe should be done to improve evaluation of mitigated wetland plans?

3. How would you rate the quality of DOT's evaluation of mitigated wetland construction in the field?

   Excellent
   Good
   Fair
   Poor

   If you answered fair or poor, how could DOT's improve field evaluation of mitigated wetlands under construction?

5. How would you rate the performance of contractors in constructing mitigated wetlands?

   Excellent
   Good
   Fair
   Poor

   If you answered fair or poor, what do you believe contractors could do to improve the construction of mitigated wetlands?

6. How would you rate monitoring plans prepared by DOT's, plans that you have been asked to implement in the fields?

   Excellent
   Good
   Fair
   Poor
   I have not implemented a DOT approved plan

7. How do mitigated wetland monitoring plans you have prepared for DOT's or others differ from those prepared by DOT's?

8. What features of your monitoring plans do you believe are improvements over DOT plans?

9. Do you believe DOT funding for post construction monitoring of mitigated wetlands is sufficient to provide an accurate picture of wetland function and structure?

   YES or NO

10. How would you rate mitigated wetland maintenance by the DOT in your state or DOT's in your region?

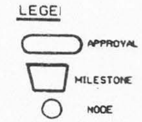
    Excellent
    Good
    Fair
    Poor

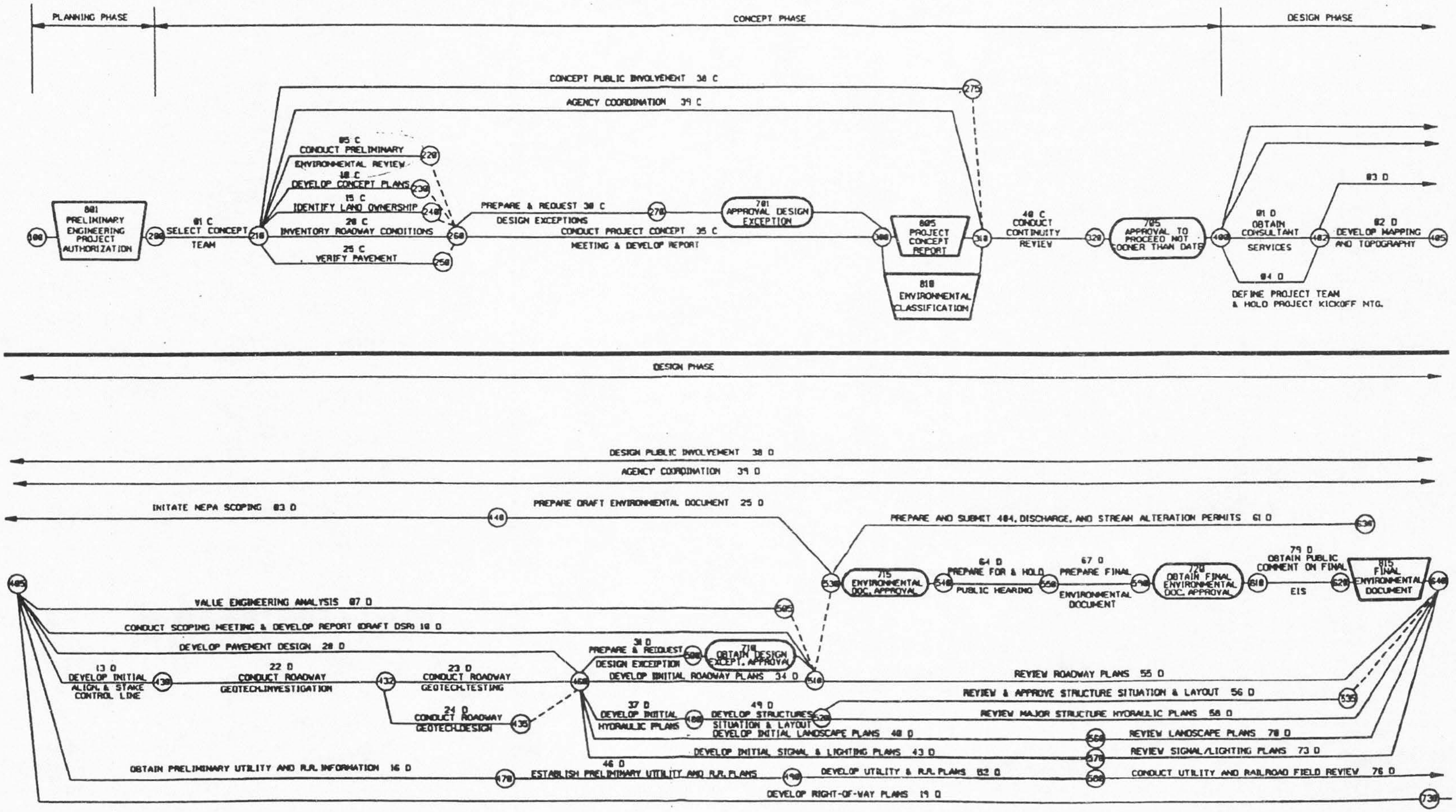
    If you answered fair or poor, what should DOT's do to improve the maintenance of mitigated wetlands?

APPENDIX D

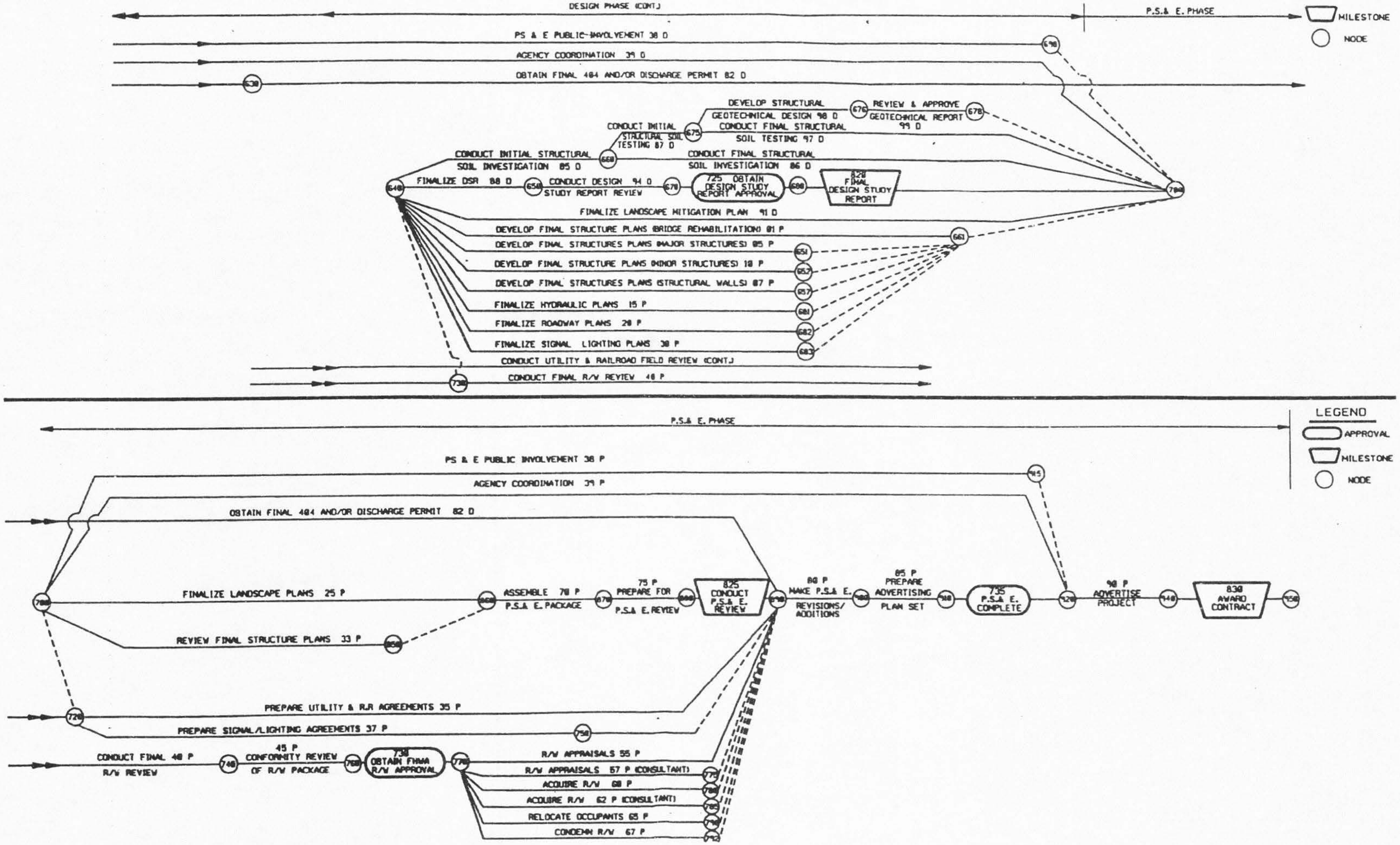
UDOT DESIGN PROCESS

UTAH DEPARTMENT OF TRANSPORTATION DESIGN PROCESS NETWORK CHART





UTAH DEPARTMENT OF TRANSPORTATION DESIGN PROCESS NETWORK CHART



APPENDIX E

STATES PARTICIPATING IN QUESTIONNAIRE

State Participation in Questionnaire:

- 35 states responded to the questionnaire.
- Response rate is 70%.

1. Alaska
2. Colorado
3. Connecticut
4. Delaware
5. Florida
6. Hawaii
7. Idaho
8. Illinois
9. Iowa
10. Kansas
11. Kentucky
12. Louisiana
13. Maine
14. Maryland
15. Minnesota
16. Mississippi
17. Missouri
18. Montana
19. Nebraska
20. Nevada
21. New Hampshire
22. New Jersey
23. New Mexico
24. North Carolina
25. North Dakota
26. Oklahoma
27. Oregon (3 Districts)
28. Pennsylvania
29. Rhode Island
30. South Dakota
31. Texas
32. Utah
33. Vermont
34. Washington
35. Wisconsin

APPENDIX F

FREQUENCY QUESTIONNAIRE RESULTS

- This appendix contains all of the results from the frequency analysis portion of this study, with the responses from each state.
- The state data presented in these charts are in random order.
- Appendix A contains the codes for the questions in these charts.

Question	Aa	Ab	Ac	Ad	Ae	C	1a	1b	1c	1d	1e
State A	0	0	0	1	0	3	0	3	3	2	2
State B	0	0	0	0	1	1	2	3	2	4	2
State C	0	1	0	0	0	3	1	1	0	1	1
State D	0	1	0	0	1	3	1	2	1	1	1
State E	0	0	0	1	0	2	1	2	2	1	1
State F	0	0	0	0	1	2	1	2	1	2	2
State G	0	0	0	1	0	3	1	2	1	0	1
State H	0	0	0	0	1	3	0	0	0	0	0
State I	0	0	0	0	1	3	1	2	1	2	1
State J	1	0	0	0	0	2	2	3	2	2	2
State K	0	0	0	1	0	3	1	2	1	1	1
State L	1	0	0	0	0	2	4	3	3	3	2
State M	0	0	0	1	0	3	0	1	0	2	0
State N	0	0	0	1	0	3	1	1	1	1	1
State O	0	0	0	1	1	2	1	1	1	1	1
State P	0	0	0	1	0	1	3	2	3	3	2
State Q	0	0	0	1	0	3	3	3	2	4	2
State R	0	0	0	1	0	3	2	2	3	3	2
State S	0	0	0	1	0	1	1	2	1	2	1
State T	0	0	0	1	0	3	1	3	2	2	2
State V	1	0	0	0	0	1	1	2	2	2	1
State W	0	0	0	1	0	2	0	0	0	0	0
State X	0	0	0	1	0	3	2	1	1	2	1
State Y	0	1	0	0	1	2	1	2	1	4	0
State Z	0	0	0	1	0	2	1	2	1	4	3
State A1	0	0	0	1	0	2	2	2	2	1	2
State B1	0	0	0	1	0	2	1	2	2	3	1
State C1	1	0	0	0	0	3	0	3	0	0	2
State D1	0	0	0	1	0	3	3	3	2	3	4
State E1	0	0	0	1	1	3	2	2	2	1	1
State F1	0	0	0	1	0	1	2	2	2	2	2
State G1	0	0	0	1	0	3	2	3	2	2	1
State H1	0	0	0	1	0	3	2	1	3	0	2
State I1	0	1	0	0	0	3	1	2	2	1	2
State J1	1	0	0	0	0	3	2	2	1	2	2
Count	5	4	0	22	8						
Frequency	14%	11%	0%	63%	23%						
N (Frequency)	35	35	35	35	35	35	35	35	35	35	35
N (Success)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Question	1f	1g	1h	1i	1j	1k	1l	1m	1n	1o	1p
State A	2	2	0	2	0	2	0	0	0	0	0
State B	1	1	1	1	2	1	1	1	1	1	4
State C	1	1	0	1	1	3	1	1	1	2	2
State D	2	2	3	1	3	4	4	2	1	3	4
State E	2	3	4	2	4	4	4	4	3	3	3
State F	1	1	1	1	2	2	1	1	1	1	1
State G	1	1	1	1	3	2	1	2	3	3	1
State H	0	0	0	0	0	0	0	0	0	0	0
State I	1	1	1	1	1	3	1	1	1	1	2
State J	1	1	1	0	1	3	1	1	1	1	1
State K	2	1	0	1	2	2	2	2	2	2	2
State L	1	1	1	2	2	2	2	2	2	2	2
State M	2	1	1	0	1	2	1	2	0	1	1
State N	1	1	2	1	2	3	2	2	2	1	1
State O	0	1	1	1	1	2	1	2	1	1	1
State P	2	2	2	2	2	2	2	2	3	2	2
State Q	2	1	0	1	1	1	2	1	0	0	1
State R	2	1	1	2	2	1	1	2	1	2	2
State S	1	1	0	1	1	1	1	2	1	3	3
State T	1	0	2	2	2	2	4	4	4	2	1
State V	1	1	1	1	2	1	2	3	2	2	2
State W	0	0	0	0	0	0	0	0	0	0	0
State X	1	2	3	2	2	2	3	2	2	4	3
State Y	3	2	1	1	2	4	4	4	4	4	4
State Z	3	3	3	2	4	4	4	4	4	4	4
State A1	3	2	3	1	3	3	4	4	4	4	3
State B1	1	2	1	1	2	2	2	2	1	3	3
State C1	0	0	0	2	2	2	2	0	0	0	0
State D1	2	1	1	3	2	3	2	4	2	3	2
State E1	2	2	1	2	2	2	1	2	1	3	0
State F1	2	1	1	1	2	2	2	1	1	1	2
State G1	0	0	1	1	3	3	3	3	2	2	2
State H1	3	2	2	1	3	3	2	3	2	3	1
State I1	1	1	1	1	2	2	2	2	1	2	1
State J1	3	3	2	2	1	3	2	3	3	3	0
Count											
Frequency											
N (Frequency)	35	35	35	35	35	35	35	35	35	35	35
N (Success)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Question	1q	1r	1s	2	3a	3b	3c	3d	3e	3f	3g
State A	0	0	0	5	1	0	1	0	1	0	0
State B	0	1	1	4	1	1	1	1	1	1	0
State C	1	1	1	4	0	0	1	1	1	0	0
State D	4	1	1	4	0	0	0	1	0	0	0
State E	3	2	1	4	1	0	1	0	1	0	0
State F	1	1	1	5	0	0	1	0	0	1	0
State G	1	2	4	1	0	0	1	0	1	0	0
State H	0	0	0								
State I	1	2	1	5	1	0	1	1	1	0	0
State J	1	0	0	4	1	1	1	1	1	1	0
State K	1	2	1	5	1	0	1	1	1	1	0
State L	2	2	2	5	0	0	1	0	0	1	1
State M	0	1	1		1	1	1	0	1	1	1
State N	2	2	1	5	1	1	1	1	1	1	0
State O	1	1	1	5	1	0	1	1	1	0	0
State P	2	2	2		1	0	0	1	0	1	0
State Q	0	0	0	5	1	1	1	1	1	1	0
State R	1	1	1	5	1	1	1	1	1	1	1
State S	1	3	1	3	1	0	0	1	1	1	0
State T	1	1	1	2	1	1	1	0	1	1	0
State V	2	1	1	5	1	0	1	0	1	0	0
State W	0	0	0	5	0	0	0	0	0	1	0
State X	2	3	1	2	0	0	0	1	1	0	0
State Y	1	4	1	3	0	0	1	1	1	0	0
State Z	1	4	0	3	1	0	1	1	1	0	0
State A1	1	4	2	3	0	0	1	0	1	0	0
State B1	1	2	1		1	1	1	1	1	1	0
State C1	0	0	0	5	0	0	1	0	0	0	0
State D1	1	1	1	4	1	1	1	1	1	1	1
State E1	2	3	1	5	1	1	0	1	1	1	0
State F1	2	1	1	1	1	0	0	1	1	1	0
State G1	1	1	1	5	0	0	1	1	1	0	0
State H1	0	1	1	4	1	0	1	0	0	1	0
State I1	0	0	1	5	0	0	0	1	1	0	0
State J1	2	3	2	3	1	1	0	0	1	0	0
Count					22	11	25	21	27	18	4
Frequency					65%	32%	74%	62%	79%	53%	12%
N (Frequency)	35	35	35	31	34	34	34	34	34	34	34
N (Success)	NA	NA	NA	NA	31	31	31	31	31	31	31

Question	3h	4	5	6a	6b	6c	7	8	9a	9b	9c
State A	0	3	3	1	1	1	0	1	0	1	0
State B	0	3	2	1	1	1	0	0	1	0	0
State C	1	3	3	1	0	1	0	1	1	0	0
State D	0	1	3	1	0	1	0	1	0	0	1
State E	0	3	2	1	0	0	0	0	0	1	1
State F	1	1	2	1	0	0	0	1	1	0	0
State G	0	1	1	0	0	1	0	1	0	0	0
State H											
State I	0	3	4	1	1	0	0	1	0	1	1
State J	1	3	2	1	1	1	1	1	1	1	0
State K	0	3	3	1	1	0	0	1	1	0	1
State L	0	3	3	1	0	0	0	1	1	0	1
State M	0	1	3	1	0	0	0	1	0	1	0
State N	0	1	3	1	1	1	1	1	0	1	0
State O	0	1	3	1	1	0	0	1	0	0	0
State P	0	3	4	1	0	0	1	1	0	0	1
State Q	0	3	4	1	0	1	1	1	0	0	1
State R	0	3	4	1	1	1	1	1	1	1	0
State S	0	3	3	1	0	0	0	1	1	0	0
State T	0	3	3	1	0	1	1	0	0	0	1
State V	0	1	4	1	0	0	0	0	0	0	0
State W	0	1	0	0	0	0	0	0	1	1	1
State X	0	3	2	1	0	0	0	1	1	1	0
State Y	0	1	2	1	0	0	1	1	0	1	1
State Z	0	3	3	1	0	0	0	0	1	0	0
State A1	0	3	3	1	0	0	0	0	0	1	1
State B1	0	3	3	1	1	0	0	1	1	1	1
State C1	0	1	0	0	0	0	0	0	0	1	0
State D1	0	3	2	0	0	1	0	0	1	1	0
State E1	0	3	3	1	0	1	1	1	0	1	1
State F1	0	3	3	1	1	1	0	0	1	1	0
State G1	0	3	2	1	0	0	0	0	0	0	1
State H1	1	3	3	1	0	0	0	0	0	0	0
State I1	0	1	3	1	0	0	1	0	1	1	1
State J1	0	3	4	1	0	0	0	1	0	0	1
Count	4			30	10	13	9	21	15	17	16
Frequency	12%			88%	29%	38%	26%	62%	44%	50%	47%
N (Frequency)	34	34	34	34	34	34	34	34	34	34	34
N (Success)	31	31	31	31	31	31	31	31	31	31	31

Question	9d	9e	9f	9g	9h	9i	9j	12a	12b	12c	12d
State A	0	0	1	0	0	0	0	0	0	1	0
State B	0	0	0	0	0	0	0	0	0	1	0
State C	1	1	0	1	0	0	0	0	0	0	1
State D	0	0	0	0	1	0	0	0	0	1	0
State E	0	0	0	1	1	0	0	0	0	1	0
State F	1	0	0	0	0	0	0	0	0	1	0
State G	0	0	0	0	0	0	0	0	0	1	0
State H											
State I	0	0	0	0	0	0	0	1	0	1	1
State J	0	0	0	1	0	0	0	1	1	1	1
State K	0	0	0	0	0	0	0	1	0	1	0
State L	0	0	0	0	0	0	0	0	0	1	0
State M	0	0	1	0	0	0	0	0	0	1	0
State N	1	0	0	0	0	0	0	0	0	1	0
State O	0	0	1	0	0	0	0	0	0	1	0
State P	0	0	0	0	1	1	0	0	0	0	0
State Q	0	0	1	0	0	0	0	1	1	1	1
State R	0	0	0	0	0	0	0	0	0	1	1
State S	0	1	0	0	0	1	0	1	0	0	1
State T	0	0	1	0	0	0	0	1	1	1	0
State V	1	0	0	0	0	0	0	0	0	1	0
State W	1	1	1	1	1	1	0	0	0	1	0
State X	0	0	0	0	0	0	0	0	0	1	0
State Y	0	0	0	1	0	0	0	0	0	1	0
State Z	0	0	0	1	1	0	0	0	0	0	0
State A1	0	0	0	1	1	0	0	0	0	1	0
State B1	0	0	0	1	0	0	0	0	0	1	1
State C1	0	0	0	0	0	0	0	0	0	1	0
State D1	0	0	1	1	0	1	1	0	0	1	1
State E1	0	0	0	0	0	0	0	0	1	0	0
State F1	0	0	1	1	0	0	0	0	0	1	1
State G1	0	1	0	0	1	0	0	0	0	1	1
State H1	1	1	1	0	0	1	0	0	0	1	0
State I1	0	0	0	0	0	0	0	0	0	1	1
State J1	1	0	0	0	0	0	0	0	1	1	0
Count	7	5	9	10	7	5	1	6	5	29	11
Frequency	21%	15%	26%	29%	21%	15%	3%	18%	15%	85%	32%
N (Frequency)	34	34	34	34	34	34	34	34	34	34	34
N (Success)	31	31	31	31	31	31	31	31	31	31	31

Question	12e	12f	12g	12h	13	15a	15b	15c	15d	15e	15f
State A	1	0	0	0	1	0	0	0	0	0	1
State B	1	0	0	0	1	0	0	0	0	0	0
State C	0	0	0	1	1	0	0	0	1	0	0
State D	0	0	1	0	0	1	1	0	0	1	1
State E	0	0	0	1	0	0	0	0	0	0	1
State F	0	0	0	0	0	0	0	0	0	0	0
State G	0	0	0	0	0	0	0	0	0	0	0
State H											
State I	1	0	0	0	1	0	0	0	0	0	1
State J	1	1	1	0	1	1	1	1	1	1	1
State K	1	0	1	1	1	0	0	0	0	0	1
State L	0	1	0	0	1	0	0	1	0	0	0
State M	1	0	0	0	1	1	1	0	0	1	1
State N	1	0	0	0	1	1	1	1	0	1	1
State O	1	0	0	0	1	0	0	0	0	0	1
State P	1	0	0	0	1	0	0	0	0	0	1
State Q	1	1	0	0	1	1	1	0	0	1	1
State R	1	0	0	0	1	0	0	0	1	0	1
State S	1	1	0	0	1	1	0	0	1	1	1
State T	0	1	0	0	0	1	1	1	0	1	1
State V	1	0	0	0	0	0	0	0	0	0	0
State W	0	0	0	0	0	0	0	0	0	0	0
State X	1	0	0	0	1	0	0	0	0	0	1
State Y	1	0	0	1	1	0	0	0	0	0	1
State Z	1	0	0	1	0	0	0	0	0	0	1
State A1	1	0	0	1	1	0	0	0	0	0	1
State B1	1	0	0	0	1	1	1	1	0	0	1
State C1	0	0	0	0	0	0	0	0	0	0	0
State D1	0	0	0	0	1	1	0	1	1	0	1
State E1	1	0	0	0	1	1	1	0	1	0	1
State F1	1	0	0	1	1	0	1	0	1	1	1
State G1	1	0	0	0	0	0	0	1	0	0	1
State H1	0	0	0	0	0	1	0	1	0	0	0
State I1	1	0	0	0	1	0	0	0	1	0	1
State J1	1	0	0	0	1	1	1	0	0	0	1
Count	23	5	3	7	23	12	10	8	8	8	25
Frequency	68%	15%	9%	21%	68%	35%	29%	24%	24%	24%	74%
N (Frequency)	34	34	34	34	34	34	34	34	34	34	34
N (Success)	31	31	31	31	31	31	31	31	31	31	31

Question	15g	15h	15i	20	21	22a	22b	22c	22d	22e	22f
State A	0	0	0	1	1	0	0	0	0	1	0
State B	0	0	0	1	1	1	1	1	1	1	1
State C	1	0	1	0	0	0	0	0	1	0	1
State D	1	0	0	1	1	1	1	0	0	1	1
State E	0	0	0	1	1	0	0	0	0	1	0
State F	1	0	1	1	0	0	0	0	0	0	1
State G	0	0	1	0	0	0	0	0	0	0	0
State H											
State I	0	0	0	1	1	1	0	0	1	1	0
State J	1	1	0	1	1	1	1	1	1	1	1
State K	0	0	0	1	1	0	0	1	0	1	0
State L	0	0	0	0	0	0	0	1	0	0	1
State M	1	0	0	0	0	1	1	0	0	1	1
State N	1	0	0	1	1	0	0	1	0	1	1
State O	0	0	0	1	1	0	0	0	0	1	1
State P	0	0	0	0	0	0	0	0	0	1	0
State Q	0	0	0	1	1	0	1	0	0	1	0
State R	0	0	0	0	1	0	0	0	0	1	0
State S	1	0	0	0	0	1	0	0	1	1	1
State T	1	0	0	1	1	1	1	1	0	0	1
State V	0	0	0	0	0	0	0	0	0	1	0
State W	0	0	1	0	0	0	0	0	0	0	0
State X	0	0	0	0	0	0	0	0	0	1	0
State Y	0	0	0	1	1	0	0	0	0	1	0
State Z	0	0	0	1	1	0	1	0	1	1	0
State A1	0	0	1	1	0	0	0	0	0	1	0
State B1	0	0	0	0	0	0	0	0	0	0	0
State C1	0	0	0	0	0	0	0	1	0	0	0
State D1	1	0	0	0	0	0	0	1	1	0	0
State E1	0	0	0	1	0	0	1	0	0	1	0
State F1	1	0	0	1	1	0	1	0	1	1	1
State G1	0	0	1	0	0	1	1	0	0	1	1
State H1	1	0	0	0	0	1	0	1	0	1	1
State I1	0	0	0	0	0	0	0	0	1	1	0
State J1	0	0	0	0	0	0	1	0	0	1	0
Count	11	1	6	17	15	9	11	9	9	25	14
Frequency	32%	3%	18%	50%	44%	26%	32%	26%	26%	74%	41%
N (Frequency)	34	34	34	34	34	34	34	34	34	34	34
N (Success)	31	31	31	31	31	31	31	31	31	31	31

Question	22g	22h	23	24	25	26a	26b	26c	26d	26e	26f
State A	0	0	1	1	1	1	1	1	1	0	0
State B	1	0	1	1	1	1	1	1	1	1	1
State C	1	1	0	1	0	1	1	0	1	0	1
State D	0	0	1	1	1	0	0	0	1	0	0
State E	0	0	0	1	1	1	0	0	1	0	1
State F	0	1	1	0	0	0	0	0	1	0	1
State G	0	1	0	0	0	1	1	0	0	0	1
State H											
State I	0	0	1	1	0	0	1	1	1	0	1
State J	0	0	1	1	1	0	0	0	0	0	0
State K	0	1	1	0	1	0	0	0	0	0	0
State L	0	0	0	1	1	0	0	0	0	0	0
State M	0	0	0	0	0	0	0	0	1	0	1
State N	0	0	0	1	1	1	0	0	1	1	1
State O	0	0	0	0	0	1	0	0	0	0	0
State P	0	0	0	0	0	0	0	0	0	0	0
State Q	0	0	1	1	1	0	1	1	1	0	0
State R	0	0	1	1	0	0	0	0	1	0	1
State S	0	0	1	1	0	1	0	0	0	0	0
State T	0	0	0	1	1	1	1	1	1	0	0
State V	0	0	0	0	0	0	0	0	0	0	0
State W	0	0	0	0	0	0	0	0	1	0	1
State X	0	0	0	0	0	1	1	1	1	0	1
State Y	0	0	0	0	0	1	0	0	0	0	0
State Z	0	0	0	1	1	1	1	0	1	1	1
State A1	0	1	0	1	1	0	1	0	1	0	1
State B1	0	0	0	1	0	0	0	0	1	1	0
State C1	0	0	0	0	0	0	0	0	0	0	0
State D1	0	0	1	1	0	0	1	0	0	0	0
State E1	0	0	1	1	1	0	0	0	1	0	1
State F1	0	0	1	0	0	0	1	0	0	0	0
State G1	0	1	0	1	1	1	0	0	1	1	1
State H1	0	0	0	1	0	0	0	0	0	0	0
State I1	0	0	0	1	0	0	0	0	0	1	1
State J1	0	0	1	0	0	0	0	0	0	0	0
Count	2	6	14	21	14	13	12	6	19	6	16
Frequency	6%	18%	41%	62%	41%	38%	35%	18%	56%	18%	47%
N (Frequency)	34	34	34	34	34	34	34	34	34	34	34
N (Success)	31	31	31	31	31	31	31	31	31	31	31

Question	26g	26h	26i	26j	26k	26l	27a	27b	27c	27d	27e
State A	1	1	1	0	0	0	1	0	0	1	0
State B	1	1	1	1	1	0	1	1	1	1	1
State C	0	0	1	0	0	0	1	0	0	1	0
State D	0	0	1	0	1	0	1	0	1	0	1
State E	1	0	1	0	0	1	1	0	0	1	0
State F	1	0	0	0	0	0	1	0	0	1	0
State G	1	1	1	0	0	0	0	0	0	1	0
State H											
State I	1	0	1	0	0	0	1	0	1	1	1
State J	0	0	1	0	0	1	1	0	1	1	0
State K	0	0	1	0	0	1	0	0	0	0	0
State L	0	0	0	0	0	0	1	0	0	0	0
State M	1	1	1	0	1	0	1	0	1	1	0
State N	1	1	1	0	1	0	1	0	1	1	1
State O	0	1	1	0	0	0	1	0	0	0	0
State P	0	0	0	0	0	0	0	0	0	0	0
State Q	1	1	1	0	0	0	1	0	1	1	1
State R	1	1	1	0	1	1	1	0	1	0	0
State S	0	1	1	1	1	0	1	1	1	0	0
State T	1	1	1	0	0	0	1	0	0	1	0
State V	0	0	1	0	0	0	0	0	0	0	0
State W	1	1	1	0	0	0	0	0	0	0	0
State X	1	1	1	0	1	0	1	0	1	1	0
State Y	0	0	1	0	0	0	1	0	0	1	0
State Z	1	0	1	0	0	0	1	0	0	1	0
State A1	1	0	1	0	0	0	1	0	0	1	0
State B1	0	0	1	0	0	0	1	0	1	0	0
State C1	0	0	0	0	0	1	0	0	0	0	0
State D1	0	1	1	0	1	0	1	0	0	0	0
State E1	1	0	1	0	1	1	1	1	1	1	1
State F1	0	1	1	0	0	0	1	0	1	0	0
State G1	1	1	1	0	0	0	1	1	0	1	1
State H1	0	0	1	0	0	0	1	0	1	0	0
State I1	1	0	0	0	0	0	0	0	0	0	0
State J1	0	0	1	0	0	0	0	0	0	0	0
Count	18	15	29	2	9	6	26	4	14	18	7
Frequency	53%	44%	85%	6%	26%	18%	76%	12%	41%	53%	21%
N (Frequency)	34	34	34	34	34	34	34	34	34	34	34
N (Success)	31	31	31	31	31	31	31	31	31	31	31

Question	27f	27g	30	31a	31b	31c	31d	31e	31f	31g	31h
State A	1	0	1	0	0	0	0	0	1	1	1
State B	1	1	1	1	1	1	1	1	1	1	1
State C	0	0	0								
State D	1	1	0								
State E	1	1	0								
State F	0	0	0	0	0	0	0	0	0	0	0
State G	0	1	0								
State H											
State I	0	1	0								
State J	1	1	1	0	0	1	0	0	0	0	0
State K	0	1	0								
State L	0	0	0								
State M	1	0	1	0	0	0	0	0	1	1	1
State N	1	1	1	1	1	1	1	0	1	0	1
State O	0	0	0	0	0	1	0	0	0	0	0
State P	0	0	0								
State Q	1	1	1	0	1	1	1	0	1	1	1
State R	0	0	0								
State S	1	0	0								
State T	1	0	0								
State V	0	0	0	0	1	1	0	0	0	0	1
State W	0	0	0								
State X	1	0	0								
State Y	0	0	0								
State Z	0	0	0								
State A1	0	1	0								
State B1	0	0	0								
State C1	0	0	0								
State D1	0	0	0								
State E1	0	0	1	0	1	1	1	0	0	0	0
State F1	0	0	1	0	1	1	1	0	0	0	0
State G1	1	0	1	1	1	1	1	0	1	0	1
State H1	0	0	0								
State I1	0	0	0								
State J1	0	1	0								
Count	12	11	9	3	7	9	6	1	6	4	7
Frequency	35%	32%	26%	25%	58%	75%	50%	8%	50%	33%	58%
N (Frequency)	34	34	34	12	12	12	12	12	12	12	12
N (Success)	31	31	31	11	11	11	11	11	11	11	11

Question	31i	31j	32	33a	33b	33c	34	36	37a	37b	37c
State A	1	0	1	1	0	0	1	1	0	0	1
State B	0	0	4	0	1	1	1	0			
State C								0			
State D								1	0	0	0
State E								1	1	1	1
State F	0	0	4	0	1	0	1	1	1	1	1
State G								1	1	0	1
State H											
State I								1	0	0	1
State J	1	0	3	1	0	0	1	1	1	1	1
State K								1	0	1	1
State L								1	0	0	0
State M	0	0	2	1	1	0	1	1	0	0	0
State N	1	0	4	1	0	0	1	1	1	1	1
State O	0	0	4	0	1	0	0	1	0	1	1
State P								0			
State Q	0	0	3	0	1	0	1	1	1	1	1
State R								1	0	0	1
State S								0			
State T								0			
State V	0	0	4	0	1	0	0	1	0	0	1
State W								0			
State X								1	0	0	1
State Y								0			
State Z								0	1	0	0
State A1								1	1	0	1
State B1								0			
State C1								1	0	0	0
State D1								1	1	0	1
State E1	0	1	1	1	0	0	1	1	0	0	0
State F1	0	0	4	0	1	0	1	1	0	1	1
State G1	0	1	4	0	1	1	0	1	0	1	1
State H1								0			
State I1								0			
State J1								0			
Count	3	2		5	8	2	9	22	9	9	17
Frequency	25%	17%		42%	67%	17%	75%	65%	39%	39%	74%
N (Frequency)	12	12	12	12	12	12	12	34	23	23	23
N (Success)	11	11	11	11	11	11	11	31	22	22	22

Question	37d	38	39a	39b	39c	39d	39e	39f	39g	39h	39i
State A	0	1	0	1	1	1	1	0	0	0	0
State B											
State C											
State D	1	0									
State E	0	1	1	1	1	0	0	0	0	0	0
State F	0	1	1	0	1	0	1	0	0	0	0
State G	1	1	1	1	1	0	0	0	0	0	0
State H											
State I	0	1	1	1	1	0	0	0	0	0	0
State J	0	1	1	1	1	1	1	1	1	1	1
State K	1	1	1	1	1	0	1	0	0	0	0
State L	1	0									
State M	1	1	1	1	1	0	0	0	0	0	0
State N	1	1	1	1	1	1	1	1	0	1	0
State O	1	1	1	1	1	0	1	1	0	0	0
State P											
State Q	0	1	1	1	1	1	1	0	0	0	0
State R	1	1	1	1	1	1	1	1	0	0	1
State S											
State T											
State V	0	0									
State W											
State X	1	1	1	1	1	1	1	1	1	1	1
State Y											
State Z	1	1	1	1	1	1	1	0	0	0	0
State A1	1	1	1	1	1	1	1	1	0	0	0
State B1											
State C1	1	0									
State D1	0	0									
State E1	1	1	1	1	1	0	1	1	0	0	0
State F1	1	1	1	0	1	1	1	1	0	0	0
State G1	1	0									
State H1											
State I1											
State J1											
Count	15	17	16	15	17	9	13	8	2	3	3
Frequency	65%	74%	94%	88%	100%	53%	76%	47%	12%	18%	18%
N (Frequency)	23	23	17	17	17	17	17	17	17	17	17
N (Success)	22	22	16	16	16	16	16	16	16	16	16

Question	39j	40	42	42a	43a	43b	43c	43d	43e	43f	43g
State A	0	1	1	1.5	0	0	0	0	0	1	0
State B			0								
State C			1	1	0	0	0	0	0	0	0
State D			1	1	0	0	0	0	0	0	0
State E	0	1	1	8	0	0	0	0	0	1	0
State F	0	1	0								
State G	0	4	1	1	0	0	0	0	0	1	0
State H											
State I	1	4	1	2	0	1	0	1	0	1	0
State J	0	1	1	16	1	1	0	1	1	1	0
State K	0	4	1	4	1	1	0	0	1	1	0
State L			0								
State M	1	2	1	6	0	1	1	0	1	1	0
State N	1	4	1	2	1	0	0	0	0	1	0
State O	0	1	1	3	0	0	0	0	1	0	0
State P			0								
State Q	0	4	0								
State R	0	4	1	1	0	0	0	0	0	1	0
State S			0								
State T			1	8	1	1	1	0	0	1	0
State V			0								
State W			1	1	0	0	0	0	1	0	0
State X	0	1	1	6	0	0	0	1	0	1	0
State Y			1	5	1	0	0	1	0	1	0
State Z	0	4	1	5	1	1	0	1	0	1	1
State A1	0	1	1	4	0	0	0	0	1	1	0
State B1			0								
State C1			1	2	1	0	0	0	0	0	0
State D1			1	3	0	0	0	1	0	1	0
State E1	1	4	1	1	0	0	1	0	0	1	0
State F1	0	1	1	50	0	1	1	1	1	1	1
State G1			1	1	0	0	0	0	0	1	0
State H1			0								
State I1			0								
State J1			1	1	0	0	1	0	0	1	0
Count	4		24		7	7	5	7	7	19	2
Frequency	24%		71%		29%	29%	21%	29%	29%	79%	8%
N (Frequency)	17	17	34	24	24	24	24	24	24	24	24
N (Success)	16	16	31	23	23	23	23	23	23	23	23

Question	43h	44	45	46a	46b	46c	46d	46e	46f	47	48
State A	0	4	4	1	1	0	0	0	0	1	1
State B		2	1	1	1	1	1	0	0	1	1
State C	1	3	2	0	1	0	0	0	0	1	0
State D	1	3	4	1	1	0	0	0	0	1	1
State E	0	3	1	0	0	1	0	0	0	1	0
State F		2	1	0	1	0	0	0	0	0	0
State G	1	2	4	0	0	0	1	0	1	0	0
State H											
State I	0	3	1	0	1	0	0	0	0	1	0
State J	0	3	3	1	1	0	0	0	0	1	1
State K	1	3	1	0	0	1	0	0	0	0	0
State L		3	4	1	1	0	0	0	0	1	0
State M	0	3	3	0	1	0	0	0	0	1	0
State N	0	4	2	1	1	0	1	1	0	1	1
State O	1	3	2	1	1	1	1	0	1	1	1
State P										0	0
State Q		3	3	0	1	0	0	0	0	1	0
State R	0	3	1	0	1	0	0	0	0	1	0
State S		2	2	1	1	0	0	0	0	1	1
State T	0	3	2	0	1	1	0	0	0	1	0
State V		3	1	0	1	1	1	0	0	0	0
State W	0	2	4	0	1	0	0	0	0	0	0
State X	0	2	2	0	1	0	1	0	0	0	0
State Y	0	2	1	0	1	0	0	0	0	0	0
State Z	0	2	1	1	1	0	1	0	0	1	1
State A1	0	3	1	0	1	0	0	1	0	1	0
State B1		3	2	0	1	0	0	0	0	1	0
State C1	0	4	3	0	0	1	0	0	0	0	0
State D1	0	2	1	0	1	1	1	0	0	1	0
State E1	0	4	1	0	1	1	1	0	0	1	0
State F1	0	1	1	1	1	0	0	0	0	1	1
State G1	0	2	4	0	1	0	0	1	1	1	0
State H1		3	4	0	1	0	0	0	0	1	0
State I1		2	3	1	1	0	0	0	0	1	0
State J1	0	3	3	0	1	0	0	0	0	1	0
Count	5			11	29	9	9	3	3	25	9
Frequency	21%			33%	88%	27%	27%	9%	9%	74%	26%
N (Frequency)	24	33	33	33	33	33	33	33	33	34	34
N (Success)	23	31	31	31	31	31	31	31	31	31	31

Question	50
State A	1
State B	0
State C	0
State D	0
State E	0
State F	0
State G	0
State H	
State I	1
State J	0
State K	0
State L	0
State M	0
State N	1
State O	0
State P	0
State Q	0
State R	0
State S	0
State T	0
State V	0
State W	0
State X	0
State Y	0
State Z	0
State A1	1
State B1	0
State C1	0
State D1	0
State E1	0
State F1	1
State G1	1
State H1	0
State I1	0
State J1	0
Count	6
Frequency	18%
N (Frequency)	34
N (Success)	31

Question C

Count of C	C		
	1	2	3
Total	5	10	20
N=35	14%	29%	57%

Question 1a

Count of 1a	1a				
	0	1	2	3	4
Total	5	16	10	3	1
N=35	14%	46%	29%	9%	3%

Question 1b

Count of 1b	1b			
	0	1	2	3
Total	2	6	18	9
N=35	6%	17%	51%	26%

Question 1c

Count of 1c	1c			
	0	1	2	3
Total	5	12	13	5
N=35	14%	34%	37%	14%

Question 1d

Count of 1d	1d				
	0	1	2	3	4
Total	5	9	12	5	4
N=35	14%	26%	34%	14%	11%

Question 1e

Count of 1e	1e				
	0	1	2	3	4
Total	4	14	15	1	1
N=35	11%	40%	43%	3%	3%

Question 1f

Count of 1f	1f			
	0	1	2	3
Total	5	14	11	5
N=35	14%	40%	31%	14%

Question 1g

Count of 1g	1g			
	0	1	2	3
Total	5	18	9	3
N=35	14%	51%	26%	9%

Question 1h

Count of 1h	1h				
	0	1	2	3	4
Total	8	17	5	4	1
N=35	23%	49%	14%	11%	3%

Question 1i

Count of 1i	1i			
	0	1	2	3
Total	4	19	11	1
N=35	11%	54%	31%	3%

Question 1j

Count of 1j	1j				
	0	1	2	3	4
Total	3	8	17	5	2
N=35	9%	23%	49%	14%	6%

Question 1k

Count of 1k	1k				
	0	1	2	3	4
Total	2	5	15	9	4
N=35	6%	14%	43%	26%	11%

Question 1l

Count of 1l	1l				
	0	1	2	3	4
Total	3	11	13	2	6
N=35	9%	31%	37%	6%	17%

Question 1m

Count of 1m	1m				
	0	1	2	3	4
Total	4	7	14	4	6
N=35	11%	20%	40%	11%	17%

Question 1n

Count of 1n	1n				
	0	1	2	3	4
Total	6	13	8	4	4
N=35	17%	37%	23%	11%	11%

Question 1o

Count of 1o	1o				
	0	1	2	3	4
Total	5	8	9	9	4
N=35	14%	23%	26%	26%	11%

Question 1p

Count of 1p	1p				
	0	1	2	3	4
Total	6	10	10	5	4
N=35	17%	29%	29%	14%	11%

Question 1q

Count of 1q	1q				
	0	1	2	3	4
Total	9	16	8	1	1
N=35	26%	46%	23%	3%	3%

Question 1r

Count of 1r	1r				
	0	1	2	3	4
Total	7	13	8	4	3
N=35	20%	37%	23%	11%	9%

Question 1s

Count of 1s	1s			
	0	1	2	4
Total	7	23	4	1
N=35	20%	66%	11%	3%

Question 2

Count of 2	2				
	1	2	3	4	5
Total	2	2	5	7	15
N=31	6%	6%	16%	23%	48%

Question 4

Count of 4	4	
	1	3
Total	11	23
N=34	32%	68%

Question 5

Count of 5	5				
	0	1	2	3	4
Total	2	1	8	17	6
N=34	6%	3%	24%	50%	18%

Question 32

Count of 32	32			
	1	2	3	4
Total	2	1	2	7
N=12	17%	8%	17%	58%

Question 40

Count of 40	40		
	1	2	4
Total	8	1	8
N=17	47%	6%	47%

Question 44

Count of 44	44			
	1	2	3	4
Total	1	11	17	4
N=33	3%	33%	52%	12%

Question 45

Count of 45	45			
	1	2	3	4
Total	13	7	6	7
N=33	39%	21%	18%	21%

Question B

Wetland Resources Specialist
Wetlands Team Leader
Environmental Scientist
Wetland Coordinator (Environmental Scientist II)
Environmental Manager
Chief Environmental Programs Division
Wetland Program Coordinator
Environmental Division Engineer
Wetland Coordinator
Wetland Mitigation Specialist
Wetland Program Manager
Senior Environmental Manager
Supervising Environmental Specialist
Environmental Analyst
Environmental Engineer
Biologist
Wetlands Biologist
Wetland Specialist
Regional Natural Resource Specialist
Environmental Scientist
Natural Resources Engineer
Biologist
Transportation Biologist
Field Coordinator, Wetland Monitoring Program
Ecologist - Statewide and Bureau of Environment
State Environmental Coordinator
Landscape Architect
Transportation Supervising Planner
Environmental Scientist
State Wetland Scientist
Environmental Section Manager

Question 11

Wetland Resource Specialist, Resident Engineer, Landscape Architect
Construction Engineers and Construction Inspectors
Construction Engineer
County Resident Engineers, Design Engineer, Civil Engineer
Consultant and In-house Project Managers, Landscape Architects, and Wetland Specialists
MDSHA has our Design Staff and Environmental Inspectors
Biologist, Civil Engineer, Highway Tech
Roadside Development (Maintenance),Biologist (Consultant)
Wetland Coordinator, Wetland Specialists, Resident Engineers, Senior Construction Engineers
Wetland Mitigation and Engineer Specialists
Wetland Biologists
Environmental Managers, Contract Administrators, and/or Consultants
Project Engineer
Environmental Analyst

Biologist
Field Division Engineer
Wetland Biologist/Construction Inspectors
Wetland Specialists, Project Construction Inspectors
District Environmental Managers, Assistant Environmental Managers, Construction Inspectors
DOT Resident Engineer (Construction Section), Environmental Scientist (Design Reviewer), Construction Overseer, Landscape Inspector
Area Engineer
Landscape Architects
Transportation Biologist
Project Inspector
Project Manager CE, District Environmental Coordinator
Project Engineer and Environmental Coordinator
Landscape Architect/Wetland Biologist
Transportation Planner
Environmental Scientists
Biologist

<u>Question 19</u>

Illinois State Geological Survey and Illinois Natural History Survey - Contractual Staff
Wetland Ecologists
Wildlife Biologist, Environmental Scientist
District Environmental Coordinators
Environmental Specialist
Environmental Programs Division
Civil Engineer, Biologist, Highway Tech
Environmental Division Engineer
Wetland Coordinator, Wetland Specialist
Wetland Mitigation and Engineering Specialists
Wetland Biologist
Environmental Managers and/or Consultants
Supervising Environmental Specialist
Environmental Analyst
Staff Biologist
Wetland Specialist/Biologist
Wetland Specialists
Assistant Environmental Manager, Consultant
Hydrologist, Environmental Scientist, Wetland Ecologist
Environmental Engineer
Landscape Architects
Transportation Biologist
Wetland Monitoring Program Manager, Field Coordinator, Remediation Coordinator, 2 Field Leads
Ecologist (Wetland Endangered Resources, Other), District Environmental Coordinators
Environmental Coordinator
Wetland Biologist
Planners
Environmental Scientist
Consultants and Biologists

APPENDIX G

SUCCESS COMPARISON QUESTIONNAIRE RESULTS

- Appendix A contains the question codes for the questions in these charts.
- A success code of 0 refers to the Low Success category of 0% to 80% success rate. A success code of 1 refers to the High Success category of 81% to 100% success rate. See Results and Discussion chapter for discussion of this distribution.
- Sample chart:

	Question 2 (success code)		
Question #	(code)	(code)	Grand Total
(code)			Row Total
(code)			Row Total
Grand Total	Column Total	Column Total	Total (N)

Question 3

Count of 3a	2		
3a	0	5	Grand Total
0	6	6	12
1	10	9	19
Grand Total	16	15	31

Percent	0	5
0	19%	19%
1	32%	29%

Count of 3e	2		
3e	0	5	Grand Total
0	2	4	6
1	14	11	25
Grand Total	16	15	31

Percent	0	5
0	6%	13%
1	45%	35%

Count of 3b	2		
3b	0	5	Grand Total
0	11	11	22
1	5	4	9
Grand Total	16	15	31

Percent	0	5
0	35%	35%
1	16%	13%

Count of 3f	2		
3f	0	5	Grand Total
0	9	7	16
1	7	8	15
Grand Total	16	15	31

Percent	0	5
0	29%	23%
1	23%	26%

Count of 3c	2		
3c	0	5	Grand Total
0	5	3	8
1	11	12	23
Grand Total	16	15	31

Percent	0	5
0	16%	10%
1	35%	39%

Count of 3g	2		
3g	0	5	Grand Total
0	15	13	28
1	1	2	3
Grand Total	16	15	31

Percent	0	5
0	48%	42%
1	3%	6%

Count of 3d	2		
3d	0	5	Grand Total
0	6	6	12
1	10	9	19
Grand Total	16	15	31

Percent	0	5
0	19%	19%
1	32%	29%

Count of 3h	2		
3h	0	5	Grand Total
0	13	14	27
1	3	1	4
Grand Total	16	15	31

Percent	0	5
0	42%	45%
1	10%	3%

Question 4

Count of 4	2		
4	0	5	Grand Total
1	3	7	10
3	13	8	21
Grand Total	16	15	31

Percent	0	5
1	10%	23%
3	42%	26%

Question 5

Count of 5	2		
5	0	5	Grand Total
0		2	2
1	1		1
2	6	2	8
3	8	7	15
4	1	4	5
Grand Total	16	15	31

Percent	0	5
0	0%	6%
1	3%	0%
2	19%	6%
3	26%	23%
4	3%	13%

Question 6

Count of 6a	2		
6a	0	5	Grand Total
0	2	2	4
1	14	13	27
Grand Total	16	15	31

Percent	0	5
0	6%	6%
1	45%	42%

Count of 6b	2		
6b	0	5	Grand Total
0	13	9	22
1	3	6	9
Grand Total	16	15	31

Percent	0	5
0	42%	29%
1	10%	19%

Count of 6c	2		
6c	0	5	Grand Total
0	8	10	18
1	8	5	13
Grand Total	16	15	31

Percent	0	5
0	26%	32%
1	26%	16%

Question 7

Count of 7	2		
7	0	5	Grand Total
0	13	10	23
1	3	5	8
Grand Total	16	15	31

Percent	0	5
0	42%	32%
1	10%	16%

Question 8

Count of 8	2		
8	0	5	Grand Total
0	8	5	13
1	8	10	18
Grand Total	16	15	31

Percent	0	5
0	26%	16%
1	26%	32%

Question 9

Count of 9a	2		
9a	0	5	Grand Total
0	8	9	17
1	8	6	14
Grand Total	16	15	31

Percent	0	5
0	26%	29%
1	26%	19%

Count of 9e	2		
9e	0	5	Grand Total
0	13	13	26
1	3	2	5
Grand Total	16	15	31

Percent	0	5
0	42%	42%
1	10%	6%

Count of 9b	9b		
2	0	1	Grand Total
0	9	7	16
5	7	8	15
Grand Total	16	15	31

Percent	0	5
0	29%	23%
1	23%	26%

Count of 9f	2		
9f	0	5	Grand Total
0	12	11	23
1	4	4	8
Grand Total	16	15	31

Percent	0	5
0	39%	35%
1	13%	13%

Count of 9c	2		
9c	0	5	Grand Total
0	10	7	17
1	6	8	14
Grand Total	16	15	31

Percent	0	5
0	32%	23%
1	19%	26%

Count of 9g	2		
9g	0	5	Grand Total
0	8	14	22
1	8	1	9
Grand Total	16	15	31

Percent	0	5
0	26%	45%
1	26%	3%

Count of 9d	2		
9d	0	5	Grand Total
0	13	11	24
1	3	4	7
Grand Total	16	15	31

Percent	0	5
0	42%	35%
1	10%	13%

Count of 9h	2		
9h	0	5	Grand Total
0	12	13	25
1	4	2	6
Grand Total	16	15	31

Percent	0	5
0	39%	42%
1	13%	6%

Count of 9i	2		
9i	0	5	Grand Total
0	13	14	27
1	3	1	4
Grand Total	16	15	31

Percent	0	5
0	42%	45%
1	10%	3%

Count of 9j	2		
9j	0	5	Grand Total
0	15	15	30
1	1		1
Grand Total	16	15	31

Percent	0	5
0	48%	48%
1	3%	0%

Question 12

Count of 12a	2		
12a	0	5	Grand Total
0	13	12	25
1	3	3	6
Grand Total	16	15	31

Percent	0	5
0	42%	39%
1	10%	10%

Count of 12b	2		
12b	0	5	Grand Total
0	13	13	26
1	3	2	5
Grand Total	16	15	31

Percent	0	5
0	42%	42%
1	10%	6%

Count of 12c	2		
12c	0	5	Grand Total
0	3	1	4
1	13	14	27
Grand Total	16	15	31

Percent	0	5
0	10%	3%
1	42%	45%

Count of 12d	2		
12d	0	5	Grand Total
0	11	10	21
1	5	5	10
Grand Total	16	15	31

Percent	0	5
0	35%	32%
1	16%	16%

Count of 12e	2		
12e	0	5	Grand Total
0	7	4	11
1	9	11	20
Grand Total	16	15	31

Percent	0	5
0	23%	13%
1	29%	35%

Count of 12f	2		
12f	0	5	Grand Total
0	13	13	26
1	3	2	5
Grand Total	16	15	31

Percent	0	5
0	42%	42%
1	10%	6%

Count of 12g	2		
12g	0	5	Grand Total
0	14	14	28
1	2	1	3
Grand Total	16	15	31

Percent	0	5
0	45%	45%
1	6%	3%

Count of 12h	2		
12h	0	5	Grand Total
0	10	14	24
1	6	1	7
Grand Total	16	15	31

Percent	0	5
0	32%	45%
1	19%	3%

Question 13

Count of 13	2		
13	0	5	Grand Total
0	6	5	11
1	10	10	20
Grand Total	16	15	31

Percent	0	5
0	19%	16%
1	32%	32%

Question 15

Count of 15a	2		
15a	0	5	Grand Total
0	9	12	21
1	7	3	10
Grand Total	16	15	31

Percent	0	5
0	29%	39%
1	23%	10%

Count of 15b	2		
15b	0	5	Grand Total
0	11	12	23
1	5	3	8
Grand Total	16	15	31

Percent	0	5
0	35%	39%
1	16%	10%

Count of 15c	2		
15c	0	5	Grand Total
0	12	12	24
1	4	3	7
Grand Total	16	15	31

Percent	0	5
0	39%	39%
1	13%	10%

Count of 15d	2		
15d	0	5	Grand Total
0	11	12	23
1	5	3	8
Grand Total	16	15	31

Percent	0	5
0	35%	39%
1	16%	10%

Count of 15e	2		
15e	0	5	Grand Total
0	11	13	24
1	5	2	7
Grand Total	16	15	31

Percent	0	5
0	35%	42%
1	16%	6%

Count of 15f	2		
15f	0	5	Grand Total
0	4	5	9
1	12	10	22
Grand Total	16	15	31

Percent	0	5
0	13%	16%
1	39%	32%

Count of 15g	2		
15g	0	5	Grand Total
0	8	13	21
1	8	2	10
Grand Total	16	15	31

Percent	0	5
0	26%	42%
1	26%	6%

Count of 15h	2		
15h	0	5	Grand Total
0	15	15	30
1	1		1
Grand Total	16	15	31

Percent	0	5
0	48%	48%
1	3%	0%

Count of 15i	2		
15i	0	5	Grand Total
0	13	12	25
1	3	3	6
Grand Total	16	15	31

Percent	0	5
0	42%	39%
1	10%	10%

Count of 20	2		
20	0	5	Grand Total
0	7	7	14
1	9	8	17
Grand Total	16	15	31

Percent	0	5
0	23%	23%
1	29%	26%

Question 21

Count of 21	2		
21	0	5	Grand Total
0	8	8	16
1	8	7	15
Grand Total	16	15	31

Percent	0	5
0	26%	26%
1	26%	23%

Question 22

Count of 22a	2		
22a	0	5	Grand Total
0	10	13	23
1	6	2	8
Grand Total	16	15	31

Percent	0	5
0	32%	42%
1	19%	6%

Count of 22b	2		
22b	0	5	Grand Total
0	9	12	21
1	7	3	10
Grand Total	16	15	31

Percent	0	5
0	29%	39%
1	23%	10%

Count of 22c	2		
22c	0	5	Grand Total
0	11	11	22
1	5	4	9
Grand Total	16	15	31
Percent	0	5	
0	35%	35%	
1	16%	13%	

Count of 22d	2		
22d	0	5	Grand Total
0	9	13	22
1	7	2	9
Grand Total	16	15	31
Percent	0	5	
0	29%	42%	
1	23%	6%	

Count of 22e	2		
22e	0	5	Grand Total
0	4	4	8
1	12	11	23
Grand Total	16	15	31
Percent	0	5	
0	13%	13%	
1	39%	35%	

Count of 22f	2		
22f	0	5	Grand Total
0	8	10	18
1	8	5	13
Grand Total	16	15	31
Percent	0	5	
0	26%	32%	
1	26%	16%	

Count of 22g	2		
22g	0	5	Grand Total
0	14	15	29
1	2		2
Grand Total	16	15	31
Percent	0	5	
0	45%	48%	
1	6%	0%	

Count of 22h	2		
22h	0	5	Grand Total
0	13	12	25
1	3	3	6
Grand Total	16	15	31
Percent	0	5	
0	42%	39%	
1	10%	10%	

Question 23

Count of 23	2		
23	0	5	Grand Total
0	9	8	17
1	7	7	14
Grand Total	16	15	31
Percent	0	5	
0	29%	26%	
1	23%	23%	

Question 24

Count of 24	2		
24	0	5	Grand Total
0	5	6	11
1	11	9	20
Grand Total	16	15	31
Percent	0	5	
0	16%	19%	
1	35%	29%	

Question 25

Count of 25	2		
25	0	5	Grand Total
0	9	8	17
1	7	7	14
Grand Total	16	15	31

Percent	0	5
0	29%	26%
1	23%	23%

Count of 26d	2		
26d	0	5	Grand Total
0	8	6	14
1	8	9	17
Grand Total	16	15	31

Percent	0	5
0	26%	19%
1	26%	29%

Question 26

Count of 26a	2		
26a	0	5	Grand Total
0	7	11	18
1	9	4	13
Grand Total	16	15	31

Percent	0	5
0	23%	35%
1	29%	13%

Count of 26e	2		
26e	0	5	Grand Total
0	14	12	26
1	2	3	5
Grand Total	16	15	31

Percent	0	5
0	45%	39%
1	6%	10%

Count of 26b	2		
26b	0	5	Grand Total
0	7	12	19
1	9	3	12
Grand Total	16	15	31

Percent	0	5
0	23%	39%
1	29%	10%

Count of 26f	2		
26f	0	5	Grand Total
0	9	7	16
1	7	8	15
Grand Total	16	15	31

Percent	0	5
0	29%	23%
1	23%	26%

Count of 26c	2		
26c	0	5	Grand Total
0	13	12	25
1	3	3	6
Grand Total	16	15	31

Percent	0	5
0	42%	39%
1	10%	10%

Count of 26g	2		
26g	0	5	Grand Total
0	9	5	14
1	7	10	17
Grand Total	16	15	31

Percent	0	5
0	29%	16%
1	23%	32%

Count of 26h	2		
26h	0	5	Grand Total
0	9	8	17
1	7	7	14
Grand Total	16	15	31

Percent	0	5
0	29%	26%
1	23%	23%

Count of 26l	2		
26l	0	5	Grand Total
0	14	11	25
1	2	4	6
Grand Total	16	15	31

Percent	0	5
0	45%	35%
1	6%	13%

Count of 26i	2		
26i	0	5	Grand Total
0		4	4
1	16	11	27
Grand Total	16	15	31

Percent	0	5
0	0%	13%
1	52%	35%

Question 27

Count of 27a	2		
27a	0	5	Grand Total
0	2	5	7
1	14	10	24
Grand Total	16	15	31

Percent	0	5
0	6%	16%
1	45%	32%

Count of 26j	2		
26j	0	5	Grand Total
0	14	15	29
1	2		2
Grand Total	16	15	31

Percent	0	5
0	45%	48%
1	6%	0%

Count of 27b	2		
27b	0	5	Grand Total
0	14	13	27
1	2	2	4
Grand Total	16	15	31

Percent	0	5
0	45%	42%
1	6%	6%

Count of 26k	2		
26k	0	5	Grand Total
0	11	12	23
1	5	3	8
Grand Total	16	15	31

Percent	0	5
0	35%	39%
1	16%	10%

Count of 27c	2		
27c	0	5	Grand Total
0	9	10	19
1	7	5	12
Grand Total	16	15	31

Percent	0	5
0	29%	32%
1	23%	16%

Count of 27d	2		
27d	0	5	Grand Total
0	6	8	14
1	10	7	17
Grand Total	16	15	31

Percent	0	5
0	19%	26%
1	32%	23%

Count of 27e	2		
27e	0	5	Grand Total
0	14	10	24
1	2	5	7
Grand Total	16	15	31

Percent	0	5
0	45%	32%
1	6%	16%

Count of 27f	2		
27f	0	5	Grand Total
0	9	11	20
1	7	4	11
Grand Total	16	15	31

Percent	0	5
0	29%	35%
1	23%	13%

Count of 27g	2		
27g	0	5	Grand Total
0	9	11	20
1	7	4	11
Grand Total	16	15	31

Percent	0	5
0	29%	35%
1	23%	13%

Count of 30	2		
30	0	5	Grand Total
0	13	10	23
1	3	5	8
Grand Total	16	15	31

Percent	0	5
0	42%	32%
1	10%	16%

Question 31

Count of 31a	2		
31a	0	5	Grand Total
0	2	6	8
1	1	2	3
Grand Total	3	8	11

Percent	0	5
0	18%	55%
1	9%	18%

Count of 31b	2		
31b	0	5	Grand Total
0	1	3	4
1	2	5	7
Grand Total	3	8	11

Percent	0	5
0	9%	27%
1	18%	45%

Count of 31c	2		
31c	0	5	Grand Total
0		2	2
1	3	6	9
Grand Total	3	8	11

Percent	0	5
0	0%	18%
1	27%	55%

Count of 31d	2		
31d	0	5	Grand Total
0	1	4	5
1	2	4	6
Grand Total	3	8	11

Percent	0	5
0	9%	36%
1	18%	36%

Count of 31e	2		
31e	0	5	Grand Total
0	2	8	10
1	1		1
Grand Total	3	8	11

Percent	0	5
0	18%	73%
1	9%	0%

Count of 31f	2		
31f	0	5	Grand Total
0	2	4	6
1	1	4	5
Grand Total	3	8	11

Percent	0	5
0	18%	36%
1	9%	36%

Count of 31g	2		
31g	0	5	Grand Total
0	2	6	8
1	1	2	3
Grand Total	3	8	11

Percent	0	5
0	18%	55%
1	9%	18%

Count of 31h	2		
31h	0	5	Grand Total
0	2	3	5
1	1	5	6
Grand Total	3	8	11

Percent	0	5
0	18%	27%
1	9%	45%

Count of 31i	2		
31i	0	5	Grand Total
0	2	6	8
1	1	2	3
Grand Total	3	8	11

Percent	0	5
0	18%	55%
1	9%	18%

Count of 31j	2		
31j	0	5	Grand Total
0	3	6	9
1		2	2
Grand Total	3	8	11

Percent	0	5
0	27%	55%
1	0%	18%

Question 32

Count of 32	2		
32	0	5	Grand Total
1		2	2
3	1	1	2
4	2	5	7
Grand Total	3	8	11

Percent	0	5
1	0%	18%
3	9%	9%
4	18%	45%

Question 33

Count of 33a	2		
33a	0	5	Grand Total
0	2	5	7
1	1	3	4
Grand Total	3	8	11

Percent	0	5
0	18%	45%
1	9%	27%

Count of 33b	2		
33b	0	5	Grand Total
0	1	3	4
1	2	5	7
Grand Total	3	8	11

Percent	0	5
0	9%	27%
1	18%	45%

Count of 33c	2		
33c	0	5	Grand Total
0	2	7	9
1	1	1	2
Grand Total	3	8	11

Percent	0	5
0	18%	64%
1	9%	9%

Question34

Count of 34	2		
34	0	5	Grand Total
0		3	3
1	3	5	8
Grand Total	3	8	11

Percent	0	5
0	0%	27%
1	27%	45%

Question 36

Count of 36	2		
36	0	5	Grand Total
0	8	2	10
1	8	13	21
Grand Total	16	15	31

Percent	0	5
0	26%	6%
1	26%	42%

Question 37

Count of 37a	2		
37a	0	5	Grand Total
0	3	10	13
1	6	3	9
Grand Total	9	13	22

Percent	0	5
0	14%	45%
1	27%	14%

Count of 37b	2		
37b	0	5	Grand Total
0	6	7	13
1	3	6	9
Grand Total	9	13	22

Percent	0	5
0	27%	32%
1	14%	27%

Count of 37c	2		
37c	0	5	Grand Total
0	2	3	5
1	7	10	17
Grand Total	9	13	22

Percent	0	5
0	9%	14%
1	32%	45%

Count of 37d	2		
37d	0	5	Grand Total
0	3	5	8
1	6	8	14
Grand Total	9	13	22

Percent	0	5
0	14%	23%
1	27%	36%

Question 38

Count of 38	2		
38	0	5	Grand Total
0	2	4	6
1	7	9	16
Grand Total	9	13	22

Percent	0	5
0	9%	18%
1	32%	41%

Question 39

Count of 39a	2		
39a	0	5	Grand Total
0		1	1
1	7	8	15
Grand Total	7	9	16

Percent	0	5
0	0%	6%
1	44%	50%

Count of 39b	2		
39b	0	5	Grand Total
0	1	1	2
1	6	8	14
Grand Total	7	9	16

Percent	0	5
0	6%	6%
1	38%	50%

Count of 39c	2		
39c	0	5	Grand Total
1	7	9	16
Grand Total	7	9	16

Percent	0	5
1	44%	56%

Count of 39d	2		
39d	0	5	Grand Total
0	2	5	7
1	5	4	9
Grand Total	7	9	16

Percent	0	5
0	13%	31%
1	31%	25%

Count of 39e	2		
39e	0	5	Grand Total
0	2	1	3
1	5	8	13
Grand Total	7	9	16

Percent	0	5
0	13%	6%
1	31%	50%

Count of 39f	2		
39f	0	5	Grand Total
0	3	5	8
1	4	4	8
Grand Total	7	9	16

Percent	0	5
0	19%	31%
1	25%	25%

Count of 39g	2		
39g	0	5	Grand Total
0	5	9	14
1	2		2
Grand Total	7	9	16

Percent	0	5
0	31%	56%
1	13%	0%

Question 40

Count of 40	2		
40	0	5	Grand Total
1	5	3	8
4	2	6	8
Grand Total	7	9	16

Percent	0	5
0	33%	20%
1	13%	40%

Count of 39h	2		
39h	0	5	Grand Total
0	5	8	13
1	2	1	3
Grand Total	7	9	16

Percent	0	5
0	31%	50%
1	13%	6%

Question 42

Count of 42	2		
42	0	5	Grand Total
0	3	5	8
1	13	10	23
Grand Total	16	15	31

Percent	0	5
0	10%	16%
1	42%	32%

Count of 39i	2		
39i	0	5	Grand Total
0	5	8	13
1	2	1	3
Grand Total	7	9	16

Percent	0	5
0	31%	50%
1	13%	6%

Question 43

Count of 43a	2		
43a	0	5	Grand Total
0	9	7	16
1	4	3	7
Grand Total	13	10	23

Percent	0	5
0	35%	27%
1	15%	12%

Count of 39j	2		
39j	0	5	Grand Total
0	7	6	13
1		3	3
Grand Total	7	9	16

Percent	0	5
0	44%	38%
1	0%	19%

Count of 43b	2		
43b	0	5	Grand Total
0	9	8	17
1	4	2	6
Grand Total	13	10	23

Percent	0	5
0	35%	31%
1	15%	8%

Count of 43c	2		
43c	0	5	Grand Total
0	10	9	19
1	3	1	4
Grand Total	13	10	23

Percent	0	5
0	38%	35%
1	12%	4%

Count of 43g	2		
43g	0	5	Grand Total
0	11	10	21
1	2		2
Grand Total	13	10	23

Percent	0	5
0	42%	38%
1	8%	0%

Count of 43d	2		
43d	0	5	Grand Total
0	7	9	16
1	6	1	7
Grand Total	13	10	23

Percent	0	5
0	27%	35%
1	23%	4%

Count of 43h	2		
43h	0	5	Grand Total
0	10	8	18
1	3	2	5
Grand Total	13	10	23

Percent	0	5
0	38%	31%
1	12%	8%

Count of 43e	2		
43e	0	5	Grand Total
0	10	7	17
1	3	3	6
Grand Total	13	10	23

Percent	0	5
0	38%	27%
1	12%	12%

Count of 43f	2		
43f	0	5	Grand Total
0	2	3	5
1	11	7	18
Grand Total	13	10	23

Percent	0	5
0	8%	12%
1	42%	27%

Question 44

Count of 44	2		
44	0	5	Grand Total
1	1		1
2	7	4	11
3	8	7	15
4		4	4
Grand Total	16	15	31

Percent	0	5
1	3%	0%
2	23%	13%
3	26%	23%
4	0%	13%

Question 45

Count of 45	2		
45	0	5	Grand Total
1	7	6	13
2	4	2	6
3	2	3	5
4	3	4	7
Grand Total	16	15	31

Percent	0	5
1	23%	19%
2	13%	6%
3	6%	10%
4	10%	13%

Question 46

Count of 46a	2		
46a	0	5	Grand Total
0	10	10	20
1	6	5	11
Grand Total	16	15	31

Percent	0	5
0	32%	32%
1	19%	16%

Count of 46b	2		
46b	0	5	Grand Total
0	2	2	4
1	14	13	27
Grand Total	16	15	31

Percent	0	5
0	6%	6%
1	45%	42%

Count of 46c	2		
46c	0	5	Grand Total
0	12	10	22
1	4	5	9
Grand Total	16	15	31

Percent	0	5
0	39%	32%
1	13%	16%

Count of 46d	2		
46d	0	5	Grand Total
0	11	11	22
1	5	4	9
Grand Total	16	15	31

Percent	0	5
0	35%	35%
1	16%	13%

Count of 46e	2		
46e	0	5	Grand Total
0	15	13	28
1	1	2	3
Grand Total	16	15	31

Percent	0	5
0	48%	42%
1	3%	6%

Count of 46f	2		
46f	0	5	Grand Total
0	15	13	28
1	1	2	3
Grand Total	16	15	31

Percent	0	5
0	48%	42%
1	3%	6%

Question 47

Count of 47	2		
47	0	5	Grand Total
0	3	5	8
1	13	10	23
Grand Total	16	15	31

Percent	0	5
0	10%	16%
1	42%	32%

Question 48

Count of 48	2		
48	0	5	Grand Total
0	10	12	22
1	6	3	9
Grand Total	16	15	31

Percent	0	5
0	32%	39%
1	19%	10%

Question 50

Count of 50	2		
50	0	5	Grand Total
0	14	11	25
1	2	4	6
Grand Total	16	15	31

Percent	0	5
0	45%	35%
1	6%	13%

APPENDIX H

NARRATIVE RESPONSES FROM QUESTIONNAIRE

10. What would you recommend to improve DOT evaluation of mitigation plans and specifications?

- Greater involvement by wetland ecologists and soil scientist.
- Better set of specifications, especially in the area of soils
- Review occurs at headquarters. We may not get plans that are done by consultants to review, which can lead to inadequate plans and pay items for field. Better training. Eliminate consultants.
- You need a note section on the plans dictating the timing of the various elements in the mitigation- not in specifications.
- Formal instruction.
- Improved transfer of info between phases of planning, design, construction, and operations.
- Multi disciplinary review teams, on-site pre-construction visits.
- Interdisciplinary training.
- Keep decisions on wetland issues to those staff that are trained and have experience. Currently, county engineers or design engineers can change specs. requirements without notifying specialists.
- We are making improvements every day and are given the time and money needed by __SHA.
- Good communication between wetland biologists, landscape architects and hydraulics engineers.

- Minimize number of consultant-designed mitigation sites. Consultants have little hands-on construction experience relative to experienced DOT biologists or ecologists.
- Need to simplify and not over-design projects as sometimes occurs in an engineering environment. Post construction review and cost analysis to look at lessening costs.
- We find that it is best if everyone involved as well as others with specific backgrounds review the plans.
- Increase the staff such that more individual time can be placed on review and oversight.
- Increased staff and time devoted to this effort.
- Provide more diverse professional/ biological evaluation of such sites.
- Greater investment of interest/ priority by engineering staff.
- Need more time. Our schedules are often compressed so that plans and specs review is rushed.
- Reviews conducted earlier in the process rather than at the PS and E stage when a letting for the project is being pursued. Development of specifications/ special provisions for wetland mitigation.
- A good checklist for all aspects of plan and detailed specifications, which should be standard on all mitigation plans.
- Get field engineers more involved.

- Have a peer review by a qualified wetlands biologist, someone who understands the relationship between soils, hydrology, and vegetation.
- More pre-construction monitoring for the hydrologic characteristics of the site.
- More oversight and communication between those individuals involved.
- Team approach- team should be composed of science professionals (hydrogeologists, surface water hydrologists, ecologists, landscape architects), engineers (civil, agricultural (if available)).

14. What would you recommend to improve the quality of supervision of wetland construction?

- More training and education.
- Civil Engineer needs to call us prior to construction commencing on wetlands – not after. More trained people.
- Allow the staff to attend more educational class, seminar, etc.
- Emphasis on soil abuse during construction and excessive compaction of soils.
- Formalized instruction.
- Let separate contracts for construction of highways and planned wetlands. They're usually tied together and wetlands work is subbed out. Include as part of contract, that a "qualified" person supervise construction.
- Consultant inspection by qualified wetland professionals.
- Interdisciplinary training.

- Have biologist/wetland scientist involved from start to finish. Work with design staff, engineers, and contractor (essential).
- The supervision should be done by an Environmental Specialist with knowledge, skills and abilities in wetland design.
- Take the time to contact the "experts" and have them visit the site during construction.
- Tighter controls to limit construction to more experienced contractors. Not likely to happen, perhaps has legal problems.
- More time for wetland staff to monitor construction. Trained project engineers with wetland construction experience. Contractors with wetland construction and design experience.
- Tell the project manager overseeing the construction if you don't see water or don't have equipment becoming stuck, call us.
- A good understanding of the proposed plan and experience.
- More specific training.
- Supervisors should be more consistently subjected to wetland construction. As it stands now, they may build one site every year. Not enough experience.
- Provide suitable training in wetland construction to field supervisors/staff. Provide more on-site supervision by biologist.
- Higher priority on having wetland specialist on-site during construction.

- More training of construction inspectors in wetland/biological sciences. Pulling the wetland mitigation /natural resource mitigation element from general road construction projects.
- We are currently designing training for wetland construction inspectors and hope to separate out wetland mitigation construction from the larger highway construction contracts in order to have inspectors with wetland experience (and contractors as well).
- One designated District Environmental /Ecologist/Wetland Biologist for all District sites – should be this individual's sole responsibility along with selecting and participating in designing and monitoring. i.e. - A district Wetland Mitigation specialist that would be onsite during construction of all sites.
- Providing wetland construction training to all staff involved in the process, both in the design phase and construction phase.
- Wetland design/enhancement short course.
- Hire a wetland biologist to supervise. However, actual construction isn't as much the problem as the design.
- Better coordination with contractor at the pre-construction meeting. Employ a non-site environmental Inspector for large sites.
- Training. More oversight more consistently applied on all projects.
- Closer oversight by design team. Presence of science professional from design team – to coordinate with construction engineer.

16. What criteria does your DOT use to evaluate the data?

- Don't have specific criteria – case by case.
- Whatever is required by the Corps.
- Qualitative reports based on the mitigation design criteria.
- Sound science and not garbage. Strong view toward successional patterns developing.
- Percent plant cover.
- We monitor for attainment of standard performance standards. We look at the data and ask if the standards have been met.
- Corp '87 manual.
- Monitoring plan, permit conditions.
- None. COE review.
- Check against goals and objectives in preliminary plan and monitoring plan.
- Interagency mitigation guidelines.
- We have standards for % cover vegetation and # of native species established.
- The criteria set forth in the permit(s) or bank agreement.
- Acceptance by Resource Agencies, any required /suggested improvements are implemented.
- The DOT utilizes the _DT Wetland Assessment Methodology to assess wetland functions and values for each site. Monitoring of each site is in accordance with Army Corps of Engineers Omaha District Monitoring Guidelines. An interagency wetland group reviews all data collected on mitigation sites.

- Hydrology, plant species composition.
- The criteria are based on the approved goals and objectives used to develop the mitigation package as well as the wetland permit conditions.
- Based on permit requirements.
- US Army Corps definition of 12.5% consecutive days of water table within 12" of surface.
- Percent cover by desired vegetation. Attainment of desired hydrology and hydroperiod. Area of mitigation wetland equals or exceeds area required. Adequate control of undesirable/ noxious vegetation. Success in achieving desired functions. Compatibility of site with adjacent land uses. Permit compliance.
- Success criteria developed in the mitigation plan – Plant survival, % area coverage with desirable plant species, whether wetland portions met 3 wetland field indicators at end of monitoring period.
- The permit criteria. Our mitigation plans generally include performance criteria, which are adopted by the regulators. We use veg. cover and hydrology as primary criteria. Also total wetland area.
- Meeting / not meeting goals established for the site. Meeting permit conditions that typical define acres, % vegetative cover, acres by wetland type, etc.
- Generally this work is done by the consultant and DOT reviews the data before forwarding it to permitting agency.

- Typically monitored by a team of resource agency representatives and environmental staff (DOT).
- (Not sure what this means) We strive for 80% cover by desired vegetation.
- Does the wetland meet the targeted functions and values? Plant survival rate. Stability of soils, control structures, etc.
- Data is collected to address site-specific standards of success. Monitoring data is evaluated to see if standards have been achieved.
- Ultimately, the establishment of wetland hydrology with adequate hydroperiod, hydric soils and hydrophytic vegetational community.

17. If the evaluation indicates that the wetland mitigation site is not meeting goals and the performance specifications of the permit, what, if any, formal procedures do you have to rectify the problem?

- No formal procedures.
- No formal, it still under construction (several year or several phase project, use work order or design in next phase). If construction complete, may have to develop separate project.
- We look at the shortfall and discuss solutions in-house first and then when we have a plan we will discuss it with the regulatory agencies.
- Letter to the Corps with suggested remedy.
- None – We would meet with the COE & FHWA to discuss a course of action.

- Oftentimes we will replant a site or augment the original. Other times, we will rely on natural regeneration and will get permission from regulatory agency.
- We sometimes get formal requests from the Corps to perform remediation at unsuccessful sites.
- To date we have an internal process with the districts.
- None.
- Address individual problems as soon as possible according to preliminary plan proposal remediation.
- We have a remediation program in place and funded.
- None.
- Always the threat of lost wetland credits.
- Nothing "formal", each is project-specific, as it should be. Only common thread is this: 1.) Consult with in-house wetland experts 2.) Discuss next with Corps.
- Goals and performance standards have just recently been implemented in _______. Previous mitigation projects had to meet acreage goals and objectives. If acreage totals were not accomplished, the _DT had to find another site to make up the difference. Monitoring has had to find another site to make up the difference. Monitoring has only recently been required of all completed projects over the past couple of years. _DT has hired a consultant to monitor sites statewide beginning in 2001. Corrective actions will be made based upon these findings.

- Field review. Discussions with project managers. Discussions with resource agencies. Develop remediation action. Implement remediation action.
- There is no formal procedure – we identify the potential problems and come up with solutions.
- Annual monitoring reports define success or failure. If remediation is necessary, work with agencies and _DOT to make corrections.
- None, so far. This has been a recurring issue, and we are working to develop a roles and responsibilities network and funding to address remediation needs.
- We notify managers/area engineers of non-compliance to work out a correction plan, hopefully before we are notified by regulators.
- No formal procedure. We negotiate via meetings and correspondence with the regulators.
- None. Some Districts voluntarily will arrange for some remediation. In most instances, little is done until the ACOE or state permitting agency threatens a violation notice.
- _DOT normally finds a mitigation site acceptable to the permitting agency before the permit is issued. If problems arise after construction, the site is usually left alone unless the hydrology is absent, leaving the mitigation site dry.
- Negotiate solution with resource agencies.
- Nothing formal. We try to modify the site to make it work, or design another wetland at a new site, if all else fails.

- All changes are coordinated with the Corps of Engineers and __ Agency of Natural Resources.
- We have a site remediation fund and program.
- Any construction measure that fails (structure 'blowout') or catastrophic event causing failure (unusual storm event) will be rectified in self-interest of maintaining established wetland. Ecological failure if not reasonably rectified on-site may be compensated (taken to) another site. "Case By Case".

18. What would you recommend to improve the way in which monitoring data is evaluated and the evaluation used to remedy wetland problems?

- Resource agencies and DOT must agree on monitoring data, mitigation goals and corrective actions prior to implementing mitigation.
- Not a priority. Until it is, we do as little is possible.
- To look at the site to determine if Mother Nature has a plan that may conflict with man's.
- Guys, to be bluntly honest, after 3 years you should know what worked and what didn't – very apparent. Just fix it or come to the conclusion that it can't be fixed. Design flaw or concept flaw.
- Track, collect, document and share with others: successes and failures.
- Set realistic objectives, select the right site... This is what we have done.
- Have knowledgeable staff and have funding available. However, the Corps must also be responsible for review and recommendation.

- Keep it simple.
- Establish better criteria, stop relying on universal, formal procedures, guidelines and policies – always make adjustments or criteria to reflect site conditions.
- Inspect more often (at least semi-annual).
- It is hoped that the monitoring efforts will identify problems and make recommendations for correction. _DT will provide funds and expertise to make corrections/adjustments to each site needing changes. FHWA needs to provide funds to make these corrections occur for the life of each site.
- Thorough documentation of site. Photos of entire site, not just monitoring plots. Correct any problems immediately.
- Agency comments are received soon enough to make changes the following summer.
- Start collecting data, more staff.
- Additional personnel and dedicated funding to implement evaluations and remediation. New construction deadlines currently take precedence over remediation of old work.
- Basically, following-up on the result of the evaluation of data. Apply 3 field criteria to determine problem. Decision matrix is attached.
- Have clear, measurable goals and performance criteria/standards for those goals.
- We have had success with multi-agency field visits to evaluate the site's "success" and recommend any remediation if needed. If they are satisfied at the

time of the site visit we frequently have little remediation to do and sometimes are absolved from further monitoring, etc.

- _DOT doesn't deal with these problems frequently. We have very few projects which require wetland mitigation- less than one per year. Therefore, many of these questions are difficult for us to address.
- Nothing, monitoring isn't our problem.
- Ensure specific, targeted, measurable function and values. Establish base points for data collection.
- Monitoring protocols are being revised. We are moving from a standardized approach to a site-specific, objective based monitoring strategy. Also, we have developed a process improvement team that's currently working on ways to facilitate communication of monitoring results and site-related problems to appropriate landscape architects, biologists, maintenance personnel, etc.
- Establish what is required during the initial feasibility study and design. Develop reasonable criteria based on the sites hydro geomorphology and restoration potential.

28. In what form do you record monitoring data?

- Whatever Corps requires.
- Tabular.
- Report to regulatory agencies.
- Written documentation and photographs.

- Tabular.
- Spreadsheet, narrative.
- Text report with photos.
- Data sheets.
- Reports (yearly).
- See monitoring form.
- Written and electronic.
- Monitoring data for the future will be placed into database and electronic formats, besides hardcopy formats required by the regulatory and resource agencies.
- In Access Database.
- Narrative, tables, photos, and plans.
- In a report.
- Vegetation plots, RDS gauges (surface, rain , groundwater).
- Annual monitoring reports.
- Data sheets.
- Data tables, maps and narrative reports.
- We have developed a data system for this data. The system includes customized report generation and District/Statewide tracking.
- Consultants prepare monitoring reports.
- Annual reports to Corps of Engineers for 3-5 years.
- Annual reports to resource agencies.
- Paper data sheets, palmtop computers.

- Tabulated data and derived graphics in EXCEL spread sheets. Some GIS use and application – not uniformly developed for statewide use.

29. What recommendations would you make to improve the quality and efficiency of construction and post construction monitoring of mitigation wetland sites?

- Publish it in journal or notes, otherwise almost useless.
- More people, better trained, relevant educational backgrounds, more time, more money, more everything.
- Formalize the process – Develop a tracking system – checklists to assist in: Qualitative, Quantitative, Data collection, Reminder to schedule, Respond to issues in a timely fashion.
- I'm happy with our monitoring program. We have excellent staff conducting wetland monitoring. Quality is tops. Efficiency drops when we have to monitor numerous small mitigation sites otherwise, I believe our monitoring is efficient.
- In a DOT setting, have a staff composed of Biologist, and Design Engineer. Prepare and let a separate contract solely for the wetland mitigation site. This ensures that the project is both completed and satisfies your requirements. Meet and work with contractor. Have wetland professional available to supervise. Set up a specific fund for mitigation to ensure availability of money.
- We are working on a new monitoring program (see attached).
- None.

- If following a rigid protocol, don't stop there – expand sampling and recording according to site and permit needs and constraints.
- More training of construction project managers in wetland construction and theory. Hiring of qualified contractors to construct wetlands based on experience, not low bid practices. Develop a short specialized list of construction contractors capable of constructing wetland and stream restoration projects.
- If no water during construction, than changes need to be made immediately.
- We generally monitor our larger sites in teams of two this seems to improve efficiency since each individual has designated monitoring/data collection tasks.
- No recommendations at this time.
- Increase funding, personnel/time allocation and maintenance support.
- Breaking the wetland construction off from the main contract/more control over wetland construction and contractor.
- Involve the agencies on site. Keep as simple as possible. Keep permit conditions/goals simple. Focus/limit intensive monitoring to sites that have problems in year 1 and 2.
- Having specific format to be followed by consultants or DOT staff who prepare reports and do the monitoring.
- Make sure the design is done by someone who understands the relationship between vegetation, soils, and hydrology, and the design is peer reviewed by someone of like qualifications.

- Ensure repeatability of the process. Ensure that the targeted functions can be measured once the area is completed.
- Presently, monitoring during the construction phase of our mitigation projects is 'hit or miss'. It would be to our benefit to have monitoring during the construction phase of all projects. We are moving to standardized monitoring protocols to an objective-based monitoring strategy that incorporates site-specific sampling designs with statistical analysis to more accurately portray site development.
- Construction: Greater presence of design and environmental staff during construction process. Monitoring: Additional part and full time staff dedicated to collection and analysis of geomorphological, hydrological, and vegetational monitoring data.

35. What recommendations would you make to improve the quality and efficiency of post construction mitigation wetland project management?

- Population based statistics.
- Provide additional staff for oversight and recruit more volunteer conservation groups to adopt a site for management on _DT owned sites. Provide a simpler way to provide landowners with funds for routine maintenance costs on wetland sites on private property.
- Training course would be great!

- We are in the process of creating a mitigation site database and establishing maintenance protocols for our maintenance crews. We also are trying to have other entities assume ownership and responsibility of mitigation sites.
- Let the resource agencies manage the site after the completion of the designated monitoring period.
- Our wetland monitoring program is taking a more active role. As part of the adaptive management cycle, monitoring personnel regularly report monitoring results to project managers. Maintenance and remediation-related issues are also communicated to the appropriate personnel via monitoring program.
- None.

41. What suggestions would you have for creating a mitigation wetland inventory that is useful, accurate, easy to access and can be rapidly updated?

- Simple as possible.
- Digital database with ArcView Applications.
- See attached.
- Encourage FHWA/TRB to complete wetland impact/mitigation database project.
- Develop a database of wetland sites across the state for inclusion on _DT's website. However, there are concerns with privacy issues and release of info without landowner approval.
- Creating a database specific to monitoring requirements.
- Electronic files. Designated Database manager.

- We will be updating ours to a web-based/ browser version. Need to have consultant access/ ability for agencies to access/ ability to update from outside the DOT.
- Keep records on computers. Establish monitoring and data collection and accounting schedules.
- GIS/GPS information would be helpful (currently under development). Currently developing individual site-specific monitoring protocols that will be available on the intra/internet and in hardcopy.
- ACCESS Data Base has been developed to handle the reporting obligation to regulatory agencies. Plans are to enhance this Data Base with new features. Use of GIS is being investigated.

49. What would you estimate the additional funding would be on a per acre basis?

- Per acre I can't easily tell you. But our district one office just let a contract for $225,000.00 to maintain 8 sites in ________ area.
- Unknown. This is done as part of our remediation program.
- Approximately $50,000 is allocated for management and maintenance at a cost per acre of approximately $80.00.
- $150.00 per acre

APPENDIX I

RESPONSES FROM TELEPHONE INTERVIEWS

<u>Regulatory Agencies Interview Responses</u>

1. **Based on your experience in assessing mitigated wetlands, what are the principle causes of wetland performance levels below agreed upon standards of wetland failure?**

    - Hydrology- lack of predictable or predicted hydrology.
    - For restoration (they don't do created)- long-term maintenance operation.
    - Lack of stable water- Quantity of water supply and timing is not consistent or stable.
    - Contractors do not follow specifications or guidelines, lack of information and proper specification by designers (sometimes designers have no ecosystem or succession understanding and this causes design problems). Lack of monitoring between 5-year period, and no adjustments based on problems found in monitoring.

2. **Has your agency developed a protocol or check list for evaluating (reviewing) mitigated wetland plans?**

    - NO.
    - NO.
    - NO.
    - Protocol policy – Run plans through appropriate specialists- wetland consultants.

A. Do you believe DOT's do an adequate job of evaluating mitigated wetland plans?

- YES- best possible.
- NO- they need help.
- Getting better.
- With resources- they do the best they can, when they bring in specialists, they seem to do a better job.

B. What would you recommend DOT's do to improve the quality of their plan evaluations?

- Pre-construction- Get Corps agreement of plan prior to approval
- Hire consultants because they don't have the necessary in-house expertise
- Consult more with other agencies who are knowledgeable about the issues
- Hire consultants on retainer.

3. Has your agency developed a protocol for evaluating mitigated wetland construction in the field?

- NO- assess prior to construction using success ratio.
- Don't evaluate during construction.
- Depends on site- not generally.
- Have process- regulatory contracting procedure which includes pre-construction conference and environmental consulting following the federal NEPA process.

4. **Does your agency have a recommended protocol for monitoring mitigated wetlands or for preparing a monitoring plan?**

- No- monitoring based on permit requirements.
- No- only evaluate UDOT's monitoring plan to look for wildlife component.
- Yes.
- Based on annual monitoring for 5 years. Have annual review. Complete transects for large areas. Other areas have on-site review and look at invasive species.

A. **Do you believe DOT's do and adequate job of monitoring mitigated wetlands?**

- No-could improve.
- No.
- Don't know.
- With resources have difficulty. Some jobs are okay, others are not.

B. **What would you recommend DOT's do to improve the quality of monitoring mitigated wetlands?**

- Outline funding sources for their monitoring and maintenance.
- They need outside help from consultants or wetland experts.
- No recommendations.
- Use consultants rather than in-house.

5. Briefly describe the interaction between the various agencies that may be involved in plan evaluation, monitoring and approval of compliance.

- For projects that receive federal aid:
  - Impact assessment developed using associated wetland values with Corps.
  - DOT's develop a plan, and it is reviewed by Corps.
  - If it is an oversight project, construction oversight by Corps and sometimes FHA.
  - Upon completion, Corps review of constructed wetland.
  - Monitoring depending on permit requirements developed by Corps.
- USFWS assists in reviewing plan that the DOT's develop. FWS works with DOT to incorporate issues that are important to the FWS.
- Corps of engineers and UDOT: Wildlife reviews of all projects relating to wildlife, but can only make suggestions. Suggestions and reviews are not always considered.
- Plan evaluation by agency in conjunction with Corps. EPA review at times, especially in the case of an environmental impact. Corps issues notice to proceed and has final say on plan goals and specifications.

6. **Do you believe that the DOT's in your state or DOT's in you region are adequately staffed in numbers and areas of expertise to adequately address mitigated wetland projects?**

    - Beneficial to have additional staff or additional training for evaluation and assessment.
    - No. Definitely not.
    - No.
    - Depends on level of project, variable.

7. **What advice would you give DOT's to assist them in meeting your agency's regulations?**

    - Identify funding sources to monitor and maintain wetlands for 5 years following construction or as required in permit.
    - They need to hire outside help or have in-house expertise (hire someone who has wetland expertise).
    - Make and keep contacts with the agencies to allow effective communication.
    - Hire consultants on retainer so that they're not understaffed or understaffed depending on amount of work. In complying, keep a close liaison with the Corps to allow immediate review to determine whether impacts will be made and start the process as quickly as possible.

Contractors Interview Responses

1. In your experience, what are the principle causes of mitigated wetland failure?

- Maintenance.
- Lack of water.
- Lack of complete understanding of what needs to be done.
- Improper site selection is number one. Design is sometimes a problem- not deep enough.

2. Do you believe that pre-construction conferences conducted by DOT personnel adequately prepare you for the mitigated wetland portion of highway construction projects?

- If individuals conducting conferences have understanding of wetlands especially hydrology.
- Yes.
- Not completely.
- No.
- Depends on how the DOT engineer handles it.

A. If your answer is NO, what would you suggest that DOT's do to make the pre-construction conference more effective regarding mitigated wetlands?

- Make sure everyone has a clear understanding of wetland issues in project ahead of time.
- Talk about wetland issues more- address them at the meeting instead of relying on specifications to communicate everything that needs to be done. I haven't been to a meeting where they addressed them. They're just in the specifications.

3. Rate the quality, clarity, accuracy, and practicability of the mitigated wetland plans you have to work from?

- No complaints, as long as they're adaptable to the ecosystem.
- Fair.
- Fair to poor.
- Fair.
- Good.

A. If you answered fair or poor, what do you believe should be done to improve mitigation wetland plans?

- Any plan is a good plan.
- Have someone that understands construction review the plans.

- More details and input from regulatory agencies approving mitigation.
- More detail.

4. Do you have any general comments that you believe would help DOT's construct higher quality mitigated wetlands?

- Wetland projects should go to companies that handle permitting, design, and build. Often times, the state staff takes on more than they are qualified. For example, seeding techniques for native grass seeds.
- Need better understanding of what works and doesn't work. Learn from past mistakes and successes.
- Provide ample time to allow for impacts that mitigating wetlands have on the rest of the job. Need to clarify in detail the scope of the work prior to bid. Define what scope of work is to clarify expectations.
- Handling of wetland mitigation is getting better. Sometimes expectations are set too high. Stick with tried and proven planting methods. Experimenting with new plants and seeding techniques is not good in large areas- it's too expensive and may not work. Experiment on smaller plots.

<u>Wetland Consultant Interview Responses</u>

1. **Based on your experience in designing and/or monitoring mitigated wetlands, what do you believe are the principle causes for poor wetland performance or failure?**

    - Improper hydrology– based on site selection and design.
    - Commitment of resources– not enough time and money to properly implement plan.
    - Improper planning and design.
    - Improper design for site selected. Poorly thought out for particular piece of ground. Negligence by permit agency- Corps signs-off and walks away from project.

2. **How would you rate the quality of mitigated wetland plan evaluation by DOT's in your state or region?**

    - Fair to poor. Major issues are lack of funding and time.
    - I haven't looked at DOT plans. I would have to say fair based on what is written and what is implemented. Need better follow-up on project and with consultant. Better communication. Don't just try to get by with minimum requirements because of time and money deadlines
    - Not applicable. No evaluation done by DOT, no internal resources. They should have a fund for contracted services so as not to increase internal funding and staffing.

- Poor. Improve who reviews project or who is project manager. DOT's use engineers/network, not these best for job. Funding poor, DOT's send rookies, pass on responsibility. Some are good and thorough

3. How would you rate the quality of DOT's evaluation of mitigated wetland construction in the field?

- Not applicable. Evaluation of construction is done by consultants and written into project.
- Not applicable.
- Fair. More wetland training in regard to function.
- Fair. Contractor in field is money driven; lowest bid process is the cause.

4. How would you rate the performance of contractors in constructing mitigated wetlands?

- Excellent, if have pre-construction meetings, which enable good communication and allow contractors to voice concerns, ask questions. It makes them more willing to call during construction if problems arise.
- Good.
- Good. Experience is the key.
- Fair. Have someone on the site other than DOT, such as consultant. Construction management should include periodic inspection.

5. **How would you rate monitoring plans prepared by DOT's, plans that you have been asked to implement in the fields?**

- I have not implemented a DOT monitoring plan.
- Poor. Need to be more rigorous. Criteria need to be carefully thought out, rigid and written down. Need to assess quantitative data. Should have standards. Photograph plots.
- Have not implemented.
- Consultants do them.

6. **How do mitigated wetland monitoring plans you have prepared for DOT's differ from those prepared by DOT's?**

- I formerly worked in a state with a DOT monitoring protocol. Excellent rating.
- Mine are rigorous. DOT's are diluted/ basic/ watered down.
- More thorough, more scientific.
- Same as 5.

7. **What features of your monitoring plans do you believe are improvements over DOT plans?**

- Use of protocol developed in another state.
- Objective data rather than photomonitoring.
- Same as 6.
- Same as 6.

8. **Do you believe funding for post construction monitoring of mitigated wetlands is sufficient to provide an accurate picture of wetland function and structure?**

    - Yes. However, monitoring is typically not considered a priority. Use volunteers or students. Corps follow-up is lacking, monitoring plans are not reviewed nor are monitoring results. Because of lack of personnel no established relationship with particular regulator.
    - Yes. 5 years adequate for monitoring, if there is consistence in sampling over time.
    - No. Never has been.
    - Yes for monitoring. No for post-monitoring.

9. **How would you rate mitigated wetland maintenance by the DOT in your state or DOT's in your region?**

    - Don't know. Standardized monitoring will yield better results.
    - Fair to Poor. Once established it tends to be cursory, limited experience of personnel to wetland issues. Should be better funding and commitment of resources.
    - Poor. Only conduct monitoring indicated maintenance. Use more outside consulting.
    - Poor. Corps or consultant needs to be there at end of monitoring period for evaluation. DOT maintenance staff does least amount of work possible.