SAVANNAH HARBOR NAVIGATION PROJECT
MITIGATION RECOVERY
CHATHAM COUNTY, GEORGIA AND JASPER COUNTY, SC

DRAFT ENVIRONMENTAL ASSESSMENT
APPENDIX A: ASSESSMENT OF POTENTIAL WILDLIFE HABITAT IMPROVEMENTS AT SAVANNAH NATIONAL WILDLIFE REFUGE

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Assessment of Potential Wildlife Habitat Improvements At Savannah National Wildlife Refuge

Performed for the Savannah Harbor Navigation Project
U.S. Army Corps of Engineers- Savannah District

by

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In collaboration with

US Fish and Wildlife Service,

South Carolina Department of Natural Resources,

Ducks Unlimited, and

Folk Land Management

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Assessment of Potential Wildlife Habitat Improvements
At Savannah National Wildlife Refuge

Introduction. The Savannah Harbor Navigation Project (SHNP) is behind schedule in meeting its wildlife habitat mitigation requirements for the Project's Dredged Material Containment Areas (DMCAs) along the Savannah River. The 1996 Savannah Harbor Long Term Management Strategy Environmental Impact Statement (LTMS EIS) described required mitigation activities (Appendix G: *Mitigation Plan for the Diking and Use of Disposal Area 14A and Miscellaneous Disposal Operations in South Carolina*), including operating the DMCAs to produce avian habitats. The LTMS mitigation plan listed the following required activities (the first six pertain to Disposal Area 14A exclusively; the last is for miscellaneous operations):

1. Construction of wildlife habitat within existing impounded disposal areas used by the SHNP and operating those areas for increased use by wildlife. Specifically, water levels would be maintained over the winter and spring each year to provide resting and feeding habitat for migrating waterfowl. Water levels would also be managed in one area with a slow drawdown during the summer, rainfall permitting, for the benefit of resident shorebirds. One disposal area from each rotational pair would be available throughout the approximately 2-year rotation period for disposal/wildlife management purposes. Drying and construction activities would be occurring in the other disposal area in the rotational pair, so that second area would provide no wildlife habitat during that period.

2. Creation of nesting mounds within the above areas for migratory shorebirds.

3. Establishment of an offshore island (in the nearshore area east of the Turtle Island Wildlife Management Area) for use by bare-ground-nesting migratory birds.

4. Establishment of an upland nesting area outside the embankment at the eastern end of the Jones/ Oysterbed Island disposal area for use by bare-ground-nesting migratory birds.

5. Restoration of, or protection of, 25 acres of tidal wetlands in South Carolina at sites identified by the South Carolina Department of Health and Environmental Control's Office of Coastal Resource Management (SC DHEC-OCRM).

6. Construction of a water-control structure at an existing 228-acre impoundment within the Savannah National Wildlife Refuge (SNWR) would allow tidal flows to be established in the impoundment, thereby benefitting fishery resources.

7. Additional unidentified activities to mitigate for the loss of 3.2 acres of wetlands in Georgia as a result of miscellaneous disposal area operations at existing CDFs (Confined Disposal Facilities IN and 2A) (at a 2:1 ratio),

Table 1 below indicates the number of habitat units (HUs) yielded for SHNP mitigation during the last six years. As the last line below indicates, LTMS commitments are deficient in three categories of habitat function: bare-ground nesting, waterfowl feeding, and shorebird feeding.

Table 1: Summary of habitat production FY08-FY13 (Habitat Units)

	Bare-Ground Nesting	Wetland Nesting Acres/ Months	Waterfowl Feeding Acres	Shorebird Feeding Acres	Annual Surplus/ Deficiency
FY13	47.0	350.0	111 .0	154.0	-1,056.3
FY12	47.5	60.0	97.3	317.6	-1199.4
FY11	52.2	289.0	284.0	389.5	-754.3
FY10	51.6	284.0	442.0	711.0	-280.4
FY09	58.4	1,127.0	873.0	681.0	1026.3
FY08	46.0	1,324.0	914.0	775.0	1318.0
Total Required/Yr	74.0	450.0	505.0	740.0	1,769.0
Deficit/ Surplus HU's	-141.0	+734.0	-309.0	-1,412.0	-946.0

Source: *Savannah Harbor Navigation Project FY13 Status Report Mitigation Compliance*

The U.S. Army Corps of Engineers, Savannah District (USACE) has identified changes in its operating plans for the SHNP that should allow it to meet its mitigation commitments at the DMCAs in the future. However, USACE expects SHNP not to meet its mitigation commitments on-site for at least four years (i.e., through 2016). USACE investigated a number of actions it could take within or adjacent to the DMCAs to make additional wildlife habitats that would yield mitigation benefits. Those actions were found to be unsuitable for various reasons (each would require additional mitigation, would result in the loss of existing wildlife habitat, would not be approved by a state or federal natural resource agency, and/or would be quite expensive). Due to the current and expected near-term, future deficit, USACE is considering other one-time actions, these at the Savannah National Wildlife Refuge (SNWR), located within three miles of the DMCAs to compensate for that deficit.

USACE is considering implementation of up to approximately 40 construction measures at SNWR to improve wildlife (specifically, avian) habitats that will aid in regaining compliance for SHNP via production of mitigation credits. These would allow for wildlife habitats similar to those required by SHNP to be produced at another location within the Savannah River estuary. The construction measures to be performed at SNWR would create or enhance wildlife habitats identical to those provided at the DMCAs (shorebird feeding, waterfowl feeding, wetland nesting, and bare-ground nesting), and would be a mechanism for SHNP to compensate for its short-term mitigation deficits. Construction measures would not include maintenance by USACE because the goal for the work at SNWR would be to supply habitat benefits only until other USACE mitigation projects were functional. USACE held a meeting with state and federal agencies on 18 June 2014 to discuss the proposed actions. No agency objected to USACE continuing to pursue this approach.

Technical Approach. USACE is investigating both the benefits and costs of the proposed construction measures at SNWR. To facilitate the former, Dial Cordy and Associates Inc., a USACE contractor, assembled a third-party study team to identify the present and potential future, with-project, habitat conditions at SNWR. The areas included for analysis were existing impoundment pools (see Figure 1 and Table 2) and associated embankments, canals, interior field drains, and water control structures (and those that were proposed).

Figure 1: Study/Assessment area at Savannah National Wildlife Refuge

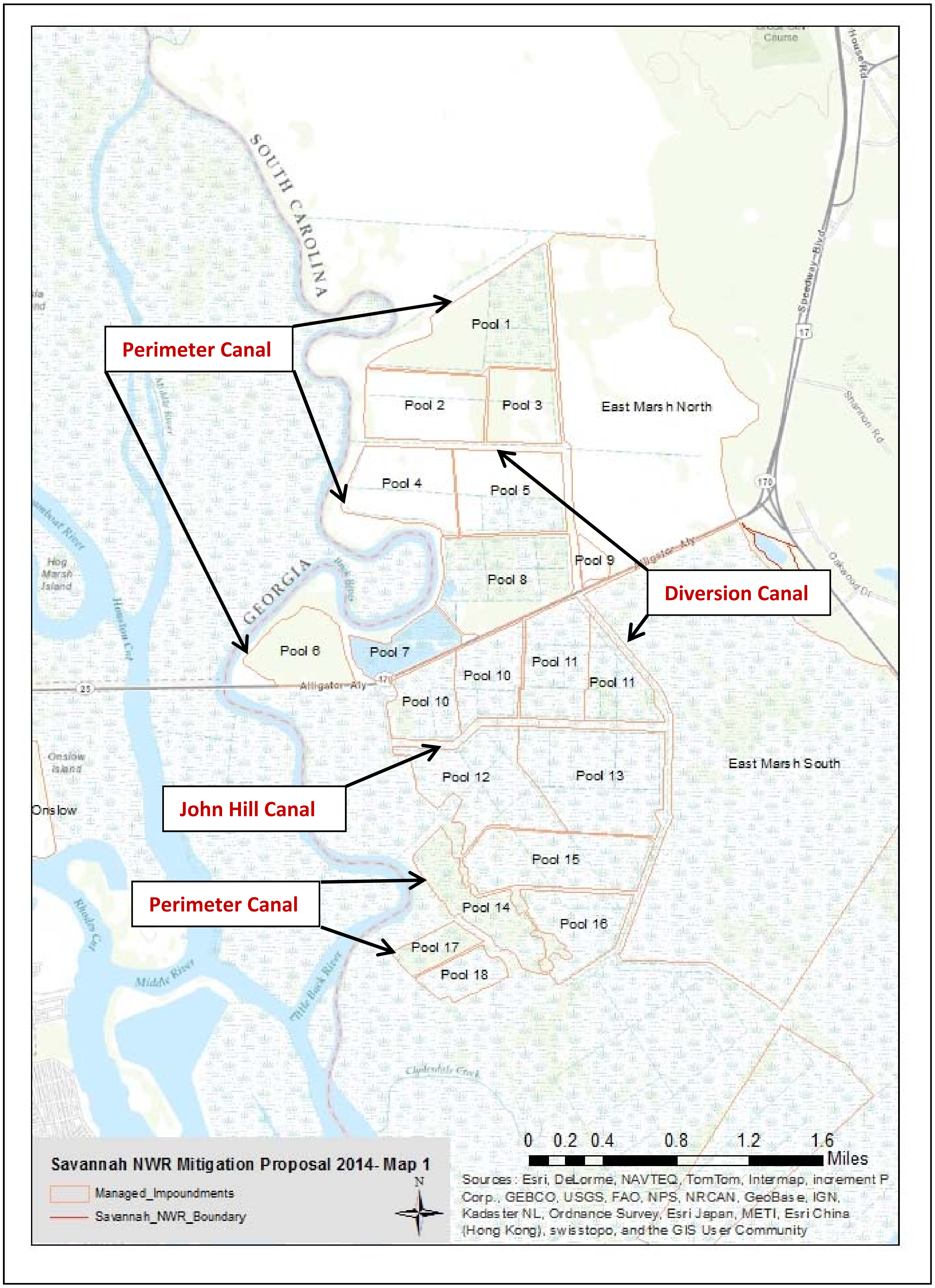

Table 2: Savannah National Wildlife Refuge impoundment pools

Impoundment Pool	Size (acres)
Pool 1	232
Pool 2	150
Pool 3	96
Pool 4	147
Pool 5	165
Pool 6	111
Pool 7	78
Pool 8	201
Pool 9	19
Pool 10	191
Pool 11	221
Pool 12	189
Pool 13	248
Pool 14	112
Pool 15	182
Pool 16	112
Pool 17	44
Pool 18	53
East Marsh North	872
East Marsh South	1,737

SNWR actively manages approximately 3,000 acres among 16 moist-soil units (Figure 2; Pools 10 and 11 are not independent of each other, neither are Pools 12 and 13). These areas range in size from 44 to 437 acres. An additional 2,600 acres of passively managed pool habitat is in the East Marsh (divided into north and south units). SNWR is primarily managed for waterfowl wintering, migrating, and breeding, and provides habitat for other species including shorebirds, wading birds, marsh birds, and other wetland-dependent species.

USACE General Permit SAC-2011-1157 describes features that are used to contain, transfer and deliver water in the impoundments, and the types of features that may be modified, constructed, or removed for the proposed mitigation project there. Such features are present at SNWR. An ***embankment*** is an earthen mound constructed to hold back water that consists of three parts: a ***field-dike*** (typically referred to simply as ***dike*** in the pages that follow), which is the elevated portion of the embankment constructed above the water level; a ***berm***, or maintenance shelf that is located to the interior of the field-dike, which helps to stabilize the field-dike; and a ***canal***, which is located to the interior of the field-dike and berm, that provides for water circulation. A ***field*** is an individual management cell located within the managed tidal impoundment. Typically, a series of fields make up a ***managed tidal impoundment*** (or MTI). At SNWR, fields are referred to as ***pools***. ***Interior field drains*** are canals within an impoundment that are typically located between interior fields, to allow water to flow to and from quarter drains, and can vary greatly in width and depth. ***Quarter drains*** are linear ditches located within the interior fields that facilitate field drainage and/or the circulation of water throughout the fields. Quarter drains are typically two-feet-wide by two-feet-deep (2'x2'). Most MTIs have numerous quarter drains. A ***water control structure*** (WCS) is a structure in a MTI or adjacent field that conveys water, controls the direction or rate of flow, and maintains a water surface elevation. WCSs in MTIs typically consist of trunks, culverts and/or spillway boxes.

The U.S. Fish and Wildlife Service (USFWS) provided the assessment team substantial details regarding the existing habitat quality within the 16 moist-soil units (i.e., technically, “fields,” or by convention, “pools,” as noted above) at SWNR. Baseline conditions were ranked from 0% (no hydrologic control) to 100% (absolute hydrologic control). Factors affecting these rankings included sizes of pools (only 4 of 16 pools <100 ac); perimeter canal, interior field drains, and quarter drain widths and depths; functionality of the canals (i.e., whether vegetation was a barrier to flow); field dike height and condition; salinity of available water source; functionality of associated WCSs; and both native and non-native invasive species proliferation (and resulting flow impediment). USFWS concluded that the perimeter canal is the single most important component to managing water inside the system and the greatest barrier to flow is vegetation proliferation. It also concluded that the large size of individual pools makes the functionality of the perimeter canal/interior quarter drain system even more important for management through efficient and effective flooding and draining. Appendix A details existing conditions for each of the impoundment pools. In consideration of potential future maintenance to address poor existing conditions, USFWS stated that the perimeter canal and associated berm/field dike cannot be effectively separated as construction elements as they work together as a unit. USFWS also observed that interior field drains and quarter drains are critical to the proper functioning of the multi-pool system. If interior water cannot reach the perimeter, dredging or widening the perimeter would be futile.

For reasons noted above, the goal of USACE for habitats at SNWR (if used for SHNP mitigation) is to improve existing habitats for shorebird feeding, waterfowl feeding, and bare-ground nesting. Given that goal, the habitat assessment team (comprising staff from USFWS; South Carolina Department of Natural Resources; Ducks Unlimited; Folk Land Management, Inc.; and Dial Cordy and Associates Inc.) was charged with estimating the habitat benefit expected to result from implementation of each of the 37 candidate construction measures (without assuming subsequent maintenance), and estimating the expected duration of that effect. Table 3 describes the sizes and types of measures considered for construction.

USFWS and the assessment team concluded that simply converting a fixed number of fields for a particular use would not be a practical or beneficial long-term method to continuously produce high-performance habitats. This was because of the complex nature of the MTI at SNWR (resulting from various sizes of fields, hydrology/hydraulics, state of disrepair in some areas, effects of invasive species, etc.), the tremendous variability of the tidal and riparian habitats at the refuge, the changing seasonal and annual requirements of targeted species groups, and the diverse needs of USACE to accomplish its mitigation goals. However, maximizing the *capability* of USFWS to manage the fields as needed through time would allow managers to meet these challenges. Therefore the effect that any construction measure imparted on the “management utility” of a given field ultimately yielded habitat benefits. (Benefits were quantified as “habitat units” for the assessment; see below for details). Management utility was a gauge of how easily refuge staff could flood, drain, and maintain vegetation and water quality to the degree necessary to provide benefits to targeted wildlife, specifically waterfowl, shorebirds, and other migratory species. The specific types of benefits that the refuge manager will be charged with creating via increased management utility include bare-ground nesting areas, waterfowl feeding areas, and shorebird feeding areas. This conceptual framework was used because it allows for the maximum flexibility of the use (i.e. purpose) of refuge impoundment pools given seasonal and annual natural variation in water supply, vegetation management needs, and waterfowl habitat needs.

Table 3: Savannah National Wildlife Refuge candidate construction measures

No.	Measure	Linear Feet	Dimensions
1	Replacement of John Hill Water Control Structure	N/A	4 pipes @ 48 in diameter
2	[1]Per Dike Raising to 12 feet MLLW (Pool 2)	1,995	2 ft raising
3	Per Dike Raising to 12 feet MLLW (Pool 4)	9,984	2 ft raising
4	Per Dike Raising to 12 feet MLLW (Pool 8)	To Be Determined	2 ft raising
5	Per Dike Raising to 12 feet MLLW (Pool 7)	To Be Determined	2 ft raising
6	Per Dike Raising to 12 feet MLLW (Pool 14 &17)	221	2 ft raising
7	[2]Int Dike Raising to 9 feet MLLW (Pool 2 & 3)	1,905	2 ft raising
8	Int Dike Raising to 9 feet MLLW (Pool 4)	1,995	2 ft raising
9	Int Dike Raising to 9 feet MLLW (Pool 5)	To Be Determined	2 ft raising
10	Int Dikes Raising to 9 feet MLLW (Pool 10 & 11)	2,892	2 ft raising
11	Int Dike Raising to 9 feet MLLW (Pool 12, 13, & 15)	5,920	2 ft raising
12	Int Dike Raising to 9 feet MLLW (Pool 15 & 16)	3,407	2 ft raising
13	Canal dredging for Pool 1 (40')	14,794 (per) + 3,332 (int) = 18,126	40 ft wide x 12 ft deep
14	Canal dredging for Pool 2 (40')	10,253 (per) + 4,733 (int) = 14,986	40 ft wide x 12 ft deep
15	Canal dredging for Pool 3 (40')	7,899 (per) + 3,965 (int) = 11,864	40 ft wide x 12 ft deep
16	Canal dredging for Pool 4 (40')	11,677 (per) + 3,881 (int)= 15,558	40 ft wide x 12 ft deep
17	Canal dredging for Pool 5 (40')	9,089 (per)	40 ft wide x 12 ft deep
18	Canal dredging for Pool 6 (40')	To Be Determined	40 ft wide x 12 ft deep
19	Canal dredging for Pool 7 (40')	To Be Determined	40 ft wide x 12 ft deep
20	Canal dredging for Pool 8 (40')	11,518 (per) + 6,705 (int) = 18,223	40 ft wide x 12 ft deep
21	Canal dredging for Pool 9 (40')	To Be Determined	40 ft wide x 12 ft deep
22	Canal dredging for Pool 10 (40')	12,352 (per) + 4,218 (int) = 16,570	40 ft wide x 12 ft deep
23	Canal dredging for Pool 11 (40')	12,907 (per) + 2,546 (int) = 15,453	40 ft wide x 12 ft deep
24	Canal dredging for Pool 12 (40')	To Be Determined	40 ft wide x 12 ft deep
25	Canal dredging for Pool 13 (40')	To Be Determined	40 ft wide x 12 ft deep
26	Canal dredging for Pool 14 (40')	12,366 (per)	40 ft wide x 12 ft deep
27	Canal dredging for Pool 15 (40')	12,975 (per) + 4,633 (int) = 17,608	40 ft wide x 12 ft deep
28	Canal dredging for Pool 16 (40')	11,071 (per) + 4,491 (int) = 15,562	40 ft wide x 12 ft deep
29	Canal dredging for Pool 17 (40')	6,092 (per)	40 ft wide x 12 ft deep
30	Canal dredging for Pool 18 (40')	6,290 (per)	40 ft wide x 12 ft deep
31	Conversion of Pool 11 Experimental Pools	To Be Determined	To Be Determined
32	Cross Dike and Water Control Structure Construction in Pool 10	2,338 new dike	48 in Diameter
33	Int Cross Dike and Water Control Structure Construction in Pool 11	3,095 new dike	48 in Diameter
34	Int Cross Dike and Water Control Structure Construction in Pool 12 & 13	3,497 new dike	48 in Diameter
35	Reclaim Ditches in East Marsh North and Establish Cypress Trees	To Be Determined	20 ft wide x 12 ft deep
36	Construct East Marsh South's South Dike with Water Control Structures Near Railroad	N/A	Multiple 48 in Diameter
37	Construct Water Control Structures for East Marsh on Diversion Canal	N/A	Multiple 48 in Diameter

[1]Per: perimeter;
[2]Int: interior

The team convened at SNWR on 29 October 2014 to (1) observe the existing management condition of each pool/site (i.e., present level of habitat function), (2) discuss which construction measures would benefit each pool/site (and how), (3) estimate the amount of management utility (ultimately, to provide habitat improvement) expected to result from each of the 37 proposed construction measures, and (4) determine the duration/life-expectancy (without any anticipated future maintenance) of the each construction measure. For items (1) and (3), the *degree of existing wildlife management utility*, or *anticipated increase in utility given a construction measure* was expressed as a percent, where 100% represented the maximum possible level of utility, i.e., habitats that could be maximized for use to target managing for ground nesting areas, waterfowl feeding areas, and/or shorebird feeding areas. If any of the proposed on-site improvements would provide a direct or indirect synergistic benefit to the field/pool function, it was noted and its relative contribution to ecosystem management (as a percent) was also determined. Estimates of habitat improvement (%) and construction measure longevity (years) were assigned based on best professional judgment of assessment team members.

Data pertaining to aforementioned items (1), (3), and (4) were entered into an MS Excel spreadsheet, in addition to the acreage of habitat that each construction measure affected, for subsequent calculations. Data from item (2) resulted in tables shown in Appendix B, which shows which measures were synergistically related to other measures (both directly and indirectly). Spreadsheet data were used to calculate the amount of initial, average annual, and lifetime habitat unit lift for each construction measure. It was assumed that each construction measure was maximally effective at year 1 (starting at the completion of construction) and no longer effective after 15, 20, or 25 years had passed (depending on which measure was being considered). Field dikes erode, canals fill with sediment and plant material, and WCSs deteriorate. The rate of decline of effectiveness was assumed to be linear for all features. To calculate initial, i.e., year 1 (and hence, maximal) lift, for each of the 37 measures, the area of effect for each measure was multiplied by the initial, i.e., year 1 (and hence, maximal) functional increase (expressed as percentage, converted to decimal format) determined in item (3) above. The average lift provided across the entire useful/effective life of each construction feature was calculated by dividing that maximum lift in half, and the total (cumulative) lift provided by each measure across its useful/effective life was the average lift multiplied by the useful/effective life (in years) of the measure.

Results. Benefits of construction measures for each pool/site are shown in Appendix B. The proposed action’s number and description (from Table 3 above) is listed in the left-most columns for each pool, under either the “direct” or “indirect” action subheading. For any action directly affecting the subject pool, the exiting habitat function (expressed as %), with-project habitat function (year 1, for reasons explained above, expressed as %), maximum functional lift (year 1, expressed as %), and effective life (years) of the construction measure is provided. If the maximum function of a direct action is contingent on another action, the measure to which it is related is listed as is the improvement gained from that synergism. Direct actions per pool ranged from one construction measure to as many as five. For actions that are not within the focal pool, and hence represent indirect synergy, only the related actions and synergistic gains were listed. Indirect actions per pool ranged from one construction measure to as many as six. The sum of all potential increases in improvement from direct actions (year 1, expressed as %) is shown in the second-to-last line in each table in Appendix B, and the last line of each table lists that total possible, maximum (i.e., in year 1), with-project function (expressed as %). In some cases, those numbers exceeded 100% due to multiple measures being used concurrently; management utility could be drastically increased over historical and existing levels. However, in practice, management utility could not exceed 100%. The results based on Appendix B tables and the calculations described above are summarized in Tables 4 and 5. With-project benefits per pool are capped at 100% in Table 5 to demonstrate potential, practical gains.

Table 4 lists the acreage directly affected by each proposed measure; the maximum (i.e., for year 1 post-construction) functional increase anticipated (expressed as %, converted to decimal format); the maximum lift in habitat units (HUs) that could be contributed in a given year (year 1); the average, annual contribution of HUs across the effective/useful life of the measure; the duration of the effective/useful life of each measure; and the cumulative number of HUs yielded by the measure across all years the measure is useful. In many cases, to achieve the noted lift, a given construction measure may need to be combined with one or more others to ensure usefulness and long-term feasibility. However, the effects of multiple measures on a given pool were not necessarily additive. Table 4 does not include any benefits that each construction measure may contribute to pools indirectly.

Among the construction measures providing the greatest increases in management utility, and ultimately habitat function, were dredging the canal servicing Pool 8, replacement of the John Hill canal WCS, and dredging canals servicing Pools 1, 11, and 15. (Note: for the John Hill canal WCS, the value of the functional increase shown was an average based on its estimated effectiveness across several pools.) Other measures providing very significant benefits were dredging for canals servicing Pools 10, 5, 4, and 2. Measures for dredging canals servicing Pools 14 and 16 performed well, as did the measure for conversion of Pool 11 experimental pools into areas that could be utilized for shorebird feeding. In most cases, benefits yielded from field-dike re-topping depended on first dredging canals servicing the various pools.

Table 5 lists the initial condition of each impoundment pool, expressed as a percent of maximum potential habitat utilization, the potential habitat gain from implementation of all possible directly related construction measures, again represented as a percent, and the resulting habitat value of the respective pools. In some cases, values in the third column exceeded 100% if multiple features were to be constructed. In such cases, the conceptual maximum of 100% was listed instead of the mathematical totals (which can be reviewed in Appendix B) to avoid confusion (i.e., a given habitat cannot be more than 100% functional/utilized) and the numbers in the second column were reduced to provide the difference (i.e., "lift") between the 100 maximum and the initial habitat value (%) in order to ease comparison of data. The table shows that the habitat function of every pool except Pool 9 can be brought to at least 80%. Pools 2, 4, 10, 11, 12, 13, and 15 could achieve 100% function if all directly related measures were constructed.

Table 4: Habitat units produced by proposed construction measures

No.	Measure	Directly Affected Acres	Max (Yr 1) Functional Increase	Max (Yr 1) Annual Lift (Habitat Units)	Average Annual Lift (HU[3]) for Measure's Effective Life	Measure Effective Life (Years)	Total HU Yield for Measure's Effective Life
1	Replace John Hill WCS	849	0.15	127.35	63.68	25	1,591.88
2	[1]Per Dike Raising (Pool 2)	150	0.16	24.00	12.00	15	180.00
3	Per Dike Raising (Pool 4)	147	0.16	23.52	11.76	15	176.40
4	Per Dike Raising (Pool 8)	201	0.16	32.16	16.08	15	241.20
5	Per Dike Raising (Pool 7)	78	0.16	12.48	6.24	15	93.60
6	Per Dike Raising (Pool 14 &17)	156	0.12	18.72	9.36	15	140.40
7	[2]Int Dike Raising (Pool 2 & 3)	246	0.12	29.52	14.76	15	221.40
8	Int Dike Raising (Pool 4)	147	0.12	17.64	8.82	15	132.30
9	Int Dike Raising to (Pool 5)	165	0.08	13.20	6.60	15	99.00
10	Int Dikes Raising to (Pool 10 & 11)	412	0.12	49.44	24.72	15	370.80
11	Int Dike Raising to (Pool 12, 13, & 15)	619	0.12	74.28	37.14	15	557.10
12	Int Dike Raising to (Pool 15 & 16)	294	0.12	35.28	17.64	15	264.60
13	Canal dredging for Pool 1 (40')	232	0.50	116.00	58.00	25	1,450.00
14	Canal dredging for Pool 2 (40')	150	0.55	82.50	41.25	25	1,031.25
15	Canal dredging for Pool 3 (40')	96	0.50	48.00	24.00	25	600.00
16	Canal dredging for Pool 4 (40')	147	0.60	88.20	44.10	25	1,102.50
17	Canal dredging for Pool 5 (40')	165	0.55	90.75	45.38	25	1,134.38
18	Canal dredging for Pool 6 (40')	111	0.50	55.50	27.75	25	693.75
19	Canal dredging for Pool 7 (40')	78	0.55	42.90	21.45	25	536.25
20	Canal dredging for Pool 8 (40')	201	0.65	130.65	65.33	25	1,633.13
21	Canal dredging for Pool 9 (40')	19	0.00	0.00	0.00	0	0.00
22	Canal dredging for Pool 10 (40')	191	0.50	95.50	47.75	25	1,193.75
23	Canal dredging for Pool 11 (40')	221	0.50	110.50	55.25	25	1,381.25
24	Canal dredging for Pool 12 (40')	189	0.20	37.80	18.90	25	472.50
25	Canal dredging for Pool 13 (40')	248	0.20	49.60	24.80	25	620.00
26	Canal dredging for Pool 14 (40')	112	0.50	56.00	28.00	25	700.00
27	Canal dredging for Pool 15 (40')	182	0.60	109.20	54.60	25	1,365.00
28	Canal dredging for Pool 16 (40')	112	0.55	61.60	30.80	25	770.00
29	Canal dredging for Pool 17 (40')	44	0.40	17.60	8.80	25	220.00
30	Canal dredging for Pool 18 (40')	53	0.40	21.20	10.60	25	265.00
31	Conversion of Pool 11 Exp Pools	221	0.32	70.72	35.36	20	707.20
32	X-dike and WCS in Pool 10	191	0.14	26.74	13.37	15	200.55
33	X-dike and WCS in Pool 11	221	0.14	30.94	15.47	15	232.05
34	Int X-dike and WCS in Pool 12 & 13	437	0.14	61.18	30.59	15	458.85
35	Ditches in E Marsh N and Trees	872	0.00	0.00	0.00	0	0.00
36	E Marsh S's S Dike w/ WCS near RR	1737	0.00	0.00	0.00	0	0.00
37	WCS for E Marsh on Diversion Canal	1737	0.00	0.00	0.00	0	0.00

*Certain complimentary/synergistic activities may be necessary to achieve these gains; see Appendix B.
[1]Per: perimeter; [2]Int: interior; [3]HU: Habitat Units

Table 5: Potential improvement by pool constructing all direct measures

Pool	Initial condition/ value (%)	Maximum (Year-1) improvement from all directly related actions (%)*	Maximum (Year-1), with-project condition if all direct actions are constructed (%)
1	30	50	80
2	25	75	100
3	30	62	92
4	20	80	100
5	25	62	88
6	30	50	80
7	25	71	96
8	15	81	96
9	0	0	0
10	30	70	100
11	30	70	100
12	60	40	100
13	60	40	100
14	30	62	92
15	20	80	100
16	25	67	92
17	40	52	92
18	40	40	80

*Actual sums of actions may have exceeded 100%; practical maxima are presented here. See appendix B for actual sums.

Discussion. Table 4 data identify the potential benefits of the various construction measures. Certain complimentary activities may be necessary to achieve the gains identified for certain measures, and other synergistic actions may enhance gains (see Appendix B). The team concurred that improved management of any pool could not be carried out by any single measure; typically at least two measures would be required to achieve any meaningful increase in habitat function. Guidance for the correct approach (how measures are paired/configured to yield the desired habitat) can be found in USACE Charleston District permits issued for moist-soil management projects (e.g., USACE General Permit SAC-2011-1157).

Specific details regarding many measures have not been determined, and the performance of measures relies on those details. Team members assumed that for the purposes of calculating benefits, the best practices of construction (for habitat management purposes) will be carried out for the embankment/canal system (i.e., canals will be dug with steep side-slopes, and “counterweight” terraces (berms) will extend from the base of the field dike out to the typical top-of-bank of the canal to prevent degradation of the dike. It was assumed that material from dredging ditches/canals will be placed on top of the dike, if needed, and along the berm and slopes of the dike. If there are areas with no berm, and given enough material from adjacent dredging, berms would be re-established. If the berm and dike are in good shape and do not require additional fill, the spoil from the canal could be veneered across the top of the floor of the field (pool).

Table 1 shows a mitigation deficit of 1,862 for certain habitat types and a total nonspecific deficit of 946 if all types are grouped together. Based on findings shown in Tables 4 and 5, it appears that with a few carefully selected and designed construction measures, USACE could bring SHNP into mitigation compliance. Regardless of which pool(s) are selected for increased management utility (and hence, wildlife habitat improvement), construction measures must be selected to avoid functional redundancies, generate the maximum possible HUs, and maximize cost-efficiency. Additional gains across the project area could be realized through indirect effects (indirect synergy) of certain measures on adjacent pools (see below paragraph). The current results do not take into account any maintenance by USACE, but do assume routine maintenance by USFWS, such as is currently performed on the refuge. Given the above, it is likely that USACE could significantly attenuate SHNP's mitigation deficit by implementing the proposed construction measures.

Table 5 shows that the pools that would benefit most from proposed construction measures (in decreasing order) are Pools 8, 4, 15, 2, 7, 10 and 11. These results (ranging from 81 to 70% increases in habitat function) are contingent on direct synergy among measures for these pools. Additional increases in benefits (management utility) would be realized for these and most other pools due to indirect synergy, principally due to pools sharing common field dikes or being connected hydrologically. The John Hill canal WCS replacement was determined to directly affect several pools along its length, but also provided a small amount of indirect benefit to pools with direct hydraulic connections to the Diversion Canal, which joins the John Hill canal.

The prolific increase in habitat function for most pools was primarily due to proposed dredging of 40-foot-wide by 12-foot-deep canals. The originally proposed, 20-foot-wide by 12-foot-deep canals yielded, in preliminary analyses, only 5% increases in function, and had a very short useful life (only two years), whereas the 40-foot wide canals had effective increases in function ranging from 20 to 65% and a useful life of 25 years. The difference was primarily due to the greater capacity of the larger canals to continue to function even as they receive sediments from dike erosion. The larger canals would also be more resistant to flow impediments from invasive vegetation, and provide a means for managers to access areas for invasive species control efforts.

Team members did concur that invasive vegetation removal itself should have been another option for assessment, but could not determine in the assessment timeframe how much functional lift would be provided by a one-time invasive species control event. Addition of this measure could result in substantial benefits for certain pools, especially in canals/ditches not proposed for dredging where plant material impedes drainage.

The team concluded that benefits to Pool 9 could not be realized because its perimeter dike has failed. Therefore, dredging more efficient canals would be futile. Indirect synergy for this pool was not recognized, because without functioning dikes, there is no baseline level of service/function sustained.

USFWS proposed that construction measure #31 (removal of experimental pools in Pool 11) should be modified to allow for the flexibility to manage the area for shorebird feeding habitats, rather than simply removing the old experimental pools that had been there (which would simply create an area with the same utility as all other areas). This would capitalize on some of the embankment structures that still exist in the area, be a more cost-effective use of the area, and provide an important habitat that is already well situated for preforming a specific avian habitat function. This feature would increase habitat utility by 32% and provide reasonable benefits to adjacent pools. Deep-water flooding would be used only for vegetation management and draw-down mudflat creation.

Construction measure #35 (reclaim ditches in East Marsh North and establish cypress trees) was determined by the team to not yield any appreciable benefits. This was because USFWS stated that there are no existing ditches in East Marsh North to reclaim, and because the marsh already has substantial new and ongoing tree growth.

The goal for moist-soil management at SNWR was to promote maximum flexibility in water control vis-à-vis reacting to environmental variables and wildlife needs. Construction measures for East Marsh South (measures #36 and 37) would require management of a 7000-ft levee with numerous water control features. The team found these construction measures to yield no benefits principally because (1) the numerous water control features that would be necessary to make that large area more amenable to waterfowl productivity would be difficult to manage (there is no precedent/historical reference in this area for intensive management of such a large area/ volume of water for moist-soil/wildlife purposes; personnel are not available to monitor and maintain such an extensive system; and maintenance costs would burden USFWS if enough water control structures (WCSs) and dike features were constructed to initially enable the system), and (2) installing fewer water control features would not likely accommodate the necessary flow regime. In either case, beneficial effects would not occur. Maximum functional improvements are achieved by the implementation of effective hydraulic controls to increase utility of site management for various purposes, not simply flooding an area one time to yield a temporary benefit.

Although this wildlife habitat assessment provides an estimate of benefits, it does not necessarily reflect the preferences or USFWS priorities of habitat improvements work at SNWR. In addition, this document is not intended to represent an agreement with USFWS for construction of any particular measure.

APPENDIX A
BASELINE/EXISTING CONDITIONS FOR IMPOUNDMENT POOLS AT SAVANNAH NATIONAL WILDLIFE REFUGE

Baseline/Existing Conditions for Impoundment Pools, SNWR
17 December 2014

<u>Pool 1 (216 ac)</u>
- Baseline Condition, 30% control
- Portions of the perimeter canal cleared of vegetation in 2013, most narrow (20' or less) and clogged with vegetation
- All interior ditches are totally clogged with vegetation
- Water controlled through two rice-field trunks, one on the Little Back River and one on Vernezobre Creek
- Perimeter levee noticeably low in places

<u>Pool 2 (143 ac)</u>
- Baseline Condition, 25% control
- Perimeter canal narrow, totally clogged with vegetation
- All interior ditches are totally clogged with vegetation
- Water controlled through 1 rice-field trunk on the Little Back River and one flashboard riser connection to Pool 3
- Indirect control through flashboard riser if salinity at rice trunk prohibits flooding that would inhibit flexibility in management actions
- Perimeter levee noticeably low in places
- Invasive infestation of water hyacinth (*Eichhornia crassipes*)

<u>Pool 3 (90 ac)</u>
- Baseline Condition, 30% control
- Perimeter canal narrow, totally clogged with vegetation
- All interior ditches are totally clogged with vegetation
- Water controlled through one flashboard riser connection to Pool 2 and one concrete box with single gate on the diversion canal

<u>Pool 4 (142 ac)</u>
- Baseline Condition, 20% control
- Perimeter canal narrow, totally clogged with vegetation
- All interior ditches are totally clogged with vegetation
- Water controlled through one flashboard riser connection to Pool 5 and one rice-field trunk on the Little Back River
- Can be restricted by salinity, if Little Back River salinity is too high, can flood slowly through Pool 5. Indirect control through flashboard riser that would inhibit flexibility in management actions.
- Perimeter levee noticeably low in places

<u>Pool 5 (160 ac)</u>
- Baseline Condition, 25% control
- Perimeter canal narrow, totally clogged with vegetation
- All interior ditches are totally clogged with vegetation
- Water controlled through one flashboard riser connection to Pool 4 and one concrete box with single gate on the diversion canal

Pool 6 (109 ac)

- Baseline Condition, 30% control
- Perimeter canal narrow, recently cleared of vegetation but growing back rapidly due to narrow width and shallow depth
- All interior ditches are totally clogged with vegetation
- Water controlled through one rice-field trunk on the Little Back River
- Can be restricted by salinity, if Little Back River salinity is too high, no other water source for flooding
- Perimeter levee noticeably low in places

Pool 7 (78 ac)

- Baseline Condition, 25% control
- Perimeter canal narrow, totally clogged with vegetation, primarily water hyacinth
- All interior ditches are totally clogged with vegetation
- Water controlled through one rice-field trunk on the Little Back River
- Can be restricted by salinity, if Little Back River salinity is too high, no other water source for flooding
- Perimeter levee noticeably low in places

Pool 8 (200 ac)

- Baseline Condition, 15% control
- Perimeter canal narrow, mostly clogged with vegetation
- All interior ditches are totally clogged with vegetation
- Water controlled only through one rice-field trunk on the Little Back River
- Can be restricted by salinity, if Little Back River salinity is too high, no other water source for flooding
- Can be easily connected to the diversion canal with the addition of one concrete box and single gate
- Perimeter levee noticeably low in places

Pool 9 (N/A)

- Baseline Condition, 0% control
- Levees are breached and no current plan to restore, now considered part of East Marsh

Pool 10 (190 ac)

- Baseline Condition, 30% control
- Perimeter canal narrow, mostly clogged with vegetation
- All interior ditches are totally clogged with vegetation
- Water controlled through one flashboard riser connection to the John Hill Canal. John Hill Canal indirectly managed through Diversion Canal.
- Levee separating Pools 10 and 11 is very low and inhibits independent water management.

Pool 11 (213 ac w/Experimental Pools)

- Baseline Condition, 30% control
- Perimeter canal narrow, mostly clogged with vegetation
- All interior ditches are totally clogged with vegetation
- Water controlled through one flashboard riser connection to the John Hill Canal. John Hill Canal indirectly managed through Diversion Canal.
- Remnant levees on the Experimental Pools inhibit water management – see below.
- Levee separating Pools 10 and 11 is very low and inhibits independent water management.

Pool 12/13 (444 ac)

- Baseline Condition, 60% control
- Perimeter canal narrow, no berm
- Semi-permanently flooded because large size precludes moist soil management techniques
- Water controlled through one rice-field trunk on the Little Back River, one concrete box and single gate on the John Hill Canal, and one concrete box with two gates on the diversion canal. John Hill Canal indirectly managed through Diversion Canal.

Pool 14 (110 ac)
- Baseline Condition, 30% control
- Perimeter canal narrow, mostly clogged with vegetation
- All interior ditches are totally clogged with vegetation
- Water controlled through one concrete box with single gate on Spur Canal and one rice-field trunk on the Little Back River
- Perimeter levee noticeably low in places

Pool 15 (178 ac)
- Baseline Condition, 20% control
- Perimeter canal narrow, mostly clogged with vegetation
- All interior ditches are totally clogged with vegetation
- Water controlled through one concrete box with single gate on the diversion canal
- Interior levee low separating Pool 15 and 16.
- Invasive phragmites potential problem

Pool 16 (113 ac)
- Baseline Condition, 25% control
- Perimeter canal narrow, mostly clogged with vegetation
- All interior ditches are totally clogged with vegetation
- Water controlled through one concrete box with single gate on the diversion canal
- Interior levee low between Pools 15 and 16.
- Invasive phragmites potential problem

Pool 17 (42 ac)
- Baseline Condition, 40% control
- Small portion of perimeter canal dug out for levee improvement
- Perimeter canal narrow, mostly clogged with vegetation
- All interior ditches are totally clogged with vegetation
- Water controlled through one concrete box with single gate on the Spur Canal and one rice-field trunk on the Little Back River
- Perimeter levee noticeably low in places
- Interior levee low between Pools 17 and 18

Pool 18 (53 ac)
- Baseline Condition, 40% control
- Small portion of perimeter canal dug out for levee improvement
- Perimeter canal narrow, mostly clogged with vegetation
- All interior ditches are totally clogged with vegetation
- Water controlled through one concrete box with single gate on the Spur Canal and one rice-field trunk on the Little Back River
- Perimeter levee noticeably low in places
- Interior levee low between Pools 17 and 18

Experimental pools proposed for shorebird pools, currently included with Pool 11
- Baseline Condition, 0% control
- Levees breached and canals clogged with vegetation
- No reasonable control of water for shorebirds in baseline condition

APPENDIX B
SAVANNAH NATIONAL WILDLIFE REFUGE
HABITAT BENEFITS PER IMPOUNDMENT POOL

Impoundment Pool 1

	Proposed Action	Existing Habitat Function (%)	Max (Yr 1) Habitat Function w/ Imprvmt (%)	Max (Yr 1) Increase in Habitat Function (%)	Effective Life (Years) of Action	Synergistic Actions	Max (Yr 1) Improvement Gained from Synergism (%)
	Direct:						
13	Canal dredging for Pool 1 @ 40' x 12'	30	80	50	25	-	-
	TOTAL, MAXIMUM POSSIBLE DIRECT GAIN			**50**			
	WITH PROJECT CONDITION, ALL DIRECT MEASURES APPLIED			**80**			

Impoundment Pool 2

	Proposed Action	Existing Habitat Function (%)	Max (Yr 1) Habitat Function w/ Imprvmt (%)	Max (Yr 1) Increase in Habitat Function (%)	Effective Life (Years) of Action	Synergistic Actions	Max (Yr 1) Improvement Gained from Synergism (%)
	Direct:						
14	Canal dredging for Pool 2 @ 40' x 12'	25	80	55	25	-	-
2	Perimeter Dike Raising to 12 feet MLLW (Pool 2)	25	41	16	15	14	16
7	Interior Dike Raising to 9 feet MLLW (Pool 2 & 3)	25	37	12	15	2,14	12
	Indirect:						
15	Canal dredging for Pool 3 @ 40' x 12'					2,7,14	10
	TOTAL, MAXIMUM POSSIBLE DIRECT GAIN			**83**			
	WITH PROJECT CONDITION, ALL DIRECT MEASURES APPLIED			**108**			

	Impoundment Pool 3						
	Proposed Action	Existing Habitat Function (%)	Max (Yr 1) Habitat Function w/ Imprvmt (%)	Max (Yr 1) Increase in Habitat Function (%)	Effective Life (Years) of Action	Synergistic Actions	Max (Yr 1) Improvement Gained from Synergism (%)
	Direct:						
15	Canal dredging for Pool 3 @ 40' x 12'	30	80	50	25	-	-
7	Interior Dike Raising to 9 feet MLLW (Pool 2 & 3)	30	42	12	15	15	12
	Indirect:						
2	Perimeter Dike Raising to 12 feet MLLW (Pool 2)					7,15,14	4
14	Canal dredging for Pool 2 @ 40' x 12'					7,15	10
1	Replacement of John Hill Water Control Structure					7,15	1
	TOTAL, MAXIMUM POSSIBLE DIRECT GAIN			**62**			
	WITH PROJECT CONDITION, ALL DIRECT MEASURES APPLIED			**92**			

	Impoundment Pool 4						
	Proposed Action	Existing Habitat Function (%)	Max (Yr 1) Habitat Function w/ Imprvmt (%)	Max (Yr 1) Increase in Habitat Function (%)	Effective Life (Years) of Action	Synergistic Actions	Max (Yr 1) Improvement Gained from Synergism (%)
	Direct:						
16	Canal dredging for Pool 4 @ 40' x 12'	20	80	60	25	-	-
3	Perimeter Dike Raising to 12 feet MLLW (Pool 4)	20	36	16	15	16	16
8	Interior Dike Raising to 9 feet MLLW (Pool 4)	20	32	12	15	3,16	12
	Indirect:						
9	Interior Dike Raising to 9 feet MLLW (Pool 5)					3,8,16,17	2
17	Canal dredging for Pool 5 @ 40' x 12' (per only)					3,8,16	8
	TOTAL, MAXIMUM POSSIBLE DIRECT GAIN			**88**			
	WITH PROJECT CONDITION, ALL DIRECT MEASURES APPLIED			**108**			

	Impoundment Pool 5						
	Proposed Action	Existing Habitat Function (%)	Max (Yr 1) Habitat Function w/ Imprvmt (%)	Max (Yr 1) Increase in Habitat Function (%)	Effective Life (Years) of Action	Synergistic Actions	Max (Yr 1) Improvement Gained from Synergism (%)
	Direct:						
17	Canal dredging for Pool 5 @ 40' x 12' (per only)	25	80	55	25	-	-
9	Interior Dike Raising to 9 feet MLLW (Pool 5)	25	33	8	15	9	8
	Indirect:						
16	Canal dredging for Pool 4 @ 40' x 12'					9,17	10
20	Canal dredging for Pool 8 @ 40' x 12'					9,17	10
3	Perimeter Dike Raising to 12 feet MLLW (Pool 4)					9,17,16	4
4	Perimeter Dike Raising to 12 feet MLLW (Pool 8)					9,17	4
8	Interior Dike Raising to 9 feet MLLW (Pool 4)					9,17,16	3
1	Replacement of John Hill Water Control Structure					9,17	2
	TOTAL, MAXIMUM POSSIBLE DIRECT GAIN			**63**			
	WITH PROJECT CONDITION, ALL DIRECT MEASURES APPLIED			**88**			

	Impoundment Pool 6						
	Proposed Action	Existing Habitat Function (%)	Max (Yr 1) Habitat Function w/ Imprvmt (%)	Max (Yr 1) Increase in Habitat Function (%)	Effective Life (Years) of Action	Synergistic Actions	Max (Yr 1) Improvement Gained from Synergism (%)
	Direct:						
18	Canal dredging for Pool 6 @ 40' x 12'	30	80	50	25	-	-
	TOTAL, MAXIMUM POSSIBLE DIRECT GAIN			**50**			
	WITH PROJECT CONDITION, ALL DIRECT MEASURES APPLIED			**80**			

	Impoundment Pool 7						
	Proposed Action	Existing Habitat Function (%)	Max (Yr 1) Habitat Function w/ Imprvmt (%)	Max (Yr 1) Increase in Habitat Function (%)	Effective Life (Years) of Action	Synergistic Actions	Max (Yr 1) Improvement Gained from Synergism (%)
	Direct:						
19	Canal dredging for Pool 7 @ 40' x 12'	25	80	55	25	-	-
5	Perimeter Dike Raising to 12 feet MLLW (Pool 7)	25	41	16	15	19	16
	Indirect:						
20	Canal dredging for Pool 8 @ 40' x 12'					5,19	10
4	Perimeter Dike Raising to 12 feet MLLW (Pool 8)					5,19,20	2
	TOTAL, MAXIMUM POSSIBLE DIRECT GAIN			**71**			
	WITH PROJECT CONDITION, ALL DIRECT MEASURES APPLIED			**96**			

	Impoundment Pool 8						
	Proposed Action	Existing Habitat Function (%)	Max (Yr 1) Habitat Function w/ Imprvmt (%)	Max (Yr 1) Increase in Habitat Function (%)	Effective Life (Years) of Action	Synergistic Actions	Max (Yr 1) Improvement Gained from Synergism (%)
	Direct:						
20	Canal dredging for Pool 8 @ 40' x 12'	15	80	65	25	-	-
4	Perimeter Dike Raising to 12 feet MLLW (Pool 8)	15	31	16	15	20	16
	Indirect:						
17	Canal dredging for Pool 5 @ 40' x 12' (per only)					4,20	8
19	Canal dredging for Pool 7 @ 40' x 12'					4,20	10
5	Perimeter Dike Raising to 12 feet MLLW (Pool 7)					4,20,19	4
9	Interior Dike Raising to 9 feet MLLW (Pool 5)					4,20,17	2
	TOTAL, MAXIMUM POSSIBLE DIRECT GAIN			**81**			
	WITH PROJECT CONDITION, ALL DIRECT MEASURES APPLIED			**96**			

	Impoundment Pool 9						
	Proposed Action	Existing Habitat Function (%)	Max (Yr 1) Habitat Function w/ Imprvmt (%)	Max (Yr 1) Increase in Habitat Function (%)	Effective Life (Years) of Action	Synergistic Actions	Max (Yr 1) Improvement Gained from Synergism (%)
	Direct:						
21	Canal dredging for Pool 9 @ 40' x 12'	0	0	0	n/a	-	-
1	Replacement of John Hill Water Control Structure					21	0
	TOTAL, MAXIMUM POSSIBLE DIRECT GAIN			**0**			
	WITH PROJECT CONDITION, ALL DIRECT MEASURES APPLIED			**0**			

	Impoundment Pool 10						
	Proposed Action	Existing Habitat Function (%)	Max (Yr 1) Habitat Function w/ Imprvmt (%)	Max (Yr 1) Increase in Habitat Function (%)	Effective Life (Years) of Action	Synergistic Actions	Max (Yr 1) Improvement Gained from Synergism (%)
	Direct:						
22	Canal dredging for Pool 10 @ 40' x 12'	30	80	50	25	-	-
10	Interior Dikes Raising to 9 feet MLLW (Pool 10 & 11)	30	42	12	15	22	12
32	Cross Dike and Water Control Structure Construction in Pool 10	30	44	14	15	10,22	14
1	Replacement of John Hill Water Control Structure	30	50	20	25	10,22,32	20
	Indirect:						
23	Canal dredging for Pool 11 @ 40' x 12'					10,22,32	10
31	Conversion of Pool 11 Experimental Pools					10,22,32,23	8
33	Interior Cross Dike and Water Control Structure Construction in Pool 11					10,22,32,31,23	3
	TOTAL, MAXIMUM POSSIBLE DIRECT GAIN			**96**			
	WITH PROJECT CONDITION, ALL DIRECT MEASURES APPLIED			**126**			

	Impoundment Pool 11						
	Proposed Action	Existing Habitat Function (%)	Max (Yr 1) Habitat Function w/ Imprvmt (%)	Max (Yr 1) Increase in Habitat Function (%)	Effective Life (Years) of Action	Synergistic Actions	Max (Yr 1) Improvement Gained from Synergism (%)
	Direct:						
23	Canal dredging for Pool 11 @ 40' x 12'	30	80	50	25	-	-
10	Interior Dikes Raising to 9 feet MLLW (Pool 10 & 11)	30	42	12	15	23	12
33	Interior Cross Dike and Water Control Structure Construction in Pool 11	30	44	14	15	10,23	14
31	Conversion of Pool 11 Experimental Pools	30	62	32	20	10,23,33	32
1	Replacement of John Hill Water Control Structure	30	50	20	25	10,23,33,31	15
	Indirect:						
22	Canal dredging for Pool 10 @ 40' x 12'					10,23,33,31	10
32	Cross Dike and Water Control Structure Construction in Pool 10					10,23,33,31,22	3
	TOTAL, MAXIMUM POSSIBLE DIRECT GAIN			**123**			
	WITH PROJECT CONDITION, ALL DIRECT MEASURES APPLIED			**153**			

	Impoundment Pool 12						
	Proposed Action	Existing Habitat Function (%)	Max (Yr 1) Habitat Function w/ Imprvmt (%)	Max (Yr 1) Increase in Habitat Function (%)	Effective Life (Years) of Action	Synergistic Actions	Max (Yr 1) Improvement Gained from Synergism (%)
	Direct:						
24	Canal dredging for Pool 12 @ 40' x 12'	60	80	20	25	-	-
11	Interior Dike Raising to 9 feet MLLW (Pool 12, 13, & 15)	60	72	12	15	24	12
34	Interior Cross Dike and Water Control Structure Construction in Pool 12 & 13	60	74	14	15	11,24,34	14
1	Replacement of John Hill Water Control Structure	60	70	10	25	11,24,34	10
	Indirect:						
25	Canal dredging for Pool 13 @ 40' x 12'					11,24,34	10
27	Canal dredging for Pool 15 @ 40' x 12'					11,24,34	10
12	Interior Dike Raising to 9 feet MLLW (Pool 15 & 16)					11,24,34,27	3
	TOTAL, MAXIMUM POSSIBLE DIRECT GAIN			**56**			
	WITH PROJECT CONDITION, ALL DIRECT MEASURES APPLIED			**116**			

	Impoundment Pool 13						
	Proposed Action	Existing Habitat Function (%)	Max (Yr 1) Habitat Function w/ Imprvmt (%)	Max (Yr 1) Increase in Habitat Function (%)	Effective Life (Years) of Action	Synergistic Actions	Max (Yr 1) Improvement Gained from Synergism (%)
	Direct:						
25	Canal dredging for Pool 13 @ 40' x 12'	60	80	20	25	-	-
11	Interior Dike Raising to 9 feet MLLW (Pool 12, 13, & 15)	60	72	12	15	25	12
34	Interior Cross Dike and Water Control Structure Construction in Pool 12 & 13	60	74	14	15	11,25	14
1	Replacement of John Hill Water Control Structure	60	70	10	25	11,25,34	10
	Indirect:						
24	Canal dredging for Pool 12 @ 40' x 12'					11,25,34	10
27	Canal dredging for Pool 15 @ 40' x 12'					11,25,34	10
12	Interior Dike Raising to 9 feet MLLW (Pool 15 & 16)					11,25,34,27	3
	TOTAL, MAXIMUM POSSIBLE DIRECT GAIN			**56**			
	WITH PROJECT CONDITION, ALL DIRECT MEASURES APPLIED			**116**			

	Impoundment Pool 14						
	Proposed Action	Existing Habitat Function (%)	Max (Yr 1) Habitat Function w/ Imprvmt (%)	Max (Yr 1) Increase in Habitat Function (%)	Effective Life (Years) of Action	Synergistic Actions	Max (Yr 1) Improvement Gained from Synergism (%)
	Direct:						
26	Canal dredging for Pool 14 @ 40' x 12' (per only)	30	80	50	25	-	-
6	Perimeter Dike Raising to 12 feet MLLW (Pool 14 &17)	30	42	12	15	26	12
	TOTAL, MAXIMUM POSSIBLE DIRECT GAIN			**62**			
	WITH PROJECT CONDITION, ALL DIRECT MEASURES APPLIED			**92**			

	Impoundment Pool 15						
	Proposed Action	Existing Habitat Function (%)	Max (Yr 1) Habitat Function w/ Imprvmt (%)	Max (Yr 1) Increase in Habitat Function (%)	Effective Life (Years) of Action	Synergistic Actions	Max (Yr 1) Improvement Gained from Synergism (%)
	Direct:						
27	Canal dredging for Pool 15 @ 40' x 12	20	80	60	25	-	-
11	Interior Dike Raising to 9 feet MLLW (Pool 12, 13, & 15)	20	32	12	15	27	12
12	Interior Dike Raising to 9 feet MLLW (Pool 15 & 16)	20	32	12	15	11,27	12
	Indirect:						
24	Canal dredging for Pool 12 @ 40' x 12					11,12,27	10
25	Canal dredging for Pool 13 @ 40' x 12					11,12,27	10
28	Canal dredging for Pool 16 @ 40' x 12					11,12,27	10
34	Interior Cross Dike and Water Control Structure Construction in Pool 12 & 13					11,12,27,24,25	3
1	Replacement of John Hill Water Control Structure					11,12,27	2
	TOTAL, MAXIMUM POSSIBLE DIRECT GAIN			**84**			
	WITH PROJECT CONDITION, ALL DIRECT MEASURES APPLIED			**104**			

	Impoundment Pool 16						
	Proposed Action	Existing Habitat Function (%)	Max (Yr 1) Habitat Function w/ Imprvmt (%)	Max (Yr 1) Increase in Habitat Function (%)	Effective Life (Years) of Action	Synergistic Actions	Max (Yr 1) Improvement Gained from Synergism (%)
	Direct:						
28	Canal dredging for Pool 16 @ 40' x 12'	25	80	55	25	-	-
12	Interior Dike Raising to 9 feet MLLW (Pool 15 & 16)	25	37	12	15	28	12
	Indirect:						
27	Canal dredging for Pool 15 @ 40' x 12'					12,28	10
11	Interior Dike Raising to 9 feet MLLW (Pool 12, 13, & 15)					12,28,27	3
1	Replacement of John Hill Water Control Structure					12,28	1
	TOTAL, MAXIMUM POSSIBLE DIRECT GAIN			**67**			
	WITH PROJECT CONDITION, ALL DIRECT MEASURES APPLIED			**92**			

	Impoundment Pool 17						
	Proposed Action	Existing Habitat Function (%)	Max (Yr 1) Habitat Function w/ Imprvmt (%)	Max (Yr 1) Increase in Habitat Function (%)	Effective Life (Years) of Action	Synergistic Actions	Max (Yr 1) Improvement Gained from Synergism (%)
	Direct:						
29	Canal dredging for Pool 17 @ 40' x 12' (per only)	40	80	40	25	-	-
6	Perimeter Dike Raising to 12 feet MLLW (Pool 14 &17)	40	52	12	15	29	12
	Indirect:						
26	Canal dredging for Pool 14 @ 40' x 12' (per only)					6,29	8
30	Canal dredging for Pool 18 @ 40' x 12' (per only)					6,29	8
	TOTAL, MAXIMUM POSSIBLE DIRECT GAIN			**52**			
	WITH PROJECT CONDITION, ALL DIRECT MEASURES APPLIED			**92**			

	Impoundment Pool 18						
	Proposed Action	Existing Habitat Function (%)	Max (Yr 1) Habitat Function w/ Imprvmt (%)	Max (Yr 1) Increase in Habitat Function (%)	Effective Life (Years) of Action	Synergistic Actions	Max (Yr 1) Improvement Gained from Synergism (%)
	Direct:						
30	Canal dredging for Pool 18 @ 40' x 12' (per only)	40	80	40	25	-	-
	Indirect:						
6	Perimeter Dike Raising to 12 feet MLLW (Pool 14 &17)					30	8
26	Canal dredging for Pool 14 @ 40' x 12' (per only)					30,6	8
29	Canal dredging for Pool 17 @ 40' x 12' (per only)					30,6	8
	TOTAL, MAXIMUM POSSIBLE DIRECT GAIN			**40**			
	WITH PROJECT CONDITION, ALL DIRECT MEASURES APPLIED			**80**			