KANSAS
INTERIM HYDROGEOMORPHIC (HGM)
FUNCTIONAL ASSESSMENT MODEL

RIVERINE WETLANDS

October 1, 2007

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Section I - Introduction

General

Wetlands have properties of both aquatic and terrestrial ecosystems. Their most widely valued function is providing habitat for fish, birds, and other wildlife (contributing to the maintenance of biodiversity). In addition to this “food chain support” function, wetlands carry out hydrologic functions and water quality improvements - all of which are important to society as a whole. They also provide recreational, educational, research, and aesthetic functions.

Wetland Functions

Wetland functions are the normal or characteristic activities that take place in wetland ecosystems or simply the things that wetlands do. Wetlands perform a wide variety of functions in a hierarchy from simple to complex as a result of their physical, chemical, and biological attributes. All wetlands do not perform all functions to the same degree of magnitude. The functions selected for assessment should reflect the characteristics of the wetland ecosystem and landscape under consideration and the assessment objectives.

The HGM system of wetland classification recognizes three broad wetland functions. They include functions related to hydrology, biogeochemical processing, and wildlife/biological habitat. Specific wetland functions have been identified with respect to the three broad functions. Moderation of groundwater flow is an example of a slope wetland function. It can be defined as “the capacity of the wetland to regulate the outflow of groundwater.” On-site effects include contribution to the maintenance of characteristic soils, vegetation, invertebrate and vertebrate communities, and the moderation of groundwater flow. Off-site effects include modification of off-site hydrology of wetland and riverine systems within the groundwater and surface water flow network.

Summary of HGM Approach

The three main components of the HGM approach include: (1) HGM (functional) classification, (2) comparison sites for wetlands, and (3) assessment models/functional indices.

HGM Classification

HGM Classification is based on three factors: geomorphic setting, water source, and hydrodynamics.

Section I - Introduction, continued

HGM Classification, continued

Regardless of how they are defined, all wetlands share some common hydrologic, soil, and vegetative characteristics. Beyond these similarities, however, wetlands exhibit wide variation in terms of their size, complexity, and physical, chemical, and biological characteristics and processes.

At the highest level of HGM classification, wetlands are grouped into HGM wetland classes. Seven hydrogeomorphic classes are recognized. They include depressions, lacustrine fringes, tidal fringes, slopes, riverines, mineral soil flats, and organic soil flats.

Comparison Sites

In order to assess impacts to wetland functions, standards of comparison must be defined for what constitutes chemical, physical, and biological integrity in the context of a wetland. Establishing comparison sites has two complications.

First, wetland ecosystems and their surrounding landscapes are dynamic and constantly changing. As the characteristics that influence function change, functional capacity may increase or decrease. These changes are the result of natural short-term processes such as seasonal cycles of precipitation and temperature; and long-term processes that include population dynamics, erosion and depositional processes, succession, drought/wet cycles, or sea level rise. In establishing comparison sites, the variability that occurs as a result of natural processes must be taken into account.

Second, establishment of comparison sites is further complicated by the variability exhibited by wetland ecosystems and landscapes in response to anthropogenic disturbance. Land-use changes and hydrologic alteration of wetland ecosystems and their surrounding landscapes and the resultant lack of undisturbed wetland ecosystems and landscapes make it difficult to establish comparison sites that reflect the functional capacity of a regional subclass under undisturbed conditions.

Because wetland ecosystems exhibit a wide range of conditions as a result of natural processes and anthropogenic disturbances, and few undisturbed wetland ecosystems or landscapes exist, this assessment approach establishes comparison sites based on reference wetlands. Reference wetlands are actual wetland sites that represent the range of variability exhibited by a regional wetland subclass as a result of natural processes and anthropogenic disturbances.

In establishing comparison sites, the geographic area from which reference wetlands are selected is the reference domain. The reference domain may include all, or part, of the geographic area in which the regional subclass actually occurs.

Section I - Introduction, continued

Comparison Sites, continued

Once the reference domain has been defined, there are a variety of approaches for selecting reference sites, establishing the variability of a regional subclass in a reference domain, and defining comparison sites.

Assessment Models/Functional Indices

Assessment models are simple representations of the relationship between attributes of the wetland ecosystem and the surrounding landscape, and the functional capacity of the wetland. Variables in the assessment model, such as plant species composition, over-bank flow, and soil type, represent the attributes. Variables are assigned a sub-index ranging from 0.0 to 1.0 based on the relationship between the variable and functional capacity.

Variables in the assessment model are assigned a sub-index based on a quantitative (interval or ratio) or qualitative (nominal or ordinal) scale data. When it is impossible or impractical to assign a sub-index based on direct, quantitative or qualitative data, it may be possible to assign a sub-index based on an indicator. Indicators are easily observed or measured characteristics that are correlated with a quantitative measure of a variable.

In addition to defining the relationship between variables and functional capacity, the assessment model defines how variables interact to influence functional capacity. The interaction between variables is defined using an aggregation function or logical rules. The result is a Functional Capacity Index (FCI), which is the ratio of the functional capacity of a wetland under existing conditions, and the functional capacity of a wetland exhibiting comparison sites for the regional subclass in the reference domain.

Recommended Tools to Use for Wetland Assessment

Office Tools

United States Geological Survey (USGS) quadrangle maps
United States Fish and Wildlife Service (FWS) National Wetland Inventory (NWI) maps
Aerial photography of wetland and surrounding watershed area
County soil survey publication
Engineering field manual
Engineers scale
Tools for acreage calculation
Farm Service Agency (FSA) color slides
Natural Resources Conservation Service (NRCS) wetland inventories

Section I - Introduction, continued

Recommended Tools to Use for Wetland Assessment, continued

Other Considerations

Insect repellent
Sunscreen
Hip or chest waders or rubber boots
Binoculars
Global positioning system (GPS)
Containers for plant collection
Local representative knowledgeable about area resources and land uses
Kansas Biological Survey Plant Identification Services

Field Tools

Slope Wetland Interim Functional Assessment Model
Aerial photography of wetland and surrounding area
surveying equipment such as; hand, abney, or transit level, rod or stadia board, measuring device (100 foot chain)
National list of plant species
Plant identification handbooks
Plant press, plastic bags, and labeling materials
Spade, soil probe, or auger
Soil field kit including; Munsell color book, tape measurer (English or metric), steel spatula or knife, acid, water, field indicators of hydric soils in the United States, hand lens
Field recording sheets
Clipboard, paper, and pencils
Flags (two or more colors suggested)
Tube markers
Calculator
Photographic equipment (optional)
Tile probe (optional)

Discussion of Riverine Wetland

This document provides the basis for applying the HGM approach of wetland functional assessment to Riverine Wetlands. "Riverine" refers to a class of wetland that has a floodplain or riparian geomorphic setting. The other classes or geomorphic settings are depressional, slope, flats, and fringe. Water source and hydrodynamics are the other

Section I - Introduction, continued

Discussion of Riverine Wetland, continued

two core factors that operate within the geomorphic setting. The water sources for the riverine class are precipitation, surface flow, and groundwater discharge. Surface flow consists of over bank flow when channel capacity is exceeded by discharge and overland flow that parallels the soil service when precipitation fails to infiltrate. The groundwater source includes discharge from saturated and unsaturated sources. The continuous nature of these three sources makes it difficult to separate classes based on water source alone. The dominant hydrodynamic factor is unidirectional horizontal flows for riverine and slope wetlands. In contrast, hydrodynamics are vertical fluctuations for depressional and flat wetlands, and bi-directional horizontal flow for fringe wetlands. Riverine wetlands occur in floodplains and riparian corridors in association with stream and river channels. They continue upstream until the features of channel (bed) and bank disappear, and are replaced by slope wetlands, poorly drained flats, depressions, or uplands. Each of these conditions lacking channel flow may be equivalent to the variable source area of Roulet (1990) where water tables during storm events rise to initiate overland flow in rivulets that eventually lead to headwater channels of the stream.

First order streams, usually designated by solid blue lines on USGS 7.5 minute topographic maps (scale 1:24,000), are normally associated with riverine wetlands. They may also continue further upstream where broken blue lines on topographic maps indicate the presence of channels. Perennial flow is not a requirement for a wetland to be classified as riverine. The extent of Riverine Wetlands, frequently flooded, perpendicular to stream channels, continues to the maximum edge of the floodplain. The riverine HGM class terminates, as it does at its headwaters, where either slope wetlands or uplands begin. In the case of large floodplains in landscapes of great topographic relief and steep hydrostatic gradients, toe-slope wetlands connected with the floodplain may function hydrologically more like slope wetlands because of dominance by groundwater sources. In headwater streams where floodplains are lacking or only weakly developed, slope wetlands may lie adjacent to the stream channel. Large riverine wetlands may themselves contain sites with affinities to other classes. For example, oxbow features in floodplains may assume depressional characteristics for most of the year.

Riverine wetlands, as used in the HGM approach, differ from the riverine class “sed” for National Wetland Inventory (NRI) maps of the United States Fish and Wildlife Service (FWS). The FWS definition includes only the river bed, bank to bank; most portions of floodplain wetlands are classified as palustrine in the FWS classification. The HGM approach classifies these areas as riverine. Rivers and floodplains in the HGM approach are assumed to be integral parts of the riverine wetland ecosystem.

Section II - Discussion of Riverine Wetland Functions and Associated Functional Capacity Index (F1 - F13)

This document is for use by a team of individuals who adapt information to riverine wetlands in specific physiographic regions. By adapting from the generalities of the riverine class to specific regional riverine subclasses, such as high-gradient streams of the glaciated northeastern United States, the procedure can be made responsive to the specific conditions found there. For example, separation of high-gradient from low-gradient streams may be necessary to reduce the amount of variation in indicators to make the assessment more sensitive to detecting impacts.

This report outlines an approach for assessing wetland functions in the 404 Regulatory Program, as well as other regulatory, planning, and management situations. The approach includes a development and application phase. In the development phase, wetlands are classified into regional subclasses based on HGM factors. A functional profile is developed to describe the characteristics of the regional subclass, identify the functions that are most likely to be performed, and discuss the characteristics that influence how those functions are performed. Reference wetlands are selected to represent the range of variability exhibited by the regional subclass in the selected reference domain, and assessment models are constructed and calibrated by an interdisciplinary team based on comparison sites and data from reference wetlands.

Comparison sites are the conditions exhibited by the undisturbed, or least disturbed, wetlands and landscapes in the reference domain. The functional indices resulting from the assessment models provide a measure of the capacity of a wetland to perform functions relative to other wetlands in the regional subclass. The application phase of the approach, or assessment procedure, includes the characterization of the wetland, assessing its functions, analyzing the results of the assessment, and applying them to a specific project. The assessment procedure can be used to compare project alternatives, determine the impacts of a proposed project avoid and minimize impacts, and determine mitigation requirements or success, as well as other applications requiring the assessment of wetland functions.

F1: Dynamic Surface Water Storage

Definition: The capacity of a wetland to detain moving water from over bank flow for a short duration when flow is out of the channel; associated with moving water from over bank flow and/or upland surface water inputs by overland flow or tributaries.

Effects On-Site: Replenish soil moisture; import/export of materials such as sediments, nutrients, contaminants); import/export of plant propagules; provide conduit for aquatic organisms to access wetland for feeding, recruitment.

Section II - Discussion of Riverine Wetland Functions and Associated Functional Capacity Indices (F1 - F13), continued

F1: Dynamic Surface Water Storage, continued

Effects Off-Site: Reduce downstream peak discharge; delay downstream delivery of peak discharges; improve water quality.

Discussion of Function and Variables: For dynamic surface water storage, the variables are frequency of over bank flow **(V_{freq})**, average depth of inundation **(V_{inund})**, macrotopographic complexity **(V_{macro})**, woody vegetation roughness **(V_{wrough})**, herbaceous vegetation roughness **(V_{hrough})**, and coarse woody debris roughness **(V_{cwd})**. Over bank flow or upland surface flow is an absolute requirement for this function. If it does not occur, the functional capacity index (FCI) score is zero as depicted in the equation. If depth and roughness variables are all absent, the FCI score is also zero. It is assumed that both factors are equally important in the comparison site.

FCI Score = $[(V_{freq} +)/V_{wetuse}2 \times (V_{iund} + V_{marco} + V_{wrough} + V_{hrough} + V_{cwd}) / 5]^{1/2}$

F2: Long Term Surface Water Storage

Definition: Capacity of a wetland to temporarily store surface water for long duration's. Source of water may be over bank flow, direct precipitation, or upland sources such as overland flow, channel flow, and subsurface flow. Storage is associated with standing water.

Effects On-Site: Replenishes soil moisture; removes sediments, nutrients, and contaminants; detains water for chemical transformations; maintains vegetative composition; maintains habitat for feeding, spawning, and recruitment for pool species; influences soil characteristics.

Effects Off-Site: Improves water quality; maintains base flow; maintains seasonal flow distribution; lowers the annual water yield; recharges surface groundwater.

Discussion of Function and Variables: Presence of water **(V_{surwat})**, macrotopographic relief **(V_{macro})**, and microtopographic complexity **(V_{micro})** are variables associated with the long term surface water storage function. There is no variable directly related to the actual length of time that water is present on the surface, but rather time of ponding inferred by vegetation and soil indicators of processes is compared with the comparison site. Longer times of ponding are not critically important to this function since the main off-site effect of over bank flow is the reduction of flood volume. In some wetland ecosystems, the length of time may be critical to some ecological processes and wetland functions. When this is the case, a time of ponding variable should be added to the model. For the time of ponding variable, consider using **(V_{durat})**.

Section II - Discussion of Riverine Wetland Functions and Associated Functional Capacity Indices (F1 - F13), continued

F2: Long Term Surface Water Storage, continued

Discussion of Function and Variables, continued:

Variables used to model the long term surface water storage function differ between low and high energy riverine systems because macrotopographical relief and microtopographic complexity variables are of widely different magnitudes in these systems. When the source of water is direct precipitation or from upland sources, long-term storage is water ponded until lost by evapotranspiration and drainage.

FCI Score: = $(V_{surwat} + V_{macro} + V_{micro}) /3$

For systems with ground water influence

FCI Score: = $V_{surwat} + V_{wtd} + V_{macro} + V_{micro})/4$

F3: Energy Dissipation

Definition: Allocation of the energy of water to other forms as it moves through, into, or out of the wetland as a result of roughness associated with large woody debris, vegetation structure, micro and macrotopography, and other obstructions.

Effects On-Site: Increases deposition of suspended material; increases chemical transformations and processing due to longer residence time.

Effects Off-Site: Reduces downstream peak discharge; delays delivery of peak discharges; improves water quality; reduces erosion of shorelines and floodplains.

Discussion of Function and Variables: Reduction in flow velocity **(V_{redve})**, frequency of over bank flow **(V_{freq})**, and site roughness **(V_{macro})** through **(V_{cwd})** are the variables describing the function. These variables must be scaled to comparison sites appropriate to the hydrologic regime. It is assumed that each of the combined roughness variables, frequency of over bank flow, and reduction of flow velocity are equally important in maintaining the function in comparison sites. Note that microtopographic complexity should usually not be used for high energy systems.

FCI Score:= $[V_{redvel}l + V_{freq} + (V_{macro} + V_{micro} + V_{wrough} + V_{cwd})/4]/3$

Section II - Discussion of Riverine Wetland Functions and Associated Functional Capacity Indices (F1 - F13), continued

F4: Elemental Cycling

Definition: Abiotic and biotic processes that convert elements such as nutrients and metals, from one form to another. The primary recycling processes.

Effects On-Site: Effects of cycling are elemental balances between gains through import processes and losses through efflux to the atmosphere, long-term retention in sediments, and hydraulic export (hydraulic export is minimal unless outlet leaves the basin; a reason to separate outlets that allow water to move elements and compounds out versus pits, which keep them on site).

Effects Off-Site: To the extent that elements and nutrients are held (and processed) on-site, they are less available for export to downstream wetlands and to other aquatic environments.

Discussion of Function and Variables: Elemental cycling requires wetland plants and soil microorganisms for uptake and release of elements through growth, decomposition, and leaching. Plants, influenced by land use activities within a riverine wetland and its adjacent buffer zone **($V_{canopy} + V_{wetuse} + V_{buff}$)**, provide a strong seasonal pulse of temporary storage and release of elements **($V_{detritus} + V_{sed}$)** (including nutrients), and provide surface area decomposition and increased surface area for microbial activity. Seasonal uptake and release is a fundamental ecological function shared by all temperate and subtropical ecosystems containing plants.

FCI Score = $[V_{canopy} + V_{wetuse} + V_{buff} + V_{detritus} + V_{sed}] / 5$

F5: Removal of Imported Elements and Compounds

Definition: Removal of elements and compounds can occur in riverine wetlands by accumulation of these constituents in sediments, denaturation of complex organics, and by processes that release them into the atmosphere, such as denitrification.

Effects On-site: Nutrients and contaminants in surface and ground water that come into contact with sediments and vegetation are either removed over the long term by sedimentation or are transformed into innocuous and biogeochemically inactive forms.

Effects -Off-site: Chemical constituents removed and concentrated in wetlands reduce potential for downstream export to other wetland and aquatic ecosystems. In addition, removal of pollutants in soil solution reduces contamination of groundwater.

Section II - Discussion of Riverine Wetland Functions and Associated Functional Capacity Indices (F1 - F13), continued

F5: Removal of Imported Elements and Compounds, continued

Discussion of Function and Variables: Removal of elements and compounds can occur in flow-through riverine wetlands by the more-or-less permanent accumulation of these constituents in sediments, by denaturation of complex organics, and by processes that release them into the atmosphere, such as denitrification. In forested riverines, storage of elements, via uptake by trees, represents a relatively long-term accumulation (sink) of elements. Therefore, land-use both within **(V_{wetuse})** and adjacent **(V_{buff})** along with surface run-off **(V_{surfin})** to a riverine and the delivery of sediments **(V_{sed})** are important to the removal of elements and compounds.

Macro and microtopographic roughness **(V_{macro}, V_{micro})**, plant density **(V_{pden})**, and detritus **($V_{detritus}$)** detain water flow to increase residence time for uptake and breakdown processes. Small scale roughness also provides surfaces for attachment of microorganisms that are responsible for much of the sequestering, interconversion, and breakdown of imported materials.

FCI Score = $[V_{wetuse} + V_{buff} + V_{sed} + V_{sorp} + (V_{freq} + V_{surfin}) /2 + (V_{macro} + V_{micro} + V_{detritus} + V_{pden})/4] /6$

F6: Retention of Particulates

Definition: Deposition and retention of inorganic and organic particulates from the water column primarily through physical processes.

Effects On-site: Sediment accumulation contributes to the nutrient capital of the ecosystem. Deposition increases surface elevation and changes topographic complexity. Organic matter may also be retained for decomposition, nutrient recycling, and detritus food web support.

Effects Off-Site: Reduces stream sediment load and woody debris that would otherwise be transported downstream.

Discussion of Function and Variables: The variables used in the retention of particulates function are use and condition **(V_{wetuse})** over bank flow **(V_{freq})**, buffer source **(V_{buff})**, roughness of wetland surfaces **($V_{wrought}$, V_{hrough}, V_{micro})**, or **($V_{detritus}$)**, and evidence of retained sediments **(V_{sed})**. In small streams where over bank flow seldom occurs because of the headwater position, a potential source of sediments would be from uplands as particulates transported in overland flow. Most headwater streams are

Section II - Discussion of Riverine Wetland Functions and Associated Functional Capacity Indices (F1 - F13), continued

F6: Retention of Particulates, continued

erosional; however, relatively undisturbed uplands do not serve as a substantial source of sediments. However, when uplands are disturbed and begin to release sediments, headwater streams may become depositional (Cooper and Gilliam 1987). This is possibly a function of an altered landscape and must be dealt with in the context of the reference domain. It is assumed that the transport group of variables and roughness factors are equally important in maintaining the function under comparison sites.

FCI Score = **[(V_{wetuse} + V_{freq} + V_{buff} + V_{sed}) /4 X (V_{wrough} + V_{hrough} + V_{micro} + $V_{detritus}$) /4]1/2**

F7: Exports Organic Carbon and Detritus

Definition: Export of dissolved and particulate organic carbon and detritus from the wetland, for example, through leaching, flushing, displacement, and erosion.

Effects On-Site: The removal of organic matter from living biomass, detritus, and soil organic matter contributes to carbon turnover (plant storage) and food web support.

Effects Off-Site: Provides support for food webs and biogeochemical processing from the wetland.

Discussion of Function and Variables: Two factors are required for the wetland to be a source of organic carbon for export; 1) a source of organic matter and, 2) water flow for transport. Water flow has two components; 1) water sources, and 2) surface hydraulic connections. The variables are frequency of over bank flow **(V_{freq})**, and overland flow or groundwater discharge from adjacent uplands **(V_{buff})**. Surface connections of the wetland with the stream channel **(V_{hydcon})** are an essential variable which provides a pathway for return flows to the channel so export actually occurs. Normally if over bank flow occurs, surface connections are present. The use and condition **(V_{wetuse})**, the roughness of the wetland **(V_{micro})**, and density of the woody and herbaceous plants **(V_{pden})** affect the amount of organic matter in the wetland. The last variable is the source of organic matter in the wetland **($V_{detritus}$)**. This includes both living and dead organic matter **(V_{organ})**. If either an organic carbon source is absent or surface hydraulic connections are lacking (i.e., the wetland is diked or otherwise isolated), then the function is lacking.

FCI Score = **[(V_{freq} + V_{buff} + V_{hydcon} + V_{wetuse} + V_{micro}) /5 x (V_{pden} + V_{organ} + $V_{detritus}$) /3]$^{1/2}$**
The function is absent if **(V_{pden} + V_{organ} + $V_{detritus}$) = 0**.

Section II - Discussion of Riverine Wetland Functions and Associated Functional Capacity Indices (F1 - F13), continued

F8: Maintains Characteristic Plant Community

Definition: Vegetation is maintained by mechanisms such as seed dispersal, seed banks, and vegetative propagation which (all) respond to variations in hydrology and disturbances such as fire and herbivores. The emphasis is on the temporal dynamics and structure of the plant community as revealed by species composition and abundance.

Effects On-Site: Creates microclimatic conditions that support the life histories of plants and animals; converts solar radiation and carbon dioxide into complex organic carbon that provides energy to drive food webs; provides habitat for feeding, and cover for resting, refuge, escape, breeding and nesting for resident and migratory animals; creates roughness that reduces velocity of floodwaters.

Effects Off-Site: Provides a source of vegetative propagules for adjacent ecosystems which assists in revegetation following drought or disturbance; provides for gene flow between populations; provides habitat for animals from adjacent ecosystems and for migrating birds, such as waterfowl and shorebirds.

Discussion of Function and Variables: This function provides a capacity to perpetuate a plant community through maintaining mechanisms for seed dispersal. Provides a substrate conductive to seed burial and storage (seed bank), and conditions conductive to vegetative propagation (a response to stressors of drought and disturbance by fire and herbivores). This function emphasizes the dynamics and structure of riverine wetland plant communities, determined by species composition and abundance.

The ability of the plant community to maintains itself, or the changes that will occur over time in the community, are captured by characterizing six variables. The present wetland use **(V_{wetuse})** determines the plant species composition of the community, **(V_{pratio})** which is used as an indicator of current conditions as compared to the comparison site, **(V_{strata})** and **(V_{canopy})** are variables that are used to characterize the vertical structure (i.e., number of vertical layers of vegetation) in the plant community to compare to reference conditions. Biomass structure is used to assess density and basal **(V_{denba})** area of trees in the plant community and provide one of the best combined measures of the maturity of the vegetation. The species present as seedlings, saplings, and as dominant herbs will provide insight into how the vegetation will change over time.

FCI Score = $(V_{wetuse} + V_{sed} + V_{denba} + V_{canopy} + V_{strata} + V_{pratio})/6$

Section II - Discussion of Riverine Wetland Functions and Associated Functional Capacity Indices (F1 - F13), continued

F9: Maintains Characteristic Detritus Biomass

Definition: The processes of production, accumulation and dispersal of dead plant biomass of all sizes. Sources may be on-site or upslope and up-gradient. Emphasis is on the amount and distribution of standing and fallen woody debris.

Effects On-Site: Provides the primary resources for supporting detritus based food chains, which support the major nutrient-related processes (cycling, export, import) within the wetland; provides important resting, feeding, hiding, and nesting sites for animals of higher trophic levels; provides surface roughness that decreases velocity of floodwaters; retains, detains and provides opportunities for *in* situ processing of particulates. The function is primarily responsible for organic composition of soil.

Effects Off-Site: Provides sources of dissolved and particulate organic matter and nutrients for downstream ecosystems. Contributes to reduction in downstream peak discharges and delayed downstream delivery of peak discharges. Contributes to downstream water quality through particulate retention and detention.

Discussion of Function and Variables: Wetland use **(V_{wetuse})** affects the abundance of standing snags **(V_{snags})** and downed detritus **($V_{detritus}$)**. The decay stages of the woody and herbaceous debris **(V_{decomp})**, and the abundance of piles of accumulated organic matter are the variables used to assess the detritus function. All variables must be scaled to existing comparison sites appropriate for the physiographic region and the wetland's functional class. The standing dead variable is assumed to be of equal importance to the average of the variables for decay stages and abundance of downed logs and other accumulations of organic matter.

FCI Score = $(V_{wetuse} + V_{snags} + V_{detritus} + V_{decomp})/4$

F10: Maintains Habitat Structure Within

Definition: The soil, vegetation, and other aspects of ecosystem structure within a wetland that would support animal populations for resting, feeding, hiding, and reproduction.

Effects On-Site: Provides potential feeding, resting, hiding, escape, nesting and brooding sites for vertebrates, and feeding surfaces for invertebrates.

Section II - Discussion of Riverine Wetland Functions and Associated Functional Capacity Indices (F1 - F13), continued

F10: Maintains Habitat Structure Within, continued

Effects Off-Site: Provides habitat cover for migratory birds and for resident wildlife.

Discussion of Function and Variables: As is true for a number of the other riverine wetland functions, land-use activities **(V_{wetuse})** and sediment delivery **(V_{sed})** are important in maintaining structural habitat. Measure the percent closure **(V_{canopy})** and attributes of vertical strata **(V_{strata})** along with **(V_{buff})** are a measure of the land use and condition of the land adjacent to the wetland.

FCI Score = $[(V_{wetuse} + V_{sed}) /2 + (V_{canopy} + V_{strata}) /2 + V_{buff} + V_{detritus}] /4$

F11: Maintains Food Webs

Definition: Food webs require both an energy source and habitat for consumers.

Effects On-Site: Provides the material of live and dead plant and animal tissue to support both terrestrial and aquatic food webs.

Effects Off-Site: Supports food webs of organisms that use other wetlands and terrestrial habitat.

Discussion of Function and Variables: Food webs require both an energy source (e.g., primary production of appropriate species of plants) and habitat for consumers. Therefore, variables pertaining to land use **($V_{wetuse} + V_{buff}$)** are heavily weighted in this function. The other indicators include the sustainability of a depression's basin **(V_{sed})**, landscape habitat factors **(V_{landsp})** native to non-native plant species ratio **(V_{pratio})** and the presence of litter and debris **($V_{detritus}$)**. All indicators that could serve as variables, these indicators should be incorporated into regional variations of "Maintains Food Web" functional model.

FCI Score = $(V_{Wetuse} + V_{sed} + V_{buff} + V_{landsp} + V_{pratio} + V_{detritus}) /6$

F12: Maintains Habitat Interspersion and Connectivity among Wetlands

Definition: The capacity of a wetland to permit aquatic organisms to enter and leave the wetland via permanent or ephemeral surface channels, over bank flow, or unconfined gravel aquifers. The wetland provides access to terrestrial and/or aerial organisms to contiguous areas of food and cover.

Section II - Discussion of Riverine Wetland Functions and Associated Functional Capacity Indices (F1 - F13), continued

F12: Maintains Habitat Interspersion and Connectivity among Wetlands, continued

Effects On-Site: The assessed wetland contributes to habitat features of the wetland complex by virtue of its position in the landscape.

Effects Off-Site: Contributes to overall landscape diversity of habitat for aquatic and terrestrial organisms.

Discussion of Function and Variables: The variables frequency of over bank flow **(V_{freq})**, duration of over bank flow **(V_{durat})**, microtopographic complexity **(V_{micro})**, contiguous vegetation cover **(V_{contig})**, corridors between wetland and upland, between channels, and between upstream-downstream areas **(V_{landsp})**, and the present use of the wetland **(V_{wetuse})** are used to assess the function of maintaining habitat interspersion and connectivity. Each indicator must be scaled to a suite of reference wetlands and conditions appropriate for the physiographic region of the wetland's functional class.

FCI Score = $[(V_{freq} + V_{durat}) /2 + (V_{landsp} + V_{wetuse}) /2 + V_{micro} + V_{contig}] /4$

F13: Maintains Characteristic Invertebrate Community

Definition: Density and spatial distribution of invertebrates that exploit and contribute to food web.

Effects On-Site: Provides food to predators, aerates soil by building tunnels, and increases availability of organic matter for nutrient cycling microbes.

Effects Off-Site: Provides food for wide ranging predators; transports seeds and propagules for germination elsewhere.

Discussion of Function and Variables: The variables, species richness and density (or some similarity index) of invertebrates in soil **(V_{sinvt})**, species richness and density (or similarity measure) of invertebrates in leaf litter and coarse woody debris **(V_{linvt})**, soil texture influencing the diversity of species **(V_{sprod})**, surface water present long enough for a invertebrate species to complete life cycles **(V_{surwat})**, and species richness and density (or a similarity measure) of invertebrates in aquatic habitats (e.g., micro-depressions, seeps, side channels) **(V_{aqinvt})**, are used to assess the function of maintaining distribution and abundance of invertebrates. Each indicator, whether determined by direct or indirect measures must be scaled to a suite of reference

Section II - Discussion of Riverine Wetland Functions and Associated Functional Capacity Indices (F1 - F13), continued

F13: Maintains Characteristic Invertebrate Community, continued

wetlands and conditions appropriate for the physiographic region of the wetland's functional class.

FCI Score = $\mathbf{(V_{sinvt} + V_{linvt} + V_{sprod} + V_{surwat} + V_{aqinvt}) /5}$

Section III - Functional Capacity Index (FCI) Score Equations

Function 1: Dynamic Surface Water Storage

FCI Score = $[(V_{freq} + V_{wetuse}) /2 \times (V_{inund} + V_{macro} + V_{wrough} + V_{hrough} + V_{cwd}) /5]^{1/2}$

Function 2: Long Term Surface Water Storage for Low Energy Systems

FCI Score = $(V_{surwat} + V_{macro} + V_{micro}) /3$

FCI Score for systems with ground water influence = $V_{surwat} + V_{wtd} + V_{macro} + V_{micro})/4$

Function 3: Energy Dissipation

FCI Score = $[V_{redvel} + V_{freq} + (V_{macro} + V_{micro} + V_{wrough} + V_{cwd}) /4] /3$

Function 4: Elemental Cycling

FCI Score = $(V_{canopy} + V_{wetuse} + V_{buff} + V_{detritus} + V_{sed}) /5$

Function 5: Removal of imported Elements and Compounds

FCI Score = $[V_{wetuse} + V_{buff} + V_{sed} + V_{sorpt} + (V_{freq} + V_{surfin})/2 + (V_{macro} + V_{micro} + V_{detritus} + V_{pden}) /4] /6$

Function 6: Retention of Particulates

FCI Score = $[(V_{wetuse} + V_{freq} + V_{buff} + V_{sed}) /4 \times (V_{wrough} + V_{hrough} + V_{micro} + V_{detritus}) /4]$ 1/2

Function 7: Export of Organic Carbon and Detritus

FCI Score = $[(V_{freq} + V_{buff} + V_{hydcon} + V_{wetuse} + V_{micro}) /5 \times (V_{pden} + V_{organ} + V_{detritus}) /3]^{1/2}$
If $(V_{pden} + V_{organ} + V_{detritus}) = 0$, then the function is absent.

Function 8: Maintains Characteristic Plant Community

FCI Score = $(V_{wetuse} + V_{sed} + V_{denba} + V_{canopy} + V_{strata} + V_{pratio}) /6$

Function 9: Maintains Characteristic Detrital Biomass

FCI Score = $(V_{wetuse} + V_{snags} + V_{detritus} + V_{decomp}) /4$

Function 10: Maintains Habitat Structure within Wetland

FCI Score = $[(V_{wetuse} + V_{sed}) /2 + (V_{canopy} + V_{strata}) /2 + V_{buff} + V_{detritus}] /4$

Section III - Functional Capacity Index (FCI) Score Equations, continued

Function 11: Maintains Food Web

FCI Score = $(V_{wetuse} + V_{sed} + V_{buff} + V_{landsp} + V_{pratio} + V_{detritus}) /6$

Function 12: Maintains Habitat Interspersion and Connectivity

FCI Score = $[(V_{freq} + V_{durat}) /2 + (Vl_{andsp} + V_{wetuse}) /2 + V_{micro} + V_{contig}] /4$

Function 13: Maintains Characteristic Invertebrate Community

FCI Score = $(V_{sinvt} + V_{linvt} + V_{sprod} + V_{surwat} + V_{aqinvt}) /5$

Appendix A
Producer Checklist

1. A mitigation site will require a permanent easement for the United States Department of Agriculture (USDA) and a deed restriction to prevent the future loss of the site. Are you willing to accept these terms? If you answer no, then establishing a mitigation site is not possible and you should seek other alternatives for your proposed project.

Yes _____ No _____

2. Do you have a suitable mitigation site located? (Mitigation site should be in same local watershed with similar soils, landscape position, and topography.)

Yes _____ No _____

3. Do you own the mitigation site? Yes _____ No _____
If no, can you obtain easement rights? Yes _____ No _____

4. Who will develop the mitigation plan?

____ Owner/operator
____ A hired consultant
____ Assistance from the Natural Resources Conservation Service will be requested
____ Kansas Department of Wildlife and Parks (KDWP)
____ U.S. Fish and Wildlife Service (FWS)

5. Are you willing to obtain any/all of federal, state, or local permits that apply to this project?

Yes _____ No _____

6. If there are any existing liens on the mitigation site, have you notified those parties of the potential mitigation site?

Yes _____ No _____

NOTE: All costs associated with the construction and maintenance of a mitigation site are the responsibility of the individual or individuals proposing the establishment of such site.

Appendix B(1)
Comparison of the Variable Example by Function

Aquatic Intertebrates (V_{aqinvt})

The distribution and abundance of invertebrates in aquatic habitats. See Function 14.

Buffer Zones (V_{buff})

The drainage in the buffer zone impacts plant communities and elemental cycling throughout the wetland. See Functions 4 - 7 and 10 - 11.

Canopy Cover (percent) (V_{canopy})

Continuous upper layers of the forest. See Functions 4, 8, and 10.

Contiguous Vegetation Cover (V_{contig})

The wetland and any adjacent riverine forest as part of the large block of forest. See Function 12.

Coarse Woody Debris (V_{cwd})

Dead and downed trees and limbs greater than four inches in diameter and longer than three feet in length. See Functions 1 and 3.

Decomposition (V_{decomp})

The evidence of decomposition of woody and herbaceous debris. See Function 9.

Tree Density and Basal Area (V_{denba})

The density and basal area of large diameter trees. See Function 8.

Detritus ($V_{detritus}$)

Soil detritus as represented by coverage of the “O” and/or “A” soil horizons, measured by the average percent of cover of the “O” horizon. See Functions 4 - 7 and 9 - 11.

Duration of Over-bank Flow (V_{durat})

The length of time water remains out-of-bank. See Function 12.

Frequency of Over-bank Flow (V_{freq})

The frequency at which the channel over-tops its banks or water is delivered to the wetland from upland sources. See Functions 1, 3, 5 - 7, and 12.

Appendix B(2)
Comparison of the Variable Example by Function

Herbaceous Vegetation Roughness (V_{hrough})

Resistance to flow due to herbaceous debris. See Functions 1 and 6.

Surface Hydraulic Connections (V_{hydcon})

Located between the wetland and having main and side channels. See Function 7.

Average Depth of Inundation (V_{inund})

The depth to which the wetland is inundated. See Function 1

Landscape (V_{landsp})

The condition of the landscape within a one mile radius of the center of the wetland being assessed. This allows for the potential dispersion of vertebrates to and from wetland and upland connectivity. See Functions 11 and 12.

Litter Invertebrates (V_{linvt})

Distribution and abundance of invertebrates in leaf litter and coarse woody debris. See Function 13.

Macrotopographic Relief (V_{macro})

Presence of features with an aerial extent sufficient to be detected by aerial photography. See Functions 1 - 3 and 5.

Microtopographic Complexity (V_{micro})

The small hummocks and depressions that occur in the soil surface. See Functions 2, 3, 5 - 7, and 12.

Organic Matter in Wetlands (V_{organ})

The presence of organic carbon includes estimates of living and dead biomass. See Function 7.

Appendix B(3)
Comparison of the Variable Example by Function

Plant Density (V_{pden})

Plant density will detain water flow to increase residence time for uptake and breakdown processes and provide entrapment of soil particles and debris. See Functions 5 and 7.

Ratio of Native to Non-native Plant Species (V_{pratio})

Species composition or plant ratio of native to non-native plants is used as an indicator of current wetland conditions as compared to the comparison site. See Functions 8 and 11.

Reduction in Flow Velocity (V_{redvel})

Velocity is reduced by surface roughness and obstructions and by spreading of water over a larger area. See Function 3.

Sediment Delivery to Wetland (V_{sed})

Evidence of retained sediments may be indicated by layers of leaves buried under sediment layers, sediment staining on leaves, and presence of natural levees formed by over-bank glow. See Functions 4 - 5, 6, 8, 10 and 11.

Soil Invertebrates (V_{sinvt})

Species composition and abundance of invertebrates by indirect measurement of the presence and activity of soil invertebrates and insects. See Function 13.

Density of Standing Dead Trees (V_{snags})

The average number of dead tree stems in a representative number of plots. See Function 9.

Sorptive Properties of Soil (V_{sorpt})

The ability of soil particles to remove dissolved elements and compounds from water. Fine texture soils have greater sorption capacities than those with coarse textures. See Function 5

Soil Productivity (V_{sprod})

Soil texture influences the diversity of species found at a site. See Function 12.

Appendix B(4)
Comparison of the Variable Example by Function

Strata Present (V_{strata})

Vegetation layers of a mature forest, namely herbaceous layer, shrub layer, vine layer, and tree layer. See Functions 8 and 10.

Surface Inflow (V_{surfin})

Precipitation and over-land flow in uplands adjacent to riverine wetlands may become a water source. See Function 5.

Presence of Surface Water (V_{surwat})

Indicators of ponding, such as asence of regeneration of annual plants, water stained leaves, and drift lines. See Functions 2 and 13.

Wetland Use (V_{use})

The present use of the wetland that may affect evapotranspiration, soil structure, and soil moisture. See Functions 1, and 4 - 12.

Woody Vegetation (V_{wrough})

Resistance to flow due to woody debris. See Functions 1, 3, and 6.

Appendix C(1)
Variables with Index Values

Model Variable	Aquatic Invertebrates (V_{aqinvt}) Measurment or Condition	Index
Definition: Distribution and abundance of invertebrates in aquatic habitats (micro-depressions, side channels, and seeps).	Presence of sutiable aquatic habitats (micro drpressions, seeps, etc.) and evidence of shell fragments (exudate, etc.) similar to comparison site.	1.0
Example: The presence of shell fragments and egg cases.	No evidence of items above, but with potential for recovery of habitat to comparison site.	0.1
	No evidence of suitable aquatic habitats and no potential for habitat recovery.	0.0

Model Variable	Buffer Zone (V_{buff}) Measurement or Condition	Index
Definition: Dominant land use and condition of the buffer zone adjacent to the wetland.	Relatively undisturbed with evidence of surface water movement to the wetland. Minimum of 100 feet wide buffer with natural vegetation.	1.0
Example: Grazing, logging burning, tillage development, and drainage activities in the buffer zone impact the delivery of elements and compounds to the wetland.	Some disturbance with indications of water movement to the wetland. Buffer 50 to 99 feet wide undisturbed with natural vegetation.	0.5
	Some disturbance with indications of water movement to the wetland. Buffer with 10 to 49 feet wide with natural vegetation.	0.25
	Disturbance (rills, gullies, bare ground, etc.) with indications of high rate of run-off with a buffer width of less than 10 feet.	0.0

Appendix C(2)
Variables with Index Values

Model Variable	Canopy Cover (V_{canopy}) Measurement or Condition	Index
Definition: Canopy cover of each stratum in each plant community.	The measurement of canopy cover is $\geq$ 75 percent in each stratum present.	1.0
Example: Measure of change in strata from reference site. Changes in strata impact quality of wetland.	The measure of canopy cover is $\geq$ 75 percent of the comparison sites in one stratum of a plant community.	0.5
	The measure of canopy cover is 0 - 75 percent of comparison sites in two strata of a plant community.	0.25
	The measure of canopy cover is 0 - 75 percent of comparision sites in three strata of a plant community.	0.10
	Vegetation is sparse or absent.	0.0

Model Variable	Contiguous Vegetation Cover (V_{contig}) Measurement or Condition	Index
Definition: Continuity among vegetation connections between channels, uplands, and upstream-downstream wetland areas.(within 0.5 km or 0.3 mi)	Recent aerial photographs taken during leaf season show abundant vegetation and vegetated corridors connecting mosaics of habitat types similar to comparison site.	1.0
Example: Wetlands 1/2 mile apart have streamside riparian vegetation connection.	Recent aerial photographs taken during leaf season show lower abundance vegetative connections than comparison site.	0.5
	Aerial photographs taken during leaf season lack of continuous vegetation connections with potential for recovery.	0.1
	Aerial photographs taken during leaf season lack of continuous vegetation connections with no potential for recovery.	0.0

Appendix C(3)
Variables with Index Values

Model Variable	Coarse Woody Debris (V_{cwd}) Measurement or Condition	Index
Definition: Volume of dead, down trees, and limbs larger than a pre-determined defined diameter (< 10cm)	Biomass and volume of CWD is >75 percent of comparison site. Presence of dead trees, snags, limbs, and debris piles.	1.0
Example: Roughness of CWD contributes to dissipation energy and slowing the movement of water	Biomass and volume of CWD is between 25 percent and 75 percent that of comparison site.	0.5
	Biomass and volume of CWD is between 0 percent and 25 percent that of comparison site; restoration possible.	0.1
	No CWD present; restoration not possible.	0.0

Model Variable	Decomposition of Wood and/or Plant Litter (V_{decomp}) Measurement or Condition	Index
Definition: An array of decompositional stages.	Visual estimate of woody debris and/or herbaceous litter in stages of decomposition between 75 percent to 125 percent of comparison site.	1.0
Example: Rotted tree log provides habitat for invertebrates and some vertebrates.	Visual estimate of woody debris and/or herbaceous litter in stages of decomposition between 25 percent to 75 percent **or** > 125 percent of comparison site.	0.5
	Visual estimate of woody debris and/or herbaceous litter in stages of decomposition between 0 to 25 percent of comparison site.	0.1
	Woody debris and litter absent, no decomposition occurring.	0.0

Appendix C(4)
Variables with Index Values

Model Variable	Detritus ($V_{detritus}$) Measurement or Condition	Index
Definition: The presence of small woody debris and litter in several stages of decomposition. (O surface horizon)	Small Woody debris and/or herbaceous litter 75 percent to 125 percent of comparison site.	1.0
Example: In combination with other roughness factors ($V_{micro,}$ $V_{detritus}$) roughness will result in a slowing of water flow and provide increased time and surface area for processing and export of organic carbon.	Small woody debris and/or litter 25 percent or 75 percent **or** > 125 percent of comparision site.	0.5
	Small woody debris and litter layer 0 to 25 percent of comparison site.	0.1
	Small woody debris and litter absent.	0.0

Model Variable	Tree Density and Basel Area (V_{denba}) Measurement or Condition	Index
Definition: The density and basal area of trees.	The measure of tree density and basal area is > 75 percent of the comparison site conditions.	1.0
Example: Changes in forested plant community impact several wetland functions.	The measure of tree density and basal area is > 25 - 75 percent of the comparison site conditions.	0.5
	The measure of tree density and basal area is > 0 - 25 percent of the comparison site conditions.	0.10
	The measure of tree density and basal area is 0 percent of the comparison site conditions.	0.0

Appendix C(5)
Variables with Index Values

Model Variable	Duration of Over-bank Flow (V_{durat}) Measurement or Condition	Index
Definition: Over-bank flow duration permits organisms sufficient time to access floodplain wetlands for spawning and feeding.	Flood duration between 75 percent and 125 percent of comparison site. Duration of connection related indicators only, and similar to comparison site.	1.0
Example: Over-bank flow allows organisms and fish access to floodplain wetland.	Flood duration between 25 percent and 75 percent or > 125 percent of comparison site. (Any indicators, i.e., aerial photos showing continuity of duration, flooding tolerance of tree species, etc., showing continuity of flooding as less than comparison site.	0.5
	Flood duration between 0 percent and 25 percent of comparison site. (Any indicators showing greatly reduced duration relative to comparison site).	0.1
	No over bank flow. Flooding is absent	0.0
* Use USGS gage data, if available, as a hydrology tool.		

Appendix C(6)
Variables with Index Values

Model Variable	Frequency of Over-bank Flow (V_{freq}) Measurement or Condition	Index
Definition: Frequency or recurrence interval at which bank-full discharge is exceeded.	Less than two year return interval; similar to comparison site. At least one of the following: aerial photos showing flooding, water marks, silt lines, alternating layers of leaves and fine sediment, drift and/or wrack lines, sediment scour, sediment de	1.0
Example: Intermittent stream over tops bank annually.	Less than two year return interval; slight departure from reference standard. As above, but somewhat greater or less than comparison site.	0.5
	Less than 10-25 year return interval; great departure from comparison site.	0.25
	Less than 25 year return interval. Extreme departure from comparison site. Above indicators absent but related indicators suggest over bank flow may occur.	0.1
	No flooding from over-bank flow. Indicators absent and/or there is evidence of alteration affecting variable.	0.0
* Use USGS gage data, if available, as a hydrology tool.		

Appendix C(7)
Variables with Index Values

Model Variable	Herbaceous Vegetation Roughnes (V_{hrough}) Measurement or Condition	Index
Definition: Corresponds to the density of herbaceous vegetation that reduces stream flow.	Herbaceous density and/or biomass scaled as a linear function of comparison site. Visual estimate of herbaceous vegetation indicates site is similar (between 75 percent and 125 percent) to comparison site.	1.0
Example: Roughness of vegetation density that detains water, trap organic debris, and slow water movement.	Visual estimate of herbaceous vegetation indicates site is less (25 to 75 percent) than comparison site.	0.5
	Herbaceous vegetation sparse or absent relative to comparison site; restoration possible.	0.1
	Herbaceous vegetation absent; restoration not possible.	0.0

Model Variable	Surface Hydraulic Connections (V_{hydcon}) Measurement or Condition	Index
Definition: The presence of surface water connections between the wetland and the stream channel.	No obstructions such as levees, dams, or diversions present. Entire floodplain connected to channel or wetland subject to natural flooding regime.	1.0
Example: Conduits of over-bank flow and drainage's provide inlets and outlets through.	Man-made obstructions present with connections to channel.	0.1
	Man-made obstructions present with no connections to channel.	0.0

Appendix C(8)
Variables with Index Values

Model Variable	Average Depth of Inundation (V_{inund}) Measurement or Condition	Index
Definition: Average flooding depth during over bank flooding events.	Depth is between 75 percent and 125 percent that of comparison site .Height of water stains and other indicators of water depth (ice scars, bryophyte lines, drift and/or wrack lines, etc.) between 75 percent and 125 percent of comparison site.	1.0
Example: Water stain on tree trunks or debris drift line present	Depth is < 75 percent or > 125 percent of comparison site. Height of water stains and other indicators of water depth (ice scars, bryophyte lines, drift and/or wrack lines, etc.) between 50 percent and 75 percent of comparison site.	0.5
	Infrequent or minor over-bank flooding relative to comparison site. Above indicators absent but related indicators suggest variable may be present.	0.1
	Flooding does not occur. Indicators absent and/or evidence of alteration affecting the variable.	0.0
* Use USGS gage data, if available, as a hydrology tool.		

Model Variable	Landscape (V_{landsp}) Measurement or Condition	Index
Definition: Condition of landscape within riverine watershed of the wetland being assessed.	Surrounding landscape supports $\geq$ 75 percent mosaic of natural plant community.	1.0
Example: Conditions of landscape in vicinity of wetland determines the quality of potential dispersal area and home range for fauna that depend upon a mosaic of wetland and upland habitats.	Surrounding landscape supports 50 to 75 percent mosaic of natural plant community.	0.5
	Surrounding landscape supports 25 to 50 percent mosaic of natural plant community.	0.1
	Surrounding landscape supports less than 25 percent mosaic of natural plant community.	0.0

Appendix C(9)
Variables with Index Values

Model Variable	Litter Invertebrates (V_{linvt}) Measurement or Condition	Index
Definition: Distribution and abundance of invertebrates in leaf litter and in coarse woody debris.	Visual assessment of galleries in logs and twigs, tunnels in wood, shells, casts, trails, holes, etc., similar to comparison site (measures may be developed that can be quantified).	1.0
Example: Insects in and under detritus material.	As above, but much less than comparison site.	0.5
	Absence of galleries in logs and twigs, tunnels in wood, shells, casts, trails, holes, etc. but with potential for habitat recovery.	0.1
	As above, but no potential for habitat recovery.	0.0

Model Variable	Macrotopographic Relief (V_{macro}) Measurement or Condition	Index
Definition: Large-scale relief in the form of oxbows, meander scar, abandoned channels, and back swamps.	Contour maps indicate gross relief and/or closed contours similar to comparison site **or** topographic survey shows relief similar to comparison site **or** soil survey water features indicate wet areas (oxbows, meander scars, abandoned channels, back swamps, et	1.0
Example: Old meander scar adjacent to stream channel.	Indicators above much less developed than comparison site and area has a low surface gradient.	0.5
	Maps and/or topographic survey indicate relief very dissimilar to comparison site. All above indicators absent and area has a moderate to steep gradient	0.0

Appendix C(10)
Variables with Index Values

Model Variable	Microtopographic Complexity (V_{micro}) Measurement or Condition	Index
Definition: Small-scale topographic relief in the form of pit-mound patterns, splays, scours and shallow depressions.	Microtopographic complexity (MC) measured (surveyed) shows MC > 75 percent of comparison site. Visual estimate indicates that microtopographic complexity MC is > 75 percent of comparison site.	1.0
Example: The roughness of a riverine wetland seen as small lows, usually less than six inches, that aid in slowing in-stream flow and provide more micro habitat.	Measured MC is between 25 percent and 75 percent that of comparison site. Visual assessment confirms MC is present, but somewhat less than comparison site.	0.5
	Measured MC between 0 percent and 25 percent that of comparison site; restoration possible. Visual assessment indicates MC is much less than comparison site; restoration possible.	0.1
	No MC at assessed site or natural substrate replaced by artificial surface. Visual assessment indicates MC is virtually absent or natural substrate replaced by artificial surface; restoration not possible.	0.0

Appendix C(11)
Variables with Index Values

Model Variable	Organic Matter in Wetland (V_{organ}) Measurement or Condition	Index
Definition: Dissolved and particulate organic matter (live and dead).	Measure standing stocks of live and dead biomass and soil organic matter. Visual estimates of litter, course woody debris, live woody vegetation, live or dead herbaceous plants, organic rich mineral soils at levels between 75 percent and 125 percent that of comparison site.	1.0
Example: Biotic breakdown of detritus material.	Measure standing stocks of live and dead biomass and soil organic matter. Visual estimates of litter, course woody debris, live woody vegetation, live or dead herbaceous plants, organic rich mineral soils at levels between 25 percent to 75 percent **or** >125 percent of comparison site.	0.5
	Measure standing stocks of live and dead biomass and soil organic matter. Visual estimates of litter, course woody debris, live woody vegetation, live or dead herbaceous plants, organic rich mineral soils at levels between 1 percent and 25 percent of comparison site.	0.1
	No organic matter; no potential for recovery	0.0

Model Variable	Plant Density (V_{pden}) Measurement or Condition	Index
Definition: Density of woody and herbaceous plants.	Density 75 to 125 percent of comparison site.	1.0
Example: In combination with other roughness factors (V_{micro}, $V_{detritus}$), roughness will result in a slowing of water flow and provide increased time and surface area for processing and export of organic carbon.	Density 25 to 75 percent or > 125 percent of comparison sites.	0.5
	Density 0 to 25 percent of comparison sites.	0.1
	Plants absent.	0.0

Appendix C(12)
Variables with Index Values

Model Variable	Ratio of Native/Non-native Plant Species (V_{pratio}) Measurement or Condition	Index
Definition: The ratio of native to non-native plant species within the wetland as indicated by the dominant native plant species or by a more extensive species survey.	All the dominant species in all zones are native species that are listed as comparison site species for zones within the wetland.	1.0
Example: The presence of a high ratio of native to non-native plant species indicates that disturbances that interrupt naturally occuring cycles and other vegetative dynamics are minimal.	75 percent to 100 percent of the species are native species.	0.75
	50 percent to 75 percent dominant species in all zones are native species that are listed as comparison site species for the same zone within the reference domain and/or 50 percent to 75 percent of the species surveyed are native species.	0.50
	25 percent to 50 percent of the dominant species in all zones are native species that are listed as comparison site species for the same zone within the reference domain and/or 25 percent to 50 percent of the species surveyed are native species.	0.25
	Less than 25 percent of the most abundant species in all zones are native species that are listed as comparison site species for the same zone within the reference domain and/or 0 percent to 25 percent of the species surveyed are native species.	0.1
	Riparian zone un-vegetated. No native species are present.	0.0

Appendix C(13)
Variables with Index Values

Model Variable	Reduction in Flow Velocity (V_{redvel}) Measurement or Condition	Index
Definition: Reduction in flow through a wetland during an over bank flooding event.	Sediment deposits on vegetation, buried root collars, stacked wracks of debris, etc. similar to comparison site.	1.0
Example: Sediment deposits debris; deposited or moved debris indicate a wetland's capacity to reduce velocity.	Sediment scour, scoured root collars, large woody debris moved about; erosion of soil surface, etc., indicating less than comparison site.	0.5
	Directionally bent vegetation, bare soil exposed (not sediment deposits), strongly departing from reference standard.	0.1
	Strong evidence of severe site degradation by channel scour, exposed root masses, suggesting variable is absent.	0.0

Model Variable	Sediment Delivery to Wetland (V_{sed}) Measurement or Condition	Index
Definition: Extent of sediment accumulation within the wetland from culturally accelerated sources.	No evidence of recent sediment delivery to the wetland.	1.0
Example: Accelerated deosition can be a vector for P and other nutrients and contaminants.	Sediment delivery is evidenced by sediment staining of detritus and/or slight accumulations of sediment along plant stems in the riparian zone.	0.5
	Sediment delivery is evidenced by buried detritus and/or vegetation on wetland edge. Recent deltas, sediment plumes, etc., in areas of concentrated flow.	0.1
	Bottom elevation of wetland raised due to sedimentation and/or infilling due to tillage	0.0

Appendix C(14)
Variables with Index Values

Model Variable	Soil Invertebrates (V_{sinvt}) Measurement or Condition	Index
Definition: Distribution and abundance of invertebrates in soil	Tunnels, shells, casts, holes, etc., in soil similar to comparison site (indirect measures may be developed that can be are quantified).	1.0
Example: Evidence of crayfish mounds and/or worm cast.	As above, but much less as comparison site.	0.5
	No evidence of items above, but with potential for habitat recovery.	0.1
	No evidence of items above but no potential for recovery of habitat.	0.0

Model Variable	Density of Standing Dead Trees (V_{snags}) Measurement or Condition	Index
Definition: The presence of dead standing woody debris. ($\geq$ 10cm DBH and $\geq$ 2m tall)	Woody debris 75 percent to 125 percent of comparison site.	1.0
Example: The density of standing dead trees relates to the suitability of a site as habitat for invertebrates and vertebrates.	Woody debris 25 percent to 75 percent or > 125 percent of comparison site	0.5
	Woody debris 0 to 25 percent of comparison site.	0.1
	Woody debris absent	0.0

Appendix C(15)
Variables with Index Values

Model Variable	Sorptive Properties of Soil (V_{sorpt}) Measurement or Condition	Index
Definition: The capacity of a soil to adsorb dissolved elements and compounds.	Physical properties of soils similar to the comparison site (texture, organic carbon content, color, structure).	1.0
Example: Clays and silts, with high organic carbon content, have greater sorption capacities than coarse texture soils and increased surface area for increased microbial activity. Measured in the upper 20 inches (50 cm).	Soil departs in texture, organic carbon content, and other properties.	0.5
	Major departures (e.g., sand to cobbles, clay to sand).	0.1
	Surface lacking soil or natural substrate properties (e.g., asphalt, road, building).	0.0

Model Variable	Soil Productivity (V_{sprod}) Measurement or Condition	Index
Definition: Soil texture influences the diversity of species found at a site.	Loamy - medium textured (very fine sandy loam, fine sandy loam, sandy loam, loam, silty loam, silt)	1.0
Example: Medium textured soils have the potential for the greatest diversity of species. Reference: Soil Survey Manual, pages 136 - 140.	Fine loamy - moderately fine textured (clay loam, sandy clay loam, silty clay loam < 34 percent clay).	0.75
	Sandy - coarse textured (sand, loamy sand, coarse sand, loamy fine sand).	0.5
	Fine and Sodic affected soils - (sandy clay, silty clay, clay, silty clay loam > 34 percent clay).	0.25

Appendix C(16)
Variables with Index Values

Model Variable	Strata Present (V_{strata}) Measurement or Condition	Index
Definition: The number of vegetation strata present in the plant community.	All appropriate strata are present.	1.0
Example: This will be adjusted based on the type of wetland the model is trying to measure. Single strata wetlands will receive a severe penalty if strata are gone.	One stratum is absent from the plant community.	0.75
	Two strata are absent from the plant community.	0.5
	Three strata are absent from the plant community.	0.25
	Vegetation is sparse.	0.1
	Vegetation is absent.	0.0

Model Variable	Surface Inflow into Wetland (V_{surfin}) Measurement or Condition	Index
Definition: Overland flow from non-wetland to a wetland.	Any of the following indicators similar to comparison site; sheet or rill erosion on adjacent non-wetland areas, lateral tributaries entering floodplain and not connected to the channel, rearranged litter and/or scour scars leading into a wetland from non	1.0
Example: Surface rills or rearranged litter leading to a wetland from adjacent non-flooded sites.	Above indicators less than the comparison sites.	0.5
	Absence of the above indicators, hydraulic gradient manipulated but restoration is possible.	0.1
	Absence of the above indicators and hydraulic gradient reversed by channelization across wetland and diversion terraces or ditches at toe of slope. Restoration is not possible.	0.0

Appendix C(17)
Variables with Index Values

Model Variable	Presence of Surface Water (V_{surwat}) Measurement or Condition	Index
Definition: Presence or indication that the surface is inundated for at least one week,	Over-bank flow sufficient to pond water for seven consecutive days **or**, direct observation of ponded water **or,** aerial photo evidence confirms flooding similar to comparison site. Compared to state comparison site; annual under story (grass and woody reprod	1.0
Example: Over-bank flow or ponding for seven consecutive days or presence of surface water in macro/micro lows.	As above, but below comparison site.	0.5
	Above indicators absent but related indicators suggest variable may be present.	0.1
	No over-bank flow; ponding minor or not evident; no evidence of flooding on aerial photos. Indicators absent and/or there is evidence of alteration affecting variable.	0.0
* Use USGS gage data, if available, as a hydrology tool.		

Appendix C(18)
Variables with Index Values

Model Variable	Wetland Land Use (V_{wetuse}) Measurement or Condition	Index
Definition: Dominant land use and condition of the wetland.	Wetland not tilled in last five years. No grazing, haying, or logging occurring. Riparian zone intact.	1.0
Example: Disturbance of the wetland impairs the ability of biotic processes to uptake and release elements.	Wetland rarely (< = 2/10) cropped, minimal impact from grazing, haying, and/or logging.	0.75
	No tillage in zones wetter than riparian zone. Riparian zone minimally impacted by light to moderate grazing, haying, logging, no channel, or drainage manipulation.	0.5
	Riparian zone tilled, heavily grazed most years or extensively logged, or channel manipulation.	0.2
	Wetland receives conventional tillage in all zones in most years; if recently tilled, evidence of vegetation, clods in furrows, severe channel, or drainage manipulation, but restorable.	0.1
	Wetland more severely disturbed than indicated above; severe manipulation and not restorable (e.g., no vegetation, rutted, feed lot, fill)	0.0

Appendix C(19)
Variables with Index Values

Model Variable	Woody Vegetation Roughness (V_{wrough}) Measurement or Condition	Index
Definition: Corresponds to the number of woody stems (trees and shrubs).	Stem density and/or tree basal area between 80 percent and 120 percent that of comparison site. Visual estimate of trees and shrubs indicates site is similar (between 80 percent and 120 percent) to comparison site.	1.0
Example: Roughness of stem density detain water, trap organic debris, and slow water movement.	Stem density and/or tree basal area between 10 percent and 80 percent that of comparison site.Visual estimate of trees and shrubs indicates site is less (10 to 80 percent) than comparison site.	0.5
	Stem density and/or tree basal area < 10 percent that of comparison site. Trees and shrubs sparse or absent relative to comparison site; restoration possible.	0.1
	Woody vegetation absent; restoration not possible.	0.0

Model Variable	Depth of Water Table (V_{wtd}) Measurement or Condition	Index
Definition: The available water storage correlates to the drawdown of the water table.	Seasonal high water table to 0.0 - 0.5m of surface, and dominant mottling of soils within 0.0 - 0.5m.	1.0
Example: Estimate by using the median seasonal high water table as listed in the soil survey or by measuring the depth to redoximorphic features.	Seasonal high water table to 0.0 - 0.5m of surface, and dominant low chroma colors.	0.5
	Soils stay nearly saturated for very long durations and are gleyed near the surface.	0.1

Appendix F(1)
Instructions for filling out Excel Workbook for Interim Kansas Riverine HGM Model

At the bottom of the workbook are the Excel spreadsheets associated with this model. They are to be used for documenting minimal effects determinations and mitigation using the HGM assessment method.

CALCULATION SHEETS

1) Minimal (Min) Effects sheet

This sheet is a stand alone calculation sheet used to determine if the alterations to a wetland site fall within the minimal effects criteria as stated in National Food Security Act Manual (NFSAM).

2) Impacted Site sheet

This sheet requires inputs for a wetland conversion that requires mitigation to replace lost Functional Capacity Indices (FCIs) and Functional Capacity Units (FCUs).

3) Mitigation Site sheet

This sheet requires inputs for the mitigation site that is being used to replace the lost FCUs for the impacted site.

4) FCU Change sheet

This sheet shows the data inputs for the impacted site sheet and the mitigation site sheet. It does not permit data entry, and shows the acres required to mitigate FCU losses for each function. The function(s) with the highest replacement acreage will determine the replacement acreage required for the mitigation.

SUPPORT SHEETS

1) "Flags" sheet:

This sheet lists the "yellow flags" and "red flags".

- Column C (cells C5 – C18) contains the yellow flags abbreviated expression used in the drop-down menu on the minimal effects and mitigation sheets.
- Column D (cells D6 – D17) contains the yellow flags complete statement listed in the NFSAM, page KS516-2a.
- Column F (cells F5 – F9) contains the red flags abbreviated expression used in the drop-down menu on the minimal effects and mitigation sheets.
- Column G (cells G6 – G8) contains the complete statement listed in the NFSAM.

Appendix F(2)
Instructions for filling out Excel Workbook for Interim Kansas Riverine HGM Model

SUPPORT SHEETS, continued

2) Variable (Var) Field Form sheet

This sheet can be printed and used in the field for entering the field variable index rating for each variable in the field. The variable rating values can then be entered in the appropriate spreadsheet.

3) Functions List sheet

This sheet is a chart listing all of the variables used in each FCI equation used in the model.

SAVING THE FILE

At the top of any of the sheets in the workbook,

1. click on the "File" option of the menu bar,
2. click on "Save As",
3. in the "Save As" box, find the "Name as" box and enter a file name (for example the Landowner's name),
4. in the "Save In" box at the top of the "Save As" screen, click on the "Down" arrow, and click on the directory/folder that you want the file saved in,
5. click "OK" in the upper right hand portion of the "Save As" screen.

Appendix F(3)
Instructions for filling out Excel Workbook for Interim Kansas Riverine HGM Model

Guidance for Data Entry in the Minimal Effects, Impacted Site, and Mitigation Site sheets

BUTTONS

Each of the three sheets has two buttons in row three at the top of the sheet.

- PRINT — This button prints the contents of the specific sheet
- RESET INPUT — This button clears all of the data entry cells and so that a set of new data can be entered.

NOTE: *It is recommended that the file be saved per the instructions above before resetting the sheet*

Wetland Area Clarification

- Minimal Effects Site area is listed for area reference. To qualify for Minimal Effects, there cannot be a reduction in wetland area.
- Impacted Site
  - Existing Conditions area is the size of the wetland prior to any alterations in the size and/or functions.
  - Predicted Conditions is the area that remains
    - after any area conversion, and/or
    - impact to functions as a result of changes within the wetland or outside of the wetland
- Mitigation Site area
  - Existing Conditions area is the size of the wetland at the mitigation site prior to any improvements in the size and/or functions.
  - Predicted Conditions is the area as a consequence of restoration, enhancement or creation.

Appendix F(4)
Instructions for filling out Excel Workbook for Interim Kansas Riverine HGM Model

Guidance for Data Entry in the Minimal Effects, Impacted Site, and Mitigation Site sheets, continued

MINIMAL EFFECTS SHEET

Data Entry

CELL		
E-F4	DATE	Enter date data collected
E-F5	WETLAND ID	Identification of person(s) for multiple calls per tract
E-F6	OBSERVERS	Person(s) collecting the variable ratings
E-F7	CONDITIONS	Site conditions
E-F8	PROJECT NAME	Name for project (could be landowner, etc.)
I-J4	REMARKS	Optional comments
I-J5	ASSESSMENT TYPE	Optional
I-J6	WETLAND TYPE NWI	National Wetland Inventory name (optional)
I-J7	**"Ground water Influence' or 'No Ground water Influence"**	**Required DROP-DOWN MENU entry** to address groundwater influence of wetland
I-J8	OWNER/OPERATOR	Name of person(s) being assisted
E-K9	PLANNED ACTIVITY	Brief description of proposed practice
E-F10	**YELLOW FLAG**	**DROP-DOWN MENU**
H-I10	**RED FLAG**	**DROP-DOWN MENU**
H-J11	**"Wooded' or 'Herbaceous"**	**Required DROP-DOWN MENU entry** to address vegetative type of wetland
E16	WETLAND AREA	Area of wetland to 0.001 acres
D19-D50	EXISTING CONDITIONS	Enter index ratings for each of the variables (index rating day before alteration)
H119-H50	PREDICTED CONDTIONS	Enter predicted post-project index ratings for each variable
H-J61 to H-J67	COMMENTS	Comments that help clarify function result

Appendix F(5)
Instructions for filling out Excel Workbook for Interim Kansas Riverine HGM Model

Guidance for Data Entry in the Minimal Effects, Impacted Site, and Mitigation Site sheets, continued

IMPACTED SITE SHEET (location generating need for mitigation)

Data Entry

CELL		
E-G4	DATE	Enter date data collected
E-G5	WETLAND ID	Identification of person(s) for multiple calls per tract
E-G6	OBSERVERS	Person(s) collecting the variable ratings
E-G7	CONDITIONS	Site conditions
E-G8	PROJECT NAME	Name for project (could be landowner, etc.)
J-K4	REMARKS	Optional comments
J-K5	ASSESSMENT TYPE	Optional
J-K6	WETLAND TYPE NWI	National Wetland Inventory name (optional)
J-K7	**"Ground water Influence' or 'No Ground water Influence"**	**Required DROP-DOWN MENU entry** to address groundwater influence of wetland
J-K8	OWNER/OPERATOR	Name of person(s) being assisted
E-K9	PLANNED ACTIVITY	Brief description of proposed practice
E-G10	**YELLOW FLAG**	**DROP-DOWN MENU**
I-J10	**RED FLAG**	**DROP-DOWN MENU**
I-J11	**"Wooded' or 'Herbaceous"**	**Required DROP-DOWN MENU entry** to address vegetative type of wetland
E16	WETLAND ACRES E	Existing wetland (just prior to conversion) to nearest 0.001 acres
I 16	WETLAND ACRES P	Remaining wetland (after conversion) to nearest 0.001 acres
E-G19 – E-G21	COPY MINIMAL EFFECTS VARIABLES BUTTON	Transfers the "existing conditions" Copies variable ratings from the "minimal effects" sheet to "the impacted site" sheet
D19-D50	EXISTING CONDITIONS	Enter index ratings for each of the variables (index rating day before alteration)
I 19-I 50		

	PREDICTED CONDTIONS	Enter predicted post-project index ratings for each variable for remaining wetland area
G-K67 toG-K79	COMMENTS	Comments that help clarify function result

Appendix F(6)
Instructions for filling out Excel Workbook for Interim Kansas Riverine HGM Model

Guidance for Data Entry in the Minimal Effects, Impacted Site, and Mitigation Site sheets, continued

MITIGATION SITE SHEET (location used for mitigation of FCU's lost)

Data Entry

CELL		
E-G4	DATE	Enter date data collected
E-G5	WETLAND ID	Identification of person(s) for multiple calls per tract
E-G6	OBSERVERS	Person(s) collecting the variable ratings
E-G7	CONDITIONS	Site conditions
E-G8	PROJECT NAME	Name for project (copied from Impacted Site sheet)
I-J4	REMARKS	Optional comments
I-J5	ASSESSMENT TYPE	Optional
I-J6	WETLAND TYPE NWI	National Wetland Inventory name (optional)
J-K7	**"Ground water Influence' or 'No Ground water Influence"**	**Required DROP-DOWN MENU entry** to address groundwater influence of wetland
J-K8	OWNER/OPERATOR	Name of person(s) being assisted
E-K9	PLANNED ACTIVITY	Brief description of proposed practice
E-G10	**YELLOW FLAG**	**DROP-DOWN MENU**
I-J10	**RED FLAG**	**DROP-DOWN MENU**
J-K11	**"Wooded' or 'Herbaceous"**	**Required DROP-DOWN MENU entry** to address vegetative type of wetland
E16	WETLAND ACRES E	Existing wetland (just prior to conversion) to nearest 0.001 acres
I 16	WETLAND ACRES P	Remaining wetland (after conversion) to nearest 0.001 acres
D19-D50	EXISTING CONDITIONS	Enter index ratings for each of the variables (index rating day before alteration)
I 19-I 50	PREDICTED CONDTIONS	Enter predicted post-project index ratings for each variable for remaining wetland area