Building a Scientific Basis for Restoration of the Mesopotamian Marshlands

Findings of the
International Technical Advisory Panel
Restoration Planning Workshop
February 2003
convened by
Eden Again Project
The Iraq Foundation

EDEN AGAIN PROJECT

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PREAMBLE

April 29, 2003

Since the International Technical Advisory Panel (ITAP) convened at the University of California Irvine in mid-February, war has been waged in Iraq; discussions on Iraq's reconstruction are now underway. In completing this report, the ITAP has taken steps to take account of this dynamic situation, and believes its findings and advice are timely and on point. The ITAP fully acknowledges that there are many pressing needs in Iraq; the ITAP believes that taking steps to support the restoration of the environmental and ecological functions, agricultural production (rice, reeds, dairy, and fish) and the cultural heritage of the Tigris-Euphrates marsh ecosystem should be an important priority to contribute to the welfare of the people of Iraq.

EXECUTIVE SUMMARY

Background

The Mesopotamian marshlands constitute the largest wetland ecosystem in the Middle East and Western Eurasia (UNEP 2001, Maltby 1994, Nicholson and Clark 2002). They play a key role in the intercontinental flyway of migratory birds, support endangered species, and sustain freshwater fisheries and those of the Persian Gulf. In addition to these important ecological benefits, these marshlands represent a unique element of our global heritage and resources (UNEP 2001). They have been home to indigenous human communities for millennia and are regarded as the site of the legendary "Garden of Eden."

The marshlands once covered over 20,000 square kilometers of interconnected lakes, mudflats, and wetlands within modern-day Iraq and Iran. However, in the past thirty years, over 90% of the marshlands have been desiccated through the combined actions of upstream damming in Syria, Turkey, Iran and Iraq as well as the development of extensive downstream drainage projects within Iraq (Figure 1).

Eden Again Project

The Iraq Foundation's Eden Again Project was initiated with the aim of supporting efforts to restore the marshlands. In June 2002, the Project Team began to assemble an international panel of scientists to provide advice on the technical aspects of marshland restoration[1] and inform the development of technical planning documents that could lay the foundation for such restoration (the International Technical Advisory Panel, or ITAP). The project team intends that the recommendations presented here be used to support the efforts of the Iraqi people and the appropriate Iraqi authorities if and when they decide to initiate restoration of this important ecosystem. Development of a locally driven participatory process for all stakeholders within Iraq to guide the decision-making process and strengthen ownership of results is vitally important. The restoration options presented within this report are just that – options – that the local stakeholders can select through a comprehensive decision-making process.

International Technical Advisory Panel

The International Technical Advisory Panel (ITAP) is an inter-disciplinary group of scientists with expertise in hydrology, biology, ecosystem restoration, and soil science. The first meeting of the ITAP, a Restoration Planning Workshop, was held on February 16th and 17th, 2003. The workshop was held at the National Academy of Sciences' Beckman Center on the campus of the University of California, Irvine in Irvine, California. The primary objectives of the meeting were to:

[1] Utilizing the approach developed in the Principles and guidelines for wetland restoration (Ramsar COP8 Resolution VIII.16), the term "restoration" is used in this document in its broadest sense, which includes both projects that promote a return to original conditions and projects that improve wetland functions without necessarily promoting a return to pre-disturbance condition. The general principles and guidelines developed in the restoration principles provide underlying ideas and a useful starting point for successful restoration planning.

a) Review existing information on the Mesopotamian Marshlands to evaluate the feasibility of restoration from a scientific perspective and identify major technical challenges;

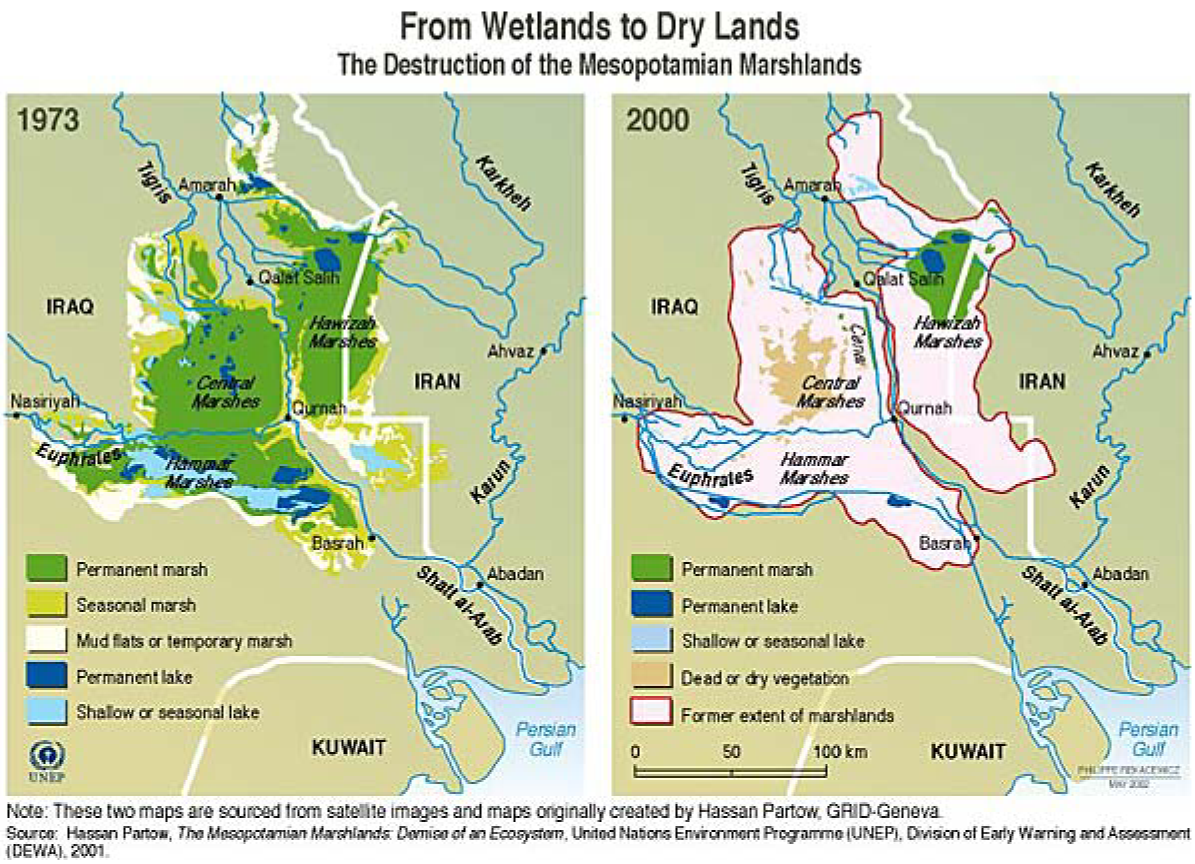

Figure 1. Location of marshlands in 1973 and 2000 (after Partow 2001).

b) Identify fundamental elements and key ecological and cultural benefits that could be provided through restoration;

c) Conceptualize potential restoration scenarios and identify demonstration projects that would promote recovery of key ecological and cultural benefits;

d) Identify technical considerations and additional data needs for successful restoration efforts; and

e) Identify and prioritize processes for increasing the probability that the restoration will successfully achieve its goals.

This report represents a consensus among the ITAP members, and is a direct output of the planning workshop, taking into account relevant available background information and the views of the expert group.

Feasibility of Restoration

Recognizing that restoration of the marshlands will be a multi-step process, the first aim of the ITAP's deliberation was to examine restoration from a scientific perspective. This discussion started with an assessment of available water levels since this will be a critical determinant of restoration potential. After evaluating the available data, the ITAP concluded that restoration is both technically feasible and worthwhile. A hydrologic analysis (Exponent, Inc. 2003) of Tigris and Euphrates flows available in Iraq indicates that although these flows have been substantially reduced, restoration of at least significant parts of the marshland is possible. While the ITAP does not foresee that there will be enough water to restore the marshlands to their pre-1980 extent, steps can be taken, such as using dikes and levees to contain water within restricted paths that will serve to create flow-through rather than stagnant water bodies and help optimize water availability and prioritize distribution consistent with identified stakeholder priorities.

It is the ITAP's expectation that any restoration scenarios would only be partially functional unless an integrated basin-wide water management plan is implemented. A decision support system for integrated water management of the entire Tigris-Euphrates basin is highly recommended and should be designed and ultimately backed by international law through a water agreement as soon as social and political conditions allow.

The ITAP also recommended caution in terms of planning for the release of water, because salt and contaminants will be present in many sites. Uncontrolled release of water over contaminated soils could result in the spread of contaminants that would further aggravate these problems. Areas that are either highly saline or toxic should not be re-hydrated without more detailed assessment; these areas should remain impermeable, at least during the initial stages of restoration. Decontamination and toxicological analysis of potential contaminants such as sewage outflow, industrial waste, heavy metals, agrochemicals, munitions, and minefields (ordnance assessment) will be required as a first phase in any restoration effort.

Fundamental Ecological and Socio-Cultural Benefits Derived from Restoration

Scientific assessments indicate that multiple ecological, economic, and socio-cultural benefits will occur from restoration of the marshlands on a local, regional and global scale (Thesiger 1957, Young 1977, Scott and Evans 1993, Banister et al 1994, Maltby 1994, UNEP 2001, Nicholson and Clark 2002, Stevens and Alwash 2003, Stevens and Alwash 2003). These benefits include flood abatement, water quality improvement, moderation of climatic extremes, limiting the rate of desertification, improvement of fish, wildlife, plant, and endangered species habitat, increased biodiversity, maintenance and recovery of sensitive species populations, increased wet agricultural productivity, resettlement of displaced communities, and expanded cultural resource benefits. The ITAP identified fundamental elements critical to restoration efforts. The ITAP also developed a matrix of benefits to evaluate the potential ecological and socio-cultural benefits of restoring portions of the marshlands under various restoration scenarios outlined below.

Restoration Scenarios and Potential Demonstration Projects

The ITAP recommended that once the agreement of the appropriate Iraqi authorities is obtained, funding secured and local support mobilized, restoration efforts should proceed in a stepwise and incremental fashion, drawing upon available information and analogous sites to plan demonstration marsh restoration projects. Because the Mesopotamian marshlands consist of three distinct, but contiguous marshes: Hawizeh, Central and Hammar, the ITAP first considered the restoration possibilities from a geographic viewpoint. The objective was to determine if certain marshland areas would be more responsive to the return of water flow and/or provide greater ecological, economic, and socio-cultural benefits.

For each of the scenarios described below, demonstration projects were conceptualized that could be implemented quickly and early in the planning process, following consultations with stakeholder groups. These projects were identified because they would be expected to quickly generate both (1) tangible results in terms of restoration and (2) valuable data on how the marshland soil and ecosystem will respond to re-hydration. If encouraged by the outcomes of the initial projects and/or if additional water became available, then efforts could be expanded in subsequent years.

The quantity of water will ultimately determine the size and type of the marshland projects that can be developed. If stream flows are low, and this volume of water is distributed over a very large area (such as the former extent of the marshlands), most of the inflows may be lost to evaporation and may not sustain standing water in the marshlands. Restoring smaller areas would ensure enough water availability to mimic natural flooding patterns and to establish permanent marshlands in some areas.

Central Marsh

The Central marsh has been desiccated for many years. The primary restoration objectives within this region would be to gradually flush out salts that have accumulated over the years and enable select areas of the marsh to become progressively useable as a freshwater ecosystem. The strategy involves identifying a relatively contained area, such as a former lake or marshland, and dividing it up into three or more compartments using existing dikes and levees. Water would be released into one compartment at a time starting with the water inlet side where the soils are expected to be less contaminated. After the water has passed through the first compartment it would be diverted to the river where contaminants would be diluted. This process could be implemented over several months to several years per site, depending on the quality and available quantity of water.

Hammar Marsh

Opportunities in this region focus on creating flow-through wetlands north of the former Lake Hammar. For this region, the ITAP recommended not restoring water to the former lake itself immediately because aerial photography suggests that it is now potentially covered with a salt crust. Rather, levees and dikes would be constructed to contain water north of the Hammar dry lakebed to create a flow-through wetland that would reconnect this marsh area to the Gulf through either the Shatt al-Arab or the Euphrates, depending on the availability of water. Such actions would restore a critical migratory pathway for saltwater and estuarine fish and shrimp to enter the marshlands.

Hawizeh Marsh

The Hawizeh Marsh still contains a significant amount of remnant habitat with the biodiversity characteristic of the Mesopotamian marshes. Since the Hawizeh marshland has not become completely desiccated, conservation of this reference marsh can provide a template for marsh restoration, a refugium for extant endangered species, and a source of propagules of plants, wildlife and fish for restoration of the other marshes. The approach recommended for this region differs from the more experimental and construction-oriented approaches recommended for the Central and Hammar Marshes, because the remnant marsh can be enhanced and enlarged. The Hawizeh Marsh thus offers the highest potential for recovery of sensitive plant and wildlife species.

Technical Considerations and Additional Data Needs

The ITAP outlined specific data needs in the areas of remediation, hydrology, biogeochemistry, ecology and culture based on their prediction of potential technical challenges that could impact restoration of the marshlands.

Remediation

High concentrations of pollutants reportedly exist in marshland soils, both as a result of deliberate contamination as well as lack of sufficient wastewater treatment upstream. Prior to any other fieldwork or remedial activity, toxicological analysis of soil and water samples should be undertaken. In addition, a survey should be done for unexploded ordnance and uncontrolled disposal of toxic wastes.

Hydrology

Second, the ITAP agreed that there is a critical need to determine how much water is available, as well as where and when it will be available, in order to account for inter-annual and seasonal variability in flow. Development of a seasonal water budget would help evaluate total water availability for restoration efforts on a seasonal and inter-annual basis and should be a top priority. As such, accurate topographic data are necessary to develop accurate hydrodynamic circulation models of the Marshlands and to manage targeted re-flooding. In addition, stream flow data should be collected from the records of the Iraqi Ministry of Irrigation. The probable fate of sediment entering the marshland with the flow and its disposition within the marshland should also be the subject of a preliminary quantitative analysis in order to avoid unwelcome sedimentation within waterways and depressions.

Soil Biogeochemistry

Before the addition of water or other restoration action is taken, a rapid soil survey needs to be conducted along each flow path to anticipate any problems that might arise from re-hydration.

Levels of salinity and contaminants especially need to be known. Re-hydration of the desiccated marshland soils could have unexpected results in soil biogeochemistry, water quality, and re-vegetation. However, there is much to be gained from local experiences, such as the fact that some areas of marshlands have been desiccated for months to years under the natural flow regime.

Ecology

Basic ecological work needs to be done in inventorying, mapping, and describing vegetation types. Baseline inventories of taxa occurring in the marshlands should be conducted by qualified scientists, including international, national, and local experts, and Marsh Dwellers familiar with the ecosystem. Focal species need to be selected and monitoring protocols and an adaptive management system implemented after site review and selection has occurred.

Socio-cultural Aspects

Historical and current settlement patterns should be defined and mapped. Systematic interviews and surveys should be conducted with refugees and surviving inhabitants to establish where people want to return, how they want to live, and what water use is required for their support. A stakeholder group should be formed to evaluate these options and inform the decision-making process.

In addition, traditional environmental knowledge and traditional resource management systems should be evaluated and implemented in restoration planning. Traditional resource management practices of Marsh Dwellers include selective harvesting of reeds, burning, multiple species management, resource rotation, and landscape management (Salim, Stevens 2003).

Applying the Ecosystem Approach

The strategy for implementation will benefit from the practical application of the Ecosystem Approach which has been adopted by the Convention on Biological Diversity as the primary framework for delivery in a balanced way of its three key objectives: Conservation of biological diversity, sustainable use of its components and fair and equitable sharing of benefits arising out of the use of genetic resources. The Ecosystem Approach recognizes that people are an integral part of the system. Its application is underpinned by principles which recognize the scientific, socio-cultural and economic complexity of the integrated management of land, water and living resources. Delivery will require appropriate participatory processes, adaptive management and partnerships which may be supported by an international multi- and interdisciplinary technical team working hand in hand with local and national expertise.

A Strategy for Restoration Planning and Implementation

A strategy for moving forward is outlined in the Section IX of the report. The strategy outlines suggested steps in the following major categories to help ensure success of restoration actions.

1. Build Processes and Structures for Stakeholder Involvement
2. Focus on Demonstration Projects
3. Build International Support and Cooperation
4. Develop a Comprehensive Restoration Strategy
5. Implement Restoration using an Adaptive Management Approach

I. OVERVIEW OF WORKSHOP

A. Eden Again Project

The Eden Again Project is sponsored by the Iraq Foundation, a non-profit corporation working for a better international understanding of Iraq's potential as a contributor to political stability and economic progress in the Middle East. The Foundation is non-partisan, non-sectarian and non-ethnic, and is not affiliated with any other organization, political party, or government.

The mission of the Eden Again Project is to promote the restoration of the Mesopotamian Marshlands. Its primary goals are to:

- Assemble a group of international experts ready to assist with the technical aspects of marshland restoration.
- Develop technical planning documents to assist with marshland restoration.
- Raise regional and global public awareness about the importance of the marshlands and the need for their restoration.
- Work with international organizations, national governments and regional organizations to achieve sustainable restoration.
- Work with grassroots organizations to foster local decision-making and stewardship of the marshlands.

Develop partnerships to build the capacity of local scientific institutions to plan and implement sustainable ecological restoration.

B. Workshop Background

The Iraq Foundation's Eden Again Project held a Restoration Planning Workshop in Irvine, California, on February 16th and 17th, 2003, at the National Academy of Sciences' Beckman Center on the campus of the University of California. The purpose of the workshop was to gather together technical experts from around the world to begin to develop scientific guidelines for the restoration of the Mesopotamian marshlands.

The Technical Advisory Panel was convened to provide scientific expertise and informed analysis on possible restoration options and priorities for the restoration of the Mesopotamian marshlands.

C. Workshop Goals for the Technical Advisory Panel

1. To bring together experts from a broad range of scientific disciplines to summarize existing knowledge and articulate the rationale for the restoration of the Mesopotamian marshlands.

2. To create restoration scenarios that could offer local stakeholders and decision-makers a range of alternatives for starting points and implementation.

3. To identify benefits that might accrue under various restoration scenarios.

4. To suggest starting points for restoration by identification of candidate areas and alternative implementation procedures for demonstration marsh restoration projects.

5. To identify knowledge gaps and articulate the next steps in terms of information gathering that can advance restoration in the Mesopotamian marshlands.

D. Program

DAY ONE			
Time	**Agenda Item**	**Speaker**	**Discussion Notes**
8:00	Welcome	Rend Rahim Francke *Iraq Foundation*	
8:10	Introduction to Workshop	Eden Again Project Azzam Alwash Suzie Alwash Michelle Stevens	Introduction
9:00	Plight of the Marsh Refugees	Baroness Nicholson Peter Clark *AMAR Appeal*	Overview of marshland destruction and Amar Appeal's role
9:30	Personal Perspectives	Ramadan Albadran Kais Mukhly *Marsh Refugees*	Define human dimension of the problem
10:00	Break		
10:15	Demise of an Ecosystem	Hassan Partow *Author, UNEP report*	A Sense of Place: Overview of marshlands and recent changes
11:00	International Dimensions	Edward Maltby *Royal Holloway University of London.* *Leader 1994 study*	Overview of 1994 and subsequent reports on the Mesopotamian Marshlands and recommendations
11:20	Break		
11:30	Marshland Ecosystem	Mike Evans *United Kingdom*	Discuss baseline biological/ ecological conditions
12:15	Gulf Fisheries	Jim Bishop *Kuwait ISR* *(presented by Dr. Coad on his behalf)*	Fisheries and the Mesopotamian Marshlands
12:30	Lunch at Beckman		
1:30	Hydrology of Restoration	Andrea Cattarossi *Exponent, Inc.*	Results of Phase I hydrologic modeling
2:00	Overview of GIS	Issam Ali *Psomas, Inc.*	Overview of capabilities for workshop
2:10	International Analogies	Rich Beilfuss *Int. Crane Fdn.*	Analogues for eco-cultural restoration
2:30	Break		
2:45	Restoration Goals & Objectives	Michelle Stevens *Eden Again Project*	Comprehensive Restoration Planning Outline
3:15	Group Discussion	Technical Advisory Panel	Feedback on goals and objectives
4:45	Tomorrow's Work	Suzie Alwash *Eden Again Project*	Breakout groups and work products

DAY TWO			
Time	**Agenda Item**	**Speaker**	**Discussion Notes**
8:00	Disciplinary Breakout Groups ▪ **Hydrology** : Crisman (leader) ▪ **Biogeochemistry** Richardson (leader)) ▪ **Ecosystem** Zedler (leader)		Purpose: identify technical opportunities and challenges, potential solutions, and immediate data needs
10:00	Break		
10:15	Discussion of Results	Technical Advisory Panel	Conference Room 1
12:00	Lunch		Beckman Center
1:00	Marshlands Breakout Groups ▪ **Hawizeh Marsh** Partow (leader) ▪ **Hammar Marsh** Maltby (leader) ▪ **Central Marsh** Evans (leader)		Purpose: develop proto-restoration scenarios and evaluate in terms of goals
3:00	Break		
3:15	Discussion of Results	Technical Advisory Panel	Conference Room 1
4:30	Future Plans/ Next Steps	Suzie Alwash *Eden Again Project*	Conference Room 1

II. MAJOR ITEMS OF CONSENSUS BY THE ITAP

The ITAP agreed upon the following major issues:

A. From a scientific perspective, restoration is warranted because it can enable the marshes to provide environmental services, ecological functions, economic goods and socio-cultural values.

The Mesopotamian marshlands play a key role in the intercontinental flyway, support endangered species, and enhance and sustain important freshwater and Gulf fisheries. Preliminary interviews with refugees from Iraq also reveal the significance of these marshes as a cultural icon, and an overwhelming desire to restore the marshes (Clark and Magge 2001, Nicholson and Clark 2002, Stevens 2002, unpublished field notes). The cultural significance of these marshes cannot be overstated. The area's indigenous inhabitants, or Marsh Dwellers, have evolved a unique lifestyle that is firmly rooted in their aquatic environment (Salim 1962, Thesiger 1964, Young 1977). Hundreds of thousands of Marsh Dwellers now live as refugees, and many long to return to their homes and livelihoods (Clark and Magge 2001, Nicholson and Clark 2002). Restoration of the marshlands is an essential prerequisite to sustain this social and cultural preference.

B. Restoration efforts are technically feasible and worthwhile.

A preliminary hydrologic analysis of water sources in Iraq indicates that at least partial restoration is possible, even during years when only minimal (worst-case scenario) flows are available. Scientific analyses indicate that multiple benefits will occur from restoration of the marshlands on a local, regional and global scale. These benefits include the following: increased agricultural and fisheries production, poverty alleviation, amelioration of climatic extremes; improvement of fish, wildlife, and endangered species habitat; water quality improvement; and opportunities for traditional cultural uses and traditional resource management of the marshes.

C. Caution is indicated, because salt and contaminants are likely to be present in many sites.

Uncontrolled release of water over contaminated soils could result in spread of contaminants that would aggravate existing problems. Areas that are either highly saline or toxic should not be re-hydrated immediately; these areas should remain dry until appropriate solutions for remediation are developed. Toxicological analyses of soil and water quality and ordnance removal will be required as a first phase in any restoration effort.

D. A stepwise strategy is the best way forward.

Subject to Iraqi government and stakeholder approval, the broad strategy outlined in this report can be readily implemented once access and funds are provided. It is recommended that the restoration should proceed in a step-wise and incremental fashion, consistent with the available resources and the approach of adaptive management. After the initial steps have been taken and additional data gathered, more detailed and comprehensive plans for restoration can be developed. Information obtained relative to alternative restoration plans, potential benefits derived from these plans, and consequences or lost opportunities from alternative selection should be presented to and evaluated by local stakeholders and decision-makers.

III. HYDROLOGIC FEASIBILITY OF RESTORATION

A. Considerations

Water supply is a major constraint on the potential to restore the Mesopotamian wetlands. A recent study (Exponent, Inc. 2003) reviewed existing hydrologic conditions in Iraq and prepared a preliminary hydrodynamic analysis of water moving across the marshlands. The base assumption was that no or minimum additional water would be released from countries upstream. This preliminary study suggests that there is sufficient water available in the Tigris-Euphrates system within Iraq to undertake some restoration activities, although the timing, magnitude, and duration of floodwaters reaching the Mesopotamian wetlands is currently known only approximately and must be determined with greater precision before any actions are designed.

Upon review of the study, the ITAP agreed on three steps that could be taken to allow more water to flow into the wetlands. First, a large portion of the current flow of the Tigris and Euphrates could be re-introduced to the marshlands by partially modifying existing hydro-engineering structures located along the rivers in southern Iraq. All such structures have been built in the last two decades and greatly affect water flow throughout the marshlands.

Second, the ITAP agreed that much depends on water management practices in other countries that share the Tigris-Euphrates basin, including Turkey and Syria, and also upon management of the Karkheh River in Iran, which feeds the Hawizeh Marsh. To this end, the ITAP recommended developing a water budget approach to quantify the inflows to and outflows from the Mesopotamian marshlands and to determine the surface water requirements for re-flooding the marshes in accordance with restoration objectives. Third, the ITAP recommended exploring the possibility of an integrated water management approach capable of accounting for water resources utilization in Iraq and in the other countries upstream in the watershed to help develop an equitable water allocation plan which would include the maintenance of the Mesopotamian marshes.

This goal could be accomplished by developing a basin-wide water budget model to quantify the regional hydrology, including the river and marshlands hydrodynamics and reservoir usage and irrigation schemes. This tool would serve the restoration plan in both the short and long term. In the short timeframe, it would provide vital information for preliminary restoration actions (evaluation of flood pulse, and maximum and minimum flow rates the marshland would receive under existing conditions). In the long term, this tool would facilitate planning of water usage in Iraq and could provide a scientific basis to support development of water release strategies.

Based on the above-mentioned considerations, the ITAP considered different approaches to allow more water to flow into the Hammar, Hawizeh and Central

Marshes. Additional alternatives should be addressed in order to provide the stakeholder group with a comprehensive number of possible management choices.

B. Hammar Marsh

For the Hammar Marsh, the ITAP envisions that the local drainage structures could be removed, allowing water to flow back into the former marsh areas. Specifically, south of Nasiriyah, at least two major man-made channels are currently diverting water flow away from the historical river path, and discharging it directly into the Gulf. The Main Outfall Drain (MOD) is carrying agricultural drainage water that may not constitute good quality water for marsh restoration. The Mother of Battles (MOB) River is taking water from the Euphrates and discharging it to the Gulf. The hydrodynamic modeling assumed that the MOD would stay in place to carry the agricultural drainage water, and the MOB would be closed and the earthen dam(s), now diverting the Euphrates River into the MOB, would be breached. A third structure, called the Loyalty to the Leader canal/pipeline is also reportedly diverting water in a similar fashion to the MOB. This pipeline can simply be closed.

The ITAP foresees that the added flow thus provided to the marshland would be more than sufficient to support the development of any demonstration marsh restoration projects, which would most likely be constrained along the northwestern edge of Hammar Lake where a large Marsh Dweller community used to live and where the hydrogeologic conditions would facilitate restoration activities. Re-flooding plans should be carefully designed to account for the presence of existing irrigation schemes, the need to flush away the salt crust now occurring in desiccated areas, and the presence of toxins or contaminants in the soils.

C. Central Marsh

Currently, the "Glory River" diverts the entire flow of the Tigris River distributaries toward the east and away from the marshes, and thence southward into the Euphrates. Accordingly, in the Central Marsh, the proposed modification to the existing desiccation structures would be minimal. Essentially, by breaching the channel’s southern levees, and by regulating the connection between the west-to-east portions of the “Prosperity River” with the north-to-south portion, the ITAP foresees that sufficient water would be available to initiate the restoration plans.

In discussing this alternative, the ITAP agreed that restoration actions might be more difficult for the Central Marshes as they cover a larger surface and thus it will be more problematic to establish flow-through. Nevertheless, the Central Marshes previously supported significant production of rice, reeds, fish, and were also internationally important sites for avian species.

D. Hawizeh Marshes

Restoration of the Hawizeh Marsh would result in expansion of the last remaining high-quality marsh area. ITAP members agreed on the priority that should be given to the area with respect to other restoration efforts. If it is further desiccated, some components of the marsh ecosystem may be lost forever, and full functional restoration of other areas will then become substantially diminished. Specifically, animal species that may be extirpated in the completely-desiccated Central marsh are more likely to be present in the Hawizeh Marsh. In addition, the restored Hawizeh marsh could function as a template for restoration of the marsh areas that have completely disappeared. Restoration of this marsh could begin with re-introduction of water as early as possible. As a transboundary wetland straddling the Iran-Iraq border, a coordinated bilateral approach eventually needs to be adopted for the conservation of this shared system.

IV. FUNDAMENTAL RESTORATION ELEMENTS

Utilizing the approach developed in the principles and guidelines for wetland restoration (Ramsar COP8 Resolution VIII.16), the term “restoration” is used in this document in its broadest sense, which includes both projects that promote a return to original conditions and projects that improve wetland functions without necessarily promoting a return to pre-disturbance condition. The general principles and guidelines developed in the restoration principles provide underlying ideas and a useful starting point for successful restoration planning.

To provide a context for evaluation and prioritization of potential demonstration marsh projects, the ITAP developed a list of key elements they determined to be fundamental to restoration activities in the marshlands. The ITAP agreed that conditions need to be created that:

- Foster natural recruitment of native plant and animal species
- Allow passive restoration with low maintenance requirements.
- Protect and expand remnant marsh patches to provide refuge for plant and animal species, provide a template for marsh restoration, and supply propagule and dispersal corridors and stepping-stones for recolonization of disturbed marshlands.
- Conserve and enhance marsh biodiversity and sustainable native marsh species, prioritizing endemic and globally threatened fish, animals and plants.
- Manage and increase populations of both the freshwater fish species that live year-round in the marshes and the migratory fish and shrimp species that seasonally migrate to and from the marshes and the Gulf.
- Manage and enhance fisheries productivity and sustainability in the Tigris-Euphrates River systems and in the northern Gulf marine region.
- Enhance and re-hydrate permanent emergent wetlands and small open freshwater lakes to provide the highest quality habitat for wintering and migratory waterfowl within the flyway.
- Establish adequate reedbed area and vegetal biomass production to support traditional resource management of the reedbed ecosystem and enhance cultural uses such as provision of fodder for water buffalo and reeds for house-building, and reed mat production.
- Facilitate implementation of treatment of wastewater from domestic, industrial and agricultural sources to provide human health benefits such as water for drinking and other beneficial uses.

- Reinstate and expand opportunities for economic development activities and poverty alleviation according to the identified needs and opportunities of the local stakeholder groups.

- Enable bioremediation of toxins and reduction in identified human health problems in the marshes.

- Improve hydrological conditions sufficient to restore biota, biogeochemical functioning, water quality, and groundwater exchange.

- Re-hydrate marshes and rehabilitate barren areas to moderate climatic extremes and abate sand and dust storms

- Arrest land degradation and desertification.

- Attempt to restrict or eliminate exotic species, particularly such fishes as goldfish, common carp, mosquitofish and Indian stinging catfish that are deleterious to the native species or to humans.

The Restoration Benefits matrix in Section VII was developed to help evaluate potential benefits and constraints for the planning and selection of demonstration marshland sites based on the key elements cited above. As more specific data are collected, these benefits can be confirmed or modified. Due to the lack of specific data, benefits described are potential rather than actual. The ITAP used analogous wetland ecosystems and value and function assessment methodologies as the basis for benefit analysis.

V. RESTORATION SCENARIOS

A. Background

The ITAP recommended that if and when funding and national/local support becomes available, restoration efforts should proceed in a stepwise and incremental fashion. Without a structured, deliberative approach, initiatives may be taken without a full appreciation or analysis of the “downstream” effects. These initiatives may have subsequent impacts that also require further remediation. The ITAP first considered the restoration opportunities from a geographic viewpoint to identify which areas of the marshlands would be (1) most responsive to the return of water flow and (2) likely to provide the most environmental, ecological, economic and socio-cultural benefits. It is emphasized that the ITAP was considering opportunities within each of the three regions, not making recommendations across.

Various potential scenarios for the marsh restoration were conceptualized. For each of the scenarios described below, demonstration projects were identified that could be implemented quickly and early in the planning process following consultations with local communities and the appropriate Iraqi authorities. These projects would not only provide some early tangible results but would also generate experimental data based on an adaptive management approach to determine how the marshland soil and ecosystem responds to re-hydration. Collecting data on a smaller scale provides feedback as to the most successful methods for re-hydrating marshes, helps confine any problems that might develop to a manageable scale, and helps increase the probability of successful restoration for further project development.

Such projects would yield valuable data that could be used to develop more substantial restoration projects. They could also employ local people in the restoration projects immediately. The ITAP recommended that the demonstration marsh projects, if successful and/or if additional water became available, could be expanded in subsequent years. Initial projects should continue to be maintained and monitored for a minimum of three years to evaluate the restoration trajectory and potential achievement of benefits. While the fundamental wetland structure may develop quickly, the corresponding ecosystem functions may take much longer. Therefore, careful monitoring of the demonstration marsh restoration projects can help inform fine-tuning of the larger programs as necessary.

B. Technical Constraints and Considerations

The extent to which restoration is possible in the Mesopotamian Marshlands will depend on a number of factors, including most importantly the availability of water, the lack of soil salinity and toxicity, and stakeholder priorities. Data on these constraints were not available at the ITAP meeting. Numerous different restoration scenarios could be envisioned. Several of these were discussed at the ITAP meeting, and additional scenarios were developed subsequent to the meeting.

The most critical constraints on the extent of marshland restoration are the availability of water resources and stakeholder priorities for the allocation of water resources to various uses. Some difficult choices may have to be made. From the perspective of water resource allocation, the following points are important:

- The Hammar Marsh is now wholly dependent on the Euphrates River water[2]. Neither the Central nor Hawizeh Marshes receive water from the Euphrates. Therefore there is no need to make a choice between restoration of the Hammar Marsh and other marshes; the choice is between restoring the Hammar Marsh and other non-marshland water uses.

- Both the Central and Hawizeh Marshes are dependent on water from the Tigris River; the Hawizeh Marsh also receives water from the Karkheh River. If the Karkheh River flow cannot support the Hawizeh Marsh, then choices may have to be made between restoration options for the Central and Hawizeh Marshes.

Restoration of the rice-growing areas cannot be separated from marshland restoration. Historically, the rice-growing areas and the marshlands were intertwined and gradational. If water is returned to the rice-growing areas, it will naturally flow into the marshlands to support other ecological functions. Therefore, planning for restoration of agriculture and other ecological values should be integrated and simultaneous. Finally, there are water quality issues associated with rice agriculture (fertilizer and pesticide use especially) that also need to be factored if flow from rice agriculture will go directly to marshes flooded for ecological purposes (e.g. water birds).

[2] Historically, there used to be overflow from the Shatt al-Gharaf and Central marshes.

VI. RESTORATION SCENARIOS

A. Desalinization of Central Marshes

Background

The Central Marsh area is bounded by the Tigris River to the east and the Euphrates River in the south. It is roughly situated within a triangular area located between Nasiriyah, Qalat Salih and Qurnah.

Historically, the Tigris River branched into numerous distributaries between Kut and Amarah, forming an interior delta that was a major area of rice production in Iraq and had a high population density. Downstream of the fan-delta, the water from the distributaries fed into the permanent marshes. These marshes were characterized by numerous small lakes, which were important areas for birds.

The Central Marsh historically had the freshest water of all the marshes. Portions of the upper marshes and a zone along the western bank of the Tigris River have been transformed to agricultural cropland (apparently wheat and barley). Rice production had been limited by the government.

Restoration Opportunities and Potential Demonstration Projects

Restoration of the Central Marsh has the benefit of connecting the Tigris and Euphrates ecosystems and connecting all the marshes together. The Central Marsh is an important food production center, is strategic for restoring bird habitat (medium-sized, shallow lakes), and formerly supported large human populations. The key elements of restoring this marshland would be to create flow-through marshes that connect the Tigris and Euphrates Rivers, and to restore the shallow lakes and reedbeds that provide important fish and wildlife habitat; wintering migratory bird habitat would be a restoration priority in this area (Scott and Carp 1982, Scott and Evans 1993, Maltby 1994, Scott 1995).

The objective would be to gradually flush out salts and enable select areas of the marsh to progressively become useable as a freshwater ecosystem. The lower ends of the distributaries on the Amarah fan are the most likely area (hydrologically) for achieving restoration goals. In general, the closer to the water source that restoration can be done, the more successful the restoration will be. The ITAP members noted that there is a great deal of experience with flushing out salts and acid sulfate soil contaminants in the Mekong Delta of Vietnam through a similar step-by-step process, primarily conducted by the University of Can Tho researchers (Minh 1996, World Bank/ADB/FAO/UND 1996, Minh, Tuong, Booltink, van Mensvoort, and Bouma 1997). The Mekong Delta also has a somewhat similar history of hydrological degradation through channelization and diversions.

The ITAP recommended an experimental, compartmentalized approach as most suitable for this region. This approach would involve identification of a relatively contained area, such as a former lake or marshland, and dividing it up into three or more compartments using existing dikes and levees. The compartments would then be flooded one compartment at a time starting with the upstream water inlet side to flush out salts. The area of individual projects could range from 100 - 1000 hectares, depending on available water. This process could range from several months to several years per site, depending on the available water quality and quantity.

Drainage water will need monitoring and may require treatment such as in newly created wetlands. Ideally, the water used to flush out the salts and contaminants from the flooded area would be diluted by addition to river flow (and be insignificant compared with current contamination from other sources). Then, the next year, if the contamination has been significantly reduced by the first year's flushing, flow to the next compartment down the system could be restored to flush out any contaminants mobilized from it and direct them into a nearby river to be diluted. This process could occur each year, with monitoring of conditions from that year's flush until a through-flowing system could be restored.

Different flow scenarios can be modeled for capturing the rare high flow periods, and determining if this water could be captured and utilized to flush salts and other toxins from the system. Higher flows also distribute sediment, carbon, and other nutrients. If sufficient flow can be made available, the restoration vision for this scenario would consist of creating a marshland belt of smaller lakes surrounded by permanent marshlands with a buffer of seasonal wetlands. These would cascade down from the Tigris southward into the Euphrates. Deeper-water canals could join each lake/wetland system. The width of the marshland belt would depend on the existing water supply, and could be as narrow as a few kilometers wide if necessary. Areas of highly toxic or saline soil could be remediated prior to introduction of water by excavation of toxics and salts or some other method. Alternatively, the water could be excluded from these areas by construction of dikes. This would increase connectivity amongst the three marshlands, create flow-through conditions in the Central Marsh, and provide the optimal bird habitat.

Target focal species recommended by the ITAP for this area would include Marbled Teal (*Marmaronetta angustirostris*) and selected migratory waterfowl and wintering birds of prey that are determined to still occur in the area. Wintering bird counts would help establish a baseline for restoration, and help guide restoration priorities and monitoring strategies.

B. Hammar Marsh

Background

The Hammar Marsh is located south of the Euphrates, historically extending from Nasiriyah in the west to the outskirts of Basrah on the Shatt-al-Arab in the east. The marsh is bordered in the south by a sand dune belt of the Southern Desert. This area also contains the Hammar Lake, which appears to now be largely a salt pan, but at one time was approximately 120 km long and 25 km at its widest point (UNEP 2001).

The Hammar marsh is a preferred habitat corridor for fish and shrimp migrations from the Gulf (Salman et al 1990, Salman and Bishop 1990, Banister 1994, Coad 1996, Soddiqui et al 1998, Ramzy 2001). The lower portion of the Euphrates reportedly still contains viable native fish populations that should be maintained and restored if possible. The marsh should be reconnected to the Gulf through either the Euphrates, or Shatt al-Arab in order to provide a pathway for migratory saltwater fish and shrimp to enter the marshlands. These connections should have water deep enough to provide fish protection.

Restoration Opportunities and Potential Demonstration Projects

The restoration vision for this marshland would be to ultimately create flow-through wetlands north of the former Lake Hammar (see Figure 2). Water should not be restored to the area of the dry Hammar lakebed in the initial stages of restoration, because the levels of soil salinity are potentially too high. If enough water is available or the salt problem is less than currently thought, this area could eventually be restored also. This option should be assessed in more detail as soon as access on the ground is possible.

In the event that the former lake needs to be avoided, levees and dikes would need to be constructed to contain water north of the Hammar dry lakebed. Dikes already exist around the oil fields in the eastern portion of the Hammar marshes. The material used to construct the levee could be dug from the upper Hammar marsh in such a way as to create a depression that would allow for a deeper-water habitat for fish – in essence, a newer, smaller Lake Hammar. The optimal patch size of the lake or lakes developed in this manner should be studied to evaluate both fish and bird habitat, amongst other keystone and focal species.

Prior to major construction of levees and canals, the ITAP recommended a demonstration marsh project be completed to evaluate the reaction of the soil and ecosystem to re-hydration. After ascertaining how much water is available and ground-truthing existing conditions, specific site selection for a demonstration project could occur. The Third River (MOD) water could be combined with water from the Euphrates River for dispersal into the demonstration marsh site; however, the MOD water should be tested before release to the marshlands as it is potentially highly polluted and saline. Target focal species recommended by the ITAP for this area would potentially include the Basrah Reed, Warbler (*Acrocephalus griseldis*), Gray Hypocolius (*Hypocolius ampelinus*), and Marbled Teal (*Marmaronetta angustirostris*). Plant species would include giant reed (*Phragmites australis*), cattail (*Typha angustifolia*) and water lily (*Nymphoides peltata*, *N. indica*, *Nymphaea caerulea* and *Nuphar spp*.) Culturally, two important pieces of information will be critical to selecting the demonstration project location including a determination of: 1) where local people are currently living and conducting agricultural or other uses of the land; and 2) where and how the local residents (including returning refugees) would like to have the marsh restored. This will avoid inundating those areas where people are currently living or diminishing current human use. At the present, it appears that the highest populations are in the rice growing area on the west side of Hammar and in villages along the Euphrates River.

C. Hawizeh Marsh

Background

The Hawizeh Marsh is located on the Iran-Iraq border, just east of the Tigris River. The Iranian section of the marshes is known as Hawr Al Azim. The northern part of Hawizeh/Al Azim remains a permanent marsh but is rapidly degrading, as it has become a closed basin due to reduced inflows. The central and southern sections have been desiccated by drainage works (UNEP 2003).

Restoration of the Hawizeh Marsh would result in expansion of the last remaining high-quality marsh area and greatly aid the conservation of the entire region's biodiversity. If this reference marsh is further reduced in size, some components of the marsh ecosystem may be lost forever, and full functional restoration of other areas will then become substantially diminished. Because of the presence of refugia for plant, freshwater fish and wildlife species, this area is important to the preservation of biodiversity and recovery of sensitive species in the entire Mesopotamian marshland ecosystem. Restoration efforts in this area would provide an important template for restoration planning and refugia for globally endangered species, narrowly restricted endemic species, and dominant plant, freshwater fish and wildlife species of the marshes. If restoration is delayed several years, this area may soon resemble the Central Marshes and would no longer serve as refugia.

Sensitive species recently sighted in the marshes include the African Darter (*Anhinga rufa*), Sacred Ibis (*Threskiornis aethiopicus*), and relatively large colonies of Marble Teal. Other endangered or sensitive species are more likely to occur here than anywhere else in the marshes. Native fish are also known to occur in the wetlands area, but no anadromous species are known to have migrated into this area. The larger patch size and connectivity of associated habitats in the Hawizeh increases both resiliency and sustainability in the ecosystem, and an increase in functional benefits is likely to occur. The Hawizeh should be used as a reference for the process and functioning of the marshes that may be attained by means of successful restoration.

Because the Hawizeh Marsh is located on the border between Iran and Iraq, it has been the site of numerous battles; and thus the area is still dangerous and mined. Mine field clearance and an ordnance assessment would need to be conducted before restoration could commence within the marshes or people could safely return.

Restoration Opportunities and Potential Projects

In the ITAP's view, this area does not need a demonstration marsh project; early reintroduction of water will be the most cost-effective and beneficial way to improve marsh benefits. A requirement for conservation and expansion of the marsh is achieving continuous freshwater flow-through. Currently, water is available from the Tigris River and the Karkheh River to feed this marshland. At this time, much of the Tigris water is controlled by Iraq and the Tigris River is less regulated than the Euphrates River. The Tigris therefore, offers the potential for a greater seasonal and interannual variability in water flows, resulting in a more dynamic (and natural) wetland hydroperiod.

The Karkheh River, however, is currently dammed and regulated for hydropower production. Downstream effects of hydroelectric generation in the Karkheh River include stabilized water conditions and potential channel-scouring flows that are unfavorable to spawning fish; peak flows will be abated and low flows augmented. The altered wetland hydrodynamics and hydroperiod resulting from upstream hydropower generation may not support biological systems that are adapted to more natural hydrological conditions In addition, water from the Karkheh River in Iran could return as water release is increased once the reservoir has filled and water is released for hydroelectric power generation. Alternatively, there may be reduction in water supply from the Karkheh River due to plans to use the water for upstream irrigation as well as transfer water from the Karkheh reservoir to Kuwait via a pipeline.

The ITAP recommends that the target focal species for this area would potentially include Bunni Fish (*Barbus sharbeyi*), African darter, Sacred Ibis, White-tailed eagle (*Haliaeetus albicilla*), Basrah reed warbler, Dalmatian Pelican (*Pelecanus crispus*), Pygmy Cormorant (*Phalacrocorax pygmaeus*), Soft shelled turtle (*Rafetus euphraticus*), and freshwater fish.

D. Conceptual Sketches

Some of these scenarios described above and variants of the scenarios depending on water availability are depicted in Figures 2 through 7. These sketches have been drawn for discussion purposes only. The sketches illustrate potential areas for marshland restoration and were drawn using the following principles:

1. Potential areas where the marshland could be restored are depicted only where the marshes occurred historically.

2. Potential areas for marshland restoration have not been depicted where the land has been effectively converted to agriculture, petroleum extraction, or urbanized areas, except where necessary to establish hydraulic connections essential for marsh functioning;

3. Potential areas for marshland restoration could encompass marsh-dependent agriculture, human settlements, and other appropriate uses.

4. Potential areas for marshland restoration have been depicted to maximize hydraulic connections and achieve hydraulic flow-through to achieve restoration success.

These sketches are intended to form a basis for discussions on restoration options with the appropriate stakeholder groups. After the stakeholder priorities have been identified, and the physical constraints on restoration defined, more definitive restoration scenarios would be developed.

The three marsh-specific scenarios discussed above are depicted in Figures 2 (Central Marsh), Figure 3 (Hammar Marsh), and Figure 4 (Hawizeh Marsh). It should be noted that the actual configuration of restoration within these marshes could be substantially different depending upon knowledge of the current constraints of soil salinity and toxicity, water availability, and stakeholder priorities.

Subsequent to the workshop, additional sketches were developed to depict how marshes could be restored with different amounts of water and relatively equal area of restoration activity within each marsh. Figure 5 depicts a restoration that would essentially restore the three marsh areas to their pre-1980 extent (Figure 1). This extensive restoration would require the largest water flows from the Euphrates and Tigris Rivers. Although it is not likely that the quantity of water available prior to 1980 will be available in the future, this depiction is useful as a term of reference for development of alternative restoration strategies.

Figure 6 depicts substantial restoration within each marsh. No marsh is fully restored, yet there are connections between every marsh and between the marshes and the rivers, and every marsh has a hydraulic flow-through. This depiction would require moderate to substantial quantities of water that may not be available, yet it is more realistically obtainable than the extensive restoration depicted in Figure 5. This depiction could be altered to accommodate different stream flow amounts by moving the levees or dikes indicated within each marsh.

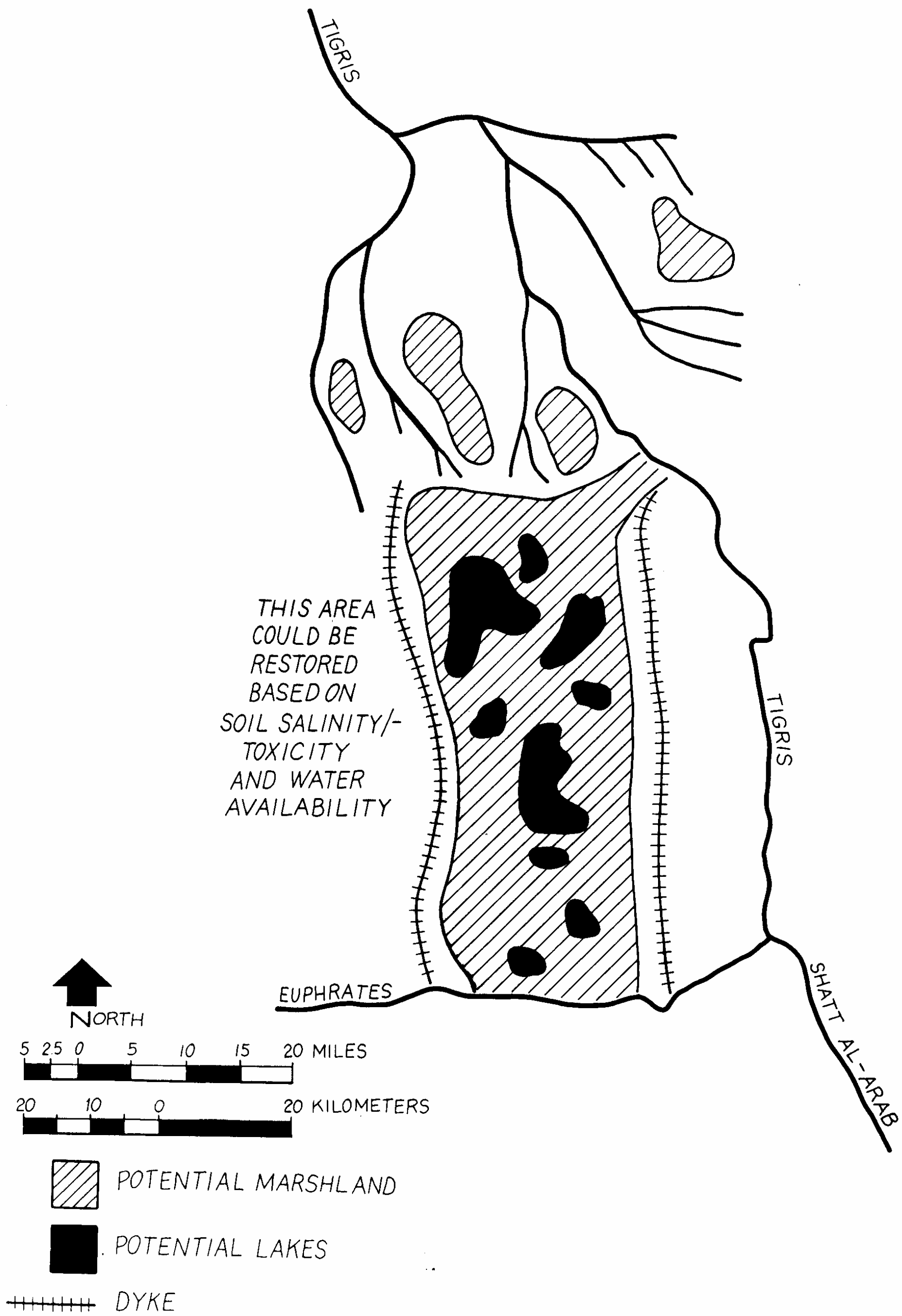

Figure 2. Conceptual sketch of potential marsh restoration in the Central Marshes. This sketch has been drawn to facilitate discussions among the appropriate stakeholders and to assist in developing hydrologic models and is not intended to represent an actual plan for restoration. The actual areas of restored marshes will likely be different from those depicted and would depend upon the constraints of soil salinity and toxicity, water availability, and stakeholder priorities. The locations of dykes could be moved to re-flood different areas based upon these constraints.

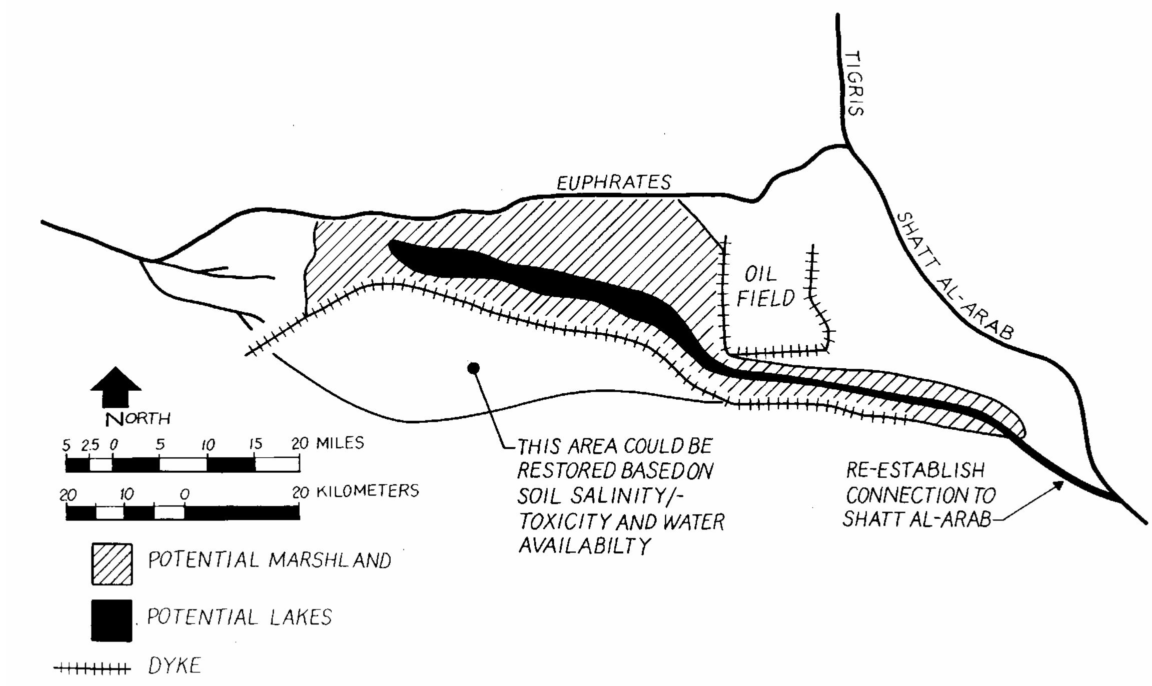

Figure 3. Conceptual sketch of potential marsh restoration in the Hammar Marsh. This sketch has been drawn to facilitate discussions among the appropriate stakeholders and to assist in developing hydrologic models and is not intended to represent an actual plan for restoration. The actual areas of restored marshes will likely be different from those depicted and would depend upon the constraints of soil salinity and toxicity, water availability, and stakeholder priorities. The locations of dykes could be moved to re-flood different areas based upon these constraints.

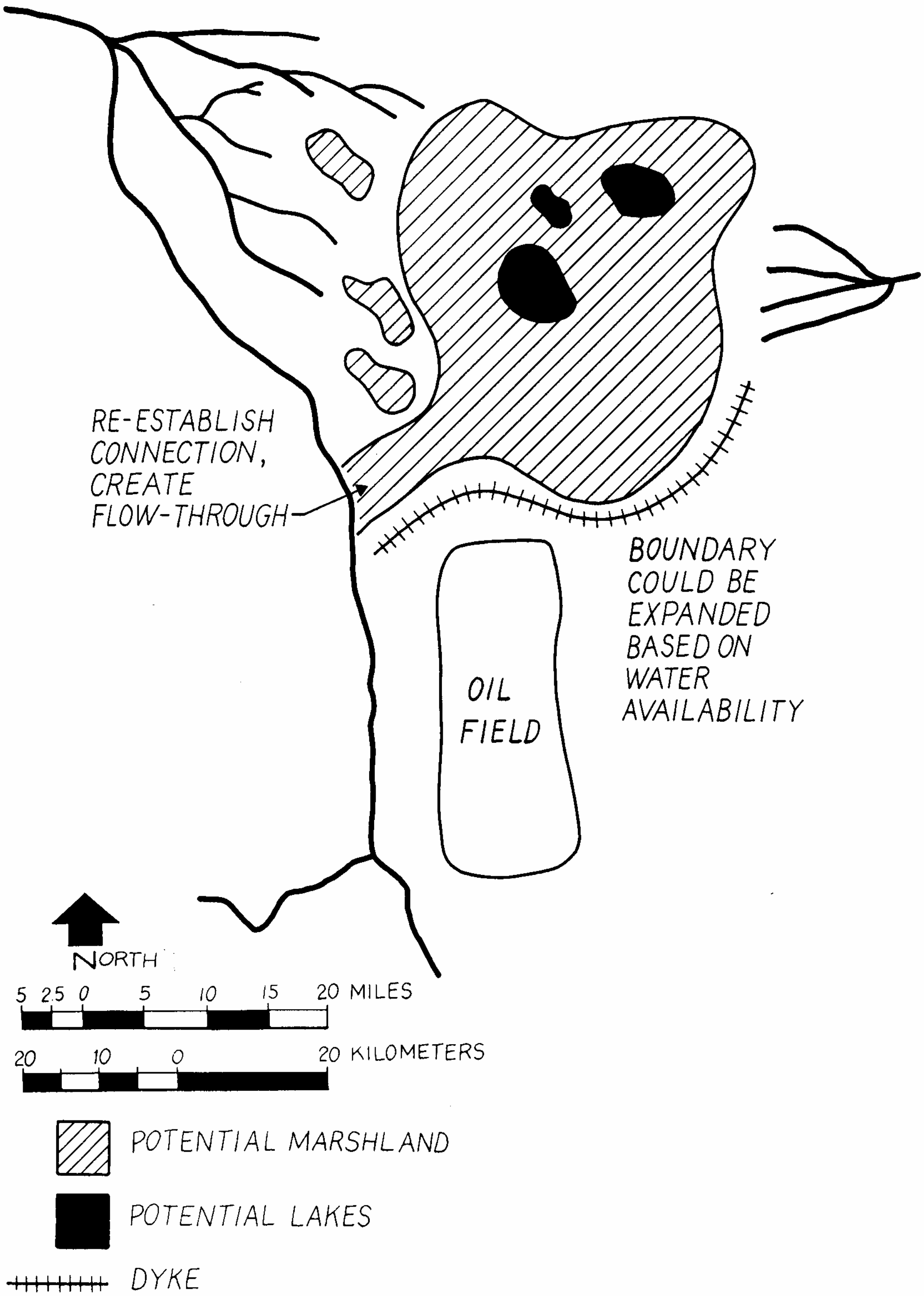

Figure 4. Conceptual sketch of potential marsh restoration in the Hawizeh Marsh. This sketch has been drawn to facilitate discussions among the appropriate stakeholders and to assist in developing hydrologic models and is not intended to represent an actual plan for restoration. The actual areas of restored marshes will likely be different from those depicted and would depend upon the constraints of soil salinity and toxicity, water availability, and stakeholder priorities. The locations of dykes could be moved to re-flood different areas based upon these constraints.

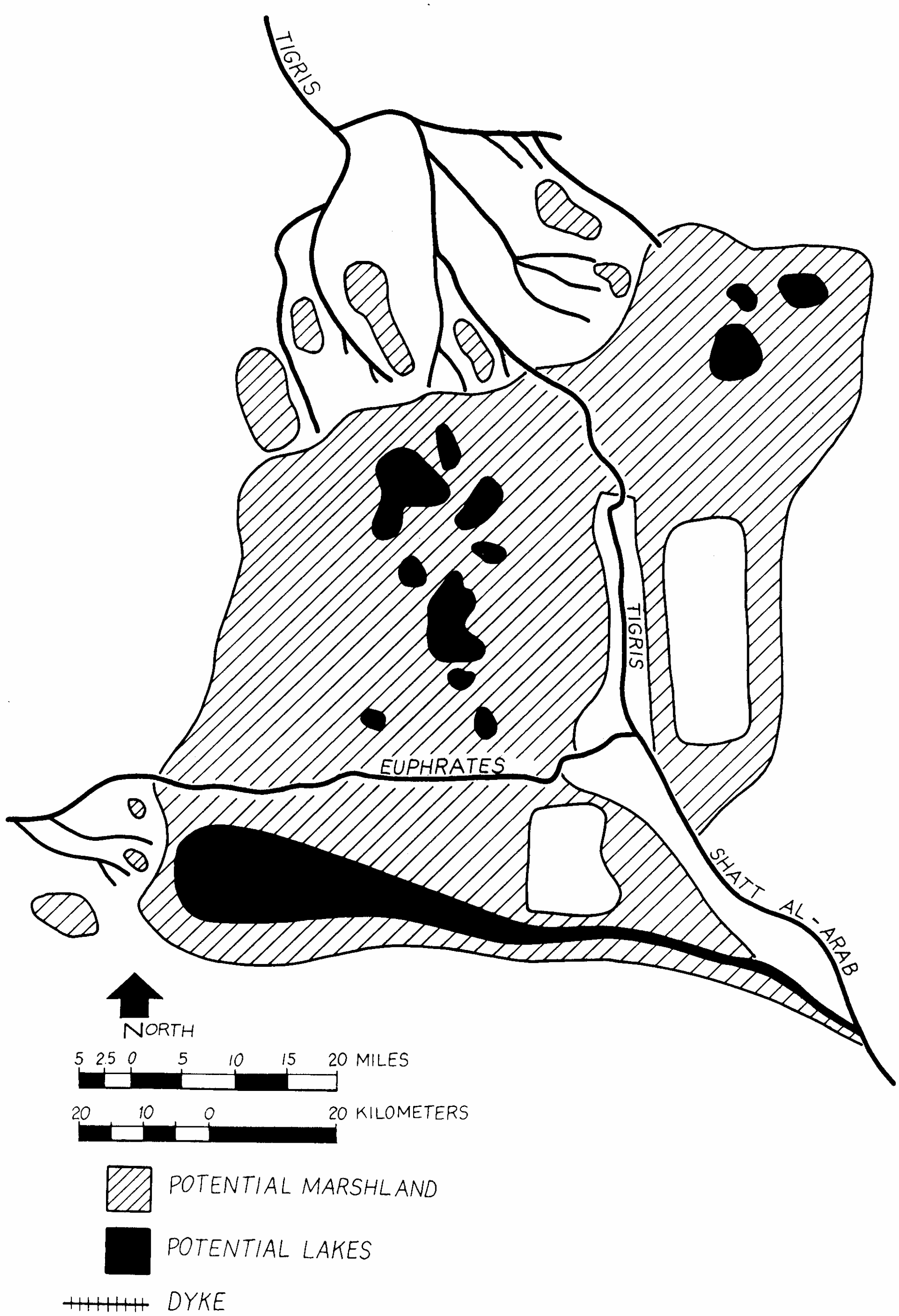

Figure 5. Conceptual sketch of extensive marsh restoration. This sketch has been drawn to facilitate discussions among the appropriate stakeholders and to assist in developing hydrologic models and is not intended to represent an actual plan for restoration. The actual areas of restored marshes will likely be different from those depicted and would depend upon the constraints of soil salinity and toxicity, water availability, and stakeholder priorities. The locations of dykes could be moved to re-flood different areas based upon these constraints.

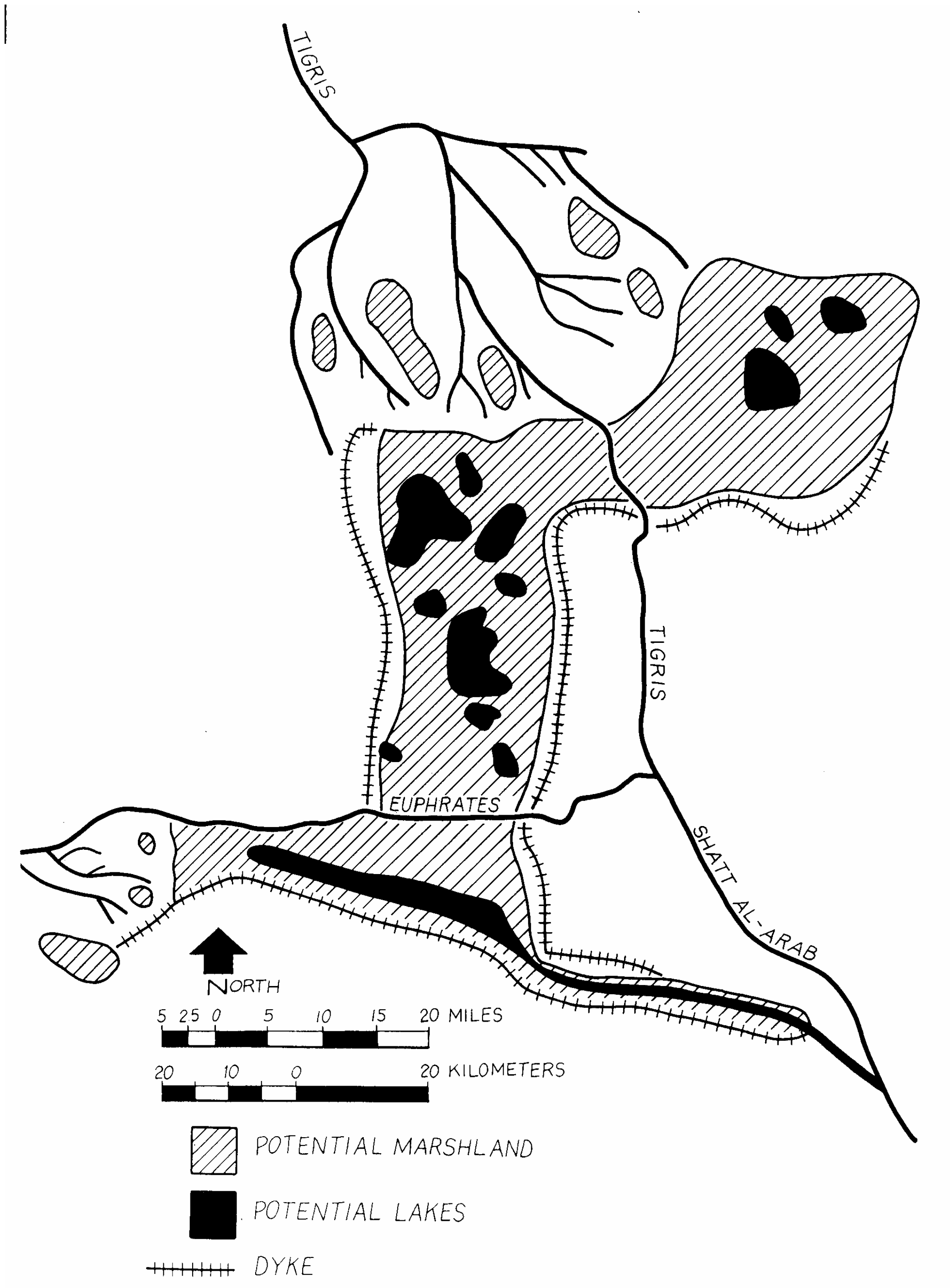

Figure 6. Conceptual sketch of substantial marsh restoration. This sketch has been drawn to facilitate discussions among the appropriate stakeholders and to assist in developing hydrologic models and is not intended to represent an actual plan for restoration. The actual areas of restored marshes will likely be different from those depicted and would depend upon the constraints of soil salinity and toxicity, water availability, and stakeholder priorities. The locations of dykes could be moved to re-flood different areas based upon these constraints.

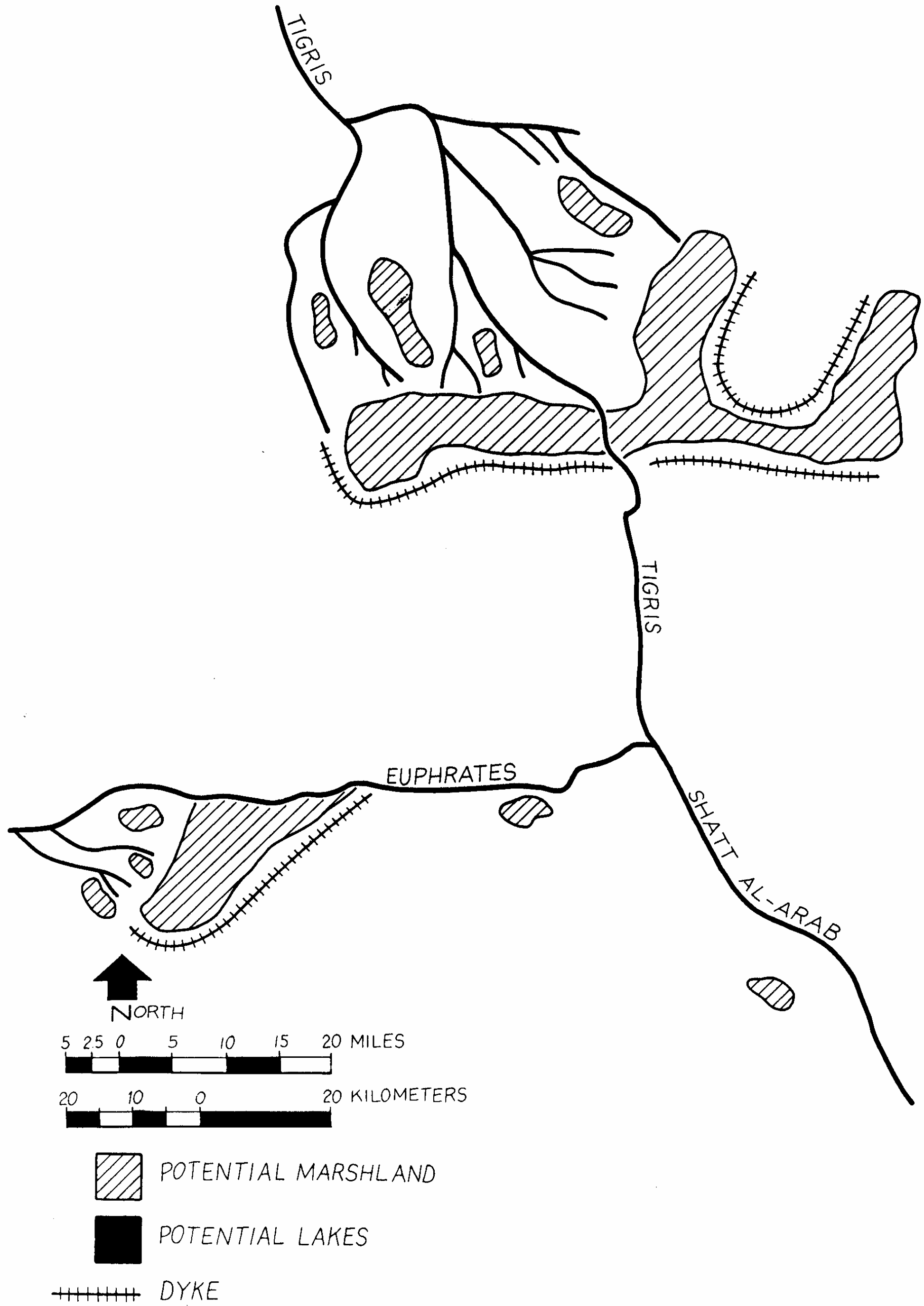

Figure 7. Conceptual sketch of limited marsh restoration (diffuse scenario). This sketch has been drawn to facilitate discussions among the appropriate stakeholders and to assist in developing hydrologic models and is not intended to represent an actual plan for restoration. The actual areas of restored marshes will likely be different from those depicted and would depend upon the constraints of soil salinity and toxicity, water availability, and stakeholder priorities. The locations of dykes could be moved to re-flood different areas based upon these constraints.

If only very low stream flows are available, only limited restoration will be possible. In this case, stakeholder priorities may indicate a preference to focus restoration on certain marsh areas, or to have smaller marsh restorations within each of the three marsh areas. Figure 7 depicts limited restoration of marshes within each area, although large areas within each marsh area are left un-restored. Here, the restored marshland areas have been drawn to be as close to the source of water as possible, to reduce salinity increases due to evaporation. Each small marsh has a hydraulic flow-through, and each marsh has a river connection. Hawizeh and Central Marshes are connected to the Tigris River and to each other. Hammar Marsh is connected to the Euphrates River, but not to any other marsh. There is no connection between the marshes and the Shatt al-Arab. It is emphasized that these sketches are drawn only for the purpose of facilitating discussion and for assisting in the development of a more comprehensive restoration plan reflective of better data and better-defined stakeholder priorities.

In considering the possible restoration scenarios in relation to each other, the ITAP noted the clear trade-offs between restoring a relatively small area with permanent flow-through wetlands and restoring a much broader area of seasonal, shallow, warm and saline wetlands. If there is only seasonal water, the marshlands could remain saline, and only salt-tolerant halophytic vegetation might grow. This could significantly shift the possibilities both for biodiversity and cultural uses. While halophytic vegetation has many uses, the plants would be very different from the historical reed marsh. Some halophytic succulents produce seeds that can be pressed to provide cooking oil, some grasses might support grazing; and other grasses can be harvested as hay for livestock bedding. It would be useful to explore the native vegetation in saline areas downstream in considering the rehabilitation of saline areas as inland salt marshes. There is currently insufficient vegetation data to determine what these species might grow in brackish to saline areas; however, cattail or reed mace (*Typha angustifolia*), pickleweed (*Salicornia europaea*), and seepweed (*Suaeda maritima*) and are strong possibilities (Guest 1966).

VII. RESTORATION BENEFITS MATRIX

In conceptualizing each of the scenarios and potential demonstration projects, ITAP identified the following key considerations in selecting areas for restoration:

- Ensure that what is done to restore marshes does not damage existing habitat or productive agricultural areas and that restoration does not diminish current human use.
- Prioritize locations where refugia are available for colonization of sites, either from the seed bank or propagule dispersal from native vegetation. Both wildlife and fish from deepwater habitats may also recolonize restoration sites from refugia.
- Prioritize the restoration of wetlands that are closest to distributaries to cut down on losses due to evaporation.
- Restore wetlands low in toxins to reduce human health risk to returning populations, scientists, and marsh biota.
- Restore wetlands that have relatively low salinity levels first.
- Prioritize projects with low to no maintenance requirements.
- Ensure local people and other stakeholders participate in and approve site selection for restoration projects.
- Target habitat requirements for focal and keystone species.
- Utilize a watershed approach in restoration planning, accounting for upstream water supply and downstream effects on the Shatt al-Arab and Gulf.
- Integrate monitoring and adaptive management into restoration planning and implementation.

The ITAP developed the following benefits matrix (Table 1) to evaluate the potential benefits of restoring portions of the marshlands under various scenarios. For each scenario, scores were provided as to the extent to which restoration actions would provide the stated benefit.

TABLE 1 RESTORATION BENEFITS MATRIX				
Potential Benefits	**Central Scenario I**	**Hammar Scenario II**	**Hawizeh Scenario III**	**Diffuse Scenario IV**
Possibility of passive restoration	+	+	++	+
Provide habitat for freshwater fish	+	+	+	+
Provide habitat for migratory fish and shrimp	0	++	0	-
Enhance fisheries	+	++	+	0
Enhance refugia	0	+	++	+
Provide habitat for focal species	+	+	++	-
Provide habitat for endemic species	+	+	+	+
Provide habitat for globally threatened species	+	+	++	+
Provide habitat for wintering and migrating waterfowl	+	+	++	+
Enhance practice of traditional marsh culture	0	+	+	+
Provide habitat for water buffalo	+	+	++	+
Enhance reed production	+	+	+	+
Enhance marshland related agriculture	++	++	++	0
Provide ecotourism opportunities	+	++	+	+
Protect human health	-	?	0	-
Allow for economic development	?	?	?	?
Allow for bioremediation	++	+	+	+
Improve drinking water supply	0	+	?	?
Improve water quality	++	+	+	+
Recharge groundwater	?	?	?	?
Flood attenuation	++	+	+	+

TABLE 1 RESTORATION BENEFITS MATRIX				
Potential Benefits	**Central Scenario I**	**Hammar Scenario II**	**Hawizeh Scenario III**	**Diffuse Scenario IV**
Provide flood hazard reduction	?	?	?	?
Improve soil quality	+	+	0	-
Provide carbon storage	+	+	+	-
Moderate climate	+	+	+	0

CHART KEY:
+ POSITIVE EFFECT
- NEGATIVE EFFECT
0 NEUTRAL
++ POTENTIAL FOR RELATIVELY MORE BENEFICIAL IMPACTS
? UNKNOWN EFFECT

VIII. TECHNICAL CHALLENGES AND CONSIDERATIONS IN RESTORATION EFFORTS

A. Remediation Issues

- Restoration areas would need to be physically cleared of unexploded ordnance and pollution sources prior to initiation of field surveys or the re-introduction of water. The clearance should include testing toxic materials that may have been dumped or may otherwise have concentrated in the marshlands. These surveys should be focused around villages and former villages, where these materials are most likely to cluster, and would be most likely to impact marsh dwellers.

- A field survey to sample and test for soil and water contamination would be needed early in the restoration process, so that appropriate health and safety protections can be made. High concentrations of pollutants have been detected in marshland soils, and limited wastewater treatment in Iraq has led to very high concentrations of contaminants in the Tigris and Euphrates Rivers, which would have been deposited in the marshlands. There have also been reports of poisons deliberately introduced into the marshes that target fish and water buffalo. It is recommended that a broad-scale survey be undertaken prior to any other field work or remedial activity, in order to develop adequate health and safety protections during subsequent action in the field.

- Subsequent field sampling and surveys would include targeted testing for contaminants, as indicated by the initial field surveys.

- Soil salinity is a major concern that must be evaluated prior to re-introduction of water. Uncontrolled release of water could result in the transport of highly saline water into the main rivers or in the development of highly saline conditions (if there is inadequate outflow) that could exacerbate the environmental damage.

- Ecotoxicological sampling of tissues from plants and animals would be warranted prior to restoration and as restoration progresses, to determine the overall health of the biota and to maintain positive standards for human health.

B. Hydrological Issues

Water supply is a major constraint on the potential to restore the Mesopotamian wetlands. The ITAP agreed that there is a critical need to determine how much water is available, as well as where and when it will be available, in order to account for inter-annual and seasonal variability in flow. Ultimately, it may be concluded that there is not enough water to restore the entire Mesopotamian

Marshlands to their pre-1980 extent. Development of a water budget will help evaluate total water availability for restoration efforts on a seasonal and annual basis, and allow for distribution of water resources in a manner that is consistent with priorities identified by the stakeholders.

Ultimately, to maintain the natural ecological character of a wetland, it is necessary to allocate water as closely as possible to the historic hydrologic regime. Re-introduction of a dynamic hydrologic regime will be critical in promoting resiliency in biotic systems. ITAP members also pointed out that heterogeneity in water depth is also important; ensuring that there is both vertical and horizontal heterogeneity helps provide a variety of habitats important for the ecosystem. The potential for creating such diversity depends strongly on the natural marshland topography as well as on any local changes that have been introduced by engineering, excavation, and diversion during the past decade. Another major consideration identified by the ITAP is the likely increases in salinity due to the high evaporation rate and therefore the need to provide flow-through.

Finally, the ITAP recommended that, where possible, the initial wetlands restored should be those closest to water source distribution points or the floodplain of major river systems to maintain flow and water quality, reduce evaporation loss, increase fish and wildlife habitat value, provide water supply, and enhance cultural and beneficial uses for people. Other considerations are as follows.

Water Quantity

Streamflow data for the Tigris and Euphrates Rivers have not been available to the project; these data must be obtained prior to finalization of demonstration projects. Additionally, streamflow measurements from canals and other water-control structures should be obtained. These data should be expressed as daily averages in cubic meters per second, and should include all known gauging stations along the rivers within Iraq. The Iraqi Ministry of Irrigation has records that go back to the 1920's.

There is a need for quantitative analysis of the flow regime to be expected under various scenarios of fluctuating climate and upstream flow storage and diversion. This analysis should consider the magnitude, timing, and duration of downstream flows in the vicinity of the Mesopotamian marshes, including seasonal variations.

The quantitative analysis should be accomplished by developing a simple water balance model for the Mesopotamian wetlands that accounts for rainfall, evapo-transpiration, surface water inflows and outflows, and groundwater inflows and outflows; and by using a river flow and reservoir routing model to account for water availability from the Tigris-Euphrates catchment using widely available software and hydrologic expertise.

Importance of re-establishing flow-through conditions

Seasonal flow-through wetlands provide oxygenated, cooler, fresher water to support biological systems such as fisheries, as well as connectivity in aquatic habitat corridors, and they prevent the build-up of salts in the aquatic ecosystem. If water cannot flow through the ecosystem, it will accumulate and evaporate, eventually creating highly saline seasonal wetlands, barren or with halophytic vegetation, that is less than optimum for habitat and cultural requirements. The geographic extent of the restored marshland may need to be restricted to establish flow-through rather than seasonal wetlands.

Seasonal flow-through conditions occur during the time of flooding in the Tigris-Euphrates system, but not during the extensive dry season when flows are minimal. Therefore, flow-through conditions can be achieved during the time of flooding, but some of that water must also be captured and stored in the marsh cells to maintain flooded conditions during (at least part of) the dry season. During the flooding season, flows should be allowed to move through the system and on to downstream points rather than simply accumulate in the cells. However, some water will certainly need to be stored for seasonal drawdown through evaporation and seepage, especially if minimal water is available for restoration.

Surface water-groundwater interactions

The vertical water flow conditions between surface and groundwater are not known, but could be important. If groundwater levels are too low, then much of the surface water re-introduced could be lost to infiltration; conversely, if the water table is very shallow, it could support the maintenance of permanent marshlands. There may be significant groundwater inflow from the southern catchments (Saudi Arabia/Iran) that is currently being drained off by the drainage canal network in Hammar marsh. If these ditches are plugged or filled, there may be a substantial increase in groundwater levels within the wetlands to help support rehabilitation of permanent wetlands. Ground water conditions could be assessed through a combination of field measurements and radar remote sensing. Some of this information can also be realized empirically when ditches are plugged and the water table rises---dry season water tables will be a reflection of groundwater inflows.

Soil salinity

The desiccated lakebeds in the marshlands (Hammar, Central and Hawizeh) that now appear to be salt pans are an issue. Without sufficient through-flow of water from the salt pans into the rivers, these areas would remain as closed systems that could function only as hypersaline wetlands. While the salts could potentially be flushed out with high water flows, the amount of water needed to flush the salt is unknown. Alternatively, the extent of former lakebeds to be flushed (and restored) could be controlled through installation of raised dikes at appropriate locations (or creative use of some of the existing marsh-drainage structures). Some guidance about the probable response of marshlands to re-hydration could be obtained from anecdotal descriptions of what has happened in the past when peripheral marshlands became re-hydrated in wet years after years or decades of dryness.

Water salinity

The salinity of water supplied to the marshlands by all potential sources needs to be determined prior to restoration of flow. Hydrologic models could include an analysis of salinity changes in space and time, which can then be combined with information on the salinity tolerance of different plant and animal species to anticipate the probable early stages of ecological succession in the re-hydrated marshlands

Water depth

Development of a heterogeneous mosaic of water depths is important to restoration of a functioning marshland. The focus should be on restoration of a functioning marsh rather than simply restoring uniform flooding conditions. Deeper channels within the shallow-water marshlands would be needed to provide cool-water refugia for fish in summer, as well as areas where permanent beds of submerged macrophytic vegetation can develop, without the risk of over-shallowing of water and die-off during the low water levels of late summer. Returning water to areas with heterogeneous topography will achieve desired habitat function if suitable water depth occurs in the planform surface. Hydrologic models should include calculation of water depth contours, in particular identifying areas with greater than 1 meter depth. These data can then be used to predict habitat quantity and distribution. For this purpose, high-resolution topography of the marshland is critical. It should be obtained as quickly as possible, either by contracting a topographic survey or by using high-resolution topography that may already have been collected.

Water Sources

Water is being stored in numerous reservoirs in northern Iraq, Iran, Syria, and Turkey. These water sources should be evaluated with respect to their ability to induce a synthetic flood pulse that might mimic historical patterns. The ITAP recommends that water quality within the reservoirs be studied prior to release; in particular, consideration should be given to salinity and temperature of water, and whether the releases will occur from the bottom or the surface of the reservoirs. However, the impact of hypolimnion water releases will be mostly felt in the river stretches immediately below the dams and the ITAP anticipates that the water will likely undergo very large changes in temperature, chemistry and sediment concentration during its flow downstream of these reservoirs. Therefore, the most important hydrological and water quality information must come from gaging stations on the main stem rivers further downstream near the Mesopotamian Marshes.

The capacity of the dams to release carefully timed flood pulses of a prescribed magnitude, timing, and duration will need to be examined. Many dams are not designed to facilitate flood pulsing, and can only release "flood freshets" downstream during years when the reservoir is near capacity.

Velocity of returning water

Water releases from impoundments will be relatively silt-free and will scour downstream channels. Erosion of marshland sediments during re-introduction of water could be a problem. Alternatively, peak flows could be beneficially used to disrupt saline crusts or to dissolve and wash away soil salts. Hydrodynamic models would include calculations of flow velocities to evaluate both marsh surface erosion and the potential to manage flows to achieve an optimal flushing effect. If erosion will be a problem, breaching of embankments should be done using a buffer diffuser.

Hydroperiod

The range of hydrological regimes, especially with respect to seasonal and inter-annual changes, should be further evaluated. These variations are critical to the development of a functioning wetland system. We need to understand the timing of water introduction and the duration of flooding. Older data (pre-1950s) are available, but more recent data should be included. If these data are compared with satellite images of comparable dates, then the functioning of the marshland and the inter-relationship between permanent and temporary marshes can be better understood. The range of hydrologic regimes, especially with respect to seasonal and inter-annual changes should be further evaluated. These variations are critical to the development of a functioning wetland system. We need to determine the best timing, magnitude, and duration of flooding for facilitating the rehabilitation of the marshlands.

Salt Wedge

A salt water wedge of high salinity may have migrated inland in Shatt al Arab and potentially the Euphrates River. Ultimately, there is a need to develop a Shatt al Arab hydrologic model to determine salt water intrusion from reduced flows. This area is tidal and hydrological conditions are very complex and difficult to model, yet the conditions in the estuary will greatly influence the long-term health of the regional ecosystems. Impacts of marsh rehabilitation, particularly of salt flushing and reduced freshwater flow to the Shatt al-Arab will need to be monitored.

C. Biogeochemical Issues

ITAP members strongly recommended confining initial restoration efforts to areas that have the least contamination and the least salinity problems. It is recommended to not re-hydrate areas that are either highly saline or toxic and leaving these areas impermeable pending more detailed assessment. If water is available to restore the saline salt pans in the dry Lake Hammar this area could be addressed in a later phase by flushing with large quantities of water. Soil is the memory of the marshland; the soils of the marshland will retain characteristics both from when it was a functioning marshland and from the desiccation. These relict characteristics form the baseline condition upon which the restoration proceeds. Other technical considerations and challenges are as follows.

Military and Industrial Contamination

Toxicological analysis of soil and water quality, in addition to ordnance assessment will be required as a first phase in any restoration effort. Uncontrolled release of water over contaminated soils could result in spread of contaminants that would aggravate the potential problems created by them.

Soil Quality

There is a general lack of soil information. Data such as pH, nutrient availability, electroconductivity, cation exchange capacity, exchangeable sodium cation percentages, sodium adsorption ratio, sulfate, gypsum, mercury, and selenium concentrations should be investigated. Both historical data on pre-desiccation conditions and data on current conditions are needed.

Soil Surveys

More definitive knowledge is needed on what soil types occur in marshlands; although some historical data are available, grading operations could have greatly changed these conditions. Therefore rapid soil surveys are needed to map the most extensive soil types and their respective quality.

Impact of Re-hydration on Soil Chemistry

ITAP members cautioned that re-hydration of the desiccated marshland soils sometimes leads to acidic soils, especially where sulfur content is high. Historically, soils have had a pH from 7.9 to 9.0, and some areas in the marshes have had large organic matter accumulation. Draining and burning of marsh soils has resulted in oxidation of soil surfaces. Acidic conditions could result from re-hydrating the soil, particularly in areas with remnant high organic content. When hydric soils are exposed to air following drainage, sulphuric acid can form. With rewetting, the soil becomes acidic and toxic to plants. Runoff can leach the acid, resulting in acidic water that becomes toxic to downstream ecosystems. Extremely acidic areas may require liming before re-flooding.

The alternative potential problem is if soils are pH neutral prior to re-hydration and the cations is flushed from the soils. In this case, soils could be overly alkaline for the first 2-4 years before the sodium is flushed out of the system.

Salts in the soil could potentially be released from the re-hydration process that could increase the salinity of the water to levels that the traditional ecosystem would not tolerate. Nutrients could be released in quantities or ratios (specifically, high phosphorus content) that would enhance algal production, decrease dissolved oxygen, and degrade habitat quality for aquatic organisms.

The potential severity of these issues can be explored by examining historical or anecdotal data on areas of the former marsh that were only periodically flooded to determine if there were algal blooms or acidic conditions. Also, laboratory-scale studies could be implemented once samples are available; these studies would take about a month to complete.

Temporary Marshlands

Once restored, the marshlands would comprise a core area of permanent marshlands with a perimeter of areas that are only periodically inundated. It is likely that the cycles of wetting and drying in these intermittent wetlands areas will provide a source of nutrients, and hence heterogeneity, in the marshland ecosystem. Nutrient cycling could be studied further. However, shallow or intermittent marshlands are unsuitable for aquatic organisms, including most fish species, due to high temperatures, reduced oxygen availability, and high salinities. There will be a trade-off between encouraging salt-tolerant vegetation (such as *Salicornia europaea* or *Suaeda maritima*) in ephemeral wetlands and reed dominated vegetation in permanent marshes. In general, the dependence of harvestable plants, fish and wildlife on the permanent reedbed marshes is much higher than other habitat types.

Downstream Issues

Re-introduction of water to the marshes should be carefully planned so that impaired water quality from agricultural drainage and increased salinity from flushing does not result in a significant impact on conditions in the Shatt el-Arab and Gulf.

Heavy Metals

Dehydration of the soils would potentially result in oxidation of metals. Some potentially toxic metals are more environmentally mobile and therefore could potentially create problems when the marsh is re-hydrated. Selenium is of particular concern.

Clean-up of Thick Salt Crusts

In some cases, where thick salt crusts have accumulated such as in former lakebeds, removal of salts by mechanical action and other clean up measures should be examined to save on limited water supplies.

Sediment Budget

The ITAP recommends development of a sediment budget analysis to determine whether the wetland/riverine habitat will erode or accrete sediment under the new flow regime. The long-term stability is determined by the relative rates of sediment accretion on the marsh and marsh surface subsidence. These two processes are somewhat self-regulating when undisturbed. However, the Mesopotamian marshland delta has changed considerably over time. Also the Tigris-Euphrates catchment has changed considerably over time, with significant reduction in sediment due to capture by dams and reservoirs. There may likely be sediment starvation from the ecosystem which can lead to: subsidence of channel and wetland bottoms and a reduction of habitat diversity, erosion of banks and vegetation, and loss of fish habitat. There may also be major problems below dam-controlled rivers, such as those draining into the Mesopotamian delta, where the trapping of sediment behind dams while the marshland surface continues to subside, causes a net lowering of the marshland surface with negative effects on wetland function. For long-term planning, it will become necessary to quantify the sediment budget of the marshes in both the modern era of their degradation and restoration and the historic era of their formation.

Wastewater and water treatment facilities

Municipal and industrial water pollution should be treated first through a wastewater treatment facility, then by constructing treatment wetlands prior to discharging into a receiving water body or marshland. Constructed wetlands would purify and treat water in a managed system prior to discharging downstream. Priority would be placed on locations immediately downstream of inhabited areas.

D. Ecological Issues

ITAP members agreed that basic ecological work needs to be done such as inventorying, mapping and describing vegetation types. Baseline inventories of taxa occurring in the marshlands would best be conducted with a combination of international, national, and local scientists, along with Marsh Dwellers familiar with the ecosystem. Given the degree of degradation of most of the marsh system, this inventory of remnant marsh patches should be a first step in restoration planning.

Before addition of water or any action is taken, an ecotoxicological study would be needed for plant and animal tissue, soils and water. Given the unknown impacts of war, lack of water treatment, deliberate poisons introduced into the marshes, and impacts of re-hydration on soils and associated contaminants, testing will be very important to protecting human safety as well as biological integrity.

A seed bank study should be completed in those areas which have high potential for restoration in terms of good soil quality. Seed bank studies are cheap and they will give some idea of what vegetation might re-establish without expensive plantings.

Patches of remnant wetlands would be identified and mapped, as these areas serve as population reservoirs for sensitive species, propagule dispersal agents and recolonization nexus points for fish and wildlife. Remnant marshes, aquatic habitat, riparian habitat and agricultural areas should be identified, protected and managed. The extent, connectivity, patch size, habitat interspersion, structural diversity and ecological richness of the Mesopotamian marshes should be prioritized in restoration planning efforts.

Permanent lake and reed bed habitat would be inventoried and mapped, as the highest proportion of the species of greatest conservation concern are dependent on this marsh type (Scott and Evans, 1993). Six of the eight threatened species and at least six of the eight endemic species, subspecies and populations are to some extent dependent on the vast permanent reed beds, and six of these are wholly dependent on this habitat (see Appendix B) (Stevens and Alwash, 2003a; Scott and Evans, 1993).

The last surveys of the marshes were conducted in 1979 or the early 1980's (Scott and Carp 1982, Scott and Evans 1993, Scott 1995). Winter bird counts by qualified avian ecologists familiar with the marshes should be a priority when access to the marshes is again available, as they are really the only consistent and replicable baseline data that exists from the marshes.

Development of an annual salinity model corresponding to salinity tolerances of different fish species will provide a useful tool for planning fish restoration. Water depths of greater than 1 meter provide the best fish habitat; mapping water depth contours will help incorporate these locations into restoration planning efforts (Coad 1996, Salman and Al-adhub, 1990, Salman and Bishop 1990).

Flagship species

Flagship species are distinctive and symbolic ecologically of the Mesopotamian Marsh ecosystem. In each marsh, flagship species could be selected because they are showy, charismatic, and historically utilized wetland habitat in the Mesopotamian Marshes. The following are potential flagship species: African Darter, Sacred Ibis, Dalmatian Pelican, Imperial Eagle, Jungle Cat (*Felis chaus*), Smooth-Coated Otter (*Lutra perspicillata maxwellii*), and Grey Wolf (*Canis lupis*). Water buffalo (*Bubalus bubalis*) are a cultural flagship species. Animals which may have been extirpated from the marshes, such as the otter, wolf, and jungle cat, could be re-introduced from adjacent habitats in the Middle East if the stakeholders decide that this is desirable.

Focal species

Focal species are indicators of good ecological health; they differ from flagship species in that they are generally more abundant in the ecosystem and thus easier to monitor (Riparian Habitat Joint Venture 2000). These species help define which spatial and compositional attributes characterize a healthy ecosystem and guide the development of appropriate conservation, restoration and management regimes. Focal species are chosen to represent habitat characteristics that encompass the habitat requirements of other species on the landscape. Final choice of focal species will depend on extant marsh conditions determined by field surveys; restoration efforts should be designed with the structural and functional habitat needs of these focal species in mind. Focal species recommended or discussed during the workshop were: Water Buffalo, Basrah Reed Warbler, Iraq Babbler, Imperial Eagle, Marbled Teal, Pygmy Cormorant, Dalmatian Pelican, Grey Hypocolius, Common Otter (*Lutra lutra*), Bunni fish, soft-shelled turtle, and penaeid shrimp species (*Maepenaeus affinis*).

Biological Indicators

Biological indicators are assemblages of organisms used as indicators of environmental quality (Bitzer 2003a and 2003b). One order of organisms that might be useful specific indicators during restoration of the Mesopotamian marshes is the Anostraca, which include, in seven families, the brine shrimp and fairy shrimp (Ibid.). There are a number of Middle Eastern species that should be investigated as potential specific bioindicators for the marsh restoration project. Assemblages of Odonates, or dragonflies, may also be useful biological indicators to assess the health and recovery of the marshlands.

Keystone Species

A keystone species is a species whose role is essential for the survival of many other species in an ecosystem. In the case of the Mesopotamian Marshland, key fish and wildlife habitat and cultural values are provided by the reedbeds.

Therefore, we refer to giant reed (*Phragmites australis*) as a keystone species, because if environmental conditions are suitable for reed recolonization, critical ecological and cultural benefits from marshland restoration will occur. Restoration of giant reed as the dominant plant in the marshland vegetation provides the keystone element to support ecological and cultural values and functions. The factors to consider in restoring and maintaining *Phragmites australis* include: inundated soils with 0.50 to 1.50 m (optimal 0.70 – 1.25 m), flow-through conditions, and protection from desiccation (Rodewald-Rudescu 1974). Harvesting and burning stimulates growth, maintains Phragmites clones in juvenile and vigorous developmental stages, and maintains a complex patchwork of heterogeneous marsh vegetation that provides habitat diversity.

Biological Conservation of Endangered, Rare or Endemic Species

The Mesopotamian marshlands provide habitat for a number of globally threatened species as listed in the IUCN Red List of Threatened Animals (Hilton-Taylor 2000), including 4 species of bird, 2 species of mammal, one species of reptile and one species of dragonfly (see Appendices II and III). In addition, the number of endemic species and subspecies that are confined to the wetlands of Mesopotamia and neighboring south-western Iran include two species and one subspecies of mammal, two species and two subspecies of birds, one species of reptile and at least one species of fish (Appendix IV). A number of rare or endemic species are found in the marshes, and given the current habitat loss must now also be classified as "globally threatened" (Scott and Evans 1993). Conservation of sensitive species requires a baseline inventory and identification of key habitat requirements.

Migratory Fish or Shrimp Species

The fate of the marshes affects the majority of the Tigris and Euphrates River systems and species which migrate up and down the river systems from the Gulf (Bannister 1994). There are 67 species identified in the Tigris-Euphrates basin, and 7 introduced or exotic species (Coad 1991, Coad 1996a; Coad 1996b). Even in permanent marshes, fish retreat to the rivers when temperatures rise (reach up to 31° C). Fish migrations occur twice a year during the rainy periods, moving up and down the rivers while using the marshes for spawning, nursery and feeding habitat.

The importance of the marshes as nursery grounds to the marine species of the Gulf is not well documented, but likely to be significant. Some species utilize deep water river channels for migration; however, the potential impact of salt-water intrusion into the Shatt al-Arab on the habitat and the species requirements should be evaluated. Salt-water fish typically migrated into the southern Hammar marshlands, which have largely been destroyed. For conservation of Penaid shrimp and other fish species that migrate up into the marshes to spawn from the Gulf, the temperature, flow and salinity of the receiving waters will have to be close enough to the pre-disturbance condition to allow uninterrupted migration corridors, spawning substrate and water conditions, and water quality and temperatures conducive to recruitment of juveniles into the adult population (Salman and Al-Adhub 1990, Salman and Bishop 1990).

Immigration of small-sized shrimp into the inland waters was historically continuous throughout the period from June-February, with one major peak between May-June. Spring recruits peak in Iraqi inland waters coincident with maximum discharge of the river (Ibid.). The maximum peak of recruitment in the nursery ground occurred in October, coinciding with the mean minimum discharge rate of the Shatt Al-Arab.

Wet Agriculture

There is an intrinsic linkage between the marshland ecosystem and traditional rice cultivation, which is likely to support some of the wetlands functions, and can provide a beneficial buffer to marshlands. Irrigated land and seasonally flooded land are of some importance for wintering waterfowl, including geese and cranes (Scott and Evans 1993). The species most likely to benefit from an increase in arable land are generally common and widespread species (Ibid.). Large-scale agricultural production in the restoration area could pose potential water quality problems due to fertilizer and pesticide usage.

Exotic and Invasive Species

Many plant species become aggressive invaders in wetlands. Some of these are highly desirable in this region (e.g., reed), but others might be considered nuisances. Among the attributes to monitoring in sites undergoing restoration are the plants that establish most readily on their own and expand to the exclusion of other species. If monotypes of aggressive invaders begin to develop, their utility and impact on more desirable species would need to be determined. Control of unwanted plants is best accomplished early in the invasion process.

Exotic fish may be competitively advantaged over native fish, as they are more resistant to lower doses of rotenone or toxaphene or other poisons that may have been deliberately introduced into the aquatic system. High toxin levels result in a complete kill, so there is no competitive advantage. Exotic species introduced into the marshes include Chinese major carps, goldfish, grass carp, goldfish and Indian or stinging catfish (which is potentially fatal to humans). Bunni is known to hybridise with the introduced goldfish. Other concerns in the marsh are mosquito fish, Gambusia, and their negative effects on amphibian populations.

It is the ITAP's expectation that exotic species are likely to exist in the system because the system has been so disturbed in the past few decades. The ITAP confirmed that is the case most everywhere else in the world, especially where hydrological conditions have been drastically altered. For this reason and the reasons stated above, the ITAP recommended that exotic species of plants or wildlife be carefully monitored to ensure they are not out-competing native species' regeneration in Mesopotamian marshlands. If rotenone was used in the marshes, non-native species may be less sensitive to rotenone toxicity. The remaining surviving fish populations may be dominated by goldfish and carp, i.e. weedy fish species that may preclude restoration of the fisheries without active management.

Examples of restoration approaches as well as information on invasive species control in the Everglades may provide a template for management of the Iraqi wetlands invasive species problems (Richardson and Huvane, 2001).

Mosquitoes and Other Waterborne Diseases

Mosquitoes are prevalent disease vectors in the marshes; mosquito control procedures should be integral to the restoration planning effort. Control measures should be designed that do not have secondary adverse impacts on the ecosystem (precluding use of DDT, for example).

E. Socio-Cultural Element

Historically, people lived in and around the wetlands and in the interior of the marshes, and derived both subsistence and market economies from extractive uses such as harvesting reeds, water buffalo dairy products, fish, waterfowl, and agriculture (Salim 1962, Maltby 1994, Clark and Magee 2001, Nicholson and Clark 2002, Thesiger 1964, Young 1977). There has been large-scale internal displacement of marsh dwellers. In addition, at least 40,000 Marsh Arabs are now living in refugee camps in Iran. There will be many areas where local people will want to return and commence with their traditional lifestyle, whereas other people will want to live along the rivers, accessing the marshland from the perimeter. The recovery of the local economy and improving people's livelihoods is a major concern. Restoration efforts should reflect the needs and desires of the local population while respecting the importance of the marshes to wider stakeholder interests such as regional and global biodiversity. Local residents and indigenous marsh dwellers will each have different life style and economic requirements in building a new life. In this process of building stakeholder approval and support, mechanisms should be put in place to provide opportunities for local community participation in restoration planning, implementation, monitoring and stewardship.

Historical and current settlement patterns should be defined and mapped. There is a critical need to establish systematic interviews with refugees to establish where people want to return to and how they want to live, to make restoration compatible with the desires of the local inhabitants. An options analysis could evaluate the trade-offs between water distribution strategies and the locations and needs of returning Iraqi people. A sociological survey could be conducted of the people in refugee camps, internally displaced, and still living in the marshlands to understand where people prefer to live and the water use required to support them. Water needs include drinking water and sanitation, irrigation, fish and wildlife habitat, reed production, grazing and fodder for water buffalo. The distinctive traditional marsh culture in each marsh should be studied, as all regions can potentially be benefited, and each region has residents that would probably like to return.

People who lived in the deep marshes may want different living conditions than those who lived in towns and villages along the marshes edge prior to being exiled (Stevens, 2002, Unpublished Field Notes). Many people may prefer to live within more developed areas that provide better health care, education, and economic opportunities. These areas could be developed as corridors along the major rivers, or along the edges of the marshlands, to allow for forays into the marshlands.

In addition to historical and current settlement patterns, traditional ecological knowledge and traditional resource management systems should be evaluated and implemented in restoration planning. This includes the cumulative body of knowledge, practice and belief, evolving by adaptive processes and handed down through generations about the relationship of living beings and with their environment (Berkes et al 1995). Traditional resource management by Marsh Dwellers includes selective harvesting of reeds, burning, multiple species management (reeds, aquatic vegetation, fish, waterfowl), resource rotation (selective reed harvesting on a phenological and seasonal basis, burning senescent vegetation to stimulate new growth, temporal restriction of fish harvest during spawning, and landscape patchiness management) (Salim 1962; Stevens 2003). Traditional resource management provides for succession management, a system of landscape patch dynamic management that increases structural and habitat diversity.

Once information is collected, technical advice needs to be available to stakeholders to help them evaluate the options that are available. These will likely include a list of opportunities and constraints, and documentation of the needs for empirical data to evaluate the opportunities and constraints. Restoration efforts should be conducted in close coordination and consultation with the local stakeholders and approval by the appropriate Iraqi authorities. Partnerships should be created with local residents and scientists to create employment and build capacity within the local community. All relevant national and local stakeholders should be included in all phases of restoration planning, implementation, monitoring and adaptive management. Training and educational opportunities could be provided. Restoration scientists could advise in development of local stewardship and land management protocols of common resources by the local community.

One important human element is the need for agricultural production to support local livelihoods. There are complementary linkages between agriculture and restoration, particularly marsh dependent agriculture such as rice, reed culture, and dairy production. Wet agricultural lands could be utilized as buffer zones or supplements to wetland function. Historical agricultural usage should be mapped, and the temporal patterns studied. Water releases for the purpose of ecological restoration should be coordinated with the seasonal needs of agriculture. The rice growing season has traditionally been April through September, and the wheat and barley growing season from November through March. The nature and format of stakeholder consultation should be informed by a stakeholder assessment, described further in section IX.

F. Interactions

There are strong interrelationships between the available topography and topographic configuration which can be modified, the hydrological regime possible and the range of environmental, ecological and socio-cultural functions which can be reinstated or promoted. Different parts of the wetland complex will be capable of delivering different combinations of benefits that result from their functioning. It is vitally important that any reconnaissance survey of the desiccated areas should attempt to assess in a preliminary way the range of possibilities which exist so that stakeholders can make more informed decisions.

The strategy for implementation will benefit from the practical application of the Ecosystem Approach which has been adopted by the Convention on Biological Diversity as the primary framework for delivery in a balanced way of its three key objectives: conservation of biological diversity, sustainable use of its components and fair and equitable sharing of benefits arising out of the use of genetic resources. The Ecosystem Approach recognizes that people are an integral part of the system. Its application is underpinned by principles that recognize the scientific, socio-cultural and economic complexity of the integrated management of land, water and living resources. Delivery will require appropriate participatory processes, adaptive management and partnerships that may be supported by an international multi- and interdisciplinary technical team working hand in hand with local and national expertise.

IX. STRATEGY FOR RESTORATION PLANNING AND IMPLEMENTATION

This report represents the ITAP's advice that was possible given the available data, the combined experience of the members, and the time set aside for deliberations. To build on the recommendations presented here, the ITAP recommends that the strategies proposed herein be verified by field data and informed by local communities. Accordingly, the ITAP recommends that the following actions be undertaken within the first year:

1. Build structures for stakeholder involvement and inclusion in the decision-making process. The ITAP can provide advice to resolve technical issues related to restoration but cannot make restoration decisions. Appropriate stakeholders may include marsh dwellers and other local inhabitants, appropriate government authorities, local scientists and resource specialists, local community organizations and grassroots environmental groups, international conservation groups, and local land use planners. An appropriate method for obtaining input from these stakeholders and developing a consensus for marshland restoration should be developed.

2. Focus initial data gathering on the development and implementation of demonstration projects. These could include smaller-scale projects in the Central and Hammar Marshes, and more extensive re-introduction of water to the Hawizeh Marsh. The data needs and field actions outlined in this report should be prioritized so that demonstration projects are initiated by the first flood season. If possible, this would mean implementation by the autumn flood season (November 2003), or at least by the first spring floods (March 2004).

3. Build international support and cooperation. Partnerships should be developed with national governments, international aid organizations and conservation groups to ensure that adequate resources are available to achieve restoration goals. Work with international partners to investigate avenues for transboundary dialogue on water allocation for the Tigris and Euphrates river system, as appropriate.

4. Once demonstration projects have begun, utilize the information gathered to develop a comprehensive restoration strategy. Complete the field surveys and technical analyses outlined in this report (see Appendix I for details) and utilize these data, along with the stakeholder priorities identified, to develop a restoration plan that is both scientifically valid and meets the needs and desires of the marsh dwellers and other stakeholders and the Iraqi government authorities. Development of this plan should involve a strong component of local scientific and indigenous knowledge along with the expertise of international scientists and the resources of international aid and conservation groups to ensure success.

5. Enable adaptive management by developing and maintaining a comprehensive monitoring strategy. Environmental restoration does not always proceed according to

plan. A comprehensive monitoring plan will provide "feedback" for assessing the responses of the restored marshes, determining if outcomes match expectations, and for using these assessments to determine when and how the restoration program could be expanded and improved. A passive assessment form of adaptive management could be initially instituted in which a system-wide monitoring plan is designed to measure progress toward meeting the restoration objectives and to provide opportunities for "learning by doing" during the period following project implementation.

The ITAP appreciates the opportunity to provide its advice on this vital issue for Iraq's future and the world at large. ITAP members look forward to the opportunity to continue this work and help make restoration a reality.

X. REFERENCES

The following are the most commonly used references for this report. Additional references are available on the Eden Again Bibliographic data base at http://www.iraqfoundation.org/project/edenagain. This Bibliographic Data Base is subdivided into subject categories for your convenience.

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APPENDIX I

IDENTIFICATION OF DATA NEEDS

REMEDIATION DATA NEEDS

- Areas should be cleared of ordnance and tested for toxic materials prior to re-introduction of water.

- An initial field survey to sample and test for soil and water contamination should be implemented, so that appropriate health and safety protections can be planned.

- Data from the surveys needs to be systematically analyzed and at least some preliminary conceptual models should be constructed of what should be expected from inundation of each tested site.

- Ecotoxicology testing of tissue samples from plants and animals, particularly those organisms typically used for human consumption, should be conducted.

HYDROLOGICAL DATA NEEDS

- **Stream Flow Measurements**
  More recent and comprehensive stream flow measurements should be obtained and evaluated and incorporated into hydrologic models to evaluate the hydrologic regime, including seasonal and inter-annual changes, and long-term changes in water supply. These data are maintained by Iraq's Ministry of Irrigation. The documented and anticipated effects of reservoir storage and water extraction needs to be incorporated into the analysis to explore probable trends and possibilities for altering the flow regime to maximize restoration potentials.

- **Hydrologic Regime Analysis**
  Restoring ecological conditions in connection with streams that are regulated by upstream dams is a complex task that must account for the fundamental changes that dams create, including removing sediments and organic material from upper watersheds, as well as downstream channel adjustments to the post-dam flow regime. A hydrologic regime analysis should be prepared which should be informed by a time-series of satellite images that correlate with the time-series of stream flow measurements. Alternatively, Synthetic Aperture Radar (SAR) technology could be employed to achieve similar results. Correlate the timing/magnitude/duration of channel flows with the extent of flooding. Habitat and hydrogeomorphic land types could be identified, mapped, and correlated with the stream flow measurements to better define seasonal and inter-annual variation, and to assist with identifying areas for habitat restoration.

Because restoring flow viability to mimic the natural hydrograph is not likely, the ITAP recommended that some other compensation be made such as diverting smaller amounts of water into smaller low-lying areas to create down-sized wetlands. A first estimate of the magnitude of the task to be faced would involve examining the frequency of water levels and discharges at sites where restoration is desired. Then a basin-wide water budget and routing modeling needs to be constructed, including the effects of various scenarios of reservoir construction and operations, approximation of how much water will be lost to evaporation, transpiration, and groundwater seepage, and better documentation and analysis of the interaction of groundwater with surface water

Such a budget model could be defined using well-accepted tools such as one of the U.S. Army Corps of Engineers Hydrological Engineering Center's reservoir routing models. Modeling should account for the impact of dam and reservoir management throughout the entire Tigris-Euphrates River Basin, account for water off-take for irrigation schemes, and help in screening for alternatives. The model would also assist future water management in Iraq. Data for basic model development are already available. Further refinement would be required as soon as access to co-riparian water usage data and policies is made available. A water budget model, along with the hydrodynamic model described in the following paragraph and hydrological models would be key in the development of a reliable decision support system for integrated water management of the entire Tigris and Euphrates basin. The implementation of such a system would be fundamental in making decisions on how to obtain the flood pulse necessary for the revitalization of the marshlands.

- **Hydrodynamic Model**
  Once the magnitude, timing, and duration of available water is known for any potential restoration site, a hydrodynamic model will be needed to compute velocity, direction and magnitude, and water depth. The hydrodynamic model should also include surface-groundwater interactions. The model should also include a calculation or evaluation of water salinity. To complete the hydrodynamic modeling, more accurate digital elevation models are needed to calculate the storage capacity of lakes and marshlands. The preliminary investigation relied on 1:100.000 scale maps, giving an unacceptable ground elevation characterization (for accurate hydrodynamic computer modeling purposes). In order to provide more accurate modeling, a Digital Elevation Model having a data point every 30 meters is needed. These data are available, but are either classified or very expensive. In addition to elevation models, cross-sectional profiles of rivers and distributaries are necessary.

- **Conduct Field Hydrologic Surveys**
  A field survey is necessary to determine the elevation of the water table through installation of groundwater monitoring wells and piezometers. The quality of groundwater should also be sampled, evaluated, and mapped. Water quality of potential water sources, including rivers and reservoirs (vertical sampling in deeper reservoirs) should be tested. Soil salinity and the composition and thickness of salt crusts on the former lakebeds should be analyzed to evaluate potential salinity problems.

- **<u>Develop a Shatt al-Arab Model</u>**
  Evaluate hydrologic connection between marshlands, Shatt al-Arab and with the Gulf. Investigate Shatt al Arab and tidal wedge, determining how far up the Shatt al Arab the tidal wedge is now located on an annual basis. Determine altered water salinities from expanded tidal wedge, determine impact of increased flows on tidal wedge, and determine the relationship between freshwater and salt water. In order to develop the model, cross-sections of the Shatt al-Arab and lower Tigris and Euphrates are needed. Bathymetric information of the Gulf at the mouth of the Shatt al-Arab is needed, along with morphological characterization of the river bed (to correctly account for river roughness) and tidal data at the mouth of the river.

<u>BIOGEOCHEMICAL DATA NEEDS</u>

- **<u>Conduct Selective Soil Survey which Includes</u>:**

  - Evaluate 20-40 cores from demonstration restoration areas from both salt-encrusted pans and residual Phragmites marsh patches

  - Complete soil chemical analyses

  - Conduct core flooding experiments to determine what comes back – seed or propagule bank or dispersal / colonization mechanisms

  - Conduct core flooding experiments to determine changes in redox states– determine if iron is oxidized or reduced, gypsum could go to acid soil components, sulfate or hydrogen sulfide forming as soils become reduced

  - Determine diffusion gradients (calculate using small cores)

  - A characterization and mapping of soil types. Soil types present at surface may be different from those that were present in former surveys.

- **<u>Evaluate Nutrient Availability and Release.</u>**
  Nutrient release vs. hydrologic regime needs to be evaluated.

ECOSYSTEM DATA NEEDS

- Streamflow and topography data referred to above are required.

- **Obtain Channel Cross Sections and Gradients of All Waterways**
  These are needed for both main channels and marshland channels. These can be defined with a differential GPS survey, simultaneously with the aerial GPS coordinates survey.

- **Conduct Aerial Surveys**
  Recommend ground truthing space imaging data by flying the area by helicopter and mapping and integrating GIS coordinates of habitat types to determine remnant marsh patches and determine connectivity in aquatic habitat corridors.

- **Conduct Baseline Study**
  In order to plan restoration, there is a need to understand what is there now, and how is can be changed to benefit the restoration process. A baseline study of the biology of the marshes and contiguous environments should be undertaken, and a long term monitoring system established with some form of adaptive assessment or management. Basic ecology work needs to be done such as inventorying, mapping and describing vegetation types, and baseline inventories of taxa occurring in the marshlands conducted with regionally experienced biologists, local biologists and Marsh Dwellers familiar with the ecosystem.

- **Conduct Habitat Inventory**
  Priority habitats such as permanent lake and reed bed habitat should be inventoried and mapped. Inventory and mapping could be conducted by HGM classification units of Lacustrine Fringe, Riverine, Slopes, Estuarine Fringe River-sourced and Estuarine Fringe Embayment or by using the hydrogeomorphic unit (HGMU) approach which would yield subdivisions of these larger zones depending on differences in hydrologic regime and soils/sediment.

- **Identify and Map Invasive Exotic Plant Species**
  Identify exotic species that might need to be monitored or eradicated if possible. There are reports of an invasive Iris-like species occurring in the drained marshlands. Possibilities include three species of Iris in the Iraq flora, a native Gladiolus (*Gladiolus* sp.*),* Nutsedge *(Cyperus* spp.*),* or Rush (*Juncus hybridus)* (Guest 1966).

APPENDIX II

THREATENED ANIMALS IN MESOPOTAMIA

As listed in the 2000 IUCN Red List of Threatened Animals
(Hilton-Taylor, 2000)

MAMMALS

Endangered	
Mesopotamian Fallow Deer (Extinct in Iraq)	*Dama dama mesopotamica*
Vulnerable	
Common Otter	*Lutra lutra*
Smooth-coated Otter	*Lutra perspicillata*
Near-threatened	
Striped Hyaena	*Hyaena hyaena*
Goitred Gazelle	*Gazella subgutturosa*
Marsh Bandicoot Rat	*Erythronesokia (Nesokia) bunnii*

BIRDS

Critical	
Slender-billed Curlew	*Numenius tenuirostris*
Endangered	
White-headed Duck	*Oxyura leucocephala*
Vulnerable	
Lesser White-fronted Goose	*Anser erythropus*
Red-breasted Goose	*Branta ruficollis*
Marbled Duck	*Marmaronetta angustirostris*
Pallas's Fish Eagle	*Haliaeetus leucoryphus*
Greater Spotted Eagle	*Aquila clanga*
Imperial Eagle	*Aquila heliaca*
Lesser Kestrel	*Falco naumanni*
Corncrake	*Crex crex*
Sociable Lapwing	*Vanellus gregarius*
Conservation dependent	
Dalmatian Pelican	*Pelecanus crispus*
Near-threatened	
Pygmy Cormorant	*Phalacrocorax pygmeus*
Ferruginous Duck	*Aythya nyroca*
White-tailed Eagle	*Haliaeetus albicilla*
Eurasian Black Vulture	*Aegypius monachus*
Pallid Harrier	*Circus macrourus*
Little Bustard	*Tetrax tetrax*

BIRDS

Houbara Bustard	*Chlamydotis undulata*
Great Snipe	*Gallinago media*
Basra Reed Warbler	*Acrocephalus griseldis*
Cinereous Bunting	*Emberiza cineracea*

Data deficient

Black-winged Pratincole	*Glareola nordmanni*

REPTILES AND AMPHIBIANS

Endangered

Euphrates Softshell Turtle	*Rafetus euphraticus*

Near-threatened

Common Tree Frog	*Hyla arborea*

INVERTEBRATES

Vulnerable

The dragonfly	*Brachythemis fuscopalliata*

APPENDIX III

GLOBALLY THREATENED AND NEAR-THREATENED ANIMALS IN THE MESOPOTAMIAN MARSHLANDS

Common Otter *Lutra lutra* (VU)

Formerly common in the marshes, but now greatly depleted in numbers and apparently very rare.

Smooth-coated Otter *Lutra perspicillata* subspecies *maxwelli* (VU)

This is endemic to the marshlands and was described from a skin and a live cub acquired by Maxwell (1957) in the marshes of Hawr Al Hawizeh in early 1956. The only further records, also in the 1950s, came from Al Azair on the Tigris, and the Central Marshes 19 km northwest of Al Azair. Firouz (2000) included it in his list of the fauna of Iran, and stated that it had been recorded from the marshes close to the Iraqi border in Khuzestan (presumably Hawr Al Azim). Otters of both species (*lutra* and *perspicillata*) had become very rare in the Mesopotamian marshes by the late 1980s, and it is likely that this endemic subspecies is on the verge of extinction, if not already extinct.

Marsh Bandicoot Rat *Erythronesokia (Nesokia) bunnii* (LR/nt)

This was discovered as recently as the late 1970s in the Central Marshes at Al Qurnah (Khajuria, 1980). Further specimens were collected by Prof. K. Al-Robaae (K.Y. Al-Dabbagh, *in litt.*) in the 1980s, but no other information appears to be available on its status in Iraq. Firouz (2000) included it in his list of the fauna of Iran, and gave its range as "marshes bordering Iraq" (presumably Hawr Al Azim).

Dalmatian Pelican *Pelecanus crispus* (LR/cd)

A fairly common winter visitor and probably also a resident breeding species. It was estimated that as many as 10% of the world population were wintering in the Mesopotamian marshes in the late 1970s.

Pygmy Cormorant *Phalacrocorax pygmeus* (LR/nt)

Formerly a common resident in Mesopotamia, and still present in the Hawr Al Hawizeh/Hawr Al Azim system in early 2002 (M. Moser, pers. com.).

Marbled Duck *Marmaronetta angustirostris* (VU)

A common breeding bird in the wetlands of Mesopotamia, but very scarce in winter. The bulk of the population apparently winters in Shadegan Marshes in neighboring south-western Iran, where concentrations of up to 20,000 (a large proportion of the world population) have been recorded as recently as 1992.

Ferruginous Duck *Aythya nyroca* (LR/nt)

A rather scarce winter visitor and passage migrant in Mesopotamia, and possibly also a scarce breeding bird.

White-tailed Eagle *Haliaeetus albicilla* (LR/nt)

A former breeding species, but now only a scarce winter visitor to the wetlands.

Pallid Harrier *Circus macrourus* (LR/nt)

A fairly common winter visitor and probably also a passage migrant.

Greater Spotted Eagle *Aquila clanga* (VU)

A fairly common winter visitor to the wetlands.

Imperial Eagle *Aquila heliaca* (VU)

A fairly common winter visitor to the wetlands and surrounding plains.

Slender-billed Curlew *Numenius tenuirostris* (CR)

Possibly still a very scarce passage migrant and winter visitor to the wetlands of Mesopotamia. There have been few recent reliable records, but there is much suitable habitat and the species is easily overlooked.

Basra Reed Warbler *Acrocephalus griseldis* (LR/nt)

The Basra Reed Warbler is reported to have been a common breeding summer visitor to the reed-beds of Mesopotamia, but very little information is available. As far as is known, the breeding range is confined to southern Iraq, along the lower Euphrates and Tigris rivers from the Baghdad area to Fao, and there have been no definite records of its occurrence in Iran. Outside the breeding season, it has been recorded on passage in Saudi Arabia, Ethiopia and Sudan, and in winter in southern Somalia, Kenya, Tanzania, Uganda, Malawi, Mozambique and South Africa (Cramp *et al.*, 1992).

Euphrates Softshell Turtle *Rafetus euphraticus* (EN)

Confined to the marshes of Mesopotamia and neighbouring Khuzestan. Reported to be common by Scott and Evans (1993), but now listed as endangered because of the recent massive drainage of wetlands in Mesopotamia.

Common Tree Frog *Hyla arborea* (LR/nt)

Known to occur in the Mesopotamian Marshes and neighbouring Khuzestan, Iran, but no other information is available.

Dragonfly *Brachythemis fuscopalliata* (VU)

Known only from Iraq, Israel and Turkey. It has been collected in the marshes of Mesopotamia, but no recent information is available on its status there (Scott & Evans 1993).

APPENDIX IV

ENDEMIC SPECIES AND SUBSPECIES OF ANIMALS IN THE MESOPOTAMIAN MARSHES

Marsh Bandicoot Rat *Erythronesokia (Nesokia) bunnii*

Mesopotamian (Harrison's) Gerbil *Gerbillus mesopotamiae*

Smooth-coated Otter *Lutra perspicillata* subspecies *maxwelli*

Iraq Babbler *Turdoides altirostris*

Basra Reed Warbler *Acrocephalus griseldis*

Little Grebe *Tachybaptus ruficollis* subspecies *iraquensis*

African Darter *Anhinga rufa* subspecies *chantrei*
This subspecies is now not generally recognized.

Euphrates Softshell Turtle *Rafetus euphraticus*