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A SURVEY OF COMPENSATORY MITIGATION

WITHIN THE TIDAL WETLANDS OF VIRGINIA

SUBMITTED TO THE

VIRGINIA COUNCIL ON THE ENVIRONMENT

BY THE

VIRGINIA INSTITUTE OF MARINE SCIENCE

COLLEGE OF WILLIAM AND MARY

THOMAS A. BARNARD, JR., PRINCIPAL INVESTIGATOR

PAMELA ANNE MASON, LABORATORY SPECIALIST

FEBRUARY 1990

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This report contains the opinions of the project investigators only and is not an official opinion of the Virginia Institute of Marine Science, College of William and Mary.

INTRODUCTION

As the population in the coastal zone continues its rapid expansion, pressures increase to develop wetlands and other sensitive natural areas. One third of the nation's wetlands have been lost in the past 200 years, and presently more than 300,000 acres are lost annually (Hamon and McConnell 1983, Tiner 1984). While much of the loss of wetlands occurs naturally due to subsidence or erosion, the majority of the loss is caused by man's activities in channelization, flood control, agricultural land conversion, and dredging (Farnell 1981, Wakefield 1982). Even though it is generally recognized that wetlands have high ecological value and provide natural services such as water quality maintenance, development pressures continue due to economic factors. In Virginia the number of wetlands permit applications reviewed by the Virginia Institute of Marine Science (VIMS) has increased from 372 in 1980 to 935 in 1989.

During this same time period, both the regulatory and development communities have been looking for methods by which the adverse impacts of wetland development might be mitigated. One method which has seen increased use is that of compensatory mitigation. Generally this is the term used for the practice of constructing a new, similar wetland as compensation for one which is filled or otherwise disturbed by development activities. In theory the new wetland would serve to offset the losses incurred by the environment due to destruction of the natural wetland.

Although the theoretical value of wetlands compensation makes it very appealing and the practice has become increasingly common, it is generally

the subject of controversy due to studies indicating less than successful implementation of the concept in application. Many of these studies are controversial in themselves due to the difficulty inherent in defining what constitutes a "successful" created wetland. Habitat creation is predicated on the theory that man-made systems can function on a par with natural systems. Major difficulties are encountered in determining when created wetlands reach ecological parity with the natural systems they theoretically replace. How does one measure and then compare the function and value of systems which at best are only poorly understood to begin with? Man-made wetlands are particularly poorly understood because the concept is relatively new and very little scientific information is available at present (Shisler and Charette 1984, Race 1985). Many plant species are slow colonizers and may take very long periods of time to attain natural densities and rates of production. In addition, the substrate changes over time as sediments and peat accumulate and different plant species invade the new wetland. During the development period, both plant production and habitat value are generally low (Thayer, et al. 1986). Also, many different types of wetland plant communities, many of which have no history of successful establishment, are being used as compensation with no predictable probability of long-term establishment. As a result, the validity of wetlands creation as a management tool has been questioned (Race and Christie 1982, Knutz 1987).

The appeal of compensation to developers, other landowners and the regulatory community is understandable. It can be looked upon as a form of having your cake and eating it too. If compensation works, development can occur, permits can be issued and at the same time resource loss is

prevented. Some states have adopted mandatory compensation for all wetlands losses. Others have refused to rely on wetlands creation except in rare circumstances. With the adoption by many federal and state programs of the "no net loss" goal for wetlands resources, pressures will very likely increase to employ compensation as one method of achieving the objective. The overall question remains, however, as to how well created marshes restore the functional values of the resources they theoretically replace and how well the compensation concept is implemented on a day-to-day basis.

This study has as its primary purpose an examination of how compensatory mitigation has worked as a wetlands management tool to date in Virginia (i.e. how well theory has been put into practice). Our approach was to look at the overall use of compensation in coastal Virginia based on regulatory records and to examine as many existing created wetlands as possible within the tidal area of the state to determine how closely these projects have come, collectively, to fulfilling the compensatory goal of wetland replacement. Secondary objectives include an examination of the literature regarding wetland compensation concept evaluation and to construct a comprehensive list of wetland compensation sites in Virginia.

LITERATURE REVIEW OF COMPENSATION EVALUATION METHODS

The scientific investigation of compensation projects can be approached from a site specific basis by investigating particular parameters of a single or of several sites. While the literature available on the assessment of mitigation/compensation sites is sparse, several studies have been published. The majority of these studies publish the ecological data

garnered from field research in man-made wetlands; few attempts are made to compare with natural systems. However, some studies (Shisler and Charette 1984, Lindau and Hossner 1981) provide data on natural marshes without making direct comparisons. Studies of man-made sites most often employ typical wetlands ecology field techniques. Most studies address the vegetative community, although a few evaluated fish (Clairain et al 1978), invertebrates (Zedler 1984, Clairain et al 1978, Cammen 1976) and bird use (Zedler 1984, Clairain et al 1978). Very few studies have addressed the abiotic component of compensation marshes, although Lindau and Hossner (1981) did a study on the substrate characteristics of an experimental marsh. Some studies have assessed more than one ecological parameter of man-made marshes. Shisler and Charette (1984) investigated the vegetative community, the invertebrates and the sediment chemistry of several compensation sites in New Jersey.

The criteria most frequently used to assess the vegetative communities included above and belowground biomass (Seneca et al 1985, Shisler and Charette 1984, Broome et al 1982, Cammen 1976), percent cover (Zedler 1984, Clairain et al 1978), density (Broome et al 1982,) and species composition (Broome et al 1982). It is apparent from our survey of the literature that there is little agreement regarding how one measures the success of efforts to establish wetlands of anthropogenic origin. The primary reasons for this are the relatively few investigations attempted and the varying approaches researchers have to defining success in the mitigation arena. The two approaches most often cited are, 1] how well does the created wetland meet the theoretical objectives set for it by its designers and, 2] how well does the new system compare to a similar natural system from an ecological

standpoint. See Appendix 2 for brief summaries of the approaches that are described in the literature.

Because our primary goal involved looking at as many sites as possible rather than a few selected ones, we decided to use the former of the two approaches presented above. We also chose to conduct vegetative cover estimations along with other more qualitative observations at each site. Even if our literature survey had been able to conclusively define how one measures success in a compensation wetland, it would be well beyond the scope of this study.

METHODOLOGY AND LIMITATIONS

This study is a survey of wetland compensation sites created through requirements of the permit process in Virginia. Wetland restoration/creation activities resulting from unpermitted activities were not assessed in this survey. The permit application and project information was reviewed and a data sheet with pertinent project information was generated for each compensation site. Field investigations including an assessment of the vegetative community were done at selected sites. Because there is no single list of sites or agency which tracks projects as they are permitted, each regulatory body in the state was petitioned and a list of compensation projects, potential survey sites, was generated from the responses of the 31 extant wetlands boards, the staff of the Virginia Marine Resources Commission (VMRC) and personnel of the Regulatory Functions Branch of the Norfolk District of the Army Corps of Engineers (COE). Personal communication and files maintained at the Virginia Institute of Marine

Science (VIMS) provided further information. The project list developed during this study is probably incomplete. Staff personnel changes over time and the lack of organized records make it a virtual certainty that projects with wetland compensation have been lost from the collective institutional memory.

The resulting list of potential compensation survey sites has 51 entries. This inclusive list was examined to determine which of the potential sites were suitable to be surveyed as part of this study. Sites eliminated were those which were too recently permitted or had had less than two years of growth. Also eliminated from sampling due to time constraints and their minimal size were 11 sites under 1,000 square feet in total area. Logistic problems, the inability to locate the site or gain access, removed 5 sites from the list. Because there is no agency tracking of compensation projects, many problems were encountered in trying to evaluate project objectives versus the outcome based on permit file data. Evaluation of a number of projects had to be eliminated or cut short for these reasons. The result was 32 sites visited.

Percent cover estimates were made at each of the compensation sites and where possible at adjacent natural sites. The time required to use this method allows for an assessment of planting successs in a comparatively short time. With the potential of over 50 sites meeting the requirements of this survey, the percent cover estimate was the most feasible method available. The same number of samples were taken in the compensation and natural sites. In highly developed areas, the compensation sites were often isolated and lacked any contiguous natural wetlands. A few sites were adjacent to natural wetlands of totally different vegetative community

character. In these cases, no cover estimate was determined for a natural site.

Transects were established in a shore normal alignment where possible. This was to decrease the influence on the sample of any differential effects of varying tide levels and increasing elevation, and usually resulted in transects running toward the tidal source and away from the upland construction access. For smaller sites, samples were taken every 5 meters along the transect and every 10 meters for larger sites. Several rectangular sites were easily sampled along one or two transects, while larger or odd shaped sites required more transects to provide a representative sample. Sample quadrats were delineated using a 0.25 m hoop. Visual estimates of percent cover of each species were made by two investigators to minimize the subjective nature of this sampling method.

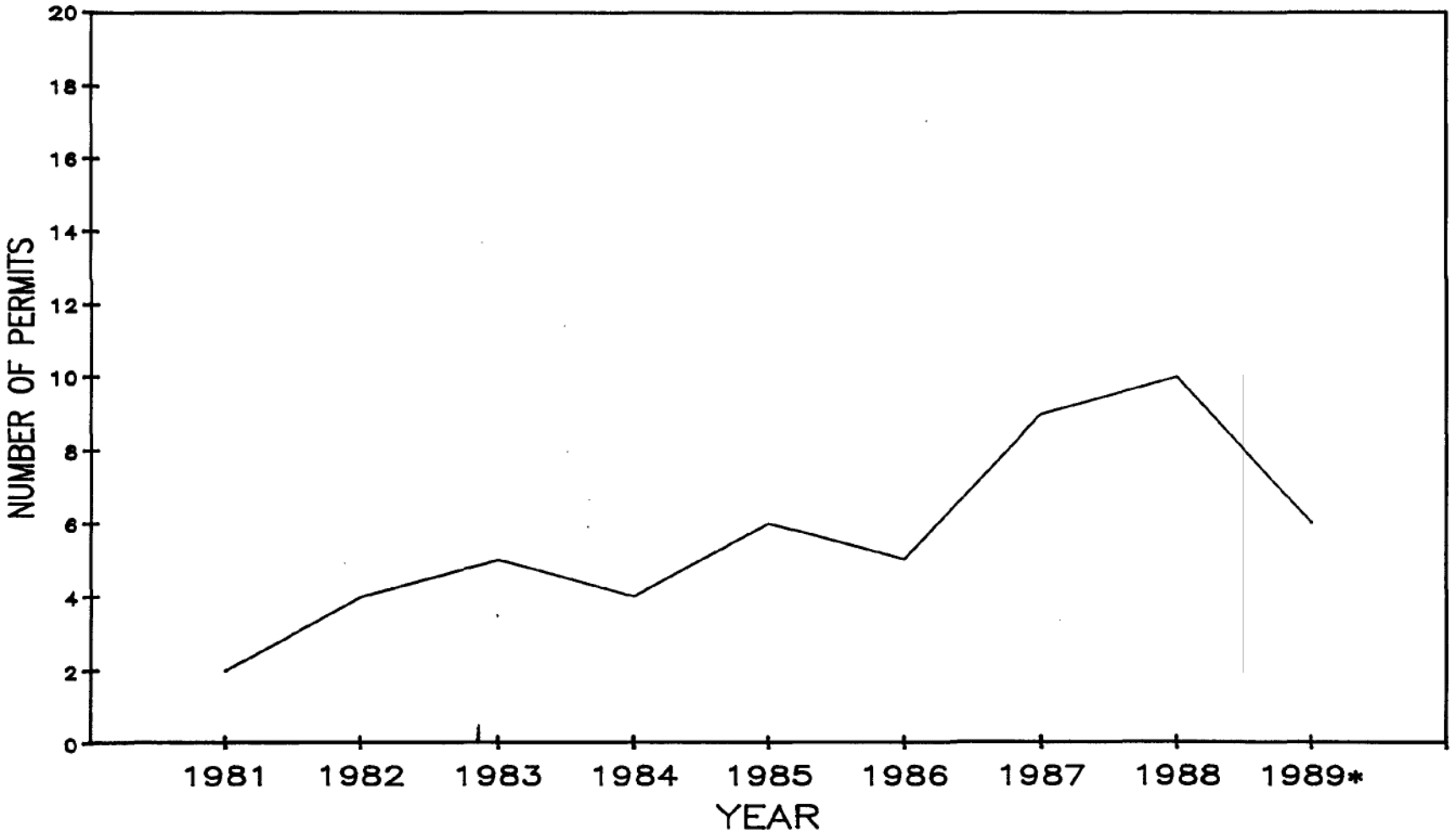
RESULTS AND DISCUSSION

A total of 51 compensatory mitigation projects were identified as a result of this survey. Each of these is numbered and described in a table in Appendix 1. Because there is no central record keeping system, the authors attempted to make this list as complete as possible. It is our belief, however, that there are a few projects which have been lost from the various institutional memories over the years. An additional problem encountered while developing the tables in Appendix 1 was the general variability of available information in the permit files on proposed wetland compensation projects. Two projects could not be located in the field due to incomplete or conflicting information available regarding their

locations, dimensions, etc. Five other projects could not be considered due to incomplete file histories. The earliest permitted wetland compensation projects identified in our survey were two which were authorized in 1981. Although somewhat variable, the number of permits issued involving wetland compensation increased generally on an annual basis between 1981 and 1989 (Figure 1). It is not possible, given the data available, to determine whether the increase in compensation projects reflects an increase in popularity of the practice among the regulatory community or whether it is accounted for simply by the increase in the total volume of permits which also climbed steadily during the same time frame. Ten compensation permits were issued in 1988, the most for any year in our survey. The permit data for 1989, the year of the survey, were incomplete. The average number of compensation projects permitted annually since 1981 was 6.3.

Since wetland compensation was first permitted for use in Virginia in 1981, a total of 32.3 acres of man-made wetlands has been ordered as compensation for projects impacting a total of 31.3 acres of aquatic habitat. The former total assumes all compensatory mitigation was successfully constructed. The latter number is based primarily on permit application data and impact reports of the Virginia Institute of Marine Science, Wetlands Advisory Group. The average size mitigation area permitted was 0.68 acres. If, however, the seven projects over one acre in size are deleted, the average man-made wetlands is 0.12 acres. The latter average is more indicative of the size projects generally constructed since a total of 43 compensation projects are below one acre in size and 9 are

WETLANDS COMPENSATION STUDY
COMPENSATION PROJECTS PERMITTED ANNUALLY: 1981-1989



* 1989 data incomplete

FIGURE 1

below 1,000 square feet. The seven large projects mentioned above account for 79% of the 32.3 acre wetland compensation total.

The theoretical acreage figures for man-made vs. natural marsh, presented in the foregoing paragraph, demonstrate an overall mitigation ratio of slightly greater than 1:1. The actual numbers from permit files are shown in Figures 2 and 3. These data demonstrate that ratios of 1:1 or less than 1:1 were the rule and were permitted 60 percent of the time. If all projects were constructed successfully, these figures would indicate a slight gain in wetland acreage. In general, a minimum ratio of 1:1 is required with some agencies recommending 1.5:1 and 2:1 when the wetland being lost is high in functional value or rare in occurrence. Project sponsors often offer to create wetlands in greater than 1:1 ratios in order to make their projects more appealing to regulatory authorities. This accounts for the greater than 1:1 overall ratio from the permit records.

Smooth cordgrass, Spartina alterniflora, was the vegetation planted or seeded in 83 per cent of the projects permitted (Figure 4). Areas were permitted to naturally revegetate in only 6 percent of the permits. Since this survey only covers tidal areas and in general smooth cordgrass has the highest planting success rate, these figures are not surprising. The use of smooth cordgrass would also be expected since it is a vigorous plant that spreads rapidly via rhizome growth. It can be established via plugging or seeding.

Eighty percent of the permits issued requiring wetland compensation were issued for construction "onsite". "Offsite, same basin" and "offsite" accounted for the remaining twenty percent (Figure 5). If implemented as

WETLANDS COMPENSATION STUDY
HISTORICAL MITIGATION RATIOS
1981-1989

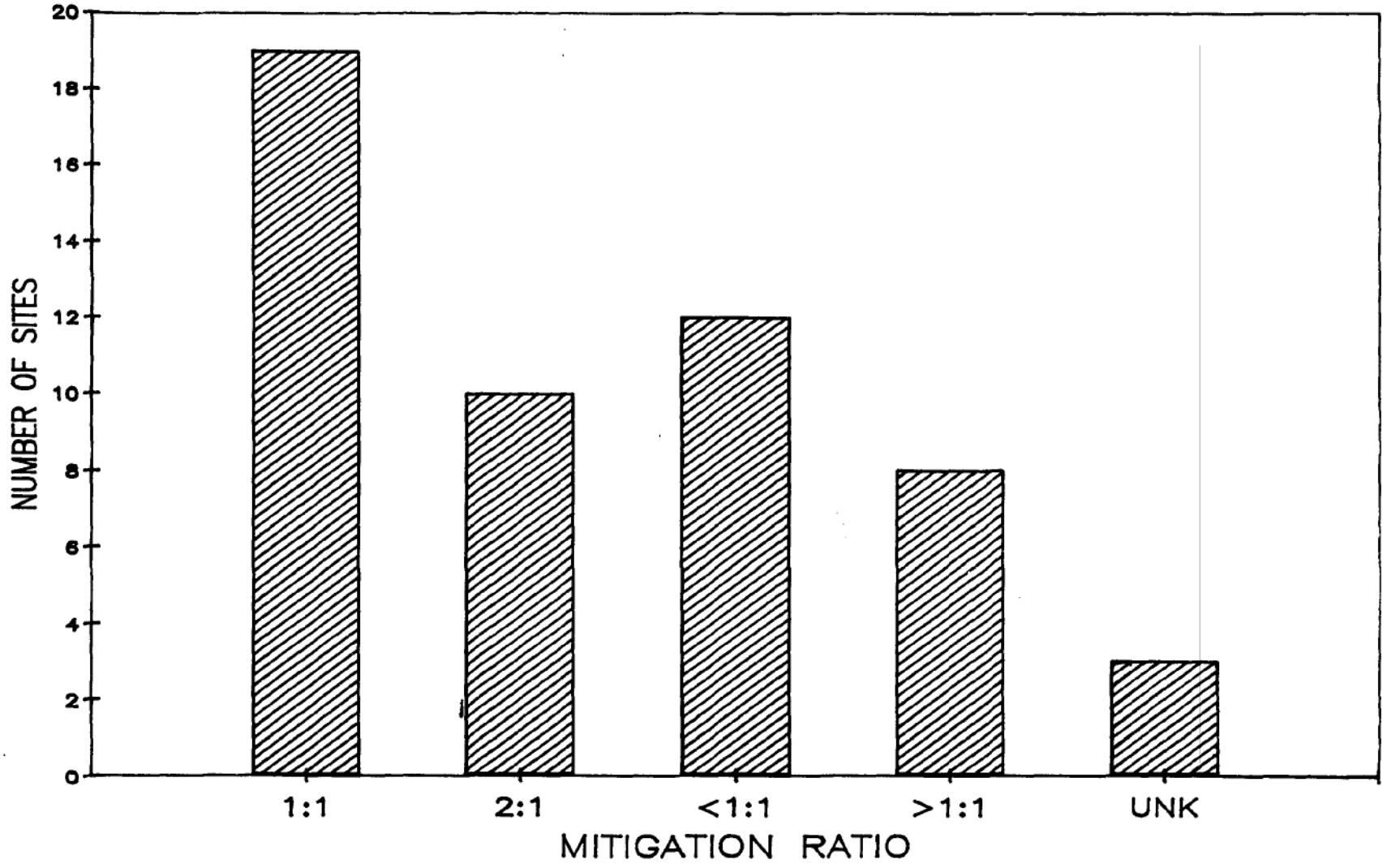


FIGURE 2

WETLANDS COMPENSATION STUDY
HISTORICAL MITIGATION RATIOS
1981-1989

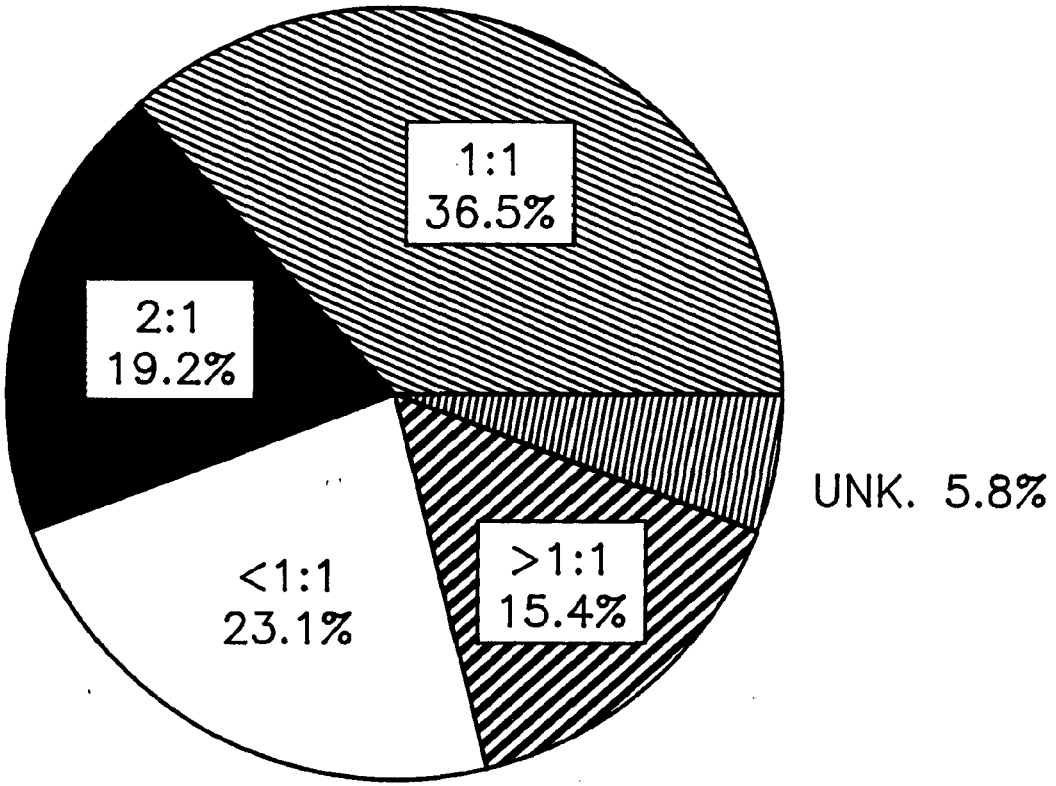
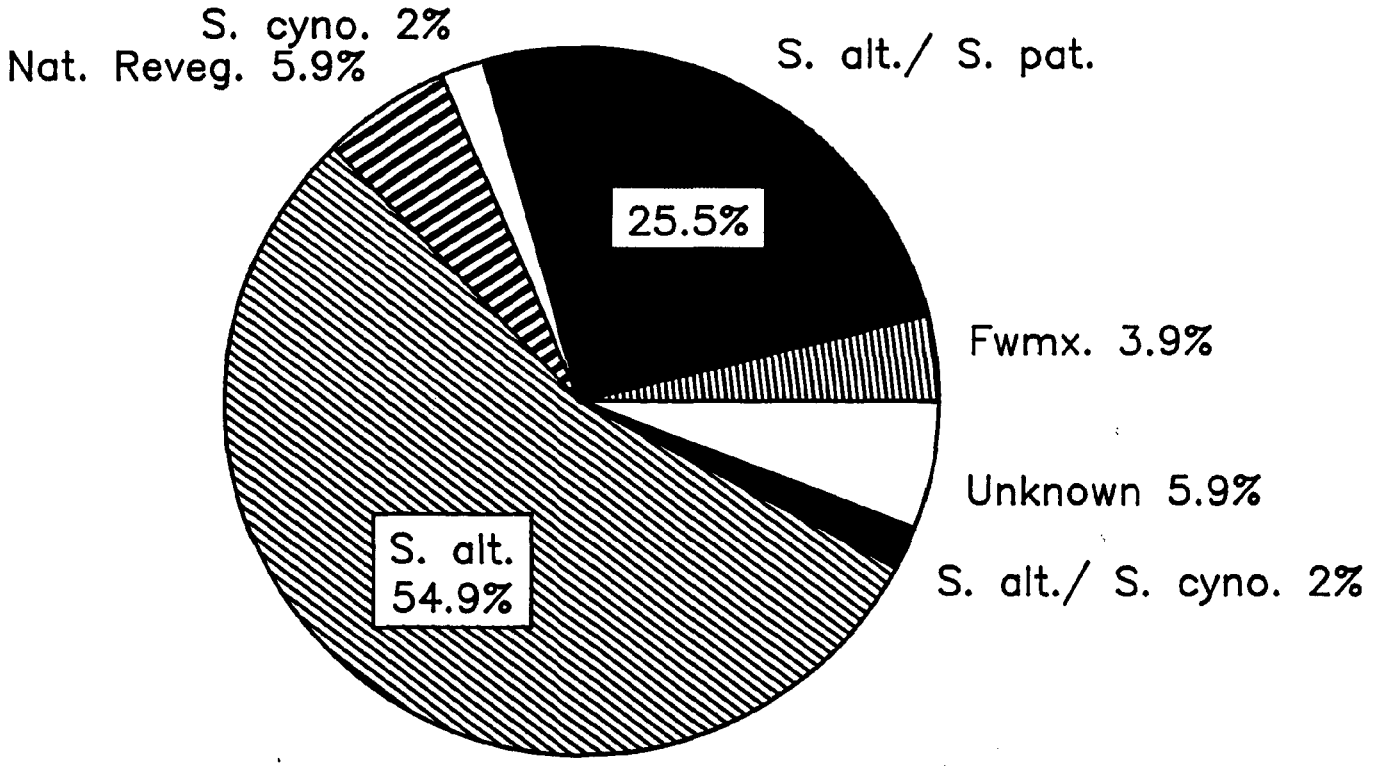


FIGURE 3

WETLANDS COMPENSATION STUDY
SPECIES PLANTED



Fwmx = freshwater mixed wetland community.

FIGURE 4

WETLANDS COMPENSATION STUDY
COMPENSATION SITE LOCATION

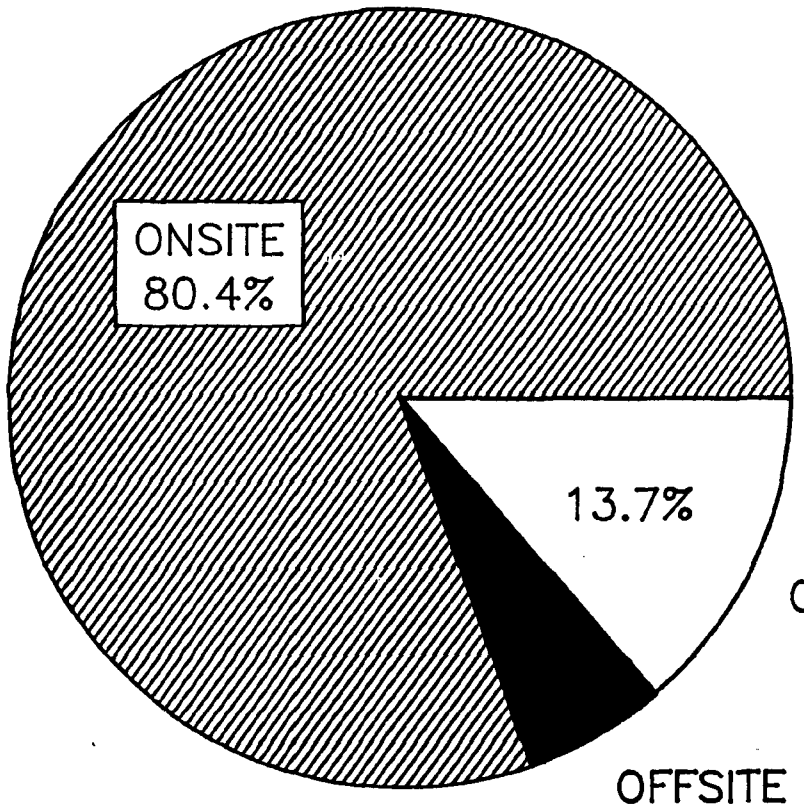


FIGURE 5

permitted, these figures indicate the generally accepted prioritization for these three choices of location are being followed in the tidal areas of Virginia.

Data on the general site character of areas permitted to be used for compensation are presented in Figure 6. Seventy percent of the permits issued required the grading down of uplands, while thirty percent involved the use of both upland and wetland, wetland only or the use of subaquatic habitat. These data indicate that if all projects are constructed as proposed, something less than thirty percent of the projects will involve the construction of wetlands on some type of existing marine habitat. To the extent that this occurs, it negates the compensatory aspects of these projects. The permit record data regarding site characteristics was often quite incomplete. Some of the permit files seemed to indicate that projects may have involved restoration of disturbed areas in some cases rather than purely wetland for wetland. In other cases it was clear that one marine habitat such as subaquatic bottom or higher elevation marsh was used to create a different marsh community for compensatory mitigation purposes.

The following are descriptions of site surveys at 21 compensation marshes. An additional 10 sites were visited during the study period, but are not reported because they were not constructed, could not be located or the landowner did not grant permission to view the site. Description of these sites is included with the general discussion. The descriptions are numbered to correspond to the numbers on the data sheets in Appendix 1. The data sheets have been generated from details available in the project permit files. The information on the data sheets is from site visits as well as

WETLANDS COMPENSATION STUDY
COMPENSATION SITE CHARACTER

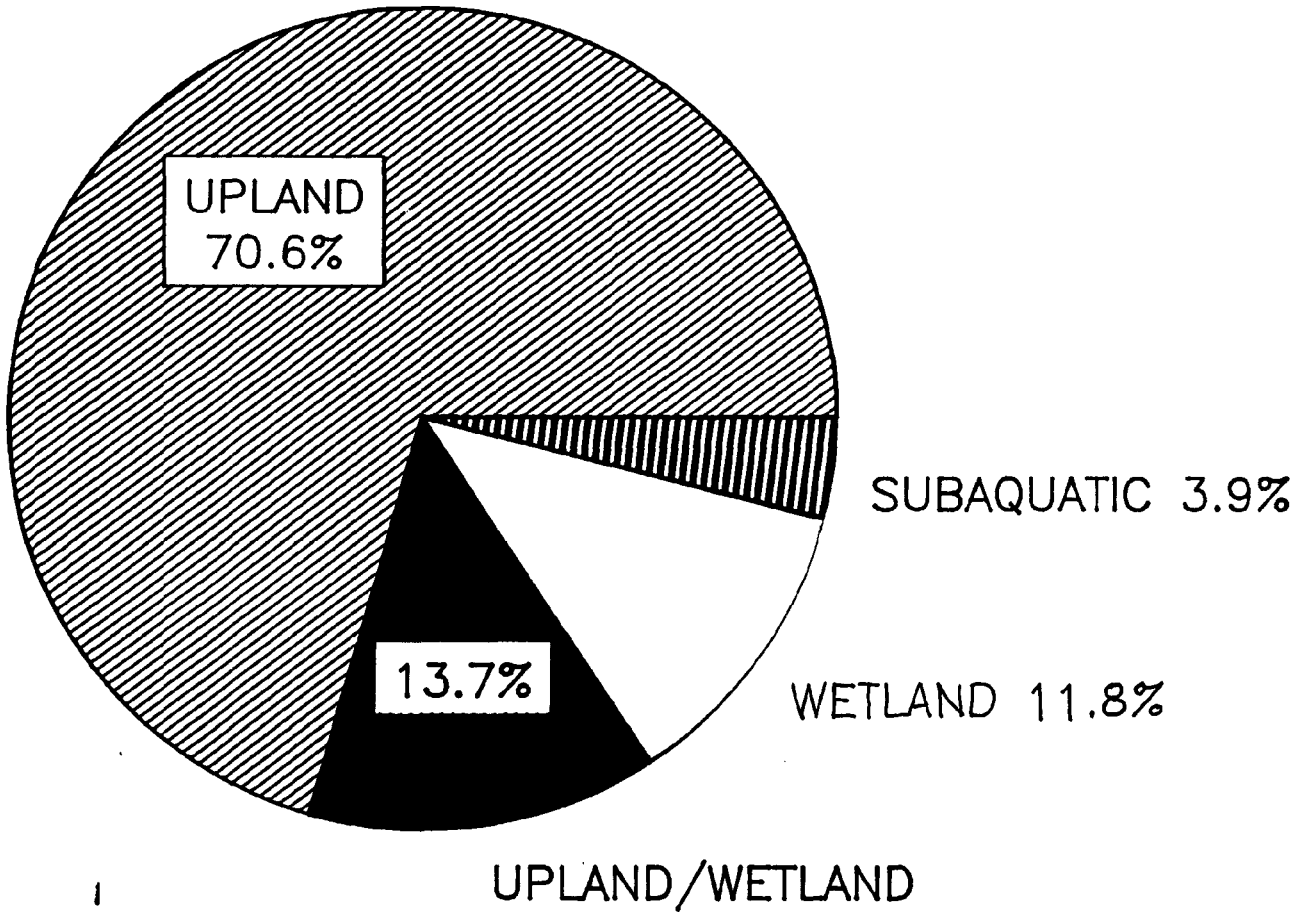


FIGURE 6

from the permit histories available from the regulatory agencies.

Site one was sampled for a percent cover estimate on October 25, 1989. The project information indicated that this site is 5 years old. The mean cover was estimated at 34 percent. The site was dominated by Spartina alterniflora, the species specified in the project plan. However, excessive deposition from an eroding upland slope has apparently increased the relative elevation of part of the site. In the areas of higher elevation the dominant vegetation was Salicornia species. An unvegetated zone was present between the two vegetative communities. There was no observed organic accumulation on the marsh surface. The areal measurements indicated the site was constructed according to the project plan. There was no obvious evidence of faunal use. Phragmites communis was not present at the site. An adjacent natural marsh dominated by S. alterniflora was surveyed and estimated to have a mean cover of 58 percent. The mean cover estimate in the natural marsh was significantly higher than that of the man-made marsh, $P < 0.01$ ($t = 7.943$, $df = 16$). Approximately 20% (1200 sq. ft.) of the created marsh was not vegetated.

The second site was sampled for cover estimates on October 10,1989. The mean cover was 47 percent. Visual observation indicated the project was constructed in 1987 according to the project plan. The dominant species were those planted, S. alterniflora and S. patens. The vegetative cover in the short form Spartina zone was relatively high. There was some evidence of vandalism affecting the graded elevations and thereby affecting the vegetative community development. The site is being used as a feeding area by great blue heron. No Phragmites communis was found at the site. An adjacent natural site, dominated by S. alterniflora and S. patens, was

sampled. Its percent cover was estimated at 57 percent. The natural marsh cover estimate was not significantly higher than that of the created wetland, $P < 0.01$ ($t = 1.707$, 18 df).

Site 3 was sampled for vegetative cover on September 27, 1989. This site was constructed in 1984. Cover was estimated at 24 percent. The vegetative distribution was very patchy with the plants growing mostly along the upland wetland interface. S. alterniflora and S. patens, the species planted, were dominant; however, the large unvegetated area was being invaded by Distichlis spicata and Salicornia species. The site was constructed according to size specifications of the project plan. There was no organic accumulation and the sediment was dry and hard. The lack of organic accumulation and the low vegetative cover appeared to be due to the marsh being planted at an elevation above normal tidal range. There was extensive use of the site by various fiddler crab species. No P. communis was found at the site. Approximately 9600 sq. ft. of the 12,000 sq. ft. total for this site was unvegetated. The site will need to be reworked if a viable marsh is to be established.

Site 4 was investigated on August 9, 1989. This compensation site has been developing for 4 years. Mean vegetative cover was estimated at 50 percent. This site includes a large unvegetated freshwater pond which was excluded from the cover estimates. It was beyond the scope of this survey to accurately verify the areal extent of the site as meeting the requirements of the permit. No project plan was available to indicate construction design or species planted. The vegetative community was very diverse, the most diverse of all the sites visited, with more than 24 species identified (Table 1). This site was unique to this study in the

type of vegetative community present. The standing water associated with the pond allowed for invasion of many freshwater species and there were also hardwood tree seedlings growing along the pond edge. At present, the only negative aspect regarding this compensation project is the fact that it is a freshwater non-tidal wetland and yet was created as mitigation for the filling of a tidal brackish water marsh located in a separate drainage basin.

A mean cover estimate of 49 percent was determined for site 5 sampled on August 22, 1989. The wetland is 5 years old. The site appeared to conform to the size specifications of the permit plan. Vegetative species at the site were S. alterniflora, S. cynosuroides, Scirpus robutus, Pluchea purpurescens, S. patens and D. spicata. Phragmites was invading along the upland edge of the site. The site was well vegetated, but there was an area of sparse vegetation as well as approximately 1500 square feet which was not vegetated. The substrate along the unvegetated upland edge was very dry and there was little organic accumulation. This would indicate that the elevation is above normal tidal range. Sampling an adjacent natural marsh dominated by S. alterniflora, S. patens and D. spicata gave a cover estimate of 71 percent. The compensation site had more than twice the species of the natural site. This would indicate that during development unvegetated areas are easily invaded by many species, even if they are not well represented in native wetlands. Were it not for the relatively bare, upper elevation edge areas, this would be by our measurements a well established wetland. Cover estimates for both man-made and natural marsh were not significantly different, $P < 0.01$ ($t = 2.616$, $df = 14$).

A mean cover estimate of 39 percent was determined from a visit to site 6 on June 13, 1989. Project plan information indicates that this site was created in 1985. The dominant species planted, S. cynosuroides, was not the dominant species in the cover samples. The dominant species sampled was Scirpus robustus. Of the three species represented in the cover samples, S. cynosuroides provided the smallest contribution to total vegetative cover. This indicates that the S. cynosuroides was difficult to establish allowing for invasion by other species. The site appeared to be constructed according to a revised permit plan. There were originally to be two sites created for compensation for impacts at this location. The second site of 2150 square feet was never planted. The first site was enlarged in order to eliminate the need for the second site. An area along the upland edge of the site was therefore graded and planted at a later date than the original construction. This was to increase the total area to be accounted for as compensation. This newer area, about 1200 square feet, was planted with plugs which were mostly saltbush, but other species (D. spicata, A. cannabinus and Salicornia spp.) were also present in the plugs. The plugs appeared healthy, but would take a long time to cover the unvegetated area. The plugs were planted on 6 foot centers resulting in sparse cover for an area of about 1200 square feet. This area was excluded from the cover samples. P. communis did not appear in the cover samples, but it was present and could become a factor as an invader. An adjacent natural marsh was sampled and determined to have a cover of 59 percent. This was not significantly higher than the man-made, $P < 0.01$, ($t = 1.402$, $df = 12$).

A site investigation was conducted on June 13, 1989 at site 7 planted in 1987. Vegetative cover was estimated at 32 percent. Measurements

verified the construction of the site according to the project application. The site was dominated by the species planted, S. alterniflora and S. patens. The S. patens was not spreading well and areas where it was planted had low vegetative cover and little organic accumulation. Large portions of adjacent marsh were vegetated by P. communis and this species was invading the compensation site. There were several types of animal tracks on the marsh surface including raccoon, ducks and egret. An adjacent marsh dominated by S. patens and saltbush was estimated to have a vegetative cover of 62 percent. This was significantly higher than the man-made marsh, $P < 0.01$ ($t = 2.933$, $df = 16$). The difference in cover may be explained by the fact that the new marsh was only 2 years old. It was, however, also being impacted by runoff from adjacent slopes.

Site 8 was sampled for vegetative cover on September 26, 1989. This site is 4 years old. The cover was estimated at 51 percent. Visual observation indicated the site was constructed according to the project plans. The site was well vegetated and dominated by S. alterniflora. Variability in the elevations of the marsh surface was reflected by the vegetative community. Where the substrate was less saturated and firmer the plants were about 5 feet in height with a dense distribution. Where the elevation appeared lower, as indicated by saturated, mucky soils, the plants were quite tall (7 feet) and not as dense. Other species present, but not represented in the cover samples include A. cannabinus, A. patula, A. tenuifolius and P. communis. Muskrat runs were ubiquitous at the site, as were red-wing blackbirds. This marsh was established at the toe of a large berm behind which a landfill was operating. Sediment erosion from the berm had adversely affected the man-made marsh to an unqualified extent. The site

is rather isolated and there were no natural sites available for cover estimates.

Site 9 was visited on September 26, 1989. The site constructed 7 years ago is over 8 acres in area. Due to the size and complex communities of this site, it is beyond the scope of this study to estimate vegetative cover. Very limited cover sampling was done and the estimate of 59 percent cover only represents one community type at the site. The community sampled was dominated by short form S. alterniflora, A. tenuifolius and P. communis. Several species present were not represented in the sampling including P. purpurascens, I. frutescens, B. halimfolia and H. moscheutos. The site is generally a stable, well vegetated marsh. The P. communis is present in the higher elevations at the site and along the upland edge. Most of the site is vegetated with medium height S. alterniflora. Heavy muskrat activity was indicated by the large number of muskrat runs and grazed areas. The site supported a large fiddler crab population. Based on our limited analysis, this marsh appeared to be successfully established.

Site 10 was investigated on October 11, 1989. The site was built in 1986. Vegetative cover was estimated to be 52 percent. The site was well vegetated with little area unvegetated. The man-made marsh was dominated by S. alterniflora, the species planted. Species either sampled or observed were T. latifolia, T. angustifolia, Juncus effusus, Scirpus validus, Scirpus americanus, Scirpus robustus, Amaranthus cannabinus, Aster tenuifolius, Pluchea purpurescens, Atriplex patula and Phragmites communis. Although no drawings were available, project information indicated that 6160 square feet of this site was to be unvegetated wetlands. The unvegetated wetlands could not be identified on the site visit. It had apparently been invaded by the

wetland grass species. Even though the nonvegetated portion of this plan had been taken over by marsh grasses from the planted areas, this project was not adversely affected. It does serve to point out, however, that all projects do not turn out as planned. This may or may not affect the successful establishment of the wetland.

Site 11 was visited on September 15, 1989. While the most recent project plan available indicated one 7000 square foot compensation site, two man-made marshes identified at the site were sampled. The sites were most likely created in 1986. The total area of both sites together falls short of the required compensation by 1300 square feet. The cover estimate was determined to be 41 percent. The vegetative community was dominated by S. alterniflora and the only other species sampled was Distichlis spicata. Species not represented in the cover samples were Atriplex patula, Aster tenuifolius and Limonium carolinianum. Phragmites communis was beginning to invade at one of the sites. The sites lacked organic accumulation and eroding upland banks were providing a sediment supply for deposition on the marsh surface. The marsh surface adjacent to the eroding bank was dry while the rest of the site was wet or even had standing water. The apparently higher, dry areas were vegetated by D. spicata. The site was providing habitat for large fiddler crab and marsh periwinkle populations. Neighboring marshes differed greatly in vegetative community and were not sampled for determination of a cover estimate.

Site 12 was sampled to determine a vegetative cover estimate on July 26, 1989. The available project plan had been outdated through the normal process of project revision. This was not discovered until the sites could not be located using the available plan. The compensation site was located

through contact with a local staff person familiar with the project. The site, about 2 years old, appeared to be the proper size and configuration. Mean vegetative cover was estimated at 33 percent. S. alterniflora, the planted species, was dominant. Phragmites was present as an invader. The vegetation was particularly sparse in an area of dry, inorganic sediment. This area was covered with rocks. The presence of the rocks would indicate a relic deposit was unearthed during the grading process. The presence of fiddler crabs and common egrets, along with deer and raccoon tracks was evidence of faunal use of the site. The native marshes are dominated by saltmeadow, but a cover estimate of the natural S. alterniflora community was 64 percent. This is significantly higher than the cover estimate for the anthropogenic wetland, $P < 0.01$ ($t = 4.188$ df 34).

Site 13 was investigated on June 27, 1989. The site was estimated to have a vegetative cover of 46 percent. The marsh was created 2 years ago. Aside from a little Distichlis spicata the marsh was a monotypic stand of S. alterniflora. The cover sampling was quite difficult due to the unstable substrate. According to the project plan the compensation was done on some degraded wetlands and probably some that had been previously filled. This could explain the apparent high sediment accumulation and unstable substrate. Visual observation indicated the site was constructed according to project application. There were several large unvegetated areas; however, the total unvegetated area was not determined. These mud-flat areas, mostly adjacent to the tidal creek, may indicate that the elevation is too low to support the planted vegetation. Killdeer and marsh rails were observed at the site and fiddler crabs were abundant. A neighboring wetland

dominated by S. alterniflora had a cover of 73 percent. The two cover estimates are significantly different, $P < 0.01$ ($t = 4.028$, df 33).

Site 14, built in 1986, was sampled for vegetative cover on September 12, 1989. The mean cover was estimated at 62 percent. This site was well vegetated with a healthy stand of the planted species S. alterniflora. Several invading species present included Atriplex patula, Pluchea purpurescens, Amaranthus cannabinus, Spartina cynosuroides, Spartina patens and Distichlis spicata. The site had been a Phragmites marsh that was graded down and sprigged with Spartina. A large stand of Phragmites had established along the upland slope and the plant was also scattered throughout the site. The nearby marshes were dominated by Phragmites and saltbush so were not sampled for a cover estimate. Based on our limited survey criteria, this was a successfully established wetland.

Cover estimate sampling was done at site 15 on September 12, 1989. The compensation site was created 4 years ago. The mean vegetative cover was 41 percent. The site was dominated by S. alterniflora and the only other species sampled was A. tenuifolius. There was a significant amount of debris on the marsh surface impeding vegetative community development. A fairly large portion of the site had standing water at low tide. The area of standing water had very low vegetative cover relative to the adjacent areas. In addition, the S. alterniflora plants appeared stunted and chlorotic. These characteristics may indicate low substrate elevation and/or excessively high soil salinities. Phragmites was not present at the site. However, Phragmites is established in the neighboring wetlands and could begin to invade this disturbed site. There was a large fiddler crab population present. The site appeared to be constructed to the size

required in the permit, although no plans were available for direct comparison. An adjacent Spartina marsh had a mean vegetative cover of 52 percent. The two cover estimates were not significantly different, $P < 0.01$ ($t = 1.717$, df 14).

Site 16 was investigated on September 12, 1989. Vegetative cover at the site planted in 1987 was estimated at 49 percent. Spartina alterniflora was the dominant species and the species planted. The few invading species were Pluchea purpurescens, Amaranthus cannabinus, and Atriplex patula. Phragmites was also present along the upland edge. The site is quite irregular in shape and difficult to measure to verify construction plans; however, a visual estimate confirmed the site was constructed according to application requirements.

Site 17, created 5 years ago, is a large brackish wetland. The Spartina alterniflora dominated site was estimated to have a mean cover of 46 percent. There is some question, yet to be resolved, as to whether the site meets the size requirements of the permit. Some of the controversy stems from the delineation of the landward edge of the site. The City of Norfolk has found the site to be 1.1 acres smaller than that required as compensation. The site is an effective faunal habitat housing fiddlers, blue crab, birds and many species of fishes. An adjacent natural site was determined to have a mean vegetative cover of 64 percent. This site was the subject of intensive monitoring in a separate study (Priest, 1989).

Site 18 was visited on September 27, 1989 and qualitatively defined. This site was constructed in 1986. The vegetative cover at the site was not sampled due to high water. The site was to have been 4500 square feet in area rather than the existing 2400 square feet. Approximately 2,000 square

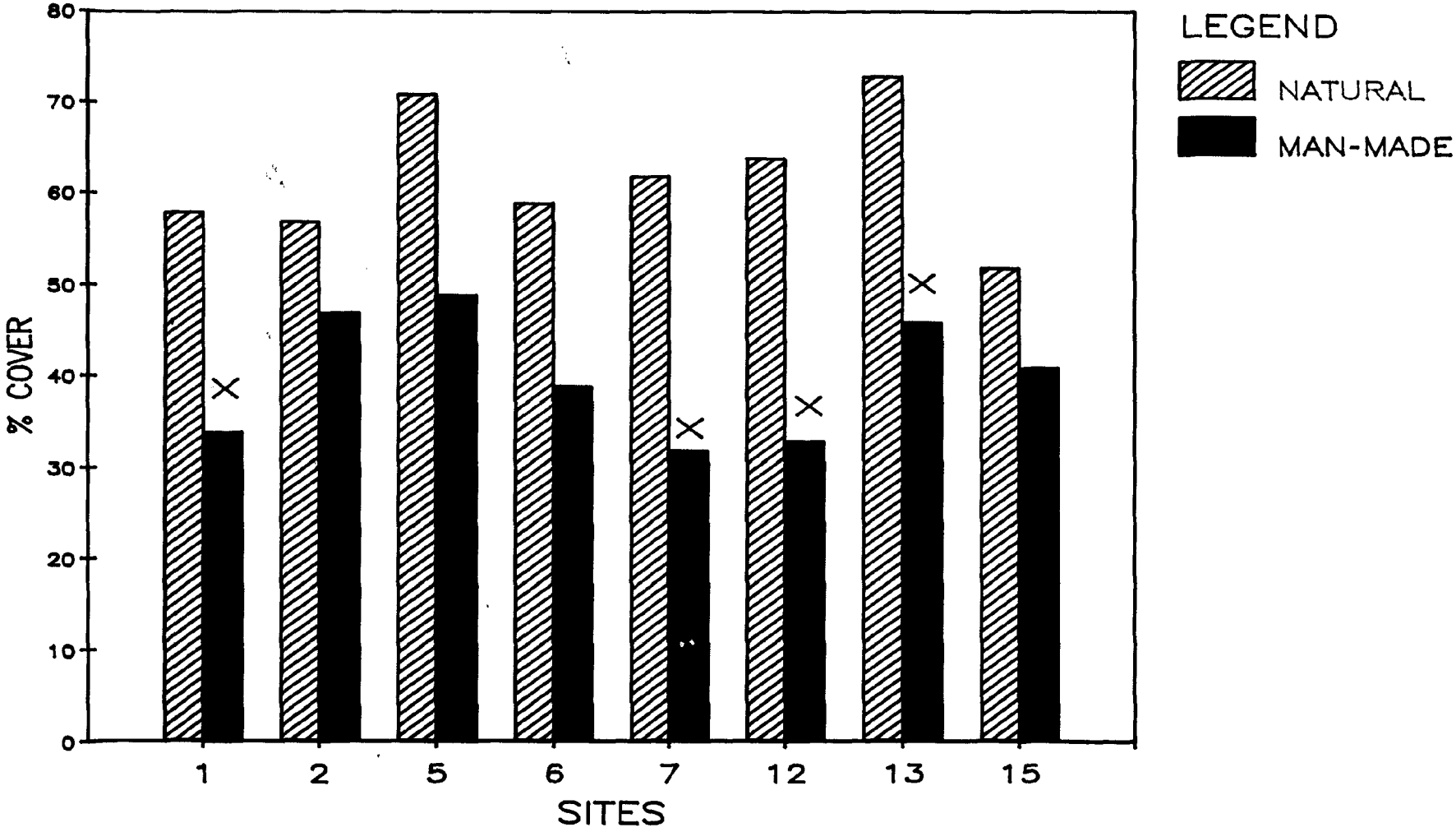
feet of the planted wetland appeared to have eroded due to wave action. The Spartina alterniflora marsh that is present was graded down from a high marsh community.

In addition to the foregoing, sites 19, 20, 21, 23, 24, 25, 26, 27, 33, 35, 36 and 50 were visited as part of this survey. No compensation was apparent at these sites except site 24 where it appeared to have just been completed. Our measurements indicated the area planted totalled 8,000 sq. ft. Sites 35 and 36 were visited but not sampled because inexact drawings made it impossible to determine their location and if the compensation had been done. Site 49 was also visited as part of this survey. However, due to adverse tidal and meteorological conditions cover estimates could not be attempted. We noted however that portions of the planted marsh "A" were eroding and it appeared that the system might be returning to its original drainage configuration, Marsh area "B" appeared healthy and stable.

Cover estimates were made at eighteen of the compensation marshes visited. The investigators were able to sample similar adjacent marshes at eight of these sites. A total of four of the eight compensation marshes sampled had significantly lower cover than their respective adjacent natural systems (Figure 7). Slope runoff and perhaps tidal communication appeared to be the problem at two of the sites. Tidal communication and substrate elevation appeared to have adversely affected vegetation at the two other sites.

The cover data for all eighteen sites were also pooled to examine the overall differences between the man-made and natural wetlands. A significant difference was found at the 99 percent confidence level for the

WETLANDS COMPENSATION SITES
COVER ESTIMATES
NATURAL vs MAN-MADE



X Significantly different, P<0.01

FIGURE 7

pooled data. The mean cover for all man-made marshes was 41 percent and that for the natural systems was 63 percent. The cover estimates noted above are an important indicator of how successful a marsh is at that particular point in time. This one parameter, however, is one indicator and not conclusive evidence of success or lack thereof. In order to say any more about the success of wetland community establishment in the man-made versus the natural marshes of this survey, destructive sampling techniques such as peak standing crop, stem density and below-ground biomass are necessary. This approach was not considered feasible for a survey of this type, dealing with many small, privately owned marshes.

In order to further examine wetland compensation in Virginia, the authors looked at the acreages proposed to be constructed and that which was found at the sites. Two of the large compensation sites could not be accurately measured and so are not included in these numbers. For the sites visited in this survey, 709,358 sq. ft. of wetland was to be constructed. Our observations indicate that 68,792 sq. ft. either was never constructed or was generally devoid of marsh vegetation at the time of our site review. This amounts to approximately 10 percent of the total extent of the compensation sites examined. If this ratio holds for all compensation within Virginia, it would mean that approximately 3.1 acres of compensation marsh is non-functional or non-existent. In addition to this factor, our survey indicates that although the exact acreages are not known, approximately 12 percent of the mitigation sites permitted in Virginia to date were on sites which were already wetlands. The compensatory value of these "wetland to wetland" areas would have to be in question.

A number of other factors were observed to be affecting the quality of some of the compensation sites examined in this survey. Several marshes were being adversely affected by sedimentation which came from unstabilized, adjacent land. Several were adversely affected by the activities which were occurring in their immediate vicinity and from which they were not buffered. In addition, 65 percent of the "new" marshes were already being invaded by the less desirable opportunist, Phragmites australis. The quality of the marsh as compensation for that lost to development may be diminished to the extent that this species is able to displace the wetlands species planted. This is not a measurable factor at present, however.

CONCLUSIONS AND RECOMMENDATIONS

In overview, our survey results support the continued use of wetland compensation by the regulatory community, but only on a highly limited basis (i.e., generally as a last resort). The study documents problems with implementation of the concept in both wetland establishment success and regulatory decision-making. Our cover data and historical decision characterization indicate that adverse impacts are probable on a local scale. If wetland compensation continues to see increasing use, these relatively small local effects could have cumulative significance. Increased planning, monitoring and research are recommended in order to effectively deal with such an eventuality. The pressures of growth in the coastal zone, and the adoption of "No Net Loss" policies almost ensure more pressure for compensatory mitigation in the future. These recommendations

along with the newly promulgated "Wetland Compensation Guidelines" should address the concerns brought out by this study.

Wetland compensation has had a relatively limited role in tidal Virginia to date. Based on the results of our survey, 32.3 acres of tidal wetlands have been proposed for creation since 1981 (the earliest application year identified). This eight-year acreage total is dwarfed by the 215,000 acre total for tidal wetlands in Virginia and is a relatively small proportion of permitted wetland losses of approximately twenty acres annually (VIMS' Wetlands Advisory Program, unpublished data). Our data indicate a slowly increasing use of compensation as a management tool. In terms of project numbers, wetland compensation in Virginia is dominated by small projects. In terms of wetland acreage, however, seven projects over one acre in size compose 79 percent of the 32.3 acre wetland compensation total. Our research indicates that 10 percent of this total was not constructed or has been adversely affected by other external factors to the point that it is not viable wetland. Additionally, the man-made compensation marshes exhibited significantly lower vegetative cover than the natural wetlands sampled.

Our study indicates that, in general, state regulators are using compensation on a conservative basis. Record keeping is highly variable and much of the permit information available is maintained at different locations within the regulatory community. There is much information that is apparently not available due to the fact that there are no standard record-keeping practices for compensation projects. In addition, there is some indication that monitoring and follow-up are being employed on a limited basis, although this effort appears to have little consistency.

Most of the follow-up which does occur appears to be at the behest of the federal regulatory authority.

If wetland compensation continues to be used as a management tool or sees increasing use, as our survey indicates is happening, steps should be taken to ensure that the compensation wetlands are constructed in a manner which will ensure that they mature, in both structural and functional aspects, into wetlands similar to existing natural systems. Based on our survey of permit records, our ten years of field experience, and the field surveys conducted as part of this study, we offer the following recommendations:

- Record-keeping for compensatory mitigation projects should be improved through consolidation and standardization. A centralized record repository is needed.

- All projects should have post-construction inspections and selected projects should be monitored for viability and ecological function. The monitoring should include similar, adjacent natural systems.

- Regulatory agencies should give greater consideration to the siting and buffering of wetland compensation areas during permit review. The aim should be to minimize the impacts to the wetland from adjacent physical features (i.e. sediment erosion and deposition), and from adjacent activities such as farming and development.

- More attention should also be directed to other planning aspects such as tidal hydrology and substrate elevation. Slow-spreading species such as Spartina cynosuroides should generally not be planted or should be mixed with faster growing species such as Scirpus robustus and Spartina alterniflora.

- Phragmites australis should be studied to determine its impact on created marshes and how best to naturally control it if this is deemed necessary.

- Wetland compensation should take into consideration regional wetland management needs through the use of comprehensive shoreline inventories or other information systems.

- Basic research aimed at increasing our knowledge of the values, structure and function of both anthropogenic and natural wetland systems should be continued.

- Long term monitoring of man-made wetlands should be initiated in order to establish what the realistic time tables are for these systems to reach ecological parity with similar natural communities. These efforts should involve multi-parameter investigations as well as structurally diverse wetland types.

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APPENDIX 1

Project Data Sheets

Table 1.

Category	Value
AREA NAME	820395
COMMUNITY TYPE PLANTED	SALTMARSH CORDGRASS
AREA	6000 SF
ASPECT	SOUTH
WATERWAY	PARTING CREEK
PLANTING YEAR	1983
SOIL TYPE	CLAY/SAND
GRASSES	YES
Species	Spaalt
Planting Rate	
Seed Mix	
Seeding Method	
FERTILIZER (Y/N)	
Type	
Date of Application	
SHRUBS	NO
Species	
Shrub Transplant Type	
MAINTENANCE/MANAGEMENT	
VEGETATED WETLANDS IMPACTED	6000 SF
NONVEG WETLANDS IMPACTED	UNKNOWN
TOTAL WETLANDS IMPACTED	6000 SF
COMPENSATION RATIO	1 TO 1
COMMUNITY TYPE IMPACTED	SALTMARSH CORDGRASS
SITE FROM UPLANDS/WETLANDS	UPLANDS
ONSITE/OFFSITE	ONSITE
COMMUNITY PRESENT	Spaalt; Salicornia
NET CHANGE- Planned	0
NET CHANGE - As Built	-1200
PHRAGMITES PRESENT	NO

Table 2.

Category	Value
AREA NAME	861583
COMMUNITY TYPE PLANTED	SALTMARSH CORDGRASS; SALTMEADOW; CATTAIL
AREA	87120 SF
ASPECT	SOUTH
WATERWAY	SARAHS CREEK
PLANTING YEAR	1987
SOIL TYPE	CLAY/SAND
GRASSES	YES
Species	Spaalt; Spapat; Typha
Planting Rate	
Seed Mix	
Seeding Method	
FERTILIZER (Y/N)	
Type	
Date of Application	
SHRUBS	NO
Species	
Shrub Transplant Type	
MAINTENANCE/MANAGEMENT	
VEGETATED WETLANDS IMPACTED	41382 SF
NONVEG WETLANDS IMPACTED	NONE
TOTAL WETLANDS IMPACTED	41382 SF
COMPENSATION RATIO	2 TO 1
COMMUNITY TYPE IMPACTED	SALTMEADOW; SCRUB/SHRUB; BOTTOMLAND HARDWOOD
SITE FROM UPLANDS/WETLANDS	UPLANDS
ONSITE/OFFSITE	ONSITE
COMMUNITY PRESENT	SALTMARSH CORDGRASS; SALTMEADOW; CATTAIL
NET CHANGE - Planned	+41,382
NET CAHNGE - As Built	+41,382
PHRAGMITES PRESENT	NO

Table 3.

Category	Value
AREA NAME	810490
COMMUNITY TYPE PLANTED	SALTMARSH CORDGRASS; SALTMEADOW
AREA	12,800 SF
ASPECT	NORTH
WATERWAY	OWLS CREEK
PLANTING YEAR	1984
SOIL TYPE	SAND/CLAY
GRASSES	YES
Species	Spaalt; Spapat
Planting Rate	
Seed Mix	
Seeding Method	
FERTILIZER (Y/N)	YES
Type	
Date of Application	TIME OF PLANTING
SHRUBS	
Species	
Shrub Transplant Type	
MAINTENANCE/MANAGEMENT	
VEGETATED WETLANDS IMPACTED	2625 SF
NONVEG WETLANDS IMPACTED	10,119 SF
TOTAL WETLANDS IMPACTED	12,744 SF
COMPENSATION RATIO	ALMOST 1 TO 1
COMMUNITY TYPE IMPACTED	>SALTMARSH CORDGRASS; NV TIDAL FLAT
SITE FROM UPLANDS/WETLANDS	UPLAND
ONSITE/OFFSITE	ONSITE
COMMUNITY PRESENT	SALTMARSH CORDGRASS; SALTMEADOW
NET CHANGE - Planned	0
NET CHANGE - As Built	-9600
PHRAGMITES PRESENT	NO

Table 4.

Category	Value
AREA NAME	831002
COMMUNITY TYPE PLANTED	BRACKISH-FRESHWATER MIXED
AREA	3 ACRES
ASPECT	WEST
WATERWAY	GREAT NECK CREEK
PLANTING YEAR	1985
SOIL TYPE	CLAY/SAND
GRASSES	YES
Species	
Planting Rate	
Seed Mix	
Seeding Method	
FERTILIZER (Y/N)	
Type	
Date of Application	
SHRUBS	
Species	
Shrub Transplant Type	
MAINTENANCE/MANAGEMENT	
VEGETATED WETLANDS IMPACTED	3.5 ACRES
NONVEG WETLANDS IMPACTED	UNKNOWN
TOTAL WETLANDS IMPACTED	3.5 ACRES
COMPENSATION RATIO	LESS THAN 1 TO 1
COMMUNITY TYPE IMPACTED	BRACKISH MIXED
SITE FROM UPLANDS/WETLANDS	UPLANDS
ONSITE/OFFSITE	OFFSITE - PROJECT ON LITTLE NECK CREEK
COMMUNITY PRESENT	BRACKISH-FRESHWATER (APPENDIX)
NET CHANGE - Planned	-21,780
NET CHANGE - As Built	-21,780
PHRAGMITES PRESENT	YES

Table 5.

Category	Value
AREA NAME	830701
COMMUNITY TYPE PLANTED	SALTMARSH CORDGRASS; BIG CORDGRASS SALTMEADOW
AREA	4750 SF
ASPECT	WEST
WATERWAY	LONDON BRIDGE CREEK
PLANTING YEAR	1984
SOIL TYPE	
GRASSES	YES
Species	Spaalt; Spacyn; Spapat; Disspi
Planting Rate	24 INCH CENTERS
Seed Mix	
Seeding Method	
FERTILIZER (Y/N)	YES
Type	18-6-12 SLOW RELEASE
Date of Application	TIME OF PLANTING
SHRUBS	NO
Species	
Shrub Transplant Type	
MAINTENANCE/MANAGEMENT	
VEGETATED WETLANDS IMPACTED	2400 SF
NONVEG WETLANDS IMPACTED	NONE
TOTAL WETLANDS IMPACTED	2400 SF
COMPENSATION RATIO	2 TO 1
COMMUNITY TYPE IMPACTED	SWALE
SITE FROM UPLANDS/WETLANDS	UPLANDS
ONSITE/OFFSITE	ONSITE
COMMUNITY PRESENT	BRACKISH MIXED- BULRUSH
NET CHANGE - Planned	+2350 SF
NET CHANGE - As Built	+1030 SF
PHRAGMITES PRESENT	YES

Table 6.

Category	Value
AREA NAME	840364
COMMUNITY TYPE PLANTED	BIG CORDGRASS
AREA	3900 SF; 1200 SF PLANTED IN 1989
ASPECT	EAST
WATERWAY	COX CREEK
PLANTING YEAR	1985
SOIL TYPE	
GRASSES	YES
Species	Spacyn
Planting Rate	18 INCH CENTERS
Seed Mix	
Seeding Method	
FERTILIZER (Y/N)	
Type	
Date of Application	
SHRUBS	YES
Species	Myrcer
Shrub Transplant Type	
MAINTENANCE/MANAGEMENT	
VEGETATED WETLANDS IMPACTED	1900 SF
NONVEG WETLANDS IMPACTED	NONE
TOTAL WETLANDS IMPACTED	1900 SF
COMPENSATION RATIO	2 TO 1
COMMUNITY TYPE IMPACTED	SWALE
SITE FROM UPLANDS/WETLANDS	UPLANDS
ONSITE/OFFSITE	ONSITE
COMMUNITY PRESENT	BRACKISH MIXED (STALBAN)
NET CHANGE - Planned	+2000 SF
NET CHANGE - As Built	+ 800 SF
PHRAGMITES PRESENT	YES

Table 7.

Category	Value
AREA NAME	VB8625
COMMUNITY TYPE PLANTED	SALTMARSH CORDGRASS; SALTMEADOW
AREA	3250 SF
ASPECT	SOUTH
WATERWAY	LITTLE NECK CREEK
PLANTING YEAR	1987
SOIL TYPE	CLAY-SAND
GRASSES	YES
Species	Spaalt; Spapat
Planting Rate	24 INCH CENTERS
Seed Mix	
Seeding Method	
FERTILIZER (Y/N)	YES
Type	OSMOCOTE
Date of Application	TIME OF PLANTING
SHRUBS	NO
Species	
Shrub Transplant Type	
MAINTENANCE/MANAGEMENT	
VEGETATED WETLANDS IMPACTED	2460 SF
NONVEG WETLANDS IMPACTED	3300 SF
TOTAL WETLANDS IMPACTED	5760 SF
COMPENSATION RATIO	LESS THAN 1 TO 1
COMMUNITY TYPE IMPACTED	PHRAGMITES
SITE FROM UPLANDS/WETLANDS	UPLANDS
ONSITE/OFFSITE	OFFSITE
COMMUNITY PRESENT	SALTMARSH CORDGRASS; SALTMEADOW
NET CHANGE - Planned	-2510 SF
NET CHANGE - As Built	-2510 SF
PHRAGMITES PRESENT	YES

Table 8.

Category	Value
AREA NAME	81029M
COMMUNITY TYPE PLANTED	SALTMARSH CORDGRASS
AREA	52,000 SF
ASPECT	EAST
WATERWAY	MILLDAM CREEK
PLANTING YEAR	1985
SOIL TYPE	NATIVE
GRASSES	YES
Species	Spaalt
Planting Rate	24 INCH CENTERS
Seed Mix	
Seeding Method	
FERTILIZER (Y/N)	
Type	
Date of Application	
SHRUBS	NO
Species	
Shrub Transplant Type	
MAINTENANCE/MANAGEMENT	
VEGETATED WETLANDS IMPACTED	52,000 SF
NONVEG WETLANDS IMPACTED	app. 150,000 SF
TOTAL WETLANDS IMPACTED	202,000 SF
COMPENSATION RATIO	LESS THAN 1 TO 1
COMMUNITY TYPE IMPACTED	
SITE FROM UPLANDS/WETLANDS	35,000 SF TIDAL DITCH; 17,000 SF UPLAND
ONSITE/OFFSITE	ONSITE
COMMUNITY PRESENT	SALTMARSH CORDGRASS
NET CHANGE - Planned	-35,000 SF
NET CHANGE - As Built	-35,000 SF
PHRAGMITES PRESENT	YES

Table 9.

Category	Value
AREA NAME	810397
COMMUNITY TYPE PLANTED	SALTMARSH CORDGRASS
AREA	8.5 ACRES
ASPECT	NORTHEAST
WATERWAY	SOUTHERN BRANCH ELIZABETH RIVER
PLANTING YEAR	1982
SOIL TYPE	NATIVE
GRASSES	YES
Species	
Planting Rate	
Seed Mix	Spaalt
Seeding Method	
FERTILIZER (Y/N)	YES
Type	OSMOCOTE
Date of Application	TIME OF SEEDING
SHRUBS	NO
Species	
Shrub Transplant Type	
MAINTENANCE/MANAGEMENT	RESPRIG AS NECESSARY
VEGETATED WETLANDS IMPACTED	6.7 ACRES
NONVEG WETLANDS IMPACTED	
TOTAL WETLANDS IMPACTED	6.7 ACRES
COMPENSATION RATIO	1.3 TO 1
COMMUNITY TYPE IMPACTED	SALTMEADOW; BLACK NEEDLERUSH; BIG CORDGRASS
SITE FROM UPLANDS/WETLANDS	UPLANDS
ONSITE/OFFSITE	OFFSITE- SAME WATERBODY
COMMUNITY PRESENT	SALTMARSH CORDGRASS- BRACKISH MIX
NET CHANGE - Planned	+1.8 ACRES
NET CHANGE - As Built	+1.8 ACRES
PHRAGMITES PRESENT	YES

Table 10.

Category	Value
AREA NAME	860914
COMMUNITY TYPE PLANTED	SALTMARSH CORDGRASS
AREA	17,237 SF - 11,077 VEGETATED
ASPECT	EAST
WATERWAY	DRUM POINT CREEK
PLANTING YEAR	1986
SOIL TYPE	NATIVE
GRASSES	YES
Species	Spaalt
Planting Rate	24 INCH CENTERS
Seed Mix	
Seeding Method	
FERTILIZER (Y/N)	YES
Type	OSMOCOTE
Date of Application	TIME OF PLANTING
SHRUBS	NO
Species	
Shrub Transplant Type	
MAINTENANCE/MANAGEMENT	
VEGETATED WETLANDS IMPACTED	11,077 SF
NONVEG WETLANDS IMPACTED	6160 SF
TOTAL WETLANDS IMPACTED	17,237 SF
COMPENSATION RATIO	1 TO 1
COMMUNITY TYPE IMPACTED	SALTMEADOW; SALTBUSH
SITE FROM UPLANDS/WETLANDS	UPLANDS
ONSITE/OFFSITE	OFFSITE- SAME WATERBODY
COMMUNITY PRESENT	SALTMARSH CORDGRASS- BRACKISH MIXED
NET CHANGE - Planned	0
NET CHANGE - As Built	0
PHRAGMITES PRESENT	YES

Table 11.

Category	Value
AREA NAME	840355
COMMUNITY TYPE PLANTED	SALTMARSH CORDGRASS
AREA	7040 SF
ASPECT	WEST
WATERWAY	HAMPTON RIVER
PLANTING YEAR	1985
SOIL TYPE	
GRASSES	YES
Species	Spaalt
Planting Rate	
Seed Mix	
Seeding Method	
FERTILIZER (Y/N)	
Type	
Date of Application	
SHRUBS	NO
Species	
Shrub Transplant Type	
MAINTENANCE/MANAGEMENT	
VEGETATED WETLANDS IMPACTED	9000 SF
NONVEG WETLANDS IMPACTED	NONE
TOTAL WETLANDS IMPACTED	9000 SF
COMPENSATION RATIO	LESS THAN 1 TO 1
COMMUNITY TYPE IMPACTED	SALTMEADOW; SALTBUSH
SITE FROM UPLANDS/WETLANDS	UPLANDS
ONSITE/OFFSITE	ONSITE
COMMUNITY PRESENT	SALTMARSH CORDGRASS
NET CHANGE - Planned	-1940 SF
NET CHANGE - As Built	-3200 SF
PHRAGMITES PRESENT	YES

Table 12.

Category	Value
AREA NAME	861637
COMMUNITY TYPE PLANTED	SALTMARSH CORDGRASS; SALTMEADOW
AREA	60,000 SF
ASPECT	EAST
WATERWAY	TABBS CREEK
PLANTING YEAR	1987
SOIL TYPE	CLAY
GRASSES	YES
Species	Spaalt; Spapat
Planting Rate	
Seed Mix	
Seeding Method	
FERTILIZER (Y/N)	
Type	
Date of Application	
SHRUBS	NO
Species	
Shrub Transplant Type	
MAINTENANCE/MANAGEMENT	
VEGETATED WETLANDS IMPACTED	30,000 SF
NONVEG WETLANDS IMPACTED	NONE
TOTAL WETLANDS IMPACTED	30,000 SF
COMPENSATION RATIO	2 TO 1
COMMUNITY TYPE IMPACTED	SALTBUSH; COMMON REED
SITE FROM UPLANDS/WETLANDS	UPLANDS
ONSITE/OFFSITE	OFFSITE- SAME WATERBODY
COMMUNITY PRESENT	SALTMARSH CORDGRASS; SALTMEADOW
NET CHANGE - Planned	+30,000 SF
NET CHANGE - As Built	+27,000 SF
PHRAGMITES PRESENT	YES

Table 13.

Category	Value
AREA NAME	772355
COMMUNITY TYPE PLANTED	SALTMARSH CORDGRASS
AREA	2.15 ACRES @90,000 SF
ASPECT	WEST
WATERWAY	SALT PONDS/ LONG CREEK
PLANTING YEAR	1987
SOIL TYPE	ORGANICS; SILT/CLAY
GRASSES	YES
Species	
Planting Rate	
Seed Mix	Spaalt
Seeding Method	
FERTILIZER (Y/N)	
Type	
Date of Application	
SHRUBS	NO
Species	
Shrub Transplant Type	
MAINTENANCE/MANAGEMENT	
VEGETATED WETLANDS IMPACTED	UNKNOWN (2.15+ ACRES)
NONVEG WETLANDS IMPACTED	UNKNOWN
TOTAL WETLANDS IMPACTED	UNKNOWN
COMPENSATION RATIO	UNKNOWN
COMMUNITY TYPE IMPACTED	SALTMARSH CORDGRASS; SALTMEADOW
SITE FROM UPLANDS/WETLANDS	BOTH - MOSTLY WETLAND
ONSITE/OFFSITE	ONSITE
COMMUNITY PRESENT	SALTMARSH CORDGRASS
NET CHANGE - Planned	-1.5 ACRES
NET CHANGE - As Built	-1.5 ACRES
PHRAGMITES PRESENT	NO

Table 14.

Category	Value
AREA NAME	850384
COMMUNITY TYPE PLANTED	SALTMARSH CORDGRASS
AREA	4200 SF
ASPECT	WEST
WATERWAY	BROAD CREEK
PLANTING YEAR	1986
SOIL TYPE	NATIVE
GRASSES	YES
Species	Spaalt
Planting Rate	12 INCH CENTERS
Seed Mix	
Seeding Method	
FERTILIZER (Y/N)	YES
Type	OSMOCOTE
Date of Application	TIME OF PLANTING
SHRUBS	NO
Species	
Shrub Transplant Type	
MAINTENANCE/MANAGEMENT	
VEGETATED WETLANDS IMPACTED	4200 SF
NONVEG WETLANDS IMPACTED	NONE
TOTAL WETLANDS IMPACTED	4200 SF
COMPENSATION RATIO	1 TO 1
COMMUNITY TYPE IMPACTED	SALTMEADOW; SALTBUSH
SITE FROM UPLANDS/WETLANDS	UPLANDS
ONSITE/OFFSITE	ONSITE
COMMUNITY PRESENT	SALTMARSH CORDGRASS
NET CHANGE - Planned	0
NET CHANGE - As Built	0
PHRAGMITES PRESENT	YES

Table 15.

Category	Value
AREA NAME	841250
COMMUNITY TYPE PLANTED	SALTMARSH CORDGRASS
AREA	3000 SF
ASPECT	EAST
WATERWAY	EASTERN BRANCH- ELIZABETH RIVER
PLANTING YEAR	1985
SOIL TYPE	NATIVE
GRASSES	YES
Species	Spaalt
Planting Rate	
Seed Mix	
Seeding Method	
FERTILIZER (Y/N)	
Type	
Date of Application	
SHRUBS	NO
Species	
Shrub Transplant Type	
MAINTENANCE/MANAGEMENT	
VEGETATED WETLANDS IMPACTED	1400 SF
NONVEG WETLANDS IMPACTED	3600 SF
TOTAL WETLANDS IMPACTED	5000 SF
COMPENSATION RATIO	LESS THAN 1 TO 1
COMMUNITY TYPE IMPACTED	SWALE
SITE FROM UPLANDS/WETLANDS	UPLANDS
ONSITE/OFFSITE	ONSITE
COMMUNITY PRESENT	SALTMARSH CORDGRASS
NET CHANGE - Planned	-2000 SF
NET CHANGE - As Built	-2000 SF
PHRAGMITES PRESENT	NO

Table 16.

Category	Value
AREA NAME	850443
COMMUNITY TYPE PLANTED	SALTMARSH CORDGRASS; SALTMEADOW
AREA	22,505 SF
ASPECT	EAST
WATERWAY	EASTERN BRANCH- ELIZABETH RIVER
PLANTING YEAR	1987 (SMALL AREA ADDED 1988)
SOIL TYPE	NATIVE
GRASSES	YES
Species	Spaalt; Spapat
Planting Rate	24 INCH CENTERS
Seed Mix	
Seeding Method	
FERTILIZER (Y/N)	YES
Type	OSMOCOTE
Date of Application	TIME OF PLANTING
SHRUBS	NO
Species	
Shrub Transplant Type	
MAINTENANCE/MANAGEMENT	
VEGETATED WETLANDS IMPACTED	19,500 SF
NONVEG WETLANDS IMPACTED	NONE
TOTAL WETLANDS IMPACTED	19,500 SF
COMPENSATION RATIO	SLIGHTLY GREATER THAN 1 TO 1
COMMUNITY TYPE IMPACTED	
SITE FROM UPLANDS/WETLANDS	UPLANDS
ONSITE/OFFSITE	ONSITE
COMMUNITY PRESENT	SALTMARSH CORDGRASS; SALTMEADOW
NET CHANGE - Planned	+3000 SF
NET CHANGE - As Built	+3000 SF
PHRAGMITES PRESENT	YES

Table 17.

Category	Value
AREA NAME	820341
COMMUNITY TYPE PLANTED	SALTMARSH CORDGRASS
AREA	7.6 ACRES
ASPECT	
WATERWAY	WILLOUGHBY BAY
PLANTING YEAR	1984
SOIL TYPE	ORGANIC CLAY/SAND
GRASSES	YES
Species	Spaalt
Planting Rate	
Seed Mix	
Seeding Method	
FERTILIZER (Y/N)	
Type	
Date of Application	
SHRUBS	NO
Species	
Shrub Transplant Type	
MAINTENANCE/MANAGEMENT	
VEGETATED WETLANDS IMPACTED	6 ACRES
NONVEG WETLANDS IMPACTED	1.6 ACRES
TOTAL WETLANDS IMPACTED	7.6 ACRES
COMPENSATION RATIO	1 TO 1
COMMUNITY TYPE IMPACTED	BRACKISH MIXED
SITE FROM UPLANDS/WETLANDS	BOTH; MOSTLY UPLANDS
ONSITE/OFFSITE	ONSITE
COMMUNITY PRESENT	SALTMARSH CORDGRASS
NET CHANGE - Planned	0
NET CHANGE - As Built	-1.1 ACRES
PHRAGMITES PRESENT	YES

Table 18.

Category	Value
AREA NAME	850109
COMMUNITY TYPE PLANTED	SALTMARSH CORDGRASS; SALTMEADOW
AREA	4500 SF
ASPECT	SOUTH
WATERWAY	LINKHORN BAY
PLANTING YEAR	1986
SOIL TYPE	NATIVE
GRASSES	YES
Species	Spaalt; Spapat
Planting Rate	
Seed Mix	
Seeding Method	
FERTILIZER (Y/N)	
Type	
Date of Application	
SHRUBS	NO
Species	
Shrub Transplant Type	
MAINTENANCE/MANAGEMENT	
VEGETATED WETLANDS IMPACTED	6500 SF (2000 SF FILL -4500 SF ENHANCED)
NONVEG WETLANDS IMPACTED	
TOTAL WETLANDS IMPACTED	6500 SF
COMPENSATION RATIO	LESS THAN 1 TO 1
COMMUNITY TYPE IMPACTED	SALTMEADOW; SALTBUSH
SITE FROM UPLANDS/WETLANDS	WETLANDS
ONSITE/OFFSITE	ONSITE
COMMUNITY PRESENT	SALTMARSH CORDGRASS
NET CHANGE - Planned	-2000 SF
NET CHANGE - As Built	-2850 SF
PHRAGMITES PRESENT	NO

Table 19.

Category	Value
AREA NAME	880386
COMMUNITY TYPE PLANTED	SALTMARSH CORDGRASS; SALTMEADOW
AREA	9000 SF
ASPECT	WEST
WATERWAY	OWL CREEK
PLANTING YEAR	
SOIL TYPE	
GRASSES	YES
Species	Spaalt; Spapat; Disspi
Planting Rate	18 INCH CENTERS
Seed Mix	
Seeding Method	
FERTILIZER (Y/N)	YES
Type	OSMACOTE
Date of Application	TIME OF PLANTING
SHRUBS	NO
Species	
Shrub Transplant Type	
MAINTENANCE/MANAGEMENT	REPORT AFTER 1ST & 2ND YEAR
VEGETATED WETLANDS IMPACTED	9000 SF
NONVEG WETLANDS IMPACTED	NONE
TOTAL WETLANDS IMPACTED	9000 SF
COMPENSATION RATIO	1 TO 1
COMMUNITY TYPE IMPACTED	SALTMARSH CORDGRASS
SITE FROM UPLANDS/WETLANDS	UPLANDS
ONSITE/OFFSITE	ONSITE
COMMUNITY PRESENT	
NET CHANGE - Planned	0

Table 20.

Category	Value
AREA NAME	880283
COMMUNITY TYPE PLANTED	PEAT MAT/ ORGANICS FROM A NON-COMMON REED WETLAND
AREA	6320 SF
ASPECT	WEST
WATERWAY	MUDDY CREEK
PLANTING YEAR	WORK DONE IN 1989
SOIL TYPE	ORGANICS; SILT/CLAY
GRASSES	NO
Species	
Planting Rate	
Seed Mix	
Seeding Method	
FERTILIZER (Y/N)	NO
Type	
Date of Application	
SHRUBS	NO
Species	
Shrub Transplant Type	
MAINTENANCE/MANAGEMENT	AFTER ONE YEAR- SPRIG/RESEED AS NECESSARY
VEGETATED WETLANDS IMPACTED	6320 SF
NONVEG WETLANDS IMPACTED	NONE
TOTAL WETLANDS IMPACTED	6320 SF
COMPENSATION RATIO	1 TO 1
COMMUNITY TYPE IMPACTED	
SITE FROM UPLANDS/WETLANDS	UPLANDS
ONSITE/OFFSITE	ONSITE
COMMUNITY PRESENT	
NET CHANGE - Planned	
NET CHANGE - As Built	

Table 21.

Category	Value
AREA NAME	881105
COMMUNITY TYPE PLANTED	FRESHWATER MIXED COMMUNITY
AREA	3333 SF
ASPECT	
WATERWAY	ST JULIANS CREEK
PLANTING YEAR	1990
SOIL TYPE	
GRASSES	YES
Species	Saucer; Leeory; Sciame
Planting Rate	24 INCH CENTERS
Seed Mix	
Seeding Method	
FERTILIZER (Y/N)	YES
Type	18-6-12 SLOW RELEASE
Date of Application	TIME OF PLANTING
SHRUBS	YES
Species	Cepocc (Buttonbush); Samcan (Elderberry)
Shrub Transplant Type	NURSERY GROWN
MAINTENANCE/MANAGEMENT	REPORT AFTER 1ST AND 2ND YEAR
VEGETATED WETLANDS IMPACTED	3300 SF
NONVEG WETLANDS IMPACTED	
TOTAL WETLANDS IMPACTED	3300 SF
COMPENSATION RATIO	1 TO 1
COMMUNITY TYPE IMPACTED	
SITE FROM UPLANDS/WETLANDS	UPLANDS
ONSITE/OFFSITE	ONSITE
COMMUNITY PRESENT	
NET CHANGE - Planned	-0-
NET CHANGE - As Built	

Table 22.

Category	Value
AREA NAME	881403
COMMUNITY TYPE PLANTED	BIG CORDGRASS
AREA	3250 SF
ASPECT	SOUTH
WATERWAY	GOOSE CREEK
PLANTING YEAR	
SOIL TYPE	
GRASSES	YES
Species	Spacyn
Planting Rate	18 INCH CENTERS
Seed Mix	
Seeding Method	
FERTILIZER (Y/N)	YES
Type	OSMOCOTE
Date of Application	TIME OF PLANTING
SHRUBS	NO
Species	
Shrub Transplant Type	
MAINTENANCE/MANAGEMENT	REPORT AFTER 1 YEAR; RESPRIG AS NECESSARY
VEGETATED WETLANDS IMPACTED	3250 SF
NONVEG WETLANDS IMPACTED	NONE
TOTAL WETLANDS IMPACTED	3250 SF
COMPENSATION RATIO	1 TO 1
COMMUNITY TYPE IMPACTED	BIG CORDGRASS
SITE FROM UPLANDS/WETLANDS	UPLANDS
ONSITE/OFFSITE	OFFSITE- SAME WATERBODY
COMMUNITY PRESENT	
NAT CHANGE - Planned	

Table 23.

Category	Value
AREA NAME	880533
COMMUNITY TYPE PLANTED	SALTMARSH CORDGRASS
AREA	1430 SF
ASPECT	
WATERWAY	GILMERTON- DEEP CREEK CANAL
PLANTING YEAR	
SOIL TYPE	
GRASSES	YES
Species	Spaalt
Planting Rate	18 INCH CENTERS
Seed Mix	
Seeding Method	
FERTILIZER (Y/N)	YES
Type	SLOW RELEASE
Date of Application	TIME OF PLANTING
SHRUBS	NO
Species	
Shrub Transplant Type	
MAINTENANCE/MANAGEMENT	
VEGETATED WETLANDS IMPACTED	1400 SF
NONVEG WETLANDS IMPACTED	
TOTAL WETLANDS IMPACTED	
COMPENSATION RATIO	1 TO 1
COMMUNITY TYPE IMPACTED	SALTMARSH CORDGRASS
SITE FROM UPLANDS/WETLANDS	UPLANDS
ONSITE/OFFSITE	ONSITE
COMMUNITY PRESENT	
NET CHANGE - Planned	0

Table 24.

Category	Value
AREA NAME	871557
COMMUNITY TYPE PLANTED	SALTMARSH CORDGRASS
AREA	13,000 SF
ASPECT	NORTHWEST
WATERWAY	LYONS CREEK
PLANTING YEAR	1989
SOIL TYPE	
GRASSES	YES
Species	Spaalt
Planting Rate	24 INCH CENTERS
Seed Mix	
Seeding Method	
FERTILIZER (Y/N)	
Type	
Date of Application	
SHRUBS	NO
Species	
Shrub Transplant Type	
MAINTENANCE/MANAGEMENT	
VEGETATED WETLANDS IMPACTED	13,000 SF
NONVEG WETLANDS IMPACTED	NONE
TOTAL WETLANDS IMPACTED	13,000 SF
COMPENSATION RATIO	1 TO 1
COMMUNITY TYPE IMPACTED	SALTMEADOW
SITE FROM UPLANDS/WETLANDS	UPLANDS
ONSITE/OFFSITE	ONSITE
COMMUNITY PRESENT	SALTMARSH CORDGRASS
NET CHANGE - Planned	0
NET CHANGE - As Built	-5000

Table 25.

Category	Value
AREA NAME	871915
COMMUNITY TYPE PLANTED	SALTMARSH CORDGRASS
AREA	6000 SF
ASPECT	SOUTH
WATERWAY	NEWTONS CREEK
PLANTING YEAR	
SOIL TYPE	
GRASSES	YES
Species	Spaalt
Planting Rate	
Seed Mix	
Seeding Method	
FERTILIZER (Y/N)	
Type	
Date of Application	
SHRUBS	NO
Species	
Shrub Transplant Type	
MAINTENANCE/MANAGEMENT	
VEGETATED WETLANDS IMPACTED	6000 SF
NONVEG WETLANDS IMPACTED	40,000 SF SUBAQUEOUS
TOTAL WETLANDS IMPACTED	6000 SF
COMPENSATION RATIO	1 TO 1
COMMUNITY TYPE IMPACTED	SALTMARSH CORDGRASS
SITE FROM UPLANDS/WETLANDS	BOTH; MOSTLY SUBAQUEOUS
ONSITE/OFFSITE	ONSITE
COMMUNITY PRESENT	
NET CHANGE - Planned	
NET CHANGE - As Built	

Table 26.

Category	Value
AREA NAME	871854
COMMUNITY TYPE PLANTED	SALTMARSH CORDGRASS; SALTMEADOW
AREA	4000 SF
ASPECT	SOUTH
WATERWAY	PHILLIPS LAKE - HAMPTON RIVER
PLANTING YEAR	
SOIL TYPE	
GRASSES	YES
Species	Spaalt; Spapat
Planting Rate	
Seed Mix	
Seeding Method	
FERTILIZER (Y/N)	
Type	
Date of Application	
SHRUBS	NO
Species	
Shrub Transplant Type	
MAINTENANCE/MANAGEMENT	
VEGETATED WETLANDS IMPACTED	2900 SF
NONVEG WETLANDS IMPACTED	70 SF
TOTAL WETLANDS IMPACTED	2970 SF
COMPENSATION RATIO	less than 1 to 1
COMMUNITY TYPE IMPACTED	
SITE FROM UPLANDS/WETLANDS	WETLANDS
ONSITE/OFFSITE	ONSITE
COMMUNITY PRESENT	
NET CHANGE - Planned	0
NET CHANGE - As Built	-4000

Table 27.

Category	Value
AREA NAME	871079
COMMUNITY TYPE PLANTED	SALTMARSH CORDGRASS
AREA	22,840 SF
ASPECT	SOUTH
WATERWAY	MILL CREEK
PLANTING YEAR	
SOIL TYPE	
GRASSES	YES
Species	Spaalt
Planting Rate	
Seed Mix	
Seeding Method	
FERTILIZER (Y/N)	YES
Type	
Date of Application	
SHRUBS	NO
Species	
Shrub Transplant Type	
MAINTENANCE/MANAGEMENT	
VEGETATED WETLANDS IMPACTED	9210 SF
NONVEG WETLANDS IMPACTED	
TOTAL WETLANDS IMPACTED	9210 SF
COMPENSATION RATIO	@ 2.5 TO 1
COMMUNITY TYPE IMPACTED	SALTMEADOW; SALTBUSH
SITE FROM UPLANDS/WETLANDS	UPLANDS
ONSITE/OFFSITE	ONSITE
COMMUNITY PRESENT	
NET CHANGE - Planned	+13630
NET CHANGE - As Built	

Table 28.

Category	Value
AREA NAME	820947
COMMUNITY TYPE PLANTED	SALTMARSH CORDGRASS
AREA	225 SF
ASPECT	WEST
WATERWAY	JACKSON CREEK
PLANTING YEAR	1984
SOIL TYPE	
GRASSES	YES
Species	Spaalt
Planting Rate	18 INCH CENTERS
Seed Mix	
Seeding Method	
FERTILIZER (Y/N)	YES
Type	OSMOCOTE
Date of Application	TIME OF PLANTING
SHRUBS	NO
Species	
Shrub Transplant Type	
MAINTENANCE/MANAGEMENT	
VEGETATED WETLANDS IMPACTED	126 SF
NONVEG WETLANDS IMPACTED	NONE
TOTAL WETLANDS IMPACTED	126 SF
COMPENSATION RATIO	1.8 TO 1
COMMUNITY TYPE IMPACTED	SALTMARSH CORDGRASS
SITE FROM UPLANDS/WETLANDS	UPLAND
ONSITE/OFFSITE	ONSITE
COMMUNITY PRESENT	

Table 29.

Category	Value
AREA NAME	77B357
COMMUNITY TYPE PLANTED	SALTMARSH CORDGRASS
AREA	4000 SF
ASPECT	NORTH
WATERWAY	CHAPEL CREEK
PLANTING YEAR	1983
SOIL TYPE	
GRASSES	YES
Species	Spaalt
Planting Rate	
Seed Mix	
Seeding Method	
FERTILIZER (Y/N)	
Type	
Date of Application	
SHRUBS	NO
Species	
Shrub Transplant Type	
MAINTENANCE/MANAGEMENT	
VEGETATED WETLANDS IMPACTED	10,000 SF?
NONVEG WETLANDS IMPACTED	UNKNOWN
TOTAL WETLANDS IMPACTED	
COMPENSATION RATIO	
COMMUNITY TYPE IMPACTED	SALTMARSH CORDGRASS; SALTMEADOW
SITE FROM UPLANDS/WETLANDS	BOTH
ONSITE/OFFSITE	ONSITE
COMMUNITY PRESENT	

Table 30.

Category	Value
AREA NAME	881948
COMMUNITY TYPE PLANTED	SALTMARSH CORDGRASS
AREA	1100 SF
ASPECT	
WATERWAY	SCOTTS CREEK
PLANTING YEAR	1989
SOIL TYPE	
GRASSES	YES
Species	Spaalt
Planting Rate	
Seed Mix	
Seeding Method	
FERTILIZER (Y/N)	
Type	
Date of Application	
SHRUBS	NO
Species	
Shrub Transplant Type	
MAINTENANCE/MANAGEMENT	
VEGETATED WETLANDS IMPACTED	480 SF
NONVEG WETLANDS IMPACTED	NONE
TOTAL WETLANDS IMPACTED	480 SF
COMPENSATION RATIO	2 TO 1
COMMUNITY TYPE IMPACTED	SALTBUSH
SITE FROM UPLANDS/WETLANDS	
ONSITE/OFFSITE	ONSITE
COMMUNITY PRESENT	

Table 31.

Category	Value
AREA NAME	830260
COMMUNITY TYPE PLANTED	SALTMARSH CORDGRASS
AREA	1600 SF
ASPECT	SOUTH
WATERWAY	LINKHORN BAY
PLANTING YEAR	1986
SOIL TYPE	
GRASSES	
Species	
Planting Rate	
Seed Mix	
Seeding Method	
FERTILIZER (Y/N)	
Type	
Date of Application	
SHRUBS	NO
Species	
Shrub Transplant Type	
MAINTENANCE/MANAGEMENT	
VEGETATED WETLANDS IMPACTED	850 SF
NONVEG WETLANDS IMPACTED	NONE
TOTAL WETLANDS IMPACTED	850 SF
COMPENSATION RATIO	ALMOST 2 TO 1
COMMUNITY TYPE IMPACTED	SALTMEADOW; SALTBUSH
SITE FROM UPLANDS/WETLANDS	UPLANDS/WETLANDS
ONSITE/OFFSITE	ONSITE
COMMUNITY PRESENT	

Table 32.

Category	Value
AREA NAME	880152
COMMUNITY TYPE PLANTED	SALTMARSH CORDGRASS; SALTMEADOW
AREA	4 ACRES
ASPECT	NORTH
WATERWAY	DEEP CREEK
PLANTING YEAR	
SOIL TYPE	
GRASSES	YES
Species	Spaalt; Spapat
Planting Rate	
Seed Mix	
Seeding Method	
FERTILIZER (Y/N)	
Type	
Date of Application	
SHRUBS	NO
Species	
Shrub Transplant Type	
MAINTENANCE/MANAGEMENT	
VEGETATED WETLANDS IMPACTED	41900 SF
NONVEG WETLANDS IMPACTED	10100 SF & 214,00 SUBAQUEOUS
TOTAL WETLANDS IMPACTED	52000 SF (1.19 ACRE)
COMPENSATION RATIO	3.3 TO 1?
COMMUNITY TYPE IMPACTED	BRACKISH MIX; MUD FLAT
SITE FROM UPLANDS/WETLANDS	UPLANDS/WETLANDS
ONSITE/OFFSITE	OFFSITE; SAME WATERBODY
COMMUNITY PRESENT	

Table 33.

Category	Value
AREA NAME	851388
COMMUNITY TYPE PLANTED	SALTMARSH CORDGRASS
AREA	3000 SF
ASPECT	EAST
WATERWAY	SCOTTS CREEK
PLANTING YEAR	1987
SOIL TYPE	NATIVE
GRASSES	YES
Species	Spaalt
Planting Rate	
Seed Mix	
Seeding Method	
FERTILIZER (Y/N)	
Type	
Date of Application	
SHRUBS	NO
Species	
Shrub Transplant Type	
MAINTENANCE/MANAGEMENT	
VEGETATED WETLANDS IMPACTED	3000 SF
NONVEG WETLANDS IMPACTED	2000 SF
TOTAL WETLANDS IMPACTED	5000 SF
COMPENSATION RATIO	1 TO 1
COMMUNITY TYPE IMPACTED	SALTMARSH CORDGRASS; MUD FLAT
SITE FROM UPLANDS/WETLANDS	UPLANDS
ONSITE/OFFSITE	ONSITE
COMMUNITY PRESENT	

Table 34.

Category	Value
AREA NAME	871940
COMMUNITY TYPE PLANTED	UNKNOWN
AREA	6000 SF
ASPECT	
WATERWAY	PAGAN RIVER
PLANTING YEAR	1988?
SOIL TYPE	
GRASSES	
Species	
Planting Rate	
Seed Mix	
Seeding Method	
FERTILIZER (Y/N)	
Type	
Date of Application	
SHRUBS	
Species	
Shrub Transplant Type	
MAINTENANCE/MANAGEMENT	
VEGETATED WETLANDS IMPACTED	6000 SF & 1800 SF SHADING
NONVEG WETLANDS IMPACTED	NONE
TOTAL WETLANDS IMPACTED	6000 SF
COMPENSATION RATIO	1 TO 1
COMMUNITY TYPE IMPACTED	
SITE FROM UPLANDS/WETLANDS	
ONSITE/OFFSITE	OFFSITE; SAME WATERBODY
COMMUNITY PRESENT	

Table 35.

Category	Value
AREA NAME	831164
COMMUNITY TYPE PLANTED	SALTMARSH CORDGRASS
AREA	10,000 SF
ASPECT	
WATERWAY	FOWLING GUT/ CHINCOTEAGUE BAY
PLANTING YEAR	1984
SOIL TYPE	NATIVE
GRASSES	YES
Species	Spaalt
Planting Rate	18 INCH CENTERS
Seed Mix	
Seeding Method	
FERTILIZER (Y/N)	YES
Type	OSMOCOTE
Date of Application	TIME OF PLANTING & 1985
SHRUBS	NO
Species	
Shrub Transplant Type	
MAINTENANCE/MANAGEMENT	INSPECT 1985; RESPRIG AS NECESSARY
VEGETATED WETLANDS IMPACTED	10,000 SF
NONVEG WETLANDS IMPACTED	NONE
TOTAL WETLANDS IMPACTED	10,000 SF
COMPENSATION RATIO	1 TO 1
COMMUNITY TYPE IMPACTED	SALTMARSH CORDGRASS; SALTMEADOW
SITE FROM UPLANDS/WETLANDS	UPLANDS
ONSITE/OFFSITE	OFFSITE
COMMUNITY PRESENT	

Table 36.

Category	Value
AREA NAME	861689
COMMUNITY TYPE PLANTED	SALTMARSH CORDGRASS
AREA	13,100 SF
ASPECT	
WATERWAY	CHINCOTEAGUE BAY
PLANTING YEAR	
SOIL TYPE	
GRASSES	YES
Species	Spaalt
Planting Rate	18 INCH CENTERS
Seed Mix	
Seeding Method	
FERTILIZER (Y/N)	YES
Type	OSMOCOTE
Date of Application	TIME OF PLANTING
SHRUBS	NO
Species	
Shrub Transplant Type	
MAINTENANCE/MANAGEMENT	
VEGETATED WETLANDS IMPACTED	6000 SF
NONVEG WETLANDS IMPACTED	
TOTAL WETLANDS IMPACTED	
COMPENSATION RATIO	2 TO 1
COMMUNITY TYPE IMPACTED	
SITE FROM UPLANDS/WETLANDS	UPLANDS
ONSITE/OFFSITE	
COMMUNITY PRESENT	

Table 37.

Category	Value
AREA NAME	860673
COMMUNITY TYPE PLANTED	SALTMARSH CORDGRASS
AREA	300 SF
ASPECT	
WATERWAY	FOWLING GUT
PLANTING YEAR	1986?
SOIL TYPE	NATIVE
GRASSES	YES
Species	Spaalt
Planting Rate	
Seed Mix	
Seeding Method	
FERTILIZER (Y/N)	
Type	
Date of Application	
SHRUBS	NO
Species	
Shrub Transplant Type	
MAINTENANCE/MANAGEMENT	
VEGETATED WETLANDS IMPACTED	300 SF
NONVEG WETLANDS IMPACTED	NONE
TOTAL WETLANDS IMPACTED	300 SF
COMPENSATION RATIO	1 TO 1
COMMUNITY TYPE IMPACTED	SALTMARSH CORDGRASS
SITE FROM UPLANDS/WETLANDS	UPLANDS
ONSITE/OFFSITE	OFFSITE; SAME WATERBODY
COMMUNITY PRESENT	

Table 38.

Category	Value
AREA NAME	880334
COMMUNITY TYPE PLANTED	SALTMARSH CORDGRASS
AREA	500 SF
ASPECT	SOUTH
WATERWAY	MATTAPONI RIVER
PLANTING YEAR	1988?
SOIL TYPE	
GRASSES	YES
Species	Spaalt
Planting Rate	
Seed Mix	
Seeding Method	
FERTILIZER (Y/N)	YES
Type	SLOW RELEASE
Date of Application	TIME OF PLANTING
SHRUBS	NO
Species	
Shrub Transplant Type	
MAINTENANCE/MANAGEMENT	
VEGETATED WETLANDS IMPACTED	250 SF
NONVEG WETLANDS IMPACTED	NONE
TOTAL WETLANDS IMPACTED	250 SF
COMPENSATION RATIO	2 TO 1
COMMUNITY TYPE IMPACTED	SALTMARSH CORDGRASS; BIG CORDGRASS
SITE FROM UPLANDS/WETLANDS	UPLANDS
ONSITE/OFFSITE	ONSITE
COMMUNITY PRESENT	

Table 39.

Category	Value
AREA NAME	881102
COMMUNITY TYPE PLANTED	SALTMARSH CORDGRASS; SALTMEADOW
AREA	@2280 SF
ASPECT	SOUTH
WATERWAY	WILLETTS CREEK
PLANTING YEAR	
SOIL TYPE	NATIVE
GRASSES	YES
Species	Spaalt; Spapat
Planting Rate	24 INCH CENTERS
Seed Mix	
Seeding Method	
FERTILIZER (Y/N)	YES
Type	OSMOCOTE
Date of Application	TIME OF PLANTING
SHRUBS	NO
Species	
Shrub Transplant Type	
MAINTENANCE/MANAGEMENT	
VEGETATED WETLANDS IMPACTED	759 SF
NONVEG WETLANDS IMPACTED	1395 SF
TOTAL WETLANDS IMPACTED	2054 SF
COMPENSATION RATIO	1 TO 1
COMMUNITY TYPE IMPACTED	SALTMARSH CORDGRASS
SITE FROM UPLANDS/WETLANDS	WETLANDS
ONSITE/OFFSITE	ONSITE
COMMUNITY PRESENT	

Table 40.

Category	Value
AREA NAME	860873
COMMUNITY TYPE PLANTED	SALTMARSH CORDGRASS
AREA	800 SF
ASPECT	NORTH
WATERWAY	RAPPAHANNOCK RIVER
PLANTING YEAR	1987
SOIL TYPE	NATIVE
GRASSES	YES
Species	Spaalt
Planting Rate	18 INCH CENTERS
Seed Mix	
Seeding Method	
FERTILIZER (Y/N)	YES
Type	
Date of Application	TIME OF PLANTING
SHRUBS	NO
Species	
Shrub Transplant Type	
MAINTENANCE/MANAGEMENT	
VEGETATED WETLANDS IMPACTED	2000 SF
NONVEG WETLANDS IMPACTED	3000 SF
TOTAL WETLANDS IMPACTED	5000 SF
COMPENSATION RATIO	LESS THAN 1 TO 1
COMMUNITY TYPE IMPACTED	SALTMARSH CORDGRASS
SITE FROM UPLANDS/WETLANDS	WETLANDS
ONSITE/OFFSITE	ONSITE
COMMUNITY PRESENT	

Table 41.

Category	Value
AREA NAME	820441
COMMUNITY TYPE PLANTED	SALTMARSH CORDGRASS
AREA	500 SF
ASPECT	WEST
WATERWAY	TOWLES CREEK
PLANTING YEAR	
SOIL TYPE	NATIVE
GRASSES	YES
Species	Spaalt
Planting Rate	
Seed Mix	
Seeding Method	
FERTILIZER (Y/N)	
Type	
Date of Application	
SHRUBS	NO
Species	
Shrub Transplant Type	
MAINTENANCE/MANAGEMENT	
VEGETATED WETLANDS IMPACTED	200 SF
NONVEG WETLANDS IMPACTED	
TOTAL WETLANDS IMPACTED	200 SF
COMPENSATION RATIO	2.5 TO 1
COMMUNITY TYPE IMPACTED	
SITE FROM UPLANDS/WETLANDS	UPLANDS
ONSITE/OFFSITE	ONSITE
COMMUNITY PRESENT	

Table 42.

Category	Value
AREA NAME	870247
COMMUNITY TYPE PLANTED	
AREA	900 SF
ASPECT	NORTH
WATERWAY	BROAD CREEK
PLANTING YEAR	1988
SOIL TYPE	NATIVE
GRASSES	
Species	
Planting Rate	
Seed Mix	
Seeding Method	
FERTILIZER (Y/N)	
Type	
Date of Application	
SHRUBS	
Species	
Shrub Transplant Type	
MAINTENANCE/MANAGEMENT	
VEGETATED WETLANDS IMPACTED	340 SF
NONVEG WETLANDS IMPACTED	
TOTAL WETLANDS IMPACTED	
COMPENSATION RATIO	
COMMUNITY TYPE IMPACTED	
SITE FROM UPLANDS/WETLANDS	
ONSITE/OFFSITE	
COMMUNITY PRESENT	

Table 43.

Category	Value
AREA NAME	831292
COMMUNITY TYPE PLANTED	SALTMARSH CORDGRASS
AREA	320 SF
ASPECT	SOUTH
WATERWAY	KINGSCOTE CREEK
PLANTING YEAR	1984
SOIL TYPE	NATIVE
GRASSES	YES
Species	Spaalt
Planting Rate	18 INCH CENTERS
Seed Mix	
Seeding Method	
FERTILIZER (Y/N)	YES
Type	OSMOCOTE
Date of Application	TIME OF PLANTING
SHRUBS	NO
Species	
Shrub Transplant Type	
MAINTENANCE/MANAGEMENT	
VEGETATED WETLANDS IMPACTED	320 SF
NONVEG WETLANDS IMPACTED	
TOTAL WETLANDS IMPACTED	320 SF
COMPENSATION RATIO	1 TO 1
COMMUNITY TYPE IMPACTED	SALTMARSH CORDGRASS
SITE FROM UPLANDS/WETLANDS	WETLANDS
ONSITE/OFFSITE	ONSITE
COMMUNITY PRESENT	

Table 44.

Category	Value
AREA NAME	881375
COMMUNITY TYPE PLANTED	SALTMARSH CORDGRASS
AREA	480 SF
ASPECT	
WATERWAY	LINKHORN BAY
PLANTING YEAR	1990
SOIL TYPE	NATIVE
GRASSES	YES
Species	Spaalt
Planting Rate	18 - 24 INCH CENTERS
Seed Mix	
Seeding Method	
FERTILIZER (Y/N)	
Type	
Date of Application	
SHRUBS	NO
Species	
Shrub Transplant Type	
MAINTENANCE/MANAGEMENT	AFTER ONE YEAR- RESPRIG IF NECESSARY
VEGETATED WETLANDS IMPACTED	240 SF
NONVEG WETLANDS IMPACTED	
TOTAL WETLANDS IMPACTED	240 SF
COMPENSATION RATIO	2 TO 1
COMMUNITY TYPE IMPACTED	
SITE FROM UPLANDS/WETLANDS	UPLANDS
ONSITE/OFFSITE	ONSITE
COMMUNITY PRESENT	

Table 45.

Category	Value
AREA NAME	871071
COMMUNITY TYPE PLANTED	SALTMARSH CORDGRASS
AREA	3713
ASPECT	EAST
WATERWAY	CRYSTAL LAKE
PLANTING YEAR	1988
SOIL TYPE	NATIVE
GRASSES	YES
Species	Spaalt
Planting Rate	18 INCH CENTERS
Seed Mix	
Seeding Method	
FERTILIZER (Y/N)	
Type	
Date of Application	
SHRUBS	NO
Species	
Shrub Transplant Type	
MAINTENANCE/MANAGEMENT	
VEGETATED WETLANDS IMPACTED	4625 SF
NONVEG WETLANDS IMPACTED	100 SF
TOTAL WETLANDS IMPACTED	4725 SF
COMPENSATION RATIO	SLIGHTLY GREATER THAN 1 TO 1
COMMUNITY TYPE IMPACTED	SWALE
SITE FROM UPLANDS/WETLANDS	UPLANDS
ONSITE/OFFSITE	ONSITE
COMMUNITY PRESENT	

Table 46.

Category	Value
AREA NAME	VB8416
COMMUNITY TYPE PLANTED	SALTMARSH CORDGRASS; SALTMEADOW
AREA	450 SF; 300 SF Spaalt -150 SF Spapat
ASPECT	SOUTH
WATERWAY	GREAT NECK CREEK
PLANTING YEAR	1985
SOIL TYPE	NATIVE
GRASSES	YES
Species	Spaalt; Spapat
Planting Rate	
Seed Mix	
Seeding Method	
FERTILIZER (Y/N)	
Type	
Date of Application	
SHRUBS	NO
Species	
Shrub Transplant Type	
MAINTENANCE/MANAGEMENT	
VEGETATED WETLANDS IMPACTED	300 SF
NONVEG WETLANDS IMPACTED	UNKNOWN
TOTAL WETLANDS IMPACTED	300 SF
COMPENSATION RATIO	1.5 TO 1
COMMUNITY TYPE IMPACTED	SALTMARSH CORDGRASS; SALTMEADOW
SITE FROM UPLANDS/WETLANDS	UPLANDS
ONSITE/OFFSITE	ONSITE
COMMUNITY PRESENT	

Table 47.

Category	Value
AREA NAME	VB8602
COMMUNITY TYPE PLANTED	SALTMEADOW
AREA	300 SF
ASPECT	NORTHWEST
WATERWAY	LINKHORN BAY
PLANTING YEAR	1986
SOIL TYPE	NATIVE
GRASSES	YES
Species	Spapat
Planting Rate	12 INCH CENTERS
Seed Mix	
Seeding Method	
FERTILIZER (Y/N)	YES
Type	18-6-12 SLOW RELEASE
Date of Application	TIME OF PLANTING
SHRUBS	NO
Species	
Shrub Transplant Type	
MAINTENANCE/MANAGEMENT	PERIODIC CHECKS; DEBRIS REMOVAL
VEGETATED WETLANDS IMPACTED	300
NONVEG WETLANDS IMPACTED	
TOTAL WETLANDS IMPACTED	300
COMPENSATION RATIO	1 to 1
COMMUNITY TYPE IMPACTED	Spapat- Ivafru
SITE FROM UPLANDS/WETLANDS	WETLANDS
ONSITE/OFFSITE	ONSITE
COMMUNITY PRESENT	

Table 48.

Category	Value
AREA NAME	826018
COMMUNITY TYPE PLANTED	UNKNOWN
AREA	3960 SF
ASPECT	NORTH
WATERWAY	NOMINI CREEK
PLANTING YEAR	1983?
SOIL TYPE	
GRASSES	
Species	
Planting Rate	
Seed Mix	
Seeding Method	
FERTILIZER (Y/N)	
Type	
Date of Application	
SHRUBS	
Species	
Shrub Transplant Type	
MAINTENANCE/MANAGEMENT	
VEGETATED WETLANDS IMPACTED	960 SF
NONVEG WETLANDS IMPACTED	3000 SF
TOTAL WETLANDS IMPACTED	3960 SF
COMPENSATION RATIO	1 TO 1
COMMUNITY TYPE IMPACTED	SALTMARSH CORDGRASS; BIG CORDGRASS
SITE FROM UPLANDS/WETLANDS	UPLANDS
ONSITE/OFFSITE	ONSITE
COMMUNITY PRESENT	

Table 49.

Category	Value
AREA NAME	826051
COMMUNITY TYPE PLANTED	SALTMARSH CORDGRASS
AREA	20,000 SF (10,000 & 10,000)
ASPECT	EAST; WEST
WATERWAY	LITTLE WICOMICO
PLANTING YEAR	1984
SOIL TYPE	DREDGE SPOIL
GRASSES	YES
Species	Spaalt
Planting Rate	12 AND 24 INCH CENTERS
Seed Mix	
Seeding Method	
FERTILIZER (Y/N)	
Type	
Date of Application	
SHRUBS	YES
Species	JUNIPERUS VIRGINIA
Shrub Transplant Type	
MAINTENANCE/MANAGEMENT	
VEGETATED WETLANDS IMPACTED	7800 SF
NONVEG WETLANDS IMPACTED	22,000 SF
TOTAL WETLANDS IMPACTED	29,800 SF
COMPENSATION RATIO	less than 1 TO 1
COMMUNITY TYPE IMPACTED	SALTMARSH CORDGRASS; SALTMEADOW
SITE FROM UPLANDS/WETLANDS	WETLANDS
ONSITE/OFFSITE	ONSITE
COMMUNITY PRESENT	SALTMARSH CORDGRASS

Table 50.

Category	Value
AREA NAME	860945
COMMUNITY TYPE PLANTED	
AREA	1446 SF
ASPECT	EAST
WATERWAY	BENNETTS CREEK
PLANTING YEAR	
SOIL TYPE	
GRASSES	YES
Species	
Planting Rate	
Seed Mix	
Seeding Method	
FERTILIZER (Y/N)	
Type	
Date of Application	
SHRUBS	
Species	
Shrub Transplant Type	
MAINTENANCE/MANAGEMENT	
VEGETATED WETLANDS IMPACTED	1800 SF
NONVEG WETLANDS IMPACTED	NONE
TOTAL WETLANDS IMPACTED	1800 SF
COMPENSATION RATIO	LESS THAN 1 TO 1
COMMUNITY TYPE IMPACTED	SALTMEADOW
SITE FROM UPLANDS/WETLANDS	UPLANDS
ONSITE/OFFSITE	ONSITE
COMMUNITY PRESENT	

Table 51.

Category	Value
AREA NAME	VB8803
COMMUNITY TYPE PLANTED	SALTMARSH CORDGRASS; SALTMEADOW & SALTBUSH
AREA	UNABLE TO DETERMINE
ASPECT	
WATERWAY	LITTLE NECK CREEK
PLANTING YEAR	1988
SOIL TYPE	
GRASSES	YES
Species	Spaalt
Planting Rate	
Seed Mix	
Seeding Method	
FERTILIZER (Y/N)	
Type	
Date of Application	
SHRUBS	YES
Species	Ivafru
Shrub Transplant Type	
MAINTENANCE/MANAGEMENT	
VEGETATED WETLANDS IMPACTED	3000 SF
NONVEG WETLANDS IMPACTED	350 SF
TOTAL WETLANDS IMPACTED	3350 SF
COMPENSATION RATIO	
COMMUNITY TYPE IMPACTED	SALTMARSH CORDGRASS; SALTBUSH
SITE FROM UPLANDS/WETLANDS	BOTH
ONSITE/OFFSITE	ONSITE
COMMUNITY PRESENT	

APPENDIX 2

Research Report Summaries

Brooks, Robert P. and Robert M. Hughes. 1986. Guidelines for assessing the biotic communities of freshwater wetlands. *Proceedings: National Wetlands Symposium. Mitigation of Impacts and Losses.* New Orleans, Louisiana.

Written for freshwater, but could be applied to estuarine wetlands. Describes specific methods for sampling vertebrates, invertebrates, vegetation, water quality, and water quantity. It is a very thorough, lengthy methodology, but it could be modified by choosing the most important parameters. The authors suggest identifying an undisturbed site in the same ecoregion as the impacted and restoration/creation sites, to serve as a control.

Broome, S.W., E.D. Seneca, and W.W. Woodhouse, Jr. 1982. Establishing brackish marshes on graded upland sites in North Carolina. *Wetlands* 2: 152-178.

The researchers compared experimental sites to nearby natural marshes. The parameters measured were:

visual survey....plant species composition
dominance
zonation
vegetation.....blade height
stem density
aboveground standing crop
substrate interstitial water salinity

The variables measured at the experimental wetland sites were:

plant height
number of stems in main plant
number of rhizome stems
number of flowering stems
aboveground standing crop
basal area of plant clusters

The authors found that the primary factors affecting wetland development were elevation, soil moisture conditions after transplanting and fertilization.

Cammen, Leon M. 1976. Macroinvertebrate colonization of *Spartina* marshes artificially established on dredge spoil. *Est. Coast. Mar. Sci.* 4: 357-372.

This study was another in the series funded by the Corps of Engineers which examined marsh development on dredged material. The parameters examined per living and abiotic system are listed below.

Macroinvertebrates

- 70.9 cm2 core, 13 cm deep, pairs 1m apart at each station, washed through 1mm mesh
- total number of taxa
- total number of individuals
- total biomass (weighed by taxa)
- Shannon-Weaver diversity

Sediment

- similar cores
  - particle size
  - organic carbon determination

Vegetation

- aboveground biomass (0.25 m2)
- belowground biomass (same cores as above)

Sediment and vegetation were not measured to evaluate the success of the project, but so that macroinvertebrate data could be related to sediment and vegetation factors. The author notes that a natural marsh will develop, but how long this will take depends on numerous factors which mediate development.

Clairain, Jr., E. J., R. A. Cole, R. J. Diaz, A. W. Ford, R. T. Huffman, L. Jean Hunt and B. R. Wells. 1978. Habitat development field investigations: Miller Sands marsh and upland habitat development site, Columbia River, Oregon. U.S. ACE Technical Report D-77-38.

Good description of methodology presented in this paper which describes marsh development on dredged material deposits.

Botanical variables observed were:

survival
percent cover
above and belowground biomass

Researchers compared the planted marshes to adjacent natural marsh and unvegetated areas. In the natural marsh areas investigators measured cover and plant production. In unvegetated areas cover was monitored in order to track natural invasion. Faunal variables in the aquatic areas of the study were designed to document changes in abundance, biomass, and composition of fish, benthic macroinvertebrates, and zooplankton communities. This study also monitored wildlife such as birds, small mammals, and terrestrial invertebrates.

Erwin, Kevin. 1986. A quantitative approach for assessing the character of freshwater marshes and swamps impacted by development in Florida. *Proceedings: National Wetlands Symposium. Mitigation of Impacts and Losses*. New Orleans, Louisiana.

"One of the principal questions which must be addressed when assessing the success of a completed wetland mitigation project is, to what extent does the reclaimed wetland provide biological and hydrological functions similar to those of the original undisturbed wetland. To determine what the success criteria should be for a particular wetland habitat restoration, the natural system must first be evaluated in order to ascertain its form, function, and contribution to the ecosystem."

The authors suggest that one could develop a standard set of criteria, but vary that set depending on the character of the natural system being examined.

Contributions of an impacted wetland (which ideally would be provided by the compensating wetland):

hydrological function
water quality
fish and wildlife values
floral species contribution

It is recommended that criteria be developed which measure aspects of all these contributions.

Newling, Charles J. 1981. Monitoring of Dredged Material Research Program (DMRP) habitat development sites. U. S. Army Corps of Engineers *Dredged Material Research Bulletin*, Vol. D-81-1.

This article reports a summary of the continued monitoring of DMRP sites (Clairain et al. described initiation of Oregon site). Sites compared to reference areas in the vicinity which were selected based on:

habitat quality
similarity to type of habitat developed at site
proximity to site

"Results from the reference area would establish the range of natural variability to which data from the experimental sites could be compared."

Plant sampling involved the use of site transects along which were deployed 0.5 m quadrats. Parameters measured were:

species occurrence
stem density (by species)
height (mean height of 10 randomly selected stems)
number of flowering stems
aboveground biomass
total root biomass

Soil sampling involved looking at the following:

particle size
volatile solids
percent moisture
bulk density
pH
TKN, TP, TOC

Oviatt, C. A., S. W. Nixon and J. Garber. 1977. Variation and evaluation of coastal salt marshes. *Environmental Management* 1(3):201-211.

Not a survey of restored/created marshes--rather an attempt to develop a system to rate the "value" of marshes.

Looked at 10 Rhode Island intertidal marshes ranging from a virtually unspoiled marsh in a waterfowl refuge to an urban marsh surrounded by development.

Measured the following parameters:

standing crop, height, density, and seed set of *Spartina*
abundance and diversity of larval, juvenile, and adult fish
abundance of grass shrimp, fiddler crabs, and insects
diversity and relative abundance of birds

Large variation within sites for almost all parameters results in no statistical differences between sites. Substantially increasing sample sizes might allow differences between sites to be manifested.

Not possible to develop a rating system of wetland values based on their research--"the most likely use of such rating schemes would be to serve as a dull tool to pry marshes out from under the protective legislation that covers them".

Pitre, Randy L. & Fred Anthamatten. 1981. Successful restoration of filled wetlands at four locations along the Texas Gulf Coast. *Wetlands* 1: 171-178.

Compared restored areas to adjacent nondisturbed wetlands.

T-test statistics were used. Authors do not give size of sampling plot or how many plots were sampled. The following parameters were measured:

total number of plants by species
mean number of plants per plot
percent cover

Quammen, Millicent. 1986. Measuring the success of wetlands mitigation. *Proceedings: National Wetlands Symposium. Mitigation of Impacts and Losses*. New Orleans, LA.

Describes studies which relate success of a project to compliance with permit conditions--rather than absolute biological or physical parameters. The studies and the wetland variables recorded in each were:

Maguire 1985 - area, vegetative cover
Dial and Dies 1986 - in-kind replacement of vegetation
Shisler & Charette 1984 - vegetative and sediment characteristics
macroinvertebrates
live, dead, & total standing crop
number of reproductive shoots
nutrients
organic matter

"The failure of permit conditions to state restoration objectives or provide sufficient technical detail about restoration design makes it difficult to develop success evaluation criteria."

It is necessary to define important habitats, functions, and species of marshes to be impacted. A measure of success could be how well restoration/creation area replaces the habitats, functions, and species of the destroyed area. This would require going back to the original permit application, which hopefully describes the area to be affected as well as the area to be created.

Race, Margaret S. 1985. Critique of present wetlands mitigation policies in the United States based on an analysis of past restoration projects in San Franciso Bay. *Environmental Management* 9(1):71-82.

Investigator conducted evaluation of wetland compensation projects in San Francisco Bay area. Very critical of the results of restoration projects based on her survey. Looked at percent survival of transplants, height of individual shoots, number of stems per area and percent cover.

Suggests that coastal managers be more specific regarding mitigation requirements and that compensatory mitigation be used with caution at the present time.

Reimold, Robert J. 1980. Creation of a southeastern United States salt marsh on dredged material. IN: Lewis, J. C. and E. W. Bunce, eds. Rehabilitation and Creation of Selected Coastal Habitats: Proceedings of a Workshop, U.S. Fish & Wildlife Service, Biological Services Program, Washington, D.C. FWS/OBS - 80/27. 162 pp.

Analysis of soil was accomplished through measurement of mineral nutrients and physical analysis of soil particles. Presence and abundance of macroinvertebrates and vertebrates were noted. Chemical analysis of surrounding waters and interstitial waters in plots was conducted. Analysis of plants was conducted by noting or measuring the following:

condition: absent/dying/stressed/stable/new growth
height (cm)
basal diameter (0.01 mm)
number of live and dead leaves
average live stem density
number of flowering stems
aboveground and belowground biomass (g/m2)

Seneca, E. D., S. W. Broome and W. W. Woodhouse, Jr. 1985. The influence of duration-of-inundation on development of a man-initiated *Spartina alterniflora* Loisel. marsh in North Carolina. *J. Exp. Biol. Ecol.* 94: 259-268.

This study involves anthropogenic marshes which the authors sampled annually for up to 12 growing seasons. In their effort to determine the impact of inundation time on success of the planted areas, the authors measured the following:

average height of five tallest culms
number of flowering culms
total number of culms
basal area
aboveground standing crop (dry wt.) of planted species
aboveground standing crop of invading species
total belowground biomass (live and dead, culm bases and roots and rhizomes, planted and invading species

Seneca, E. D. 1980. Techniques for creating salt marshes along the East Coast. IN: Lewis, J. C. and E. W. Bunce, eds. *Rehabilitation and Creation of Selected Coastal Habitats:* Proceedings of a Workshop. U. S. Fish & Wildlife Service, Biological Services Program, Washington, D.C. FWS/OBS - 80/27. 162 pp.

The author planted saltmarsh cordgrass, *Spartina alterniflora* on dredged material deposits and then monitored areas to determine degree of successful establishment. Parameters measured were aboveground and belowground biomass and number of culms per unit area.

Shisler, Joseph K. and David Charette. 1984. Evaluation of artificial salt marshes in New Jersey. New Jersey Agricultural Experiment Station, Publ. No. P-40502-01-84. Rutgers University, New Brunswick, New Jersey.

The investigators selected eight representative artificial marshes to be quantitatively evaluated. The variables assessed for this study were:

standing crop
community composition
relative elevational gradients
density
height
stem diameter
number of reproductive heads

Also examined were a number of sediment variables including pH, magnesium, phosphorus, ammonium and organic matter. Macroinvertebrate density and community composition were also examined. The authors concluded that artificially created high marshes were failures and that only low marshes (i.e. below mean high water) should be planted at compensation sites.

Webb, J. W. and C. J. Newling. 1984. Comparison of natural and man-made salt marshes in Galveston Bay Complex, Texas. *Wetlands* 4:75-86.

The authors compared an artificial marsh to three nearby natural marshes with similar vegetative composition. The artificial marsh was created in 1976-77 and sampled in 1978-79 (also in 1980, 81, 82, for additional studies).

Six plots were sampled at each of 3 elevations in each marsh for the following parameters:

vegetative sampling:
- aboveground
- standing live biomass, standing dead biomass, live stem density, and stem height of *S. alterniflora*
- stem density and biomass of *Salicornia bigelovii*
- biomass of all other species
- percent cover
- total aboveground biomass
- total belowground biomass

sediment sampling:
- organic matter
- total Kjeldahl nitrogen
- ammonia - nitrogen
- cation exchange capacity
- extractable phosphorus
- clay content

The authors found that total aboveground biomass was higher in the planted marsh while belowground biomass was highest in the natural wetlands. The authors concluded that the planted marsh was still in an early stage of development.

Zedler, Joy. 1984. Salt Marsh Restoration; A Guidebook for Southern California. California Sea Grant Report No. T-CSGCP-009. University of California, La Jolla, California 92093.

Author discusses the following list of parameters as possible approaches to monitoring and determination of degree of success among projects.

elevation
soil salinity
toxic compounds
plant species composition
percent cover and height for each species
density of *Spartina alterniflora*
invertebrate species composition
bird use

Recommends against destructive sampling techniques, i.e. biomass sampling. Recommends annual aerial photographs.