APPENDIX C
ENVIRONMENTAL IMPACTS ANALYSIS

C.1 MANAGEMENT GOALS

C.1.1 Relevant Laws and Executive Orders

The Corps permit program is an important element of the Clean Water Act, which has as its goal, "the restoration of the physical, chemical and biological integrity of the Nation's waters". The Corps permit process is driven by the objectives of the Clean Water Act and other Federal laws. Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act of 1899 are the primary regulatory authorities of the Corps. The Clean Water Act opened non-Federal jurisdiction to the impact assessment process under the National Environmental Policy Act. Compliance with the National Environmental Policy Act, Endangered Species Act and other Federal, state and local laws affect the Corps permit process. Compliance with related laws also is described in Chapter 2.

The permit program is designed to mitigate the impacts of dredge and fill material placement on the functioning of a wide variety of aquatic environments, including wetlands. The Clean Water Act extends the Corps permit process to all of the Nation's waters excluding private lands under agricultural use, various agriculturally related artificial reservoirs and channels, isolated waters determined not to have interstate commerce effect, and other minor exceptions. Because beneficial development of land- and water-use is desirable as long as it is compatible with environmental goals, the Corps permit program is intended to promote beneficial development while assuring environmental goals are pursued. The Clean Water Act focuses on aquatic habitats.

Wetlands are included among the Nation's waters identified in the Clean Water Act and stand out in the Corps permitting process because they are most frequently impacted by permit decisions (close to 80% of permitted impacts in FY 1998 as described in Chapter 4). Wetlands also are among the more threatened and highest valued of naturally functioning ecosystems (see Chapter 4). Therefore national goals set for wetlands have major implications for the Corps regulatory program. National goals have been established in law, executive order and policy. Those goals focus on sustaining and eventually increasing the acreage, function, and value of wetlands.

A national wetlands protection policy of no overall net loss of wetland acres and function was recommended in the late 1980s by the National Wetland Policy Forum to facilitate a more effective "wetlands protection goal" (The Conservation Foundation 1988). They recommended specifically that "the nation establish a national wetlands protection policy to achieve no overall net loss of the nation's wetlands base, as defined by acreage and function, and to restore and create wetlands, where feasible, to increase the quality and quantity of the nation's wetlands resource base." No-overall-net-loss goal attainment meant establishing an equilibrium between losses and gains nationally. The Forum's policy recommendations had impacts in law and executive action.

Section 307 of the Water Resources Development Act of 1990 sets an interim national goal for Corps wetland policy of "no overall loss of the Nation's remaining wetlands base, as defined by acreage and function", and a long term goal "to increase the quality and quantity of the Nation's wetlands, as defined by acreage and function." Wetland also is the only ecosystem category directly impacted by the permit program that has been identified by Federal administrative order for maintenance under a goal of no overall net loss of function and value. Attainment of the goal of overall no net loss meant establishing an equilibrium between losses and gains nationally. Both the George H. W. Bush and the Clinton administrations adopted a similar policy goal (White House 1991; 1993) soon after the Congressional mandate in 1990. Because of the unique status of wetlands, the Corps regulatory program keeps the most complete database for wetland impacts.

The way the policy of no-net-loss of wetlands is carried out is an important determinant of net environmental impact because wetlands make up such a large fraction of the water resources impacted by the Corps permit program. The Corps relies heavily on compensatory mitigation to offset unavoidable wetland losses that result from activities authorized by Corps permits. The Corps regulatory policy is to comply programmatically with the goal of "no overall loss"; not on a case-by-case basis. Compensatory mitigation also is commonly required for other waters and especially those waters identified in addition to wetlands as special aquatic areas.

Corps mitigation policy is found in 33 CFR 320.4(r) (Federal Register 1986). Mitigation policy is also indicated for standard permits and for special aquatic sites in a 1990 Memorandum of Agreement (MOA) between the Environmental Protection Agency and the Department of the Army. The EPA-Army MOA recognizes wetlands as deserving of special resource attention through a policy of no overall net loss of wetland functions and values. The MOA alludes to the practical limitation of mitigating for every permit action: "it is recognized that no net loss of wetlands functions and values may not be achieved in each and every permit action. However, it remains a goal of the Section 404 regulatory program to contribute to the national goal of no overall net loss of the nation's wetland base." Because compensatory mitigation requirements of individual developers are prohibited from being greater than the actual loss incurred, and because some filling is allowed without Corps notification under general permit, the loss incurred can not in theory be fully compensated to prevent programmatic loss. That loss must be compensated through other means if the national goal is to be met.

Compensatory mitigation effectiveness assumes great importance for this wetland management policy. Its role is key to the no overall net loss policy because permitted unavoidable direct impact rates have remained substantial, as indicated by the 1998 data. Even though the 1990 MOA does not apply to permits other than standard permits, discretionary requirement of compensatory mitigation has steadily increased for general permits.

In law and policy three measures were established to account for changes in wetlands and to assure no interim net loss while planning for long term gains. Those measures are acreage, function, and value. The affected environment, including mitigation activities, is described in Chapter 4 and this Appendix in terms of these three measures. Of the three measures, acreage is conceptually and economically the easiest one to make. It however, is only a proxy for function and value, which are more relevant in determining the significance of environmental impacts. Acreage, function, and value and their measurement are described in detail in Chapter 4 and in other sections of Appendix C.

C.1.2 Permit Process

The Corps permit process seeks to eliminate unnecessary negative impact to the Nation's waters by minimizing total negative impact on all environments and diverting unavoidable negative impact to locations of lower functional value, including some terrestrial locations. Under the Clean Water Act, impact avoidance mitigation typically translates into protecting aquatic ecosystems at some cost associated with functional degradation of natural terrestrial ecosystems. This results because water is more of a public resource than land is and laws protective of terrestrial ecosystems are not nearly as comparable in inclusiveness to the Clean Water Act.

While functions and values are the objects of wetlands no overall net loss policy, wetland delineation (boundaries placement) and measurement are issues of great concern because ecosystem functions and values are difficult to measure and often reach far beyond boundaries based on ecosystem structure. The Corps regulatory program has avoided difficult and costly measurement of functions and values. Instead, it has focused on delineating the boundaries of aquatic ecosystems based on changes in ecological structure and measuring the acreage unavoidably impacted and mitigated "in kind" (similar ecological structure). Because structure and function usually are closely associated, functions are assumed to be replaced with in-kind replacement of structure. Similarly, value is assumed to be defined by structure and function. The degree to which these assumptions are met has much to do with determining the impact of the permit program alternatives.

As this Appendix will show, the context of negative impact and mitigation is critical for sustaining function and value and successful mitigation is anything but guaranteed. The degree to which function and value remain proportional to structural measures, depends on how the creation or restoration of a mitigation site is situated both ecologically and socially. Because of this, on-site mitigation was for many years preferred over off-site mitigation. By mitigating on site, location ceased to become a complicating variable. But as experience accumulated, it became clear that many on-site mitigation actions failed to achieve their objectives. As a consequence, off-site mitigation, including mitigation banks, became an acceptable and often preferred alternative. But off-site mitigation also introduced questions about how functions and values compare in different locations.

Unlike most waters and wetlands, the Corps does not regulate discharges of dredged or fill material in upland areas. Even so, avoidance of impact in high-value aquatic environments often results through the permitting process in impact to upland sites less valued for their natural environmental services. For example, a road might be moved out of the floodplain to less valued upland or a less-valued dry depression might be filled for housing development instead of a wet depression. Even though the Corps has no direct authority over activities outside aquatic habitats, impacts on upland watershed areas and riparian buffers are included in consideration of mitigating alternatives when they might significantly impact aquatic systems, are critical habitat for sensitive species, or otherwise hold significance for the national interest. The general policy is to encourage the least overall negative environmental impact, including avoidance of negative impact to highly valued uplands.

Terrestrial impacts relevant to the Federal interest is mitigated through careful compliance with provisions of the Endangered Species Act, Clean Water Act, the National Historic Preservation Act, and other Federal laws—conditions that must be satisfied to obtain a Corps permit. Through those laws, the Corps permit process encourages protection of certain important terrestrial resources, such as critical habitat for endangered species, public sanctuaries and other public holdings. To a practicable degree (limited by knowledge, economic forces and other social considerations) the permit process also encourages mitigating impacts on those terrestrial ecosystems providing a protective buffer for the natural functions underlying aquatic ecosystem services. Because of this focus on water and other public resources, the Corps record of regulatory impact does not include acreage of terrestrial impact incurred on private lands.

The Corps permit program impacts numerous environmental services associated with the affected areas. The combined use of the four approaches to permitting (i.e. permit types) is intended to result in a practical and flexible approach to minimizing the impact on environmental function and human services, including the costs to the regulated public and the taxpayer. The four permit types have been described in detail in Chapter 3. The fundamental issue guiding this review of the affected area is the question of how effective the nationwide permits have been in minimizing ecological and social impacts as it has been used in combination with the other permit types. Data sufficiency and assumptions are described throughout the results of this analysis.

Corps enforcement of Section 404 of the Clean Water Act and compliance with the Endangered Species Act and other laws greatly mitigates costly environmental impacts associated with the Nation's waters as defined for the Clean Water Act. By placing high resource value on water resources and endangered species through protective policy, these laws guide land and water resource development toward significantly reduced environmental impact on aquatic resources. Because the intent of the Corps permit program is to minimize impact on the functions and values of aquatic ecosystems, the areas described here emphasize the Nation's waters, including wetlands.

The Corps permit process has become integrated into private and public resource development planning processes. Ideally, it guides development planning to direct impacts away from alternatives that infringe upon the public interests to alternatives that confine impacts to the private realm while minimizing costs to both private and public interests. Evaluating alternatives for optimally protecting both public and private interests, including minimization of environmental impacts, requires an assessment of affected geographical areas, ecological functions, environmental services and environmental values, as well as private and public community costs.

C.2 DELINEATING AQUATIC SYSTEMS

The Nation's waters, including wetlands, are the focus of the Corps permit program. A good general source of information about wetland classification and delineation is provided by Tiner (1999). Cowardin et al. (1979) classified wetland and deepwater habitats as palustrine, riverine, lacustrine, estuarine and marine systems. This classification scheme places virtually all of the Nation's waters into categories of ecological function. Since 1997, all Corps regulatory data for nationwide permit activities have been classified by this approach. Much less consistency exists among Corps districts in tracking impacts authorized by other permit types according to the Cowardin et al. (1979) classification system. The Corps also discriminates between tidal and nontidal waters. Tidal waters include all estuarine and marine systems and small fractions of the Nation's riverine, lacustrine, and palustrine waters.

The system designation is the main indicator of ecological function for those areas permitted for impacts from discharges of dredge and fill material. The *palustrine* system includes the largest reported area in acres directly impacted by discharge of dredge and fill material administered under the nationwide permit program. It includes inland wetlands in permanently and periodically flooded waters dominated by persistent woody or non-woody plants in areas where ocean-derived salinity is below 0.5 ppt (500 mg/liter). Most of the remaining area directly impacted under the nationwide permit program is in the *riverine system.* It includes all channeled deep waters and wetlands except where ocean-derived salinities exceed 0.5 ppt (500 mg/liter) and wetlands are dominated by persistent, emergent non-woody, or woody plants. Minor direct impact of the nationwide permit program occurs in the *lacustrine system.* It occurs in naturally or artificially inundated basins that are virtually uninfluenced by oceanic salinity (up to 0.5ppt) and have no more than 30% coverage by persistent, emergent, woody or non-woody vegetation. Little direct impact occurs under the nationwide permit program in the *estuarine system.* It is transitional and tidal, existing in drowned river mouths and lagoons between non-tidal inland waters and marine-system environments. Least impacted under the nationwide permit program is the *marine system,* which includes ocean extending from high-tide coastline and estuaries out to the edge of the continental shelf.

Wetlands exist as classes in each of the five general systems of the Cowardin et al. (1979) classification. Each system and class exhibits different functions and provides different human services important for determining environmental impacts. Whereas the palustrine system is made up entirely of wetland classes, each of the other systems have wetland subsystems that make up small but functionally important fractions of system areas. Consistency and precision are important aspects of determining cumulative impacts based on available information, which is categorized by system and classes. Corps districts inconsistently categorize by wetland class, but differentiate Corps-defined wetland from other aquatic ecosystems (i.e., other waters).

Differences between the Cowardin et al. (1979) definition of wetlands and the definition based on interpretation by the EPA and the Corps of the Clean Water Act need to be clarified. Only a subset of the Cowardin et al. (1979) wetland subsystems meet Corps criteria for wetlands based on Corps regulations. This difference derives from the separation into special aquatic areas by

U.S. EPA regulations (Federal Register 1980) of areas all categorized as wetland by Cowardin et al. (1979). These are identified in U.S. EPA rules and regulations (Federal Register 1980) as wetlands, mudflats, and vegetated shallows.

While the Cowardin et al. (1979) definition of wetlands requires only one of three criteria based on soils, vegetation, and hydrology to classify as wetlands, the U.S. EPA and Corps jurisdictional definition requires three criteria to qualify for wetland classification. Cowardin et al. (1979) state: "Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this classification wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes; (2) the substrate is predominantly undrained hydric soil; and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year."

U.S. EPA rules and regulations (Federal Register 1980, 1986) state that: "wetlands consist of areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas."

Corps- defined wetlands exclude mudflats and vegetated shallows and are limited to areas that are 1) flooded with surface water during the growing season, or are either periodically or permanently saturated below the surface during the growing season, 2) have hydric soils and 3) are temporarily (nonpersistent) to persistently occupied by emergent, rooted hydrophytic vegetation. Soil saturation has to persist long enough to meet the hydrology definition provided in the Corps wetland delineation manual (CEEL 1987). Unlike the Cowardin et al. (1979) classification, Corps jurisdictional wetlands exclude all drained areas with residual hydric soils.

Most past studies of wetland function and value have not been done using the more limited Corps definition of wetlands, but rather a definition closer to that of Cowardin et al. (1979). These policy and ecological complications make assessment of already uncertain scientific information less certain. We assume that results of scientific study of functions and values based on the broader delineation of wetlands also applies to the narrow jurisdictional delineation.

C.3 ENVIRONMENTAL IMPACT METHODS

C.3.1 Corps Regulatory Analysis Management Systems Data

C.3.1.1 Database Organization

The Corps regulatory program maintains two sets of data within the Regulatory Analysis Management System database (hereafter referred to as the RAMS database). One set of data is used by Corps headquarters for wetland accounting for all permit types (later referred to as the OCE data set). A second data set is input in separate fields for nationwide permits for monitoring activity, impact and mitigation (hereafter referred to as the NWP data set). This latter data set is available for years since 1997.

The OCE data set pertains to impact and mitigation information for Corps-defined wetlands and serves the purpose of monitoring no net loss of wetland acreage across all permit types (Standard, Letter of Permission, Regional and Nationwide) by non-tidal and tidal water categories. All impact and mitigation data were recorded in acres in this data set. No data were regularly maintained for open-water resources, with the exception of two districts (Chicago and Alaska), which maintained both wetland and open-water impacts in FY 1998. Data from three districts (Honolulu, Charleston and New England) could not be included in the analysis based on the OCE data set.

The NWP data set maintains data associated with all nationwide permit actions, regardless of water resource status. It includes all wetlands and other waters; that is, riverine, lacustrine, estuarine, marine, and palustrine systems (see Appendices C.2 and C.3 for descriptions). The NWP data set aggregates wetlands and other waters into totals for each system. The NWP data set includes impacts in either linear feet or acres for water resource categories other than Corps-defined wetlands. These linear measures were used especially for riverine impacts, but also were used to lesser extent for shoreline impact to ponds, lakes, estuaries and seashores. Because no mean width data were recorded, acres could not be precisely calculated from linear-feet data. Required mitigation is recorded in acres or in linear feet depending on how the impact was recorded. The NWP data from six districts (Honolulu, Charleston, New England, Norfolk, Alaska, and Chicago) could not be included in the analysis.

Both data sets include breakdowns of wetlands into tidal and non-tidal wetlands. Data also were recorded consistently according to the systems of Cowardin et al. (1979). Some districts provided subsystem and class information, but the practice was inconsistent across all districts. Because the only indication of functional status is their classification, minimum information is available to judge function and value.

The database for FY 1998 was used because it was representative of the impact assessment period and this was the first year the two data sets were complete. Acreage of program impact and initiated compensatory mitigation for FY 1998 are similar from 1995 through 1999.

C.3.1.2 Estimating Impacts

Total permit activity, impact and compensatory mitigation were estimated based on the sample of districts available to us. We assumed that the sample districts were representative of the districts for which there were no data. In each case the sample size is large. For the OCE data set, the three missing districts include a wide range of wetland impact possibilities. Because the 3 districts make up less than 8% of the districts and collectively were fairly representative of the whole program, the estimation error for all 38 districts should be quite small. For the OCE data sets the sums from the 35 districts supplying data were multiplied by 1.0857 (38/35) to estimate the total number of permits and acres. For the NWP data set, 6 districts were missing (nearly 16%) and the missing ones may have collectively had somewhat higher than average impacts, indicating that the total was more likely to be underestimated than overestimated. Even so the sample size was over 84% of the 38 districts and the error thought to be small, albeit larger than for the OCE data. For the NWP data set, the sums of the 32 districts were multiplied by 1.1875 (38/32) to estimate the total numbers of permits and acres in the various categories.

Except for entry error, the difference between the OCE and NWP data sets for nationwide permits should have been caused by differences in the recording of data for impacts to other waters. Therefore, once the program totals were calculated, the differences between the OCE and NWP data-set totals were used to estimate the impacts to other waters in each of the Cowardin et al. (1979) categories for nationwide permits.

Another way to estimate the acreage of other waters impacted was to use the data reported by the two districts (Chicago and Alaska). We expected estimates from the two districts to be less representative and a substantially more approximate estimator of total acreage of other waters impacted, but used it to check the results from the OCE and NWP data sets. When the Chicago and Alaska data were expanded to an estimate for all 38 districts, by multiplying by 19 (38/2), the estimated total number of permits issued was 70% as large as the estimate made by the difference between the OCE and NWP data sets. In other words, the estimate based on the two districts was within 30% of the estimate based on the difference between OCE and NWP data sets. The general similarity of results increased confidence in the estimated impacts to other waters, but with substantial uncertainty in the estimate. The estimate based on difference was the larger of the two estimates and was preferred to err on the side of impact overestimation and because it was derived from a larger sample size.

The only data available to estimate the distribution of impact acreage among all permit types was the data collected by the Chicago and Alaska districts. The percentages of other waters reported for the different permit types by Chicago and Alaska were used to estimate the program distribution of impacts to other waters among permit types. The fractions for the four permit types determined from Chicago and Alaska records were used with the impacted acreage difference between OCE and NWP data sets to estimate the impacts to other waters in each permit type. Because of the small sample size and the exceptional qualities of Alaska and Chicago, the estimates of the distributions of impacts to other waters among standard permits, letters of permission, and regional general permits should be considered with careful regard for the data limitations.

C.3.1.3 Relative Reliability of the OCE and NWP Data Sets

The NWP data set is considered less reliable than the OCE data set because linear feet appear to have been mixed accidentally with acreage estimates in the NWP data set. Use of the NWP acreage required a screening to eliminate improbably large acreage records that were most likely linear feet estimates. For both data sets, a significant part of the data had not been entered (fields have been left open) without explanation. This is especially true for data fields where impact should have been recorded. Based on interviews with district personnel, we learned that many of these blank data fields in the database were intended to be zero impacts but many also were for impacts to other waters, for which there was no required entry of impact data .

The NWP data set for other waters included conversions from linear feet based on a crudely estimated mean width of impacts. In addition to the permits where acres were the unit of impact measure, 7,421,368.6 feet were reported impacted in waters other than wetlands for the 32 districts included in the NWP database. To get a total national estimate, the length was expanded by 38/32 or 1.188 and converted to miles. Lacking any estimate of average linear impact width, we made a crude estimate of 5 feet based on the permit activity and general knowledge of impacts. Much of the linear impact was for bank stabilization. Five feet was believed to be a liberal estimated width. However, this estimation adds to the uncertainty associated with the data for other waters.

C.3.1.4 Impact Size Distributions and Below-Notification Threshold Losses

The number of acres impacted below the notification threshold for nationwide permit 26 was estimated based on the assumption that a consistent relationship existed between the size of the impacts and the acreage impacted (Figure C.3.4-1). A line was fitted to the three size categories

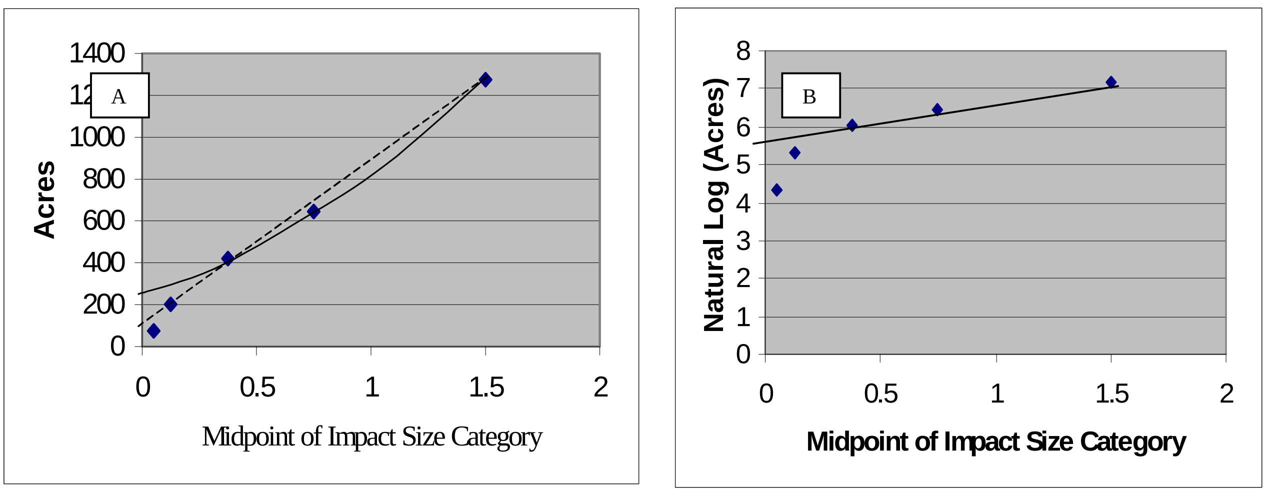

Fig. C.3.1.4-1. Impact Size Distribution and Below-threshold Losses. A. Linear and non-linear model fits of the data; B. Natural log transform of the non-linear model in Fig. A. Once fitted to the three data points above the required notification threshold, the lines were extrapolated to the lowest size category of impact. Figure C.3.1.4-1A indicates how a linear model and a non-linear model compare directly. The non-linear model was transformed to a linear relationship by multiplying by the natural log as shown in Figure C.3.1.4-1B.

As shown in Figure C.3.1.4-1A, use of the non-linear model results in the higher estimated acreage of impact below the one-third acre notification threshold. A precise estimate is 326 acres. Because the data were from 35 of 38 districts a multiplier of 1.085 (38/35) was used to estimate the total acreage impacted, which was 355 acres. If a linear model were extrapolated, the estimated unreported impact would be much smaller; about 100 acres. For each of the categories below the notification threshold size (the impact sizes authorized without notifying the Corps) the difference between the extrapolated line and the observed acreage was determined and summed to estimate the total unreported acreage. We used the non-linear model because the transformed model appeared to fit the data better and estimated the higher amount of unreported impact. A similar transformation was made for all nationwide permit impacts other than nationwide permit 26. In that case, the two smallest categories varied along the extrapolated line indicating no measurable under-reportage.

C.3.2 Information Needs

C.3.2.1 Database Deficiencies

As described elsewhere in C.3 and C.5, the database presented a number of problems that made it more difficult to estimate environmental impact and progress toward a goal of no net loss of wetlands. The following summation of deficiencies fall into two categories. The first category includes deficiencies that should entail relatively little additional work to greatly improve reliability and utility of the database.

The second category includes deficiencies that hamper interpreting the net effect of impact and compensatory mitigation on national wetland function and value. This information may require expertise and financial support from outside the Corps regulatory program.

C.3.2.1.1 Easily Corrected Database Deficiencies

Corps Headquarters has explicit guidance for field office data entry into the Corps regulatory database (Regulatory Analysis and Management System (RAMS) and is continuing efforts of the past nine years to improve data entry practice. Among the data entry deficiencies that need to be addressed and emphasized for immediate improvement are the following.

1. First, a standard database does not exist across all districts and there is no national-level guidance that explains why the data are needed for national environmental accounting, how the districts might use the data, and explicitly what data should be recorded in each data field for each permit type.

2. Impact and mitigation data are not gathered consistently for the entire permit program other than the nationwide permits. The lack of data for impacts to other waters and associated mitigation under standard permits, letters of permission and regional general permits limited a comparison of effectiveness for alternative programs. Cowardin wetland system data are not provided for permits other than nationwide permits. These data would improve future environmental impact statements and contribute to improved assessments of environmental status, such as progress toward national environmental goals.

3. Blank data fields in the data base cannot be interpreted with certainty because they may be zero impact, temporary impact, impacts to open waters of undocumented degree, or missing data. This deficiency has greatly limited the value of the database for impact analysis.

4. Functional data are not easily obtained from the database for both impact and compensatory mitigation with reporting categorized only at the systems level of the Cowardin et al. (1979) classification. Class level identification, including hydrogeomorphic (HGM) classification

when available, would make functional assessments of compensatory mitigation effectiveness that much more thorough.

5. The existing database does not assure that temporary impacts cannot be misinterpreted as permanent impacts. Similarly, there is no way to identify wetland class conversion it that is considered a loss or gain in function.

6. Database evidence strongly suggests that data entered for impact and compensatory mitigation under nationwide permit 27 restoration activities were often confused with the restoration results leading to overestimates of impacts, mitigation and mitigation/impact ratios.

7. Stream and other “linear” impacts in classes of other waters cannot be calculated as acreage of impact because mean width of impact is not recorded. Without estimating all impacts in acres, total impact cannot be summed accurately. In addition, descriptions of impacts in Verification letters do not describe activity in the detail needed, including all units.

8. Compensatory mitigation is not now categorized in the data base by the action taken, i.e., identified as restoration, creation, preservation, enhancement, or a mix of actions. This results in an underestimate of mitigation action taken.

9. Corps permit fate cannot be tracked in the existing data base through the state water quality and other permit process to assure that all activities ultimately denied by the state are not counted toward impact or compensatory mitigation and that the impact did in fact ultimately occur.

C.3.2.1.2 Other Data Base and Information Deficiencies

The above deficiencies might be corrected relatively easily by universal changes in data base entry. Other deficiencies are more involved however, and might be corrected using a much smaller representative sample of permit actions to obtain statistically rigorous data. The data base is especially deficient about impact on and compensatory mitigation for ecosystem functions. This deficiency limits interpretation of impact and compensatory mitigation effect on wetland function because there is no information about the locations of impact and mitigation with respect to the affected watershed or other ecoregional definition. In addition there is no estimation of the relative completeness of functional impact or compensatory mitigation, which is especially relevant when enhancement is used for compensatory mitigation. The functions of one acre of wetland often are impacted partially between no permanent impact and complete permanent impact, which are the only data options now recorded. Similarly, there is no information provided about the relative functional integrity of the ecosystem before impact and compensatory mitigation. There is no information provided about the valued functions associated with the area of impact or compensatory mitigation, nor is there information tracking mitigation based on consistent national guidelines focused on sustaining functions and values.

In addition to the database deficiencies other knowledge deficiencies hamper regulatory effectiveness and efficiency. There is less than sufficient knowledge about ecosystem function and service levels for each Cowardin et al. (1979) class of aquatic habitat, such as the rates of production, organic export, materials sequestration, hydrologic effects, and habitat in process index models that can ultimately be translated into service value. Another general deficiency is knowledge about the factors that contribute most to the value of ecosystem services and elements in models that might be developed for relatively rapid estimation of values. Some of this function and value information exists but has yet to be integrated into useful models for regulatory applications. As the regulatory data base now stands, the data cannot be easily analyzed in a landscape (geographic) context.

C.4 SYSTEM ATTRIBUTES, FUNCTIONS AND SERVICES

C.4.1 System Attributes Used To Delineate Areal Boundaries

Cowardin et al. (1979) describe ecosystem attributes in detail. Data on the status and relative abundance of different systems and classes can be found in Dahl (2000) and NRCS (2000). Good general resources on aquatic ecosystem attributes and processes relevant to this discussion include Lerman (1985), Day et al. (1989), Cole (1994), Horne and Goldman (1994), Allan (1995), Nybakken (1996), Scheffer (1998), Mitsch and Gosselink (2000), and Wetzel (2001). Daily (1997) provides a good introduction to ecosystem services.

C.4.1.1 Palustrine System Attributes

The palustrine system includes permanently and periodically flooded, shallow aquatic and semiaquatic ecosystems dominated by persistent woody or non-woody plants in areas where ocean-derived salinity is below 0.5 ppt (500 mg/liter). Based on data in Table 4.2-2, palustrine waters and wetlands make up nearly two thirds of conterminous United States waters and wetlands, excluding subtidal marine and deepwater Great Lake environments. However, a fraction of the palustrine wetlands included in Table 4.2-2 are more properly classified as lacustrine and riverine fringe wetlands. They are impractical to separate with the remote imagery technology used for wetland inventory and often are categorized by default with palustrine wetlands.

The palustrine system includes all inland aquatic areas of open water less than 20 acres in surface area if they are less than 6.6 feet (2 meters) maximum depth during low water and there are no wave-formed or bedrock features along the shore. The permanently flooded shallow waters without emergent vegetation often are referred to as ponds, including small artificial impoundments. Inland palustrine salinities derived from other than ocean sources often exceed 0.5 ppt and may attain substantially higher concentrations in arid areas or regions with highly soluble salts in the watershed. The palustrine system is bounded by upland or by riverine, lacustrine, estuarine or marine systems.

Forested wetlands are most abundant, comprising over half of the total palustrine system. Most is located in cypress swamps along the southern Atlantic and Gulf coastal plains and larger warm-water rivers or in cedar swamps of the Great Lakes area and northern Atlantic shore. About one fourth of palustrine wetland is herbaceous emergent wetland dominated by grasses, rushes, sedges, cattails and other nonwoody hydrophytes. About 15% is scrub-shrub swamp, some of which is early successional forest.

Palustrine wetlands are less likely to provide direct erosion control services and storm protection services than fringe wetlands. Even palustrine wetlands in old riverine floodplains are relatively isolated and only incidentally contribute to erosion control during exceptional flood events. The relative isolation of many palustrine wetlands greatly reduces particulate organic matter export service in support of valued species off site compared to riverine and tidal wetlands. Bogs, potholes, fens and other palustrine wetlands are more likely to be sinks for particulate organic matter than sources of organic matter. Even where palustrine wetlands are adjacent to flowing water, they are often located in areas that do not get frequent flooding or other flushing action. Sport and commercial fisheries are relatively unimportant services of isolated palustrine wetlands because large fish typically need connection to deeper waters to flourish. Seasonally flooded palustrine wetlands in floodplains are among the most likely to serve as nursery areas for fish species.

C.4.1.2 Riverine System Attributes

The riverine system includes all channeled deep waters and wetlands except where ocean-derived salinities exceed 0.5 ppt (500 mg/liter) and wetlands dominated by persistent, emergent non-woody, or woody plants (palustrine system). River salinities derived from other than ocean sources often exceed 0.5 ppt and may attain substantially higher concentrations in arid areas or regions with highly soluble salts in the watershed. River channels are either natural or artificial conduits that contain at least periodically flowing water or at least periodically connect two bodies of standing water. Rivers are bounded on the landward side by upland or palustrine environments. Based on the boundary defined by palustrine wetlands, river channels in floodplains extend to the channel depth that is flooded semipermanently but exclude floodplain environments that are only temporarily to seasonally saturated and show clear signs of soil development. Rivers terminate in lacustrine-system, estuarine-system, or dry-basin environments.

Riverine subsystems include tidal, lower perennial, upper perennial and intermittent flows. All but the intermittent systems maintain surface water continuously. River surface area makes up a relatively small fraction (about 3.4%) of the total U. S. water resource area in Table 4.2-2. The water level of the tidal subsystem fluctuates with ocean tides. The lower-perennial subsystem has lower-gradient and finer sediments than the upper perennial subsystem. Floodplains are well developed in the lower perennial subsystem. Because riffles and pool complexes are special aquatic sites, many streams of the upper perennial subsystem qualify as special aquatic areas in the Clean Water Act. The fraction of stream area that qualifies as a special aquatic site decreases as stream size increases and a small fraction of lower perennial subsystems qualifies as special aquatic site.

Non-persistent emergent vegetation typifies riverine wetlands. These are hydrologically differentiated from palustrine wetlands by the extent of annual flooding connecting the wetlands to open-water riverine system. Riverine wetlands are flooded more often than not and palustrine wetlands are no more than seasonally flooded. Because one often grades into the other riverine wetlands and palustrine floodplain wetlands can be difficult to differentiate, especially using areal imagery. The exact extent of riverine wetland is unknown and is typically lumped with herbaceous palustrine wetland in Table 4.2-2. It is unlikely that riverine wetlands add up to more than 5% of total river surface, or a maximum of perhaps 250,000 acres located in low gradient perennial rivers.

C.4.1.3 Lacustrine System Attributes

The lacustrine system occurs where at least 20 surface acres of inland water virtually uninfluenced by oceanic salinity occupies a natural depression or an artificial impoundment and has no more than 30% coverage by persistent, emergent, woody or non-woody vegetation. Lacustrine waters may be less than 20 surface acres where water depth exceeds 6.6 feet (2 meters) at low water or where the shore at least in part is formed of bedrock or wave-generated features. The EPA (1998) estimates there to be about 41.7 million acres of lacustrine waters including the Great Lakes, which make up about half of the total lake area in the conterminous U. S. Lacustrine waters include artificial impoundments, which continue to increase lake area (Table 4.2-2) as they are constructed. However, the rate of increase is decreasing as impoundment construction decreases and as existing lakes fill with sediment.

Lacustrine waters may be tidal or non-tidal. Ocean derived salinity is less than 5 ppt (500 mg/liter). Lacustrine salinities derived from other than ocean sources often exceed 0.5 ppt and may attain substantially higher concentrations in arid areas or regions with highly soluble salts in the watershed. Lacustine waters are bounded by upland, palustrine wetlands, waters are influenced by ocean salinity, and where the basin constricts to river channel width. Subsystems include deep (over 6.6 feet at low water) limnetic waters and shallower littoral waters. In the Cowardin et al. (1979) classification all littoral waters are wetland habitats and may extend deeper than 6.6 ft to the greatest depth occupied by non-persistent emergent plants. In the Clean Water Act, vegetated littoral waters (shallows) are considered special aquatic sites but they are not classified as wetlands in Corps regulations. Lacustrine system substrates vary from bedrock and boulder to unconsolidated sediments of gravel, sand, fine silt and clays and organic matter.

C.4.1.4 Estuarine System Attributes

The estuarine system is transitional and tidal, existing between non-tidal inland waters and marine-system environments. Estuarine waters occupy drowned river mouths and lagoons behind coastal barrier islands. Estuarine environments are partly to mostly enclosed by land and have at least sporadic connection to the open ocean. On the ocean side of estuaries oceanic salinity is at least occasionally diluted by runoff from the land. On the land side of estuarine waters, salinities at least occasionally exceed 0.5 ppt (500 mg/liter). In lagoons with weak oceanic connection and limited freshwater runoff, salinity may periodically increase to levels greater than ocean concentrations because of local evaporation effect. Estuaries include tidal wetland and deep-water habitats over 2 meters deep at low tide. Most tidal wetland is estuarine. Subsystems of the estuary system of Cowardin et al. (1979) include the intertidal and subtidal environments.

Because they are often nearly surrounded by land, estuaries have more low-energy environments than marine ecosystems, and more substrates dominated by fine sediments. Mudflats are special aquatic sites under the Section 404(b)(1) guidelines that are most common in estuaries, which also are identified for special concern in the Clean Water Act. Mudflats are deposits of sediments typically rich in organic matter. Estuarine mudflats function as habitat for numerous deposit-feeding invertebrates, which, in turn, provide forage for fish, shorebirds and other wildlife.

Being transitional environments, estuarine surface area is identifiable by degree of difference from inland waters and ocean waters. Depending on criteria used, this results in different estimates. The total acreage estimated by Dahl (2000) in Table 4.2-2 is very conservative compared to the EPA (1998) estimate, which is nearly 3 times the surface area. The difference is in estimated subtidal habitat. The fraction of estuary supporting wetlands depends on the amount of deepwater habitat included in the estimate and is lower using EPA data.

C.4.1.5 Marine System Attributes

The ocean extending from high-tide coastline to the edge of the continental shelf comprises the marine system. Near shore environments are most relevant to nationwide permit program impacts. A salinity that consistently exceeds 30 ppt (30,000 mg/liter) is the primary attribute separating marine ecosystems from adjoining aquatic systems. Near-shore hydroregime patterns are dominated by daily tidal flux, varying regularly within monthly cycles and in response to differences in shore topography, and by currents determined by winds, Coriolis force, and shore configuration. Periodically many of these environments endure or are reshaped by extremely erosive turbulence, waves, and currents associated with intense storms. Protected bays and other coastal irregularities create local environments of relatively low energy and erosive force. Substrates range from bedrock to coarse sands in high-energy environments to silts and clays in low-energy environments. The two subsystems are intertidal and subtidal.

Corp-defined wetlands tolerant of salinity are scarce outside estuaries. Based on estimates in Dahl (2000) and Table 4.2-2, 0.1% of all Corps-defined wetland is marine. In the subtidal system, areas occupied by sea grasses and coral reefs are of special concern, but are not included among Corps-defined jurisdictional wetlands. Special aquatic sites support some unique and vulnerable species, and their maintenance is one of the more important services that they provide. In addition, they absorb hydraulic energy and moderate shore erosion rates.

C.4.2 System Functions

C.4.2.1 Palustrine Functions

Mitsch and Gosselink (2000) is a good general source of information about wetland structure, function, and services. The largest impacts of Corps permitting occur in palustrine systems and especially in palustrine wetlands. Because they are typically inland and often are isolated from riverine, estuarine, lacustrine, and marine waters, palustrine wetlands provide a somewhat different mix of functions than the fringe wetlands of other systems. There is, however, much variation in function, depending on how often and how thoroughly they are connected by surface flow to other waters and their wetlands. Because palustrine wetlands usually are more hydrologically isolated, the depressions they occupy are much more likely than fringe wetlands to intercept runoff and reduce watershed sources of flooding before it gets to streams and lakes. Whereas system import of eroded soil, organic matter, and nutrients may be high, export from most palustrine wetlands to river, lake and marine systems is likely to be relatively low. Exceptions occur on river and lake margins where periodic flooding of palustrine wetlands may result in significant flux of organic matter.

As habitat, palustrine wetlands are less likely to provide for species that require substantial connection to other waters, such as many of the larger species of fish. As a consequence, they are more likely to support species sensitive to fish predation, such as many amphibians, certain crustaceans, and large insects. Birds, of course, have ready access to isolated locations and numerous species are adapted to palustrine wetlands. Few bird species are uniquely adapted to palustrine wetlands, however. Also because of isolation, palustrine wetlands are more likely to support locally distributed and unique plants than are riverine, lacustrine, estuarine, or marine fringe wetlands.

The way palustrine wetlands function depends greatly on their ratios of surface water and transported material discharge to basin storage capacity. Palustrine system functions vary depending on the storage ratio. In contrast with riverine and lacustrine fringe wetlands, most palustrine wetlands have a high storage ratio, especially for water-transported materials. Because they are more hydrologically isolated, the depressions occupied by palustrine wetlands are much more likely than fringe wetlands to intercept runoff and reduce watershed sources of flooding before it gets to streams and lakes. Whereas system import of eroded soil, organic matter, and nutrients may be high, export to river, lake and marine systems is likely to be relatively low. Many palustrine systems are maintained by groundwater and rarely import materials through surface runoff. Bogs and fens in particular fall into this category.

Habitat functions are linked closely to form of vegetation dominating the wetlands. Emergent herbaceous wetlands and forested wetland provide different habitats for different communities. But even within a wetland subsystem, community members vary regionally with temperature, geographical isolation and other variables. Because of their isolation, they tend to support species that do not require a mix of aquatic habitats, such as many larger fish species require. Certain birds, amphibians, insects, and other invertebrates are particularly linked to palustrine wetland habitats.

C.4.2.2 Riverine Functions

Riverine functions are impacted by the Corps permit program at a rate second only to palustrine functions. Riverine process links terrestrial and watershed process to other inland, estuarine and marine processes. Rivers function foremostly as water and other material transport systems and "assimilation" systems for terrestrial organic detritus. Because they have high exchange rates, rivers function more to move materials than to store them, but "process" the transported materials in route, breaking down coarse particles into fine particles. They function as habitat for many species adapted to seasonally variable flow and to the transport of organic detritus, which serves as a major source of nourishment. Rivers also function as corridors for fish and wildlife movement among habitats, and they transport sediments, nutrients, and organic matter to downstream riverine habitats and estuaries where they contribute to the maintenance and productivity of other systems.

Rivers erode and deposit materials, creating a dynamic within the channel and in the vegetated floodplain that sustains specialized natural communities in a continuum (Vannote et al 1980). In small, shallow and naturally erosive streams and rivers with riffle and pool structure, many species are adapted to life on and in bottoms of gravel, cobble and boulders littered with woody debris. As rivers become larger and consistently more depositional, natural communities increasingly become more planktonic or adapted to life in fine bottom sediments. In the headwater streams, terrestrial organic matter often is the major source of nutrition and the dominant consumers shred organic detritus. Larger leaves and other organic matter remain trapped and smaller particles are transported downstream where organisms adapted to collecting or filtering fine organic matter dominate. Where streams widen to shallow rivers with stable substrates attached algae also becomes an important source of nutrition and food webs diversify based on animals that scrape and consume the algae where there is sufficient light and collect and filter fine organic matter from upstream. In larger rivers, a planktonic community develops above the bottom. Many of the consumers collect or filter a combination of living phytoplankton and dead particulate organic matter exported from upstream sources. Whether natural or artificial, dams alter virtually all of the many transport functions of rivers in addition to impeding fish migration.

Riverine systems in the United States have evolved unique faunas of mollusks, crustaceans and small fishes, which make their species-level functions especially unique, especially in the southeastern and western United States. In addition, they and their riparian habitats serve as connecting habitats for migratory species, including high-profile fish species and numerous passerine bird species passing through semiarid and arid environments.

Wetland classes existing along rivers and in estuaries are sustained by the natural watershed discharge and river-channel erosion that determines wetland sediment supply. Riverine wetland functions depend on the natural erosion, transport, and deposition processes, which are controlled by variation in river discharge between base flow and flood flow. Most material transport occurs during flood flows. As the recede to and maintain base flow, rivers and their floodplains trap and convert terrestrial organic matter to biomass and cycle some materials back to the atmosphere. Low-lying floodplains along free-flowing rivers typically are dynamic and have few fixed features. River channels meander and migrate through the floodplain alluvium and old channel depressions eventually fill. In these environments many riverine wetlands are naturally created and destroyed, but total wetland area and function is more or less sustained.

High levels of human-caused erosion and artificial flood control can reduce wetland area and greatly alter natural functions in riverine, estuarine, and marine systems. The condition of the watershed, including the condition of palustrine wetlands, contributes to determining the degree of erosive flooding, sedimentation and turbidity. Many of the nation's rivers have been altered by greatly reduced capacity of watersheds, including palustrine wetlands, to dampen runoff and erosion rates. In addition, many rivers carry elevated levels of nutrients because of intense use of fertilizers for agricultural and domestic purposes. Consistently high levels of erosion and flooding can eliminate riverine wetlands. In combination with too much diversion of river flow away from wetlands by water-control structures, nutrient-rich sediments may end up in deep oceanic waters where they can cause algal blooms and severe oxygen depletion from organic decomposition.

Compared to many palustrine wetlands, riverine wetlands are transitory features that temporarily hold back sediments during low- to normal-flow periods and deliver sediments to estuaries during high-flow periods. Many riverine wetlands, such as arrow-arum and pickerel-weed marshes, erode away during floods and stabilize fine sediments in backwaters only during periods of low-to-normal river flow. In a fully functional state, riverine wetlands are adapted to the high degree of connectivity between wetlands along rivers and usually reestablish quickly, following local destruction, from propagules carried in from other wetlands once normal and low flows return. In normal-to-low flows, entrapment and stabilization of sediments by riverine wetlands reduce turbidity that may limit riverine and estuarine productivity, but they transport most materials through the system during floods. Riverine wetlands function to enhance riverine assimilation of organic matter and some potentially toxic materials during low to normal flows, but are much less effective during flood flows.

C.4.2.3 Lacustrine Functions

The Corps permit program impacts lacustrine systems relatively little. The degree to which lakes function differently from rivers depends on their water exchange rate. As exchange rate increases, lakes function increasingly like rivers. Artificial lakes are more likely than natural lakes to function like rivers because of relatively high average exchange rates. Lakes with low exchange rates function to store water and materials trapped in lake sediments. They typically moderate water and material release rates from their watersheds. They assimilate terrestrial organic detritus transported to them by rivers and other overland flow. Lakes function as habitat for production of numerous species adapted especially to planktonic existence and secondarily to benthic existence.

The extent of lacustrine fringe wetland is an important determinant of the dominant fish and wildlife species found in and near lakes. Many species of fish spawn most successfully in fringing wetlands. Few species spawn in open water. Fringe wetlands reduce shore erosion and retain fine sediments, reducing lake turbidity. To a relatively small extent compared to palustrine wetlands, lacustrine wetlands contribute to maintenance of nutrient cycles with a gaseous phase (carbon, sulfur, nitrogen).

C.4.2.4 Estuarine Functions

Corp permit program impacts on estuarine functions are quite limited. Tidal fluctuation at regular intervals acting in conjunction with watershed runoff in rivers establishes many of the unique functions of estuaries, but estuary shape contributes importantly. Where tide and river flow meet, material transport switches rapidly from erosive to depositional and back again with great regularity. These are zones where sediments deposit along the fringes of the main hydraulic forces until they are eroded by the next erosive storm or become colonized by plants able to resist storm erosion. In this dynamic environment, sediments remain in place either because plant roots hold them in place or local hydraulic energy encourages net deposition of fine material in mudflats and sandbars a bit too dynamic for wetland vegetation to colonize.

Estuaries with shallow basins and high shoreline development (high shoreline length per unit area of water) enclosed by barrier beaches are more likely to establish wetlands than estuaries with deep basins and low shoreline development open to the ocean. As plants colonize, they reinforce deposition, further colonization and expansion until an equilibrium condition is attained. Estuarine plants that compose fringe wetlands are dominated by salt-tolerant grasses, and, in tropical settings, by a few woody species in mangrove forests. Offshore, submerged sea grasses become established where depth, turbidity, salinity and hydraulic energy is appropriate. Both emergent-wetland and sea-grass expansion is limited by offshore depth, erosive forces, high turbidity, and impenetrable substrate.

The net effect of estuary processes is temporary to relatively permanent sequestration of sediments rich in organic matter and inorganic nutrient. The sediments undergo continuous nutrient renewal, supporting high production of plants and benthic animals adapted primarily to filtering out or deposit-feeding on organic detritus. Rooted vegetation acts like a sponge that absorbs hydraulic energy, dampens erosion along estuary shores, and transfers inorganic nutrient to an organic form, much of which enters detritus food webs within and outside the wetlands. The flushing action of the tides transports much of the organic matter produced in fringe wetlands to offshore locations in estuaries and ocean habitats. Both emergent wetlands and submerged sea grasses function as habitats for numerous fish and wildlife species uniquely adapted to tidal waters. Some, such as sea turtles and manatees are endangered species.

C.4.2.5 Marine Functions

Corp permit-program impacts in marine systems are quite small. Coastal marine ecosystems without wetlands function as habitat for many marine species. These are occupied primarily by benthic communities that depend on the continuous supply of detrital plankton from offshore marine sources and organic matter transported along shore from estuarine sources. Most of the animal consumers at the lowest food-web level filter-feed on organic detritus. Farther from shore, planktonic communities progressively dominate. In high-energy environments, the dominant species are able to attach to rock and other stable substrate or are able to survive on or buried in unstable sands. Natural sandy beaches function as spawning and nesting sites for a number of species, some of which are endangered (e.g., sea turtles).

More specialized communities exist in marine wetlands, sea grass beds, kelp communities, and coral reefs. They typically are areas of relatively high productivity that support unique marine species. Fully marine emergent wetlands outside estuaries are relatively scarce, existing only in areas most protected from high-energy hydrodynamics where fine sediments accumulate. Submerged sea grasses occupy areas of lower hydraulic energy. In cool waters off the west coast, large, substrate-attached brown algae dominate kelp communities of complex structure, which dampens hydraulic energy and traps organic matter transported shoreward from the open sea as well as organic matter produced by the kelp community. Colonies of hydrozoan coelenterates form coral reefs in shallow, moderately-warm waters mainly off the Florida peninsula and Hawaii. The hydrozoans filter the water of its fine organic matter for nutrition but also depend on symbiotic algae. To continue function, corals require water of high transparency and minimum suspension of fine inorganic particles.

C.4.3 System Natural Services

C.4.3.1 Palustrine Services

Because they are typically inland and often are relatively isolated from deeper waters, palustrine wetlands provide a mix of services somewhat different from other system wetlands. Palustrine wetlands are less likely to provide direct erosion control services and storm protection services than fringe wetlands. Even palustrine wetlands in old riverine floodplains are relatively isolated and only incidentally contribute to erosion control during exceptional flood events. The isolation of palustrine wetlands greatly reduces or eliminates organic-export in support of valued species off site. Sport and commercial fisheries are relatively unimportant services of isolated palustrine wetlands because large fish typically need connection to deeper waters to flourish.

Palustrine wetlands are less likely than fringe wetlands to perform efficient control of nuisance pests, such as mosquitoes. Small and isolated wetlands are more likely to produce mosquitoes and associated disease than fringe wetlands that are routinely flushed and open to fish predators. Perhaps as a consequence of these service differences, many palustrine wetlands may not be valued quite so highly for their aesthetic appeal and local property value as are well-flushed fringe wetlands along lacustrine and estuarine shores.

The flood-reduction service is complex. Floodplains downstream from palustrine headwater wetlands developed in the presence of those wetlands. Thus the service they provide should be estimated by the increased level of flooding that would result from wetland filling with less permeable material.

Palustrine wetlands also are more likely than fringe wetlands to contribute to clean drinking water supply through groundwater recharge, but are at least as likely to occur at groundwater springs and seep discharges with no recharge service. Palustrine wetlands can be quite effective removing contaminants from water used for consumption and recreation. Much more than fringe wetlands, which typically function to export large fractions of produced organic matter, palustrine wetlands accumulate and store organic matter in anaerobic sediments, resulting in long-term carbon sequestration and moderate cycling of gaseous nitrogen and sulfur to the atmosphere. Collectively they may be exceptionally important in regulating greenhouse gasses, but the mass balance calculations are only rudimentarily determined. Peat accumulation in bogs and fens may be most effective in this regard. Peat also provides a commodity production service of some commercial importance locally.

Palustrine habitat supports hunting, nature study, and other recreation service similar to fringe wetlands. Migratory water birds are especially associated with palustrine wetland service values. Just as with fringe wetlands, unique, endangered species habitat is provided by some of these wetlands and the genetic information they contain is sustained for possible future use.

The major services of Corps-defined wetlands classified as palustrine are most connected with flood damage reduction, water supply, water treatment, and bird-based recreation. Fisheries related recreational and commercial services are limited because Corps-defined wetlands do not support large fish nor much boating or other water sports.

C.4.3.2 Riverine Services

Riverine system functions support numerous natural services, including water delivery, navigation, recreation, aesthetic, endangered species, commercial fisheries, mineral products (e.g. sand and gravel), education, and other services. Compared to lakes, however, riverine systems are relatively poor at water storage, sedimentation and other water treatment. Many aquatic species complete at least part of their life cycles in backwater and seasonally flooded riverine wetlands in support of recreational and commodity production service, especially in lower perennial river systems. Transport within rivers and export of organic matter and nutrients to estuaries are important functions in support of endangered species, fisheries, and recreational wildlife typical of those areas. Riverine wetlands often are important waterfowl wintering areas in the southern United States.

Riverine wetlands make up a significant but relatively small part of the permit-impacted wetlands reported in the RAMS database. Because of difficulty in sorting palustrine wetlands in floodplains from riverine wetlands, there may be some confusion assigning wetlands to these two systems. However, they provide quite different services. Riverine wetland functions are complex and their service contributions are often difficult to discern—especially their capacity for providing property and health protection by flood and sediment control. Riverine wetlands come and go with other low-lying floodplain features. Because headwater, riverine and estuarine wetland services are so closely interdependent, their values also are related and are best evaluated holistically in a watershed context.

The degree that floodplain wetlands (either palustrine or riverine wetlands) moderate flood intensity compared to other floodplain features is not easily calculated and may be overstated. At best it redistributes flooding to less damaging locations. Flooding is to some extent self-regulating independent of wetlands. Flood flows create and maintain floodplain depression storage through sediment erosion and deposition. Because wetland development typically resists erosion and enhances sediment entrapment, it can result in less depression volume and decreased flood reduction service. Whether it is aquatic or upland, floodplain vegetation both slows flood velocity and displaces water volume, raising water levels once groundwater rises to the surface. This can increase the extent of flooding in adjacent and upstream areas while reducing it downstream. Because wetlands concentrate fine sediments, they may become less effective at infiltrating water than floodplains where the particle size is coarse.

C.4.3.3 Lacustrine Services

Lakes provide major water supply and water-quality improvement services, depending on their size and exchange rate, but typically much more than free-flowing rivers. Their capacity for water supply and flood water storage has been a major motivator for converting riverine systems to lacustrine systems through construction. Water treatment service is inversely proportional to lake exchange rate and is associated with the fraction of entering materials that settle to the bottom as sediment. This can be very effective for particulate matter as well as nutrients such as phosphorus and iron. Large lakes provide navigation service and moderate climate. They also provide habitat for recreational, commercial and endangered species adapted mostly to a planktonic food web and only secondarily to a benthic food-web.

Lacustrine wetlands fringing the shorelines of lakes provide services associated with shore erosion protection, storm-surge protection, habitat support for recreational, commercial and endangered species of fish and wildlife, export of organic matter to support valued species offshore, and various aesthetic, educational, and scientific services.

They provide relatively little storm-runoff flood damage reduction compared to palustrine and riverine wetlands. Lacustrine wetlands may provide some water treatment for potable water service, but compared to other watershed properties, this is likely to have a small overall impact on water quality. Lacustrine wetlands provide some water treatment service in support of water-based recreation and some municipal water supplies. Lacustrine wetlands provide little water storage service (they may slow runoff slightly) and may slightly reduce the storage capacity of the basins they occupy.

C.4.3.4 Estuarine Services

Estuaries, including fringing wetlands, provide numerous services associated with shore erosion protection, storm-surge protection, habitat support for recreational, commercial and endangered species of fish and wildlife, export of organic matter to support valued species offshore, and various aesthetic, educational, and scientific services. More than any other aquatic community, estuarine wetlands support commercial fisheries. They contribute significantly to maintenance of gaseous nutrient cycles (carbon, sulfur, nitrogen), but provide little storm-runoff flood-damage reduction. Estuarine wetlands typically provide little service with respect to water treatment and storage for potable or irrigation water supplies, but do improve water quality in support of water-based recreation and maintenance of commercial and endangered fish and wildlife. The open waters of estuaries also provide recreational and commercial navigation services of limited sufficiency. These services are among the most frequently enhanced by dredging navigational channels.

C.4.3.5 Marine Services

Coastal oceans support many fish and wildlife species of recreational and commercial-food and other importance, as well as a few endangered species. Barrier beaches, which are a product of coastal erosion following the post glacial sea-level rise, moderate the inland effects of storm-caused flooding and erosion. Off-shore marine systems provide navigational services.

Naturally scarce Corps-defined wetlands in the marine system provide very limited services associated with shore erosion protection, storm-surge protection, habitat support for recreational, commercial and endangered species of fish and wildlife, export of organic matter to support valued species offshore, and various aesthetic, educational, and scientific services. Compared to estuarine wetlands, they provide little storm-water storage service. No service is provided with respect to water treatment for potable water supplies and treatment in support of water-based recreation is minor. Sea-grass, kelp, and coral communities also provide similar services but to different degrees.

C.5 SOURCES OF ERROR FOR ENVIRONMENTAL ANALYSIS

A number of evident and possible errors and deficiencies occurred in the Corps database, which introduced uncertainty in data interpretation. Some deficiencies are mentioned elsewhere among appendices, as well, especially in Appendix C.3 on methods. Table C.5-1 summarizes the sources of error described in this Appendix.

C.5.1 Blank (No Entry) Data Fields

An important possible source of error in estimates of total adverse impact to all aquatic ecosystems results from the high fraction of unexplained "no-entry" (blank) data fields in the record for acreage of impact. Overall, in data for FY 1998 about 41,550 data fields were left empty in the Corps database including all permits. This amounted to about 49% of the total. Some of these are likely to be zero values because of the common practice of using blanks as a proxy for zero to save time. This conclusion was reached based on interviews with regulators and an analysis of the data.

Many, however, were likely to be impacts for open-waters (including zero impacts) because open-water impacts did not have to be recorded even though a record of each permit did have to be recorded. Some of the blank data fields may have been omission errors of permanent impacts. There is no way to accurately determine from the data set the dimensions of these errors. To the extent real impacts failed to be recorded, the data underestimate the FY 1998 impact and overestimate the mitigation ratio. To the extent that zero values were recorded as blanks, the indicated willingness to notify the Corps unnecessarily (below permit requirement) may be underestimated.

Data also may have been omitted when temporary impact occurred (which is zero permanent impact). A data field recording temporary impact would catch this type of error and would also provide more insight into total impact because temporary impacts require a Corps permit and sometimes prove not to be as temporary as might be implied. Some project managers record temporary impacts as permanent loss of aquatic function and service value. The net effect of these uncertainties is likely to be an overestimate of impact.

C.5.2 Impact and Mitigation Boundary Estimation Error

Boundary estimation error is another source of uncertainty for judging the relative effectiveness of the permit types. It especially becomes important in consideration of reduced impact sizes. Because the average size of impacted area is larger for standard permits than for the other permit types, the error associated with the acreage impacted is likely to be less. Boundary error remains relatively constant with respect to the size of a plot with otherwise similar attributes and similar estimation effort. Therefore, the effect of error on the area estimate increases as the size of the impact decreases.

Assuming, for example, that the 95% confidence interval for defining a wetland boundary were plus or minus 5 feet, the area within the confidence interval around a 1-acre wetland would be 8.4%. For a 0.1-acre wetland the uncertain fraction would be about 3 times larger, or 26.9%. At 0.05 acres the uncertain fraction mushrooms to 76%. Because of this effect, the acreage reported impacted in FY 1998 under different permit types is more confidently reported for standard permits than for the other permits. The area impacted by nationwide permits might be considerably less or considerably more than indicated in the data base, while standard permits are much more reliable estimates of the actual acreage permitted. If the fractional error is to be made constant, more effort will be required to measure the impacted perimeter precisely as the ratio of perimeter to impacted area increases.

This progression of increasing relative error also indicates that the certainty in estimating cumulative impact decreases as the average size of the permitted impact decreases. The error associated with the sum of many small impacts can be expected to be larger than the error associated with the sum of fewer larger impacts. With a consistent 5-ft uncertainty in boundary estimation, 1000 acres comprised of 10,000 impacts of 0.1 acre size could be as little as 731 acres or as much as 1,269 acres. In contrast the range for 100 impacts of 10 acres each would be quite small—973 to 1027 acres. For very small impacts less than 0.01 acre, the range of uncertainty approaches 0 to 2,000 acres impacted.

Just as the actual error associated with water resource measurement has not been well investigated, the degree to which bias exists is not well estimated either. The more probable bias is to err on the side of protecting water resources rather than to slow down the permitting process over boundary determinations. However, some regulators will correct such overestimates where obviously misrepresentative to avoid appearance of inaccuracy of any kind. To the extent that overestimation bias exists, the direct impact on water resources is overstated. If boundary

Table C.5.-1. Sources of error and probable bias in affecting cumulative impacts from nationwide permits.

<table>
<tr><th colspan="2">Variable</th><th>Estimation Status</th><th>Cumulative Estimate Effect</th></tr>
<tr><td colspan="2">Avoidance Mitigation</td><td>Underestimated (not recorded in its entirety)</td><td>Undervalues program for long-term protection effectiveness.</td></tr>
<tr><td colspan="2">Impacted Area Delineation</td><td>Overestimated permitted impact</td><td>Grows in size as average size of impact decreases</td></tr>
<tr><td colspan="2">Impact permanence</td><td>Overestimated permitted impact</td><td>Temporary impacts are counted as permanent more than vice versa</td></tr>
<tr><td colspan="2">Impact intensity</td><td>Overestimated permitted impact</td><td>(1) Aquatic functions and values are not always totally eliminated.
(2) Some authorized wetland losses have minimum wetland functions.</td></tr>
<tr><td colspan="2">State Permit Issuance</td><td>Overestimated permitted impact</td><td>State denial of permits is not tracked, overestimating permitted impact</td></tr>
<tr><td colspan="2">Empty data fields</td><td>Underestimated permitted impact</td><td>Most blank data fields probably are zero values but some may be omitted acres.</td></tr>
<tr><td colspan="2">Below-threshold impact</td><td>Underestimated permitted Impact</td><td>Some below threshold impact occurs, but is likely to be relatively small.</td></tr>
<tr><td colspan="2">Inevitability of Impact</td><td>Overestimates permitted impact in long-run</td><td>Climate, urbanization, sea-level and other changes will destroy site functions anyway.</td></tr>
<tr><td colspan="2">Project never built</td><td>Overestimates permitted impact</td><td>Overestimates cumulative impact.</td></tr>
<tr><td colspan="2">Total Estimated Impact</td><td>Overestimated permitted impact</td><td>Overestimated cumulative effect</td></tr>
<tr><td rowspan="4">Compen-sation Error</td><td>Empty Data Fields</td><td>Underestimated Compensation</td><td>Net national impact overestimated</td></tr>
<tr><td>Data Error</td><td>Uncertain effect</td><td>Net national impact uncertain</td></tr>
<tr><td>Incomplete (e.g., if multiple measures)</td><td>Underestimated compensation</td><td>Net national impact overestimated</td></tr>
<tr><td>Temporary impact reported and mitigated</td><td>Underestimated compensation</td><td>Net national impact overestimated</td></tr>
<tr><td colspan="2">Failure to compensate functional impact but wetland area created</td><td>Overestimated compensation</td><td>Based on data, mitigation failures often create wetlands of lesser functional value</td></tr>
<tr><td colspan="2">Failure to compensate functional impact because no wetland results</td><td>Overestimated compensation</td><td>Based on data, mitigation rarely is a complete failure.</td></tr>
<tr><td colspan="2">Compensation from Preservation of function</td><td>Underestimated</td><td>Only compensation effect on acreage is consistently recorded</td></tr>
<tr><td colspan="2">Compensation from enhancement of function</td><td>Underestimated</td><td>Only compensation effect on acreage is consistently recorded</td></tr>
</table>

Table C.5.-1. (Continued)

Compensation reliance on out-of-kind measures	Overestimated compensation for some functions and underestimated for others	In-kind mitigation is the only safeguard for assuring proportional sustenance of functions
Failure to institutionally protect compensatory mitigation	Unknown	History of mitigation action is too short to estimate reliability of protection.
State Permit denial effects on compensatory mitigation	Uncertain	May be neutral, as long as state permit denials are independent of mitigation
Total Compensation Error	***Complex, but dominated by uncertainty of mitigation success***	***Uncertain, but likely to result in less cumulative mitigation effect than may be inferred from the database.***
Total Program Impact	***Complex, but uncertainty of mitigation success is key***	***Net effect greatly dependent on compensatory mitigation effectiveness***

estimates were consistently moved out 5 feet from the actual boundary, the average nationwide permit impact area would be about 3 times more overstated than the standard permit impact area (approximately 25% for nationwide permits and 8% for standard permits).

The actual size of the boundary placement error is a function of several variables. Wetlands that grade very gradually into uplands are more difficult to delineate than wetlands that abut a sharply changed slope at the boundary. Where soils are dried out for long periods soil profiles are more difficult to interpret than where inundation dominates. Where facultative wetland plants dominate boundaries, delineation is more difficult than where obligate wetland plants dominate. The error is greater where the boundary is highly convoluted or the area is greatly elongated, as many wetlands, streams and linear impacts are. The confidence interval can vary greatly depending on these circumstances.

The probable effect of boundary error is to overestimate impacts and mitigation. The degree of overestimation probably increases as the mean size of the action decreases. A statistical study of this type of error can be easily executed and could reduce the uncertainty of the error effects discussed here.

C.5.3 Recording Temporary Impact as Permanent

Only permanent impact was to be included in the database. However, some regulators enter temporary impacts into this column of the database. In addition, maintaining an accounting system based solely on acres impacted, without a measure of the intensity of impact on functions and services, implies all of the original natural aquatic functions and services were eliminated where the impact is judged permanent. Therefore, sources of unmeasured uncertainty in estimated acreage are associated with the amount of temporary impact that was included as permanent impact and the degree the permanent impact eliminated aquatic functions.

We believe relatively little error of this type occurred where the permitted area was to be filled and converted to an entirely different nonaquatic use, such as for roads and bridge footings. The uncertainty enters where function and value are not entirely converted to another form but rather altered, such as might occur when a mature forested wetland is cut to install utility lines and maintained thereafter as a shrub wetland. Even relatively extreme conversion to suburban lawn and garden maintains some functional value, such as groundwater recharge and flood-runoff reduction.

On the other hand, impacts considered temporary may have subtle long-term effects that significantly degrade the natural services of an area. No representative monitoring of past actions has been done to assess the degree to which this uncertainty could affect estimates of long-term cumulative impact. The net effect of these sources of uncertainty is more likely to be an overestimate of permanent impact than an underestimate.

C.5.4 Final Disposition Of The Permit

Another source of error in the database is associated with the final disposition of the permit proposal at the state level. Once the Corps permit process is completed, the proposed project often needs to obtain state or local permits that are sometimes denied. No record is kept of these subsequent denials and anecdotal estimates from district regulators of 10 to 20% must be observed with caution. This source of error results in an overestimate of the permitted impacts. If as high as 20%, a significant overestimate of impacts is indicated. This form of error would have no effect on mitigation ratio, unless some unknown relationship exists between the probability of eventual permit denial and mitigation requirements.

C.5.5 Error Associated With Estimating Functional Impact

Maintaining an accounting system based solely on acres impacted, without a measure of the intensity of impact on functions and services, implies that all of the original natural aquatic functions and services were eliminated. In fact, many functions are maintained at least in part unless there is total conversion to footings, paved foundations and the like. For example, fill resulting in lawns and gardens around homes retains some water storage, water quality treatment, habitat, sediment control and other important functions that support desired human services.

C.5.6 Required Mitigation Ratio

Possible error and inaccuracy in the database may have contributed to inaccurate estimates of the mitigation ratios in Table C.5.6-1. Some of those issues have already been described for the record of permits issued. Where records of temporary impact were recorded in the RAMS database field normally reserved for permanent impact, no mitigation was required because there was no permanent loss. A temporary impact is self-mitigating on-site; it corrects for temporary loss of function and value as original conditions become restored either through natural or managed processes. Depending on how many temporary impacts were recorded as permanent, this type of error could result in an underestimate of the compensatory mitigation ratio. This type of error would have been most frequently associated with nationwide permit 12, which had a significant contribution to the recorded impact acreage and a low mitigation ratio. Most of the impacts authorized by nationwide permit 12 are temporary, in particular the clearing of utility line rights-of-way and the backfilling of utility line trenches**.**

Table C.5.6-1 Relative contribution of the most significant nationwide permit activities to permit process and impact and mitigation acreage. The data are based on reports from 32 Corps districts. Data were not available for 6 Corps districts.

Nationwide Permit Number	% Permits	% Impacted Acres	% Mitigation Acres	Mitigation/ Impact
# 3	12.53	10.53	1.58	0.23
#12	20.34	7.66	2.18	0.44
#13	16.76	3.32	1.05	0.49
#14	12.38	2.40	0.09	0.58
#18	4.21	5.13	0.04	0.01
#21	0.23	9.48	7.48	1.22
#23	2.17	1.72	1.04	0.94
#26	17.99	22.62	27.30	1.87
#27	1.84	19.60	55.15	4.38
#31	0.47	8.74	1.16	0.21
Total/Mean	88.92	91.20	97.07	1.66
Other nationwide permits	11.08	8.80	2.93	0.38
All nationwide permits	100.00	100.00	100.00	1.61
All minus nationwide permit 27	98.16	80.40	44.85	0.71

Closer examination of the nationwide permit data reveals a probable significant source of uncertainty in the meaning of the mitigation/impact ratio reported in Table C.5.6-1. Because of the disproportionate effect of nationwide permit 27, when it is left out of the calculation the program mitigation acreage is reduced more than half and the mitigation/impact ratio falls below 1.0 (Table C.5.6-1). While the relative number of nationwide permit 27 authorizations is small (1.8%), the average size of the impact acreage and the total acres is large (19.6%). Because of the high percentage of mitigation acres attributed to nationwide permit 27, any uncertainty in data associated with it has a large effect on the confidence in conclusions about program cumulative impacts (Table C.5.6-1).

Confusion appears to have existed over what constitutes both the impact and the mitigation acreage for restoration activity covered by nationwide permit 27. This permit authorizes wetland restoration and creation impacts to aquatic ecosystems as long as there is a net increase in aquatic resource functions and values at the project site. Sometimes existing water resources are unavoidably impacted, such as the loss incurred placing a water control structure. These impact losses typically are small compared to the area restored. For situations where previous water resources existed, some error appears to have occurred by placing the acreage of the restored or created area in the impact category, possibly in the belief that the existing water resources were impacted. While this type of action may restore, rehabilitate, enhance, or even reduce the function and value of what was there, it would not create any new water resource areas. This type of error would understate the actual mitigation ratio, which was, even so, much higher than all other permit categories.

This type of error also identifies a pervasive underlying problem with an accounting system based solely on the acreage impacted and mitigated. While restoration or other management would not be implemented if the value in it were not perceived to be positive, the acreage of water resource can remain the same as it was once managed differently. This modification of function is not reflected in acreage records.

The exceptionally large mitigation ratio of nationwide permit 27 signals another probable source of error in identifying mitigation acreage properly. Proper accounting should include only the permanent loss of aquatic resource area caused by the restoration action, which usually is small. Compensatory mitigation for the unavoidable loss should be in addition to the acreage restored in the actual project. Review of the data indicate that the restoration action is sometimes mistakenly counted as mitigation for incurred losses, creating a misleadingly high mitigation ratio because a regulated activity cannot also serve as mitigation acreage. While the correct mitigation ratio may not be as low as 0.71, the uncertainty in proper accounting could have elevated a ratio actually less than 1.0 to the reported ratio, which was substantially over 1.0 (Table C.5.6-1). Because compensatory mitigation is a crucial aspect of mitigation strategy for wetlands, this probable source of error needs close attention.

C.5.7 Functional Representation of Mitigation Ratios

Programmatically, the RAMS data indicate that the areal compensatory mitigation more than counterbalances the losses even when nationwide permit 27 is eliminated from the account. The program mitigation ratio of 1.58 (Tables 4.2-3 and 5.3-3) decreases to 1.30, which appears more than adequate for compensation as long as the mitigation action is successful and functions and values are mitigated proportionally. However, the mitigation ratios summarized in Table C.5.6-1 may indicate that all wetland functions are not being sustained as expected under a no-net-loss policy and the programmatic impact on wetland functions and values may not be replaced according to the no-net-loss policy.

Examination by activity shows that only three nationwide permit activities have mitigation ratios above 1.0. One of those activities, nationwide permit 27, probably counts mitigation incorrectly as described above and is likely to have a much lower ratio. From the standpoint of compensating for functions and values, the assumption that average function and value is sustained through the Corps permit program depends on the mitigation actions taken under two nationwide permit categories, both of which are exceptional. Nationwide permit 26 does not authorize activities in any waters adjacent to or in aquatic ecosystems below headwaters. In FY 1998, many of the impacted waters were isolated wetlands functionally quite different from interconnected waters. Nationwide permit 21 authorizes discharges of dredged or fill material in wetlands associated with mined locations. The vast majority of wetlands affected by these nationwide permits are palustrine.

Other activities (especially nationwide permits 12, 13, and 14) are associated with wetlands in other Cowardin et al. (1979) systems, as well as the palustrine system. Even though individual mitigation actions are typically "in kind" replacements, a differential rate of mitigation requirement among the nationwide permit types results in programmatic losses from riverine, lacustrine, estuarine, and marine wetlands at a greater rate than palustrine wetlands. This result suggests that all wetland functions may not be sustained according to a no-net loss policy because wetland functions differ among the systems.

This result does not necessarily mean that the value is diminished if the palustrine wetland value is equal to or exceeds the value of fringe wetlands of rivers, lakes, estuaries and oceans. Existing data indicate that palustrine wetland values may be relatively high to the extent that past studies are representative. In the short run, the net wetland value could be increasing, indicating a positive programmatic impact. In the long-run, however, if fringe wetlands become more scarce their relative value is likely to increase if the general economic rule applies.

Another uncertainty in the function and acreage relationship is associated with the degree to which creation, restoration, enhancement and preservation of wetland acreage contributes to the compensatory mitigation total, or whether the mitigation is on-site or off-site (except for the notation of whether a mitigation bank is involved). Neither enhancement or preservation are consistently recorded separately for compensatory mitigation of wetland *functional* loss. The extent to which all districts include enhancement and preservation in compensatory mitigation also is unclear. Mitigation with enhancement and preservation of wetlands is not universally accepted as appropriate for attaining a no overall net loss goal because the acreage in both cases already exists. The programmatic amount of enhancement and preservation is unknown relative to creation and restoration actions. This causes uncertainty both in the actual acreage change and in the functional change.

Enhancement contributes substantially to the uncertainty of effects on functions. The definition of enhancement is not universally clear. It can be interpreted as enhancement of functions associated with specific services, such as waterfowl-based recreation, or it may translate to a more holistic recovery from an impaired state of all natural functions. It is clear, however, that enhancement does not actually add to existing wetland acreage and may be difficult to assess remotely through aerial imagery. The degree of functional enhancement may vary from marginal changes to complete recovery of natural function from a totally dysfunctional state. The contribution, at least regionally, may be significant. In a random sample of projects in Washington State, Johnson et al. (2000) found enhancement contributed to 57% of the mitigation projects. In general, this source of uncertainty is likely to result in an overstatement of both acreage and functional mitigation, but more so the acreage.

The effect of preservation on the no-net-loss account is more difficult to assess. Preservation of sites under imminent threat is more certain of success than mitigation once the wetland is lost. Johnson et al. (2000) found preservation contributed to 26% of the projects in a study of wetlands in Washington State. When extended to wetlands that would otherwise soon be converted, preservation can be a very effective alternative to the creation or restoration of wetlands for the purpose of eliminating net loss of wetlands. However, official preservation of physically secure wetlands not exposed to imminent threat (e.g., remote from development) is a much less effective alternative. For preservation compensatory mitigation, the Washington Department of Ecology has developed mitigation ratios that are typically two to five times or more the ratio required for creation and restoration and higher ratios also are used in some Corps districts. The uncertainty here rests with the general severity and immediacy of the threat facing the wetlands preserved in compensation. If the threats are high, the mitigation acreage estimate is a reliable estimate of the functions sustained by the wetland type. If the threat is low, preservation overestimates the compensatory mitigation. While Corps policy suggests that the mitigation through preservation is effective, no confirming data are provided in RAMS.

C.5.8 Authorized Impacts Below Notification Threshold

The Corps regulatory database only includes the verified permitted impacts. These have been estimated to be relatively small based on the high incidence of zero impact reporting and extrapolating larger impact reporting to below notification thresholds (see Appendix C.3). The estimates lead us to believe these impacts are small and approximately accounted for (see Chapter 4).

C.5.9 Preservation and Enhancement Mitigation

Neither preservation nor enhancement are indicated consistently in the acres of impact recorded in the database because they do not contribute new acreage. When loss of a water resource is imminent, especially within the data accounting year, prevention of that loss by preservation is better than the equivalent in required restoration or creation for assuring compensation. The result is more certain because functions and values can be measured directly rather than estimated based on restoration or creation expectations. Under a condition of imminent loss otherwise, preserved acreage can logically be summed with restored and created compensatory mitigation.

Real enhancement adds to the service value of systems by increasing or restoring service-supportive functions of a degraded wetland, but without changing total wetland area. It would always fall short in functional compensatory mitigation compared to full restoration of similar wetland from a presently dry habitat. However, enhancement contributes significantly to compensatory mitigation of function and service losses. Leaving it out of the database results in an overestimate of negative cumulative impact on functions and values. On the other hand, assuming that enhanced acreage is equivalent to acreage restored or created from terrestrial habitat overestimates the compensatory mitigation of lost functions.

C.5.10. Watershed Context

The condition of the watershed serving a wetland or other water introduces a large source of uncertainty and possible error in cumulative impacts of Corps program permit activities. Two important effects are not documented. The first relates the true impact incurred by the Corps program. If, for example, a Corps-permitted wetland impact occurs in a watershed that is totally altered by development, such as results from increased impervious watershed surface, the true impact on wetland function and service value is much lower than if the watershed were totally intact (free of any development). The site is eventually doomed by upland alterations anyway. Thus the "permanent impact" of Corps permit activity is not on the pristine water or wetland in its undisturbed watershed, but rather on the functionally degraded water or wetland in its highly altered watershed. This type of accounting overestimates the functional impact assigned to the permit program and underestimates the cumulative impact from other sources.

It also follows that avoidance of impacts in a watershed bound for major alteration overestimates the effectiveness of the program in preventing impact. This is one of the major reasons why requiring avoidance in highly altered watersheds under rapid development is less desirable than requiring mitigation in a secure natural watershed elsewhere. Similarly, on-site mitigation often is undesirable wherever there is less certainty about the future of the watershed condition. For any mitigation action, the certainty of the future watershed condition is paramount for long-term success. Not accounting for this underestimates the cumulative impact.

C.6 MITIGATION ISSUES

C.6.1 Acres As A Proxy for Functions and Values

Acreage often is used as a surrogate for aquatic-ecosystem functions and values because it is cost-effective and representative when certain assumptions are met. The assessment of wetland functions and values for each permit decision has been considered prohibitively expensive and time consuming. In keeping with policy, compensatory mitigation for unavoidable loss should result in a gain of wetland area at least equal in functions and values to the unavoidable wetland loss incurred through the permitted activity.

No net loss of function and value due to program permitted impacts is gauged by acreage mitigated based on two assumptions: First, compensatory functions and values will ultimately follow restoration or creation as the mitigation site matures. Second, any variation in resulting compensatory functions and values from the impacted functions and values will "average out" over the entire area of impact and compensatory mitigation. The second assumption requires random variation. Biased variation will have a cumulative effect resulting in net loss of some ecosystem functions and a net gain in others. In the short run this bias could result either in decreased or temporarily increased functional values. As certain services become more scarce in the long run, functional values will ultimately decrease.

The Cowardin et al. (1979) classification is based much on wetland structure. Even though functions are expected to closely align with structure, much functional variation occurs within Cowardin et al. (1979) system categories, depending on how hydrologic, geologic, topographic and ecological processes come together. Forested wetlands, for example, may develop different dominant tree species and different plant compositions resulting in different animal habitats. Even when situated in the same watershed, a forested wetland in a frequently flooded riverine floodplain functions differently from one occupying an isolated basin. A mature ecosystem may require decades if not centuries to become fully created or restored through natural succession.

How waters interconnect and juxtapose with watersheds and other waters and wetlands is critical to their function and value.

In addition, value is affected by the demand for the services supported by system functions. The economic value of ecosystems depends on many factors associated with the distribution of people in respect to the distribution of the services. King et al. (2000) discusses these factors and a conceptual framework for their consideration in permit program processes. The hydrogeomorphic method (HGM) was developed (e.g., Smith et al. 1995) to facilitate regulatory decisions based on functions. However, HGM requires in kind mitigation because the relative functional capacity of different ecosystem types cannot be directly compared.

The effectiveness of this policy is increasingly affected by the difficulty of replacing functions and values through in-kind acreage or functional measures such as HGM. In the past, mitigation adjacent to the impact site usually was regarded as the most effective way to compensate for impact loss as long as mitigation was successful. This eliminated the effects of uncertainties in the relationships between functions and ecosystem classification. It also eliminated uncertainty in relationships between functional values and geographic location. Off-site mitigation was thought to increase the likelihood for altered ecosystem function and demand for services, resulting in uncertain changes in value depending on site locations and mitigation success. On-site mitigation was preferred until results suggested that on-site mitigation was no more certain of successfully sustaining function and value than off-site mitigation. Much depended on site condition and the condition of the servicing watershed (see Appendix C.5 on error in estimating cumulative impacts associated with altered watershed conditions).

The Corps regulatory program has relied on water resource classification, especially by Cowardin et al. (1979) and, most recently, through the HGM (Smith et al. 1995) to guide “in-kind” mitigation. Hydrologic variation was minimized by usually requiring mitigation in the same watershed. For example, the Corps typically would require replacement of impacted forested wetlands by creation or restoration of forested wetlands within the same watershed. However, scarcity of wetlands of the same type and rapid watershed degradation sometimes made in-kind mitigation less feasible than in kind mitigation in different watersheds or out-of-kind mitigation in the same or different watersheds. To do that effectively required assessment of both functions and values. While King et al. (2000) are developing a concept for comparing relative values across wetlands with different functions, the methodology has yet to be tested and published.

C.6.2 Mitigation Success

The methodology for creating, restoring and enhancing wetlands extends back to the development of wetlands for waterfowl use before the turn of the century. With that long history, the mixed results found in recent studies of mitigation success may appear unsettling. However, most early efforts were focused on maximum production of waterfowl and not replacement of all functions in kind for previously lost wetlands. Kentula (1996), Kusler and Kentula (1990), NRC (1995), and NRC (1992, page 316) doubted that certain wetlands can be easily rebuilt, enhanced or created in such a way as to replace natural wetland functions and values. Some wetlands such as prairie potholes are readily restored (Kentula 1996) while others take centuries (e.g., forested wetlands) and some may be impossible to restore or create (Mitsch and Gosselink 2000) in the foreseeable future (e.g. bogs).

Mitigation success has been evaluated in two ways. The more common approach has been to determine how well mitigation sites meet mitigation requirements stated in Corps permits. These typically emphasize structural indicators of function, such as basin form and presence of targeted vegetation. Less common, but more relevant is determination of ecological functioning, such as plant production rates, actual habitat use, and import/export dynamics of nutrients and organic matter. Because there is a great deal of variation in the performance measures used, the rigor of measurement, and the intensity of study of different ecosystem types, past mitigation success is difficult to judge at the national level based on compliance with performance standards. Most studies have been concentrated in coastal areas and especially along the west coast.

Johnson et al. (2000) summarized five recent studies, including their own, reporting compliance rates of 18%, 21%, 29%, 42% and 52%. The average is 32.4%. However, Johnson et al (2000) indicated that compliance success rates were not necessarily indicative of functional success. DeWeese (1994), however, found a positive correlation (r = 0.69) between compliance rating and later functional success. About half of the variation is unexplained, indicating that compliance performance is a relatively weak predictor of ecological performance except when compliance was judged to be poor. Compliance may be good and functional performance still fail. DeWeese (1994) found permits commonly had inadequate compliance criteria for assuring success.

Relatively few studies address how well ecological functions are being performed and most studies are subjective (Ambrose In Press). In a review, Zedler (1996) summarized some of the concerns that remained with compensatory mitigation. A high fraction of studies have been made on salt marsh restoration. The early history of compensatory mitigation produced mixed results, but often were disappointing, such as early attempts in San Francisco Bay (Race 1985). Race and Fonseca (1996) found that even after 10 years of experience and some improvement, compensatory mitigation continued to have a poor performance record.

In a subjective evaluation of function at 30 projects in San Francisco Bay, De Weese (1994) found an average rank of 4.66 out of 10.0 (46%), with 10.0 having quality like that of the better habitat found in reference sites. In another subjective study of California coastal efforts, McEnespy and Hymanson (1997) found a higher performance result, with a rank averaging about C + on an academic scale from F through A. This suggests about 75% functional performance. Allen and Feddema (1996) found a 69% success rate in California but a wide variation between counties (40% to 75%). They found very little difference in the ecological functioning of small and large mitigation projects (73% large and 66% small).

The most quantitative study of mitigated wetland function revealed much lower success for California riverine wetlands. Sudol (1996) applied the hydrogeomorphic method (Smith et al. 1995) to 40 mitigation sites. None of the sites was judged to be totally successful based on functional capacity. Based on the total mitigation acreage, out of 256 acres that appeared to be mitigated, 241 acres failed to function as riverine wetland and 15 acres were partially successful. Sudol (1996) also found that a subjective evaluation of the same sites based on vegetation structure revealed a mitigation failure of only 84 acres and a complete success on 63 acres. This dichotomy of result suggests that other subjective studies of vegetation structure showing relatively high success could overestimate the functional success.

One key measure of success is development of a self-sustaining ecosystem. In the only study of this important measure, Josselyn et al. (1993) found that 55% of 22 restoration projects in California did not produce a self-sustaining ecosystem, meaning that wetland characteristics changed through time. This was true even though they found that 61% of the projects had restored critical functions. These results suggest that what appears to be success based on a criterion of self-sustenance may be transitory for some projects. However, this criterion is difficult to judge because wetlands change naturally as their environments naturally change and as they are naturally colonized by different species.

In one of the few detailed and long-term studies, Zedler and Callaway (1999) found that sediment created from dredge material had failed to become more like a natural reference site after 12 years. However, the fish using the site were similar in composition (Zedler et al. 1997).

The sum of studies indicates 1) variation in the way that success is judged, 2) a relatively low positive relationship between mitigation compliance based on performance standards and ultimate success, 3) a higher likelihood of success based on subjective measures of vegetation structure than on more rigorous measures of function, 4) not all types of wetland loss can be mitigated , and 5) monitoring for more than a decade is likely to be required to ascertain mitigation success for all functions. Substantial uncertainty remains about mitigation success and the Corps regulatory program should consider supporting research to determine the effectiveness of those important aspects of its program based on compensatory mitigation.

C.7 ANALYSIS OF IMPACTS BELOW NOTIFICATION THRESHOLD SIZE

Nationwide permit 26 provides a clear example of an activity with a notification threshold requirement. In 1998, it was 1/3 acre. For nationwide permit 26 in FY 1998, over 60% of the requested verifications were for impacts below the 1/3 acre lower threshold size. The average permitted size for nationwide permit 26 is relatively large compared to other nationwide permit activities. For all nationwide permits, over 88% of the impacts were smaller than 1/3 acre. The distributions of impacts are indicated in Figure C.7-1.

In Figure C.7-1, the distribution of the reported acreage impacted in different size categories for nationwide permit 26 shows the higher than expected reporting below the 1/3 acre reporting threshold. If permittees followed the guidelines closely, all values below 1/3 acre would be zero. Instead, the distribution follows a rate of decline below the minimum threshold size of 1/3 acre slightly less than that expected from extrapolation of the logarithmic rate of decline above threshold size categories. Differences between the extrapolated rate and observed rate of reporting indicate that about 355 acres of additional impact may have occurred below the 1/3 acre threshold—the equivalent of 3,000 authorized development actions having an average impact of about 0.1 acre each. This average impact size and the number of actions are similar to the reported numbers and impact size below the notification threshold. While of limited statistical reliability, the trend suggests that more than half of the below-threshold impact was reported for nationwide permit 26. The extrapolated trend is shown as a natural logarithmic transformation of the curvilinear relationship because it fit the data above the threshold value best of the models examined.

The distribution of impacts for nationwide permits other than nationwide permit 26 indicated no consistent short-fall below the extrapolated prediction of a full reportage of impacts. Nationwide permit 26 appeared to contribute mostly, if not entirely to the below threshold impact that was not reported (Figure C.7-1). Based on the high reporting with respect to that expected for full reporting along the extrapolated line in Figure C.7-2, about the same unreported acreage was estimated for all nationwide permits as for nationwide permit 26. This suggests that nearly all acreage was reported for any permit types other than nationwide permit 26, regardless of notification thresholds, such as for nationwide permits 12 and 14. Utilities and transportation agencies are most involved with these permit types. These distribution analyses support the contention of experienced regulators that most impacts regardless of verification requirement are in fact verified and recorded as impacts.

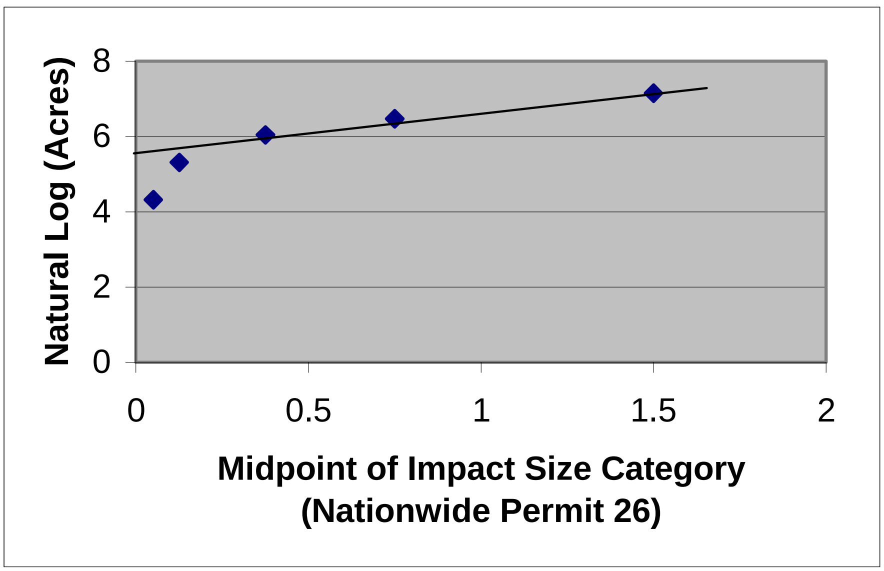

Figure C.7-1 The distribution of impact acres in impact size categories for nationwide permit 26. The size categories are 0.05, 0.125, 0.375, 0.75, and 2.0 acres. The relationship among the three largest size categories is logarithmic. The line is fitted by eye through the three points larger than 1/3 acre and extrapolated to the y axis.

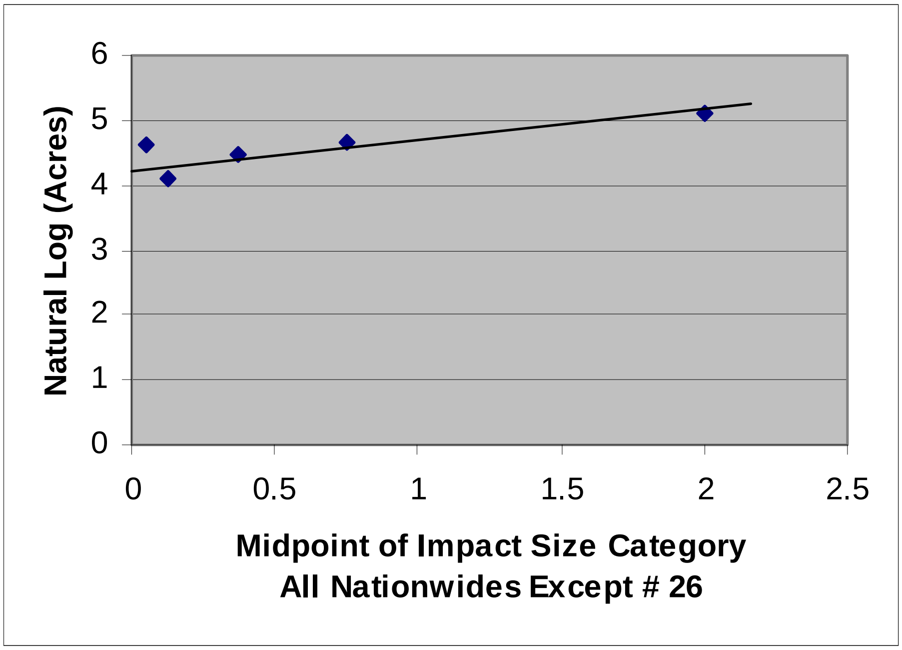

Figure C.7-2 Distribution of impact acres in impact size categories for all nationwide permits other than nationwide permit 26. The midpoints of size categories are 0.05, 0.125, 0.375, 0.75, and 2.0 acres. The relationship among the three largest size categories below 3 acres approximates a natural logarithmic relationship. The line is fitted by eye through the three points larger than 1/3 acre and extrapolated to the smallest impact size category.

For regional general permits (Figure C.7-3), the distribution of permit impacts also indicated high reporting of small impacts and little indication that significant impact occurred below notification thresholds. Based on the extrapolation from larger size categories, about 355 acres, or about 5% of the impact reported in acres, went unreported for nationwide permit impacts. The high fraction of verifications issued for zero impact activities provides additional evidence that a high proportion of below-threshold impacts were processed for Corps verification of minimum impact. These zero impact activities are well below the lower reporting threshold. The estimated 355 acres of authorized impact would expand the acreage of impact estimated in Table 4.2-5 to about 8,475 acres. In addition to the estimated 1,000 acres of impact expressed in linear-foot measures of other waters, the total estimate approaches 9,500 acres impacted by activities authorized by nationwide permits. We assume a similar small percentage would fall below the notification threshold for impacts to other waters measured in linear feet, but the data were not nearly as reliable.

If developers are requesting verification of zero-impact actions to ensure compliance with the law, which seems likely, they are also likely to request verification for real impacts below threshold requirement. In sum, the total below-threshold area impacted is not as great as it would be if developers did not request notification for many below-threshold activities to verify

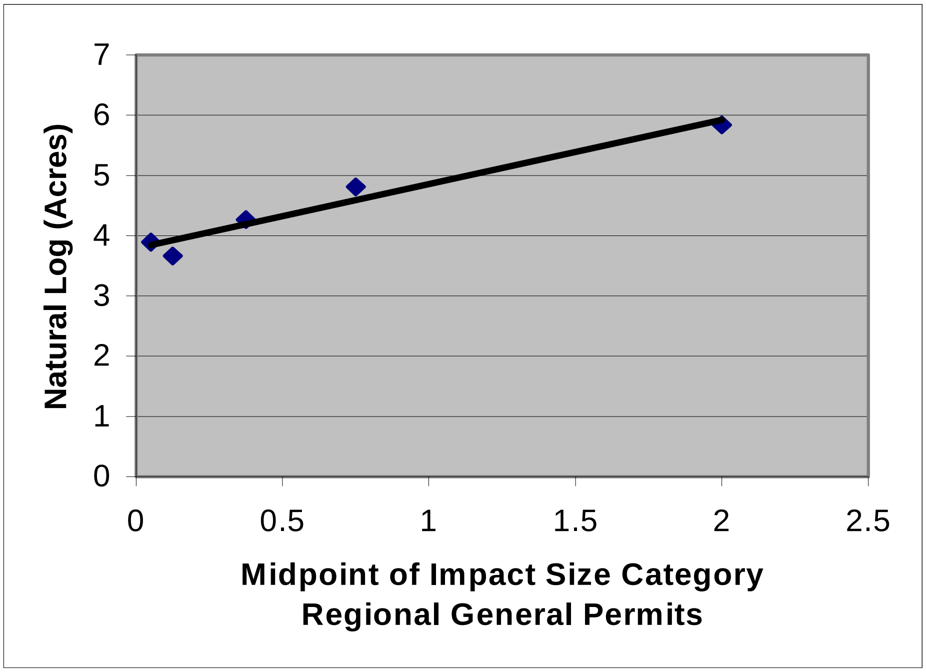

Figure C.7-3 Distribution of impact acres in impact size categories for all regional general permits. The midpoints of size categories are 0.05, 0.125, 0.375, 0.75, and 2.0 acres. The relationship among the three largest size categories below 3 acres approximates a natural logarithmic relationship. The line is fitted by eye through the three points larger than 1/3 acre and extrapolated to the smallest impact size category.

compliance with the nationwide permit and avoid possible violations. This appears to be about 355 acres in total unreported impacts, virtually all for nationwide permit 26. Based on the types of permits with notification thresholds, utilities and transportation agencies appear most likely to report all impacts regardless of whether notification is required

However, these extrapolations are uncertain estimates of authorized impacts below notification threshold. The most reliable way to estimate this impact would be by randomly sampling development sites near and in wetlands. Such data do not exist to our knowledge. Because of the effect of below threshold impacts, we believe the data indicated in Table 4.2-5 are slightly conservative (about 5%) estimates of the total area impacted. With respect to the total program impact this slightly exceeds 1%.

C.8 ANALYSIS OF FY 1998 NATIONWIDE PERMIT DATA FOR PEIS ALTERNATIVES

To determine how the new and modified nationwide permits (Alternative A1) that replaced nationwide permit 26 would affect the relative numbers of standard permits and nationwide permit verifications issued by Corps districts, data from 35 of the 38 Corps districts for FY 1998 were analyzed. Since 1997, Corps districts have been tracking which general categories of activities were authorized by nationwide permit 26. Activity category data collected from May 1, 1997, to December 31, 1997, were used to determine how many FY 1998 nationwide permit activities, including authorized wetland impact acreage, would shift to standard permits as a result of the 1/2 acre limit and the two new general conditions for most of the new and modified nationwide permits.

First, the data for each district were sorted to identify stacked authorizations. Each stacked authorization with a unique permit number was counted a single and complete project. To determine the number of nationwide permit 26 activities and their corresponding wetland impacts would shift to standard permits as a result of the 1/2 acre limit, the wetland impact acreage for each project was summed. Activities authorized by the new and modified nationwide permits that impacted more than 1/2 acre of wetlands were assumed to shift to standard permits.

For those nationwide permit 26 activities that did not shift to standard permits as a result of the 1/2 acre limit, two shifting factors were applied to estimate the number of remaining nationwide permit 26 activities that would shift to standard permits as a result of the new nationwide permit general conditions for designated critical resource waters and fills within 100-year floodplains. For the general condition prohibiting discharges of dredged or fill material into designated critical resource waters and adjacent wetlands, it was assumed that 1% of the total waters of the United States were designated critical resource waters. Therefore, 1% of the nationwide permit 26 activities would shift to standard permits as a result of this general condition. For the general condition limiting fills within 100-year floodplains, it was assumed that 28.4% of the nationwide permit 26 activities (and 28.4% of the corresponding impact acreage) below headwaters would shift to standard permits and 1.7% permits for nationwide permit 26 activities (and 1.7% of the corresponding impact acreage) in headwaters would shift to standard permits.

After applying these shifting factors, the totals of permit shifts and acreage shifts were calculated for the 35 districts.

C.9 DESCRIPTION OF NATIONWIDE PERMITS

Of all the nationwide permits other than nationwide permit 27, which is described in detail in Chapter 4, nine contributed most to either the number of permits or the total impact. They are briefly described here.

NWP 3 Nationwide permit 3 authorizes the maintenance of existing structures. Maintenance dredging and beach nourishment are not authorized. It accounts for 12.5% of the nationwide permit verifications issued in FY 1998 and 10.5 % of the nationwide permit area impacted. Nationwide permit 3 only authorizes the repair and maintenance of existing structures and fills. It requires some impacts near the maintained structures, which are often temporary. However, it is unclear to what extent the permitted area reported under nationwide permit 3 in RAMS is permanent. Activities authorized by nationwide permit 3 often have positive impact on the benefits associated with aquatic resources, such as when a seawall is replaced, reducing unnatural erosion and turbidity, or a culvert is replaced allowing fish passage.

NWP 12 Nationwide permit 12 authorizes utility-line backfill and bedding provided that there is no change in water bottom contours. No permanent impact is allowed in wetlands. This activity mostly involves impacts from trenching for buried utility lines in waters other than wetlands. Excess excavated material must be deposited on upland sites. Nationwide permit 12 comprised 20.3% of the nationwide permit verifications issued and 7.7% of the total area impacted. This permit has no acreage limit. However, any impact length over 500 linear feet requires review as does any proposed impact involving mechanical land clearing of forested areas. Any lines that parallel streams and rivers or involve crossing of Section 10 waters (i.e., navigable waters) require pre-construction notification. Much of the aquatic area impacted under this nationwide permit is likely to involve temporary impact once the utility line is buried. It is unclear how much of the impact is permanent or of extended duration, such as forested land clearing and temporary impacts may have been accidentally recorded as permanent especially for this permit activity.

NWP 13 Nationwide permit 13 authorizes placement of stabilizing structures along shores of waters other than wetlands and other special aquatic sites only where necessary to prevent erosion of the existing bank line. This activity does not authorize restoration of an original bank line to its original location. It does not authorize discharges into wetlands or fills that would impede any water flowing to or from a wetland area. Nor does it authorize discharges into wetlands, mud flats, vegetated shallows, coral reefs, sanctuaries and refuges, or riffle and pool complexes of flowing waters. Another permit type is required for bank stabilization in these special aquatic areas, usually a standard permit. Nationwide permit 13 accounts for 16.8% of all verifications issued and 3.3% of the total area impacted. The average size of each area impacted is relatively small. It is not to be used for channelization and each district is to use discretionary authority to prevent more than minimal cumulative adverse effects. Where high value resources might be impacted, the district may require a regional general permit below the above-stated thresholds, or a standard permit.

NWP 14 Nationwide permit 14 authorizes minor road crossings. The authorized activities cannot impact more than 1/3 acre of waters of the United States and no more than 200 linear feet of the road crossings can be in special aquatic sites, including wetlands. It accounts for 12.4% of all nationwide permit verifications issued in FY 1998 and 2.4% of area impacted. The average size of each area impacted is relatively small. It is limited to individual crossings. There is no limit to the number and acreage of total crossings for linear project activities. Each crossing of a water body (e.g., a stream) could be authorized by nationwide permit 14. A mix of permanent and temporary impacts is likely.

NWP 18 Nationwide permit 18 authorizes minor discharges of dredged or fill material associated with excavation and filling. It accounts for 4.2% of all nationwide permit verifications issued and 5.1% of the total area impacted. It authorizes the discharge of no more than 25 cubic yards below the plane of the high-water mark or high-tide line and no more than 0.1 acre impacted within special aquatic sites below high water mark. Landward of those boundaries only the 0.1 acre limit pertains. However, the average size of the impact reported indicates that a larger threshold is operating.

NWP 21 Nationwide permit 21 authorizes discharges of dredged or fill material into waters of the United States for surface coal mining activities. It accounts for a very low percentage of nationwide permit verifications issued in FY 1998, a relatively high percentage of the total area impacted (9.5%), and the largest individual areas impacted. Both previously mined and unmined areas are included. A bond is required for compensatory mitigation if one is not required by a Federal or state agency. A compensatory mitigation plan approved by the Office of Surface Mining or the state is required. There is no acreage limit. Notification to the district engineer is required for all activities. Each application reviewed by the Corps to determine if the activity, with any required compensatory mitigation, will result in minimal adverse effects on the aquatic environment.

NWP 26 Nationwide permit 26 authorized discharges of dredged or fill material into headwaters and isolated waters. This nationwide permit originated after most other Nationwide permits, in 1984 and was recently replaced with five new nationwide permits. This PEIS evaluation is for procedures as they were carried out during the period from 1996 to 2000 and based on data collected in 1998. At that time, Nationwide permit 26 had a 3-acre upper limit and a notification threshold of 1/3 acre. For linear impacts to stream beds, nationwide permit 26 was limited to 500 linear feet. This nationwide permit was particularly controversial because it authorized many different types of activities. As a consequence, the acreage limit and notification threshold for nationwide permit 26 were reduced in 1996 from previous levels and an intent was stated to eventually replace nationwide permit 26 with activity-based nationwide permits. These activity-specific nationwide permits were issued on March 9, 2000. In FY 1998, nationwide permit 26 accounted for 18.0% of the nationwide permit verifications and 22.6% of the impacted area.

NWP 27. This permit authorizes wetland restoration and creation impacts to aquatic ecosystems as long as there is a net increase in aquatic resource functions and values at the project site. Sometimes existing water resources are unavoidably impacted during creation or restoration activities, such as the loss incurred placing a water control structure for creation purposes. While the relative number of nationwide permit 27 authorizations was small (1.8%) in FY 1998, the total acres reported for fill-related impart was large (19.6%). However, the data for nationwide permit 27 were suspected of exceptional error in over-reporting negative impact. Suspected errors in reporting are discussed in Chapter 4 and Appendix C.5.

NWP 31 Nationwide permit 31 authorizes the maintenance of existing flood-control projects. It authorizes the excavation and removal of accumulated sediment and associated vegetation for maintenance of existing flood control structures. It accounts for a small percentage of nationwide permit verifications issued in FY 1998 and 8.7% of the total area impacted. The average size of impacted area ranks second after nationwide permit 21. There are no specific threshold limits. The district engineer determines a maintenance baseline and can require mitigation.

Remaining Nationwide Permits. The remaining nationwide permit activities accounted for less than 9% of the directly impacted acres in 1998. Their combined mitigation-to-impact ratio was 0.38, which fell far short of full compensation in 1998. There is little indication in the data that these impacts were distributed much differently from the activities with the greatest impact. Therefore, the mitigation for other activities may compensate for the relatively small loss associated with these activities, if mitigation success is high.

C.10 WETLAND VALUES

C.10.1 Values Indicated By Law And Policy

Environmental services have economic value demonstrated by the willingness of people to pay for them either through the market place or through some indirect economic measure such as the travel-cost methodology used for estimating recreational value. Values vary depending on functional attributes and the location of demand for the services they provide. At a national level the value of natural services provided by water resources is recognized most comprehensively by legislation and policy protecting wetlands, endangered species, and water, air and other environmental quality.

The social value of wetland functions and services has become increasingly evident and, in the past three decades especially, numerous local, state and Federal laws have been enacted to protect and restore that value in lieu of private transactions. Water ownership law varies across the nation, but in most places the basins and channels of larger water bodies are either held in government trust or use is closely regulated. Much water resources law is based in the concept of public ownership of the land lying under historically inundated area. However, many smaller water bodies, including most wetlands, are privately owned and are relatively easily converted to other uses by fill and draining.

Heimlich et al (1998) indicated that 77% of the Nation's wetlands are privately owned. About half of the Nation's wetlands, something over 100 million acres, has been converted to other use since the United States was founded (Dahl 1990). Many of the natural services provided by wetlands are diffuse and even on private properties cannot be contained to charge for them (Alvayay and Baen 1990). For example, wetlands on private property might produce migratory birds and fish, less flood-prone drainage, cleaner downstream water and cleaner air far from the private property--all free of charge. Because private owners often cannot easily capture those service values in profit and may have no personal interest in their continuation, the government has to encourage protection and restoration in the regional and national interest through law and economic incentive. The "swampbuster" provision of the Food Security Act of 1985 is an excellent example of government action pertaining to wetlands.

Virtually all coastal states have enacted wetland protection laws and most states recognize wetlands as exceptional resources that warrant protection. The west coast states and New Jersey have especially strong state laws (Ambrose In Press). Florida and the Federal government both recently agreed to contribute half of about $8 billion to water resources management, including the largest-ever wetlands restoration effort. Louisiana is seeking Federal partnership in wetlands restoration of similar dimension. But most protective and restorative activities are smaller and have incremental impact. Many aquatic ecosystem restoration activities initiated under the Water Resources Development Act are wetland focused. The Clean Water Act and the swampbuster provision of the Food Security Act are outstanding examples of Federal wetland protection legislation.

By identifying the Nation's waters for restoration and maintenance, the Clean Water Act confers *de facto* a higher natural environmental value on the Nation's waters than on all of the upland environments for which there is no comparable law regulating discharge and fill activities. Except for local zoning and other state and municipal restrictions, developers are encouraged to convert upland ecosystems to human use as an alternative to impacting wetlands and other aquatic ecosystems. One reason water surface is more highly valued for protection of its natural services is that it is much scarcer than upland—perhaps 7% of the total within coastal boundaries—and its natural services are more easily recognized. Similarly, the Clean Water Act confers different levels of protection need to different types of aquatic ecosystems based a lot on their relative scarcity, but also based on perception of greater natural service value. Special aquatic sites deserve more careful attention, implying more rigorous mitigation of impacts. These special sites typically include most of the shallow-water environments of the United States and those intermittently flooded areas known as wetlands.

All Corps jurisdictional waters are not equally valued with respect to the protection afforded them in the permitting process. The Section 404 (b)(1) guidelines establish a basic resource valuation principle which states: "From a national perspective, the degradation or destruction of special aquatic sites, such as filling operations in wetlands, is considered to be among the most severe environmental impacts covered by these Guidelines. The guiding principle should be that degradation or destruction of special sites may represent an irreversible loss of valuable aquatic resources." Special aquatic sites include sanctuaries and refuges, wetlands, mudflats, coral reefs, vegetated shallow waters, and riffle and pool complexes. Based on Section 404 (b)(1) guidelines, the most stringent permit criteria pertain equally to all special aquatic sites and not exclusively to wetlands as legally defined. By inference, less valuable aquatic resources include most waters too deep, turbulent, rocky, infertile or otherwise too limiting to develop vascular aquatic vegetation. The few exceptions are mudflats, coral reefs, and pool and riffle complexes.

Among special aquatic sites, wetlands have been further identified for the highest level of special consideration in environmental protection law. Congressional and Administrative actions have conferred exceptional value to wetland acres and function by establishing a national goal of no overall net loss of wetlands. All else held equal, this policy emphasis has created a four-tiered resource valuation framework with wetlands in the top tier, other special areas in the next level, other waters in the next to lowest tier and uplands in the lowest level. This structure is not intended to imply that all wetlands are more valuable than all other aquatic and upland environments, but it does imply a higher average value based on the economic tradeoffs demanded by the policy.

C.10.2 Economic Values For Wetlands

The results of economic studies of values assigned by people to wetlands tend to support in general the relatively high value of wetlands compared to other waters and uplands indicated in Chapter 4. Closer examination of wetland value estimates , however, reveals the variation and uncertainty associated with past valuation. Table C.10.2-1 summarizes the estimated values of wetlands found in the review by Heimlich et al. (1998). A disproportionate emphasis of study of wetland economic value has been for fish and wildlife-based services, even though these services are not valued as highly as water treatment and flood damage reduction. This probably relates to the early recognition of fish and wildlife-based services, which are more obvious than flood reduction, water treatment, and water supply services. Perhaps because of this attention, the review presented here indicates that the recreation and commercial fishing values are most reliably estimated and other values of much more uncertain; especially non-use values.

For individual direct services, the lowest estimated values in Table C.10.2-1 include aquifer recharge, food fisheries waterfowl hunting, visual services, and storm protection. These range from $37 to $2,842 per acre. Higher values are associated with sportfishing, water quality improvement, and flood control, which ranged from $7,509 to $35,074 in average value. Among these values, sport and commercial fishery values would be expected to be low in palustrine wetlands, where fisheries are sparse, and higher in riverine and other fringe wetlands. While flood-control value of palustrine wetlands might be expected to be significant, the only two flood-control studies included in Heimlich (1998) were of riverine “wetlands”. These values probably reflect the entire floodplain service and not just wetland services. If so, these wetland values are likely to be inflated.

For studies of aggregate direct services, total recreational fish and wildlife service value

Table C.10.2-1. Estimated mean value (rounded to the nearest $10.00) and range (as reported) of U. S. values for various wetland services reported in a summary by Heimlich et al. (1998). Because of overlap in categories, the sum overestimates the total mean value.

Service	Number of Studies	$/Acre Mean	$/Acre Range	Systems
Commercial Fisheries	7	730	7-1,390	Estuarine 6, Lacustrine 1
Sportfishing	6	7,500	95-28,845	Estuarine 3, Lacustrine 2, Riverine 1
Waterfowl Hunting	4	1,340	156-3,101	Estuarine 2, Riverine 1
Sportfishing and Hunting	10	5,040	156-28,845	Estuarine 5, Lacustrine 3, Riverine 3
Total Fish and Wildlife Recreation	4	2,700	105-9859	Palustrine 2, Estuarine 2
Non-user habitat value	6	121,470	1155-347,548	Not identified
Total recreation	7	3,390	91-4,287	Estuarine 4, Riverine 2
Visual amenities	4	2,720	83-9,910	Riverine 1, Lacustrine 1, Estuarine 1
Water Quality Improvement	4	14,950	1-51,874	Estuarine 1, Riverine 3
Aquifer Recharge	1	40	-	Not identified
Storm Protection	3	2,840	17- 8,435	Estuarine 3
Flood Control	2	35,070	3,916-66,233	Riverine 2

averaged $2,710 per acre and total recreation service value averaged $3,393 per acre. Deducing that recreation other than that based on fish and wildlife is valued as the difference, or $683 per acre, is quite uncertain given the wide range of estimates and small sample sizes. Recreation other than that based in fishery and wildlife use is uncommon, however, and is not expected to equal fish and wildlife values. An average of the 10 U. S. studies that included sport fishing and waterfowl hunting was $5,043 per acre, which is nearly twice the estimated total fish and wildlife recreational value. Presumable this total value includes both non-consumptive (e.g., bird watching) and consumptive (e.g., hunting and fishing) recreational activities, and would be expected to be larger than the consumptive recreation value, adding to the uncertainty of these estimates.

A major problem with past economic studies of individual sites is site representation of the entire range of wetland area providing services. Single sites are rarely chosen randomly. Some expectation of high value per acre often drives such studies. National data available from separate sources based on total or representative values very generally confirms estimates for commercial fisheries and for sport fishing and hunting. Recent surveys indicate, for example, that sportfishing is valued at about $36 billion annually in 1990 economic activity (FWS&CB 1993), dock-side value of food fisheries was over $6 billion annually in the late 1980s (Miller and Johnson 1989) and waterfowl hunters spend about $1 billion annually on their sport (FWS&BC 1993). Even though methods differ, results should be more or less comparable to those determined by multiplying mean value per acre found in individual studies to total contributing wetland acreage.

They appear comparable for food fisheries when only those wetlands most likely to contribute to commercial food fisheries are considered. The life cycles of the majority of food fisheries in the United States are associated with estuarine wetlands. Assuming they were entirely dependent on tidal wetlands, the estimate of $733 per acre for food fish production, which is mostly tidal, would amount to about $3.6 billion for all tidal wetlands, which is reasonable, given that the dock-side value of food fishes has been about $6 billion in recent studies (Miller and Johnson 1989) and many food fishes are more-or-less independent of wetlands.

Also correcting for wetlands that do not contribute much support to recreational fisheries, values for recreational fishing from the national hunting and fishing survey (FWS&CB 1993) compare reasonably to estimates of contributing wetland acreage times the average value per acre in Table C.10.2-1. The sportfishing mean value in Table C.10.2-1, at $7,500 per acre, sums to about $788 billion annually if all of the approximately 105,000,000 acres of wetland in the contiguous United States contributed uniformly to national sportfishing value. This is over 20 times the national survey estimate of sportfishing value and obviously an overestimate. Either the studies overestimated the sportfishing value of the wetlands under study or the wetlands selected for study were exceptionally valued for their sportfishing. The latter is likely because most sportfishing valuation studies are associated with the wetland fringes of estuaries, lakes and rivers rather than the much less suitable but much more abundant palustrine wetlands. If tidal waters were the only wetlands that contributed to sportfishery habitat, the total value of sportfisheries would amount to $37.5 billion (5 million acres times $7,500 per acre), which is much closer to the independent estimates ($36 billion) of national sportfisheries value for 1991 (FWS&BC). Adding lacustrine and riverine fringe wetlands would raise the total acreage of prime sportfishery wetlands, but that additional amount is unknown. They contribute relatively little to the total inland wetland area compared to more isolated palustrine wetlands, however, and probably do not sum to more than a few million acres.

If the mean value per acre ($1,345) in Table C.10.2-1 were representative of waterfowl hunting value, the total national value would be over $141 billion annually. The national survey data indicate a much smaller value in the neighborhood of $1 billion per year. If all wetlands contributed equally to waterfowl hunting use, the documented expenditure by hunters would amount to about $10 per acre, which is much lower than the $1,345 reported value in the literature. It is closer to but still much lower than the lowest study estimate ($156), suggesting a past study bias toward excellent hunting areas. Most palustrine wetlands may not be quite so attractive for hunting purposes as other sites. Only two palustrine wetlands could be confidently identified among the studies summed by Heimlich et al. (1998). These were both prairie potholes treated in the same study, which averaged $438 in non-market fish and wildlife value. The value is lower than average, perhaps because of the isolated location and privately owned status of most prairie potholes, which are especially important for waterfowl production, and because potholes typically have limited fishery value. Many palustrine wetlands are not valued for their hunting use because of their physical form, difficult access, size, low waterfowl use during the hunting season, and other attributes, but do contribute to waterfowl production. Thus the hunting value may be overstated for those many wetlands that provide good hunting but are not very good for producing waterfowl or carrying them over winter. Another complication is the high contribution of Canadian duck production to hunted waterfowl populations, probably decreasing the average United States wetland value for hunting.

The highest average wetland value estimated in the studies summarized by Heimlich et al (1998) was associated with habitat non-use value, which averaged $121,471 per acre over 6 studies. These estimated values varied widely between $1,155 and $347,548 per acre. If all studies were representative of all wetlands, this result would indicate that people perceive 95% of wetland fish and wildlife habitat value to be non-use value. However, much uncertainty is associated with estimated values in Table C.10.2-1. The wide range of estimated values is indicative. But mean values also may be biased. Values studies are rarely motivated by a random selection of representative locations. This is especially true for non-use values.

The highest values for non-use in Table C.10.2-1 appear to have been estimated for areas selected non-randomly because of their endangered resources and other exceptional support services. There is, however, no national data to check against as there are for hunting, fishing and commercial fisheries. However, total United States domestic product can be compared. When expanded to a national level, the non-use "average" value of about $120,000 per acre per year approaches unimaginable dimensions. The 105,000,000 acres of wetland now existing in the contiguous United States would sum to a value of over $12 trillion per year, outstripping the United States domestic product. In reality, few wetlands attain such high value per acre because of outstanding endangered species or other scarce resource; the vast majority do not attain anywhere near that value. The low value in the very wide range, $1,155 is likely to be more indicative of most wetland non-use value, but may still be a high estimate. At a total value of about $115 billion annually based on that low non-use value per acre, the non-use value would vie for value dominance with the $100 billion estimated for the national fish- and wildlife-based recreational activity (FWS&BC 1993).

Values for water treatment and flooding are particularly relevant for the palustrine and riverine wetlands that make up most of the wetlands permitted by the Corps for discharge impact. These values are among the least well developed through economic analysis. The one aquifer recharge study revealed an estimate of $37 per acre. If representative and half of the inland wetlands were associated with recharge rather than discharge (a better estimate appears not to be available), then the total recharge value would approach $2 billion per year. This is a relatively small contribution to the value of wetlands compared to the estimates for water quality treatment and flooding.

Based on the studies summarized here, palustrine wetlands have received relatively little attention from economists. Most studies have emphasized fringe wetlands; especially in tidal areas and the Great Lakes. It is not possible with existing information to more closely estimate wetland values for the majority of wetlands impacted by discharge permitting.

C.11 ASSUMPTIONS ABOUT PERMIT COMPARISONS

C.11.1 Direct Impacts

Corps data are most thorough for nationwide permit activities and for wetland activities. The Corps did not consistently track impacts in waters other than wetlands for individual permits (standard permits and letters of permission) or regional general permits. Nor does it track impacts on upland locations. Accordingly, less certainty is associated with the analysis of the relative impact of different permit types for activities in ecosystems other than wetlands. To a great extent, we have relied on comparison of the relative impacts of different permit types in wetlands to assess relative performance of nationwide permits and other permit types.

The relatively high average service value of wetlands compared to other waters and to uplands, shown in Table 4.4-2, indicates that the focus on wetlands in the database includes over 90% of the natural value associated with the impacted ecosystems. While certain permitting decisions outside wetlands may have had an occasional undocumented impact of exceptional positive or negative value, the scrutiny of wetland impacts is appropriately placed. For the small value involved, less than 10% of the total, any differences in the performance of the four permit types in waters other than wetlands would have relatively minor effect on the outcome of analysis of alternatives to the nationwide permits.

C.11.2 Indirect Impacts

No quantified data on area of indirect impact are available at a national scope. The most typical form of indirect impact appears as water quality change near the direct impact, such as suspended sediment and nutrient transport away from the impact area. While numerous examples of indirect effects have been discovered through research, their areal impact is more difficult to assess than direct impacts and tends to be overlooked except where obvious and adjacent to the location of direct impact. Water quality effects are regulated by the U.S. Environmental Protection Agency, states, or tribes under Section 401 of the Clean Water Act. A Corps regulatory condition for any permit involving discharges of dredged or fill material is compliance with other sections of the Clean Water Act and other relevant laws. Corps regulatory action assumes that water quality law is effectively administered across permit types although the process differs among types.

For general permits, the states may waive certification review for individual applications for certain activities because they determine them to be of minimal impact. For other activities and for standard permits, each individual permit application is reviewed by the state. The Corps leaves the minimization of indirect off-site impacts to state enforcement of water quality standards. All indirect effects may not be addressed by state water quality standards. For any particular state, there are no data indicating that general permits and standard permits differ in effectiveness with respect to reducing off-site water quality impacts.

Other than habitat loss, including death of sedentary life forms, the potential indirect impacts include physical displacement of wetland wildlife, which, except for endangered and migratory species, is regulated by the States. For endangered species, the process includes careful determination of endangered species status including coordination with the Fish and Wildlife Service or National Marine Fisheries Service. Actions must avoid disruption of migratory bird nesting under the Migratory Bird Treaty Act. For most activities, indirect physical-chemical impacts are likely to be temporary and locally contained (i.e., isolated waters), diluted or assimilated. These permit conditions are assumed to be equally applied regardless of permit type.