Appendix B – Cost Effectiveness / Incremental Cost Analysis

Mitchell Lake, San Antonio, TX

General Investigations Feasibility Study
Integrated Draft Feasibility Report and Environmental Impact Assessment

December 2019

US Army Corps of Engineers®
Fort Worth District

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List of Acronyms

AAHU	Average Annual Habitat Unit
CE/ICA	Cost Effectiveness / Incremental Cost Analysis
EGM	Economic Guidance Memorandum
ICA	Incremental Cost Analysis
IDC	Interest During Construction
NER	National Ecosystem Restoration
OMRR&R	Operations, Maintenance, Repair, Replacement, and Rehabilitation
WWTP	Wastewater Treatment Plant

1 Introduction

Comparing benefits and costs for ecosystem restoration provides a challenge to planners and decision makers because benefits and costs are not measured in the same units. Environmental restoration benefits can be measured in habitat units or some other physical unit, while costs are measured in dollars. Therefore benefits and costs cannot be directly compared. Two analyses are conducted to help planners and decision makers identify plans for implementation, though the analyses themselves do not identify a single ideal plan. These two techniques are cost effectiveness and incremental cost analysis. Use of these techniques are described in the Economic and Environmental Principles and Guidelines for Water and Related Land Resource Implementation Studies (U.S. Water Resources Council 1983).

Cost effectiveness compares the annual costs and benefits of plans under consideration to identify the least cost plan alternative for each possible level of environmental output, and for any level of investment, the maximum level of output is identified.

Incremental cost analysis of the cost effective plans is conducted to reveal changes in costs as output levels are increased. Results from both analyses are presented graphically to help planners and decision makers select plans. For each of the best buy plans identified through incremental cost analysis, an “is it worth it?” analysis is then conducted for each incremental measure or plan to justify the incremental cost per unit of output to arrive at a recommended plan.

For this study, the environmental output is the average annual habitat unit (AAHU). The development of the AAHU is discussed in detail in the Environmental Resources appendix.

2 Area Plans and Measures

Management measures were formulated incrementally for the study and measures were built in combination with one another in each area. These measures include: native riparian, submergent, and emergent wetland planting, invasive vegetation management, clearing and excavation, low quality vegetation removal, implementation of seasonal pulses, polder operational management, habitat structure augmentation, installation of nesting structures, berm construction, and pipeline installation.

In addition to management measures, sites were identified as feasible for project implementation. The measures were built in combination with one another based upon site conditions. More detailed information can be found in the Environmental Resources appendix.

2.1 Measures

2.1.1 Native Riparian, Emergent, and Submergent Planting

This measure entails increasing the vegetative structure and species diversity of riparian habitats along the Cottonmouth Creek below the Mitchell Lake Dam and along specified coves within Mitchell Lake. It would include planting a diverse community of high quality native tree and shrub species, including mast producers, bald cypress, and other species native to the San Antonio area.

The core areas of the existing wetland habitats are dominated by cattails or willow baccharis (*Baccharis salicina*) fringed by a single species of spike sedge. This measure entails the planting of native high quality wetland species to increase the diversity and sustainability of the wetland vegetation community.

2.1.2 Invasive Vegetation Management

This measure includes the removal and management of invasive plant species to allow a native and diverse vegetative community to become established. Depending on the species, invasive species may be controlled by biological, mechanical, or chemical methods incorporating an integrated pest management approach. Larger non-native invasive trees could be treated with herbicide and left standing to provide standing snag habitat for numerous wildlife species.

2.1.3 Clearing/Excavation

In order to create the hydrology required for the target restoration habitats, excavation may be required to create suitable conditions to ensure sustainability for the ecosystem restoration. Excavation can include widening and deepening of wetland areas using machinery such as bulldozers, graders, and backhoes.

2.1.4 Low Quality Vegetation Removal

The vegetative communities in the Mitchell Lake study area are skewed towards low quality hackberry (*Celtis occidentalis*), huisache (*Vachellia farnesiana*), palo verde (*Parksonia spp*.), willow baccharis, and cattail (*Typha spp*.) dominated habitats depending on the area with little to no additional diversity. Most of the areas are dominated by one or two of these species. In order to increase the diversity of the communities, select trees and shrubs would be removed to provide room for the planting of additional site specific native species. Similar to the invasive vegetation management, larger trees could be treated with herbicides and left standing in order to created habitats for numerous wildlife that utilize standing snag habitats. The creation of standing snags would remove the overstory canopy cover opening up gaps in the canopy for the establishment of seedling shrubs and trees.

2.1.5 Seasonal Pulses

This measure includes managing the flow of water through the Mitchell Lake study area to mirror natural historical flood/drought processes. The seasonal pulses would support wetland habitats through periodic inundation and desiccation required to support a diverse aquatic, wetland, and riparian community. Additionally, the control of water surface levels in the wetlands facilitates the control of cattails within the existing and/or proposed wetland areas in the study area. The seasonal pulse measure would be dependent on either the measures for relocating the Wastewater Treatment Plant (WWTP) outfall structure and/or the construction of a pipeline from Mitchell Lake to the upstream portions of the study area. The measure would also include the construction or modification of water control structures to allow manipulation of the flows and inundation of the wetlands.

2.1.6 Polder Operational Management

This measure entails the manipulation of water in the polders to manage the area for migratory shorebirds. By draining the polders on a periodic systematic schedule, mud flats would be exposed during migration providing foraging habitat for shorebirds. The inundation phase of the polder management would ensure that vegetation would not become established within the polders reducing the shorebird foraging habitat quality. When the polders are inundated, habitat for waterfowl would be available. The polder management would require the modification and/or construction of water control structures to facilitate the draining and filling of the polders.

2.1.7 Habitat Structure Augmentation

This measure entails habitat improvement through the addition of habitat structures in the project area such as brush piles, fallen logs, root wads, rock piles, snags, etc. These structures could be aquatic or terrestrial (riparian) in nature and would provide cover habitat for fish and wildlife species. This measure would be dependent on the excavation and low quality

vegetation removal measures as these measures would provide the source material for the creation of these features.

2.1.8 Installation of Nesting Structures

This measure would include the installation of artificial nesting structures for bats, wood ducks (*Aix sponsa*), bluebirds (*Sialia spp*.), and other cavity nesting species in the study area.

2.1.9 Construction of Berms

This measure would entail reducing the size of the east and west polders to create a more manageable and appropriately sized mudflat in Area 6. The utilization of excavated materials from the creation wetland or offsite borrow material could be to create berms within these two polders to create additional mudflat cells. This measure would be dependent on the polder operational measure above. In addition, this measure would include the construction of berms at the downstream wetlands (Area 10) to create wetland cells to create and manage the wetlands.

2.1.10 Installation of Pipeline

This measure would entail the placement of a pipeline that would enable pumping of water from Mitchell Lake to the wetland areas at the upper portions of the Mitchell Lake watershed. The construction of a pipeline to the upper areas would provide a reliable water supply allowing better manipulation and sustainability of the wetlands.

2.2 Area Plans

2.2.1 Bird Pond Wetlands (Area 1)

Area 1 is located at the northern extent of the study area adjacent to Bird Pond near the Mitchell Lake Audubon Center. The small existing wetland is located east of the levee/road on the downstream end of Bird Pond. The existing wetland has limited habitat value due to the shallow surface water (<6”) and a monoculture of cattails. The lack of water surface level fluctuations has contributed to the dominance of cattails in this wetland. Potential restoration goals for this site would include improving the vegetative diversity of the site and improving the hydrology of the system. The measures implemented for this area include: invasive vegetation management, clearing and excavating, low quality vegetation removal, native emergent wetland planting, implementation of seasonal pulses, habitat structure augmentation, installation of nesting structures, and pipeline installation.

2.2.2 Central Wetlands (Area 2)

Area 2 is south of Area 1 and the two wetland complexes are connected to each other by a shallow, nondescript drainage channel. The wetland consists of a complex of wetlands connected to each other by wetland swales with higher, upland areas interspersed in the wetland. Area 2 is part of the same wetland complex as Area 3, but is separated from that area by a pipeline right-of-way between the two areas; therefore, the areas are treated as separate areas. Area 2 is comprised of a shallow wetland with areas of deeper water (6-12” in depth) and dominated by cattails and willow baccharis. Potential restoration goals for this site would include improving the vegetative diversity of the site and improving the hydrology of the system. The measures that can be implemented in combination with one another at this site include: invasive vegetation management, clearing and excavating, low quality vegetation removal, native emergent wetland planting, implementation of seasonal pulses, habitat structure augmentation, installation of nesting structures, and pipeline installation.

2.2.3 Skip’s Pond (Area 3)

As noted in the Area 2 discussion above, Area 3 is part of the same wetland complex as Area 2, but is separated from that area by a pipeline that transects the area. In addition, Area 3 is comprised of deeper water wetlands up to 2-feet in depth and supports different vegetation than Area 2. Therefore, this area was separated from the Central Wetland complex. Potential restoration goals for this site would include improving the vegetative diversity of the site and improving the hydrology of the system. Measure combinations for this area include: invasive vegetation management, clearing and excavating, low quality vegetation removal, native emergent wetland planting, implementation of seasonal pulses, habitat structure augmentation, installation of nesting structures, and pipeline installation.

2.2.4 Polders (Area 6)

This plan is focused on the structural modification and operational management of the water within the polder cells to increase the availability of mudflat habitat for shorebirds within the study area. Managing the water distribution within the polders and the creation of mud flat habitats would result in restoration opportunities for this area. Management measures for this area include: polder operational management, installation of nesting structures, and the construction of berms.

2.2.5 Fringe Wetlands (Area 7)

Area 7 includes the restoration of fringe emergent and submergent wetland habitats within three coves of Mitchell Lake. Future management of Mitchell Lake will result in the water surface elevation being lowered to 517'. Therefore, the restoration opportunities include the restoration of emergent and submerged fringe wetlands in areas that are open water under the existing pool elevation. The measures identified for this area include: native riparian, emergent, and submergent planting, invasive vegetation management, habitat structure augmentation, and installation of nesting structures.

2.2.6 Dam Forested Wetlands (Area 9)

The forested wetland areas below the Mitchell Lake Dam comprise the proposed restoration area for Area 9. The hydrology of these wetlands are maintained by seepage through the dam and are dominated by hackberry woodlands. The drainage below the dam forms a linear series of in channel wetlands with several ponded areas along the upstream section of the drainage. The combination of measures for this site include: native riparian and emergent planting, invasive vegetation management, clearing and excavating, low quality vegetation removal, habitat structure augmentation, and installation of nesting structures.

2.2.7 Downstream Wetlands (Area 10)

The Area 10 restoration plan entails the construction of a wetland complex adjacent to the proposed water quality treatment wetlands that would be constructed by SAWS. The Area 10 wetlands would contribute to the capture of synergistic benefits associated with combining the low habitat quality SAWS treatment wetlands with high habitat quality wetlands, creating an edge transition between the wetlands, and providing an opportunity to further filter and improve the water quality of water from the treatment wetlands. Implementation of this area plan would include utilizing measures such as: clearing and excavating, native emergent planting, implementation of seasonal pulses, habitat structure augmentation, installation of nesting structures, and berm construction.

3 Average Annual Habitat Units and Costs

In order to determine benefits of an environmental restoration plan, future with-project environmental outputs are compared to future without-project outputs. The difference between the two represents the benefits from project implementation.

3.1 Existing and Future-Without Project AAHU

For this study, future without-project conditions (FWOPC) are assumed to be the same as existing conditions, given the existing habitat quality.

3.2 Future With-Project AAHU

Environmental restoration benefits are calculated by subtracting the FWOPC AAHU from the future with-project condition (FWPC) AAHU. For the comparison of measures, both environmental outputs and costs were annualized over a 50 year planning horizon. The resulting benefits are then used, along with annual costs, to identify cost effective plans and perform incremental cost analysis. The calculation of benefits (outputs) are shown in Table 3-1.

Table 3-1. Annual AAHU Benefits

Management Measure Area	Alternatives	FWOPC AAHU	FWPC AAHU	Annual Benefits AAHU	FWPC Acres
Area 1: Bird Pond Wetlands	1A: Enhancement of Existing Wetlands	0.86	2.39	1.53	3.17
	1B: Expansion/Enhancement of Existing Wetlands and Enhancement of Additional Wetlands	0.86	4.71	3.85	6.42
Area 2: Central Wetlands	2A: Enhancement of Existing Wetlands	2.85	7.88	5.03	10.46
	2B: Expansion/Enhancement of Existing Wetlands and Enhancement of Additional Wetlands	2.85	13.54	10.69	18.37
Area 3: Skip's Pond	Enhancement of Existing Wetlands	0.59	1.64	1.05	2.18
Area 6: Polders	Management/Modification of Existing Polders/Basins	30.21	48.35	18.14	49.52
Area 7: Fringe Wetlands	7A: Enhancement of Cove 1 (Wetland/Riparian Plantings)	13.43	43.33	29.9	53.68
	7B: Enhancement of Cove 2 (Wetland/Riparian Plantings)	2.96	9.56	6.6	11.84
	7C: Enhancement of Cove 3 (Wetland/Riparian Plantings)	1.71	5.52	3.81	6.84
	7D: Combination of Coves 1 & 2	16.39	52.89	36.5	65.52
	7E: Combination of Coves 1 & 3	15.14	48.85	33.71	60.52
	7F: Combination of Coves 2 & 3	4.67	15.08	10.41	18.68
	7G: Combination of Coves 1, 2 & 3	18.1	58.41	40.31	72.36
Area 9: Dam Forested Wetlands	9A: Enhancement of Existing Wet Riparian Habitat	0.71	1.19	0.47	2.55
	9B: Expansion/Enhancement of Existing Wet Riparian Habitat and Enhancement of Additional Riparian Habitat	1.25	2.08	0.83	4.48
Area 10: Downstream Wetlands	Creation of Wetlands Downstream of Mitchell Lake	0	36.73	36.73	51.32

3.3 Costs

Total project economic costs were annualized using the annualizer tool in IWR Planning Suite. A period of analysis of 50 years was used, along with a federal discount rate of 2.875% (per

EGM 19-01 dated 17 October 2018). Prices are expressed in October 2018 dollars. Details of the development of costs can be found in the Cost Engineering Appendix.

Table 3-2 provides a summary of total and annual costs, including Operations, Maintenance, Repair, Replacement, and Rehabilitation (OMRR&R). Construction first cost includes construction cost and plantings. Real estate cost is not included in construction first cost, because all real estate is owned by the sponsor with the exception of some land for Plan 10, the downstream wetlands. This land is not considered a project first cost, because it would be purchased in the future without-project condition. Interest during construction is combined with construction first cost and real estate cost to obtain the economic cost for purposes of calculating the annual investment cost. The annual with-project OMRR&R is added to the annual investment cost to obtain the total annual cost.

Table 3-2. Cost Inputs for IWR Planning Suite CE/ICA Analysis

Management Measure Area	First Cost	Real Estate	IDC	Economic Cost	Annual Investment Cost	Annual OMRR&R	Total Annual Cost
Bird Pond 1A	$580,481	$38,040	$4,404	$622,925	$23,639	$6,340	$29,979
Bird Pond 1B	$648,528	$77,040	$5,166	$730,734	$27,730	$12,840	$40,570
Central Wetlands w/ Bird Pond 2A	$568,202	$125,520	$820	$694,542	$26,357	$20,920	$47,277
Central Wetlands w/o Bird Pond 2A	$842,092	$125,520	$1,144	$968,756	$36,762	$20,920	$57,682
Central Wetlands w/ Bird Pond 2B	$716,999	$220,440	$4,443	$941,882	$35,743	$36,740	$72,483
Central Wetlands w/o Bird Pond 2B	$893,744	$220,440	$5,281	$1,119,465	$42,482	$36,740	$79,222
Skip's Pond 3	$62,951	$6,540	$62	$69,553	$2,639	$4,360	$6,999
Polders 6	$144,780	$4,952	$44	$149,776	$5,684	$8,000	$13,684
Cove 1 7A	$1,503,040	$13,420	$897	$1,517,357	$57,581	$107,360	$164,941
Cove 2 7B	$331,520	$2,960	$198	$334,678	$12,700	$23,680	$36,380
Cove 3 7C	$191,520	$1,710	$114	$193,344	$7,337	$13,680	$21,017
Cove 1 & 2 7D	$1,834,560	$16,380	$2,189	$1,853,129	$70,323	$131,040	$201,363
Cove 1 & 3 7E	$1,694,560	$15,130	$2,022	$1,711,712	$64,956	$121,040	$185,996
Cove 2 & 3 7F	$523,040	$4,670	$468	$528,178	$20,043	$37,360	$57,403
Cove 1, 2, & 3 7G	$2,026,080	$18,090	$2,417	$2,046,587	$77,664	$144,720	$222,384
Dam Forested Wetland 9A	$606,339	$15,300	$1,103	$622,742	$23,632	$5,100	$28,732
Dam Forested Wetland 9B	$647,212	$26,880	$1,196	$675,288	$25,626	$8,960	$34,586
Constructed Wetlands 10	$1,515,669	$333,580	$6,568	$1,855,817	$70,425	$102,640	$173,065

3.4 Cost Effectiveness and Incremental Cost Analysis

To conduct the CE/ICA analysis, environmental restoration benefits (increase in with-project AAHUs) and annual costs (expressed in thousands of dollars) were entered into IWR Planning Suite. This data is presented in Table 3-3. Using the management measures, the plan generator in the software was used to create all possible combinations of the measures. This resulted in 1,728 plans.

Table 3-3. Annual Benefits and Annual Cost for Each Alternative

Project Area	Alternatives	Annual Benefits AAHU	Annual Cost ($1,000) October 2018 Prices
Area 1: Bird Pond Wetlands	1A: Enhancement of Existing Wetlands	1.53	$29.98
	1B: Expansion/Enhancement of Existing Wetlands and Enhancement of Additional Wetlands	3.85	$40.57
Area 2: Central Wetlands	2A: Enhancement of Existing Wetlands	5.03	$47.28
	2B: Expansion/Enhancement of Existing Wetlands and Enhancement of Additional Wetlands	10.69	$72.48
Area 3: Skip's Pond	Enhancement of Existing Wetlands	1.05	$6.90
Area 6: Polders	Management/Modification of Existing Polders/Basins	18.14	$13.68
Area 7: Fringe Wetlands	7A: Enhancement of Cove 1 (Wetland/Riparian Plantings)	29.9	$164.94
	7B: Enhancement of Cove 2 (Wetland/Riparian Plantings)	6.6	$36.38
	7C: Enhancement of Cove 3 (Wetland/Riparian Plantings)	3.81	$21.02
	7D: Combination of Coves 1 & 2	36.5	$201.36
	7E: Combination of Coves 1 & 3	33.71	$186
	7F: Combination of Coves 2 & 3	10.41	$57.40
	7G: Combination of Coves 1, 2 & 3	40.31	$222.38
Area 9: Dam Forested Wetlands	9A: Enhancement of Existing Wet Riparian Habitat	0.47	$28.73
	9B: Expansion/Enhancement of Existing Wet Riparian Habitat and Enhancement of Additional Riparian Habitat	0.83	$34.59
Area 10: Downstream Wetlands	Creation of Wetlands Downstream of Mitchell Lake	36.73	$173.07

3.4.1 Cost Effective Plans

Using the generated plans, their costs and benefits, a cost effective analysis was performed using the IWR Planning Suite Software. Cost effective plans are defined as the least expensive plan for a given set of benefits, or environmental output. In other words, no other plan would provide the same or more benefits for a lower cost. Of the 1,728 plans (including various scales), 29 were identified as cost effective plans (including no action). The results are shown graphically in Figure 3-1. Note that cost effective plans (red triangles) include those identified as "Best Buy" plans (green squares), which will be discussed in the next section.

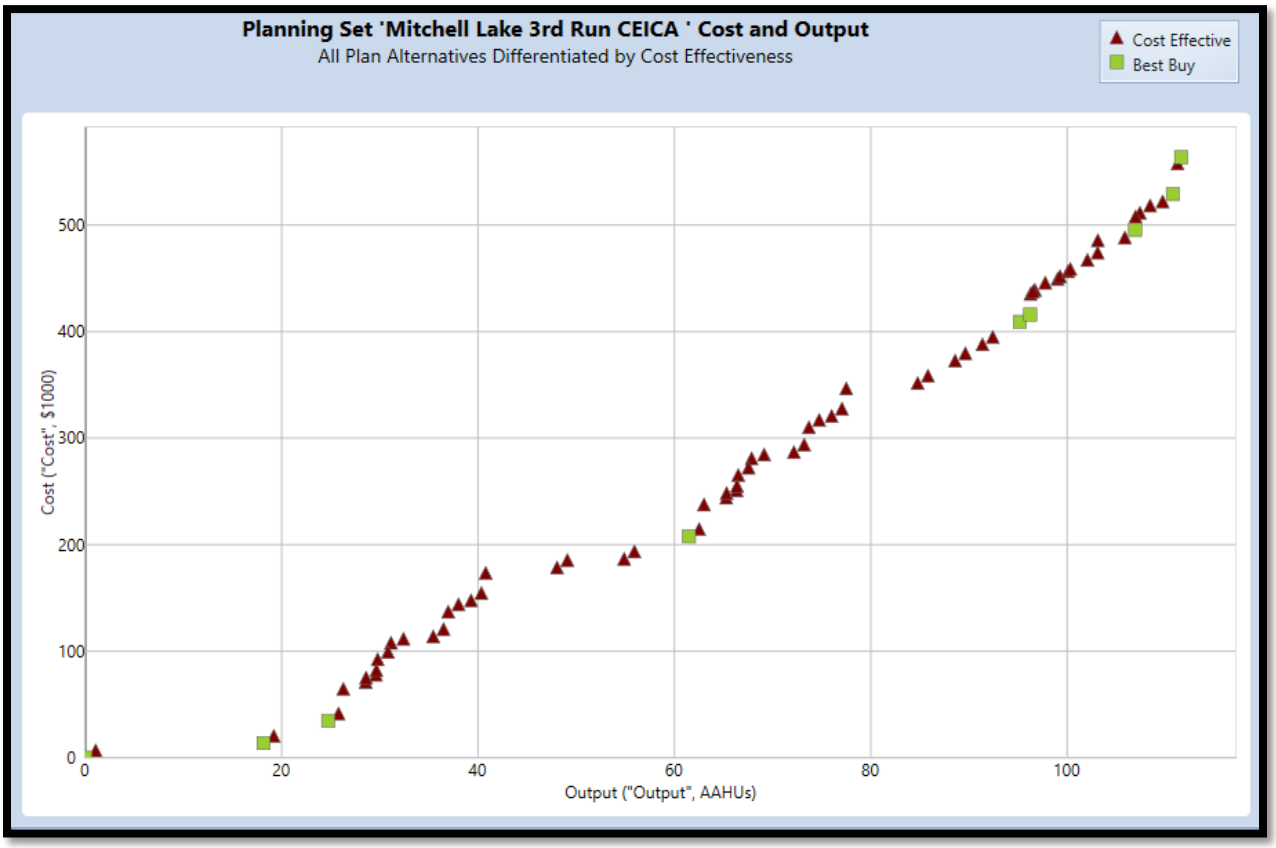

Figure 3-1. Cost Effective Results

3.4.2 Incremental Analysis and Best Buy Plans

The next step in the CE/ICA analysis is to perform an incremental cost analysis (ICA) on the cost effective plans. ICA compares the incremental cost per incremental benefit (output, or lift in environmental output) among the plans to identify plans that maximize the last dollar spent. Starting with the no action plan, the incremental cost per incremental benefit is calculated from the no action for each cost effective plan. The plan with the least incremental cost per incremental output is identified as the first of the "with-project" best buy plans. Then starting with that plan, the incremental cost per incremental benefit is calculated between that plan and each remaining cost effective plan, and the one with the least incremental cost per incremental benefit is identified as the next plan in the array of best buy plans. This process continues until there are there are no remaining plans. The last plan in the best buy array, is typically the "kitchen sink" plan, or the plan that contains all of the management measures being analyzed.

From the cost effective alternatives, nine were identified as "Best Buy" plans (including the no action plan). The results of the analysis is shown graphically in Figure 3-2. The alternative best buy plans are:

Plan 1: No Action

Plan 2: Polders

Plan 3: Polders + Cove 3

Plan 4: Polders, Cove 3, Downstream Wetlands

Plan 5: Polders, Coves 1, 2, and 3; Downstream Wetlands

Plan 6: Plan 5 + Skip's Pond

Plan 7: Plan 6 + Central Wetlands (scale 2)

Plan 8: Plan 7 + Bird Pond Wetlands (scale 2)

Plan 9: Plan 8 + Forested Wetlands below the Dam

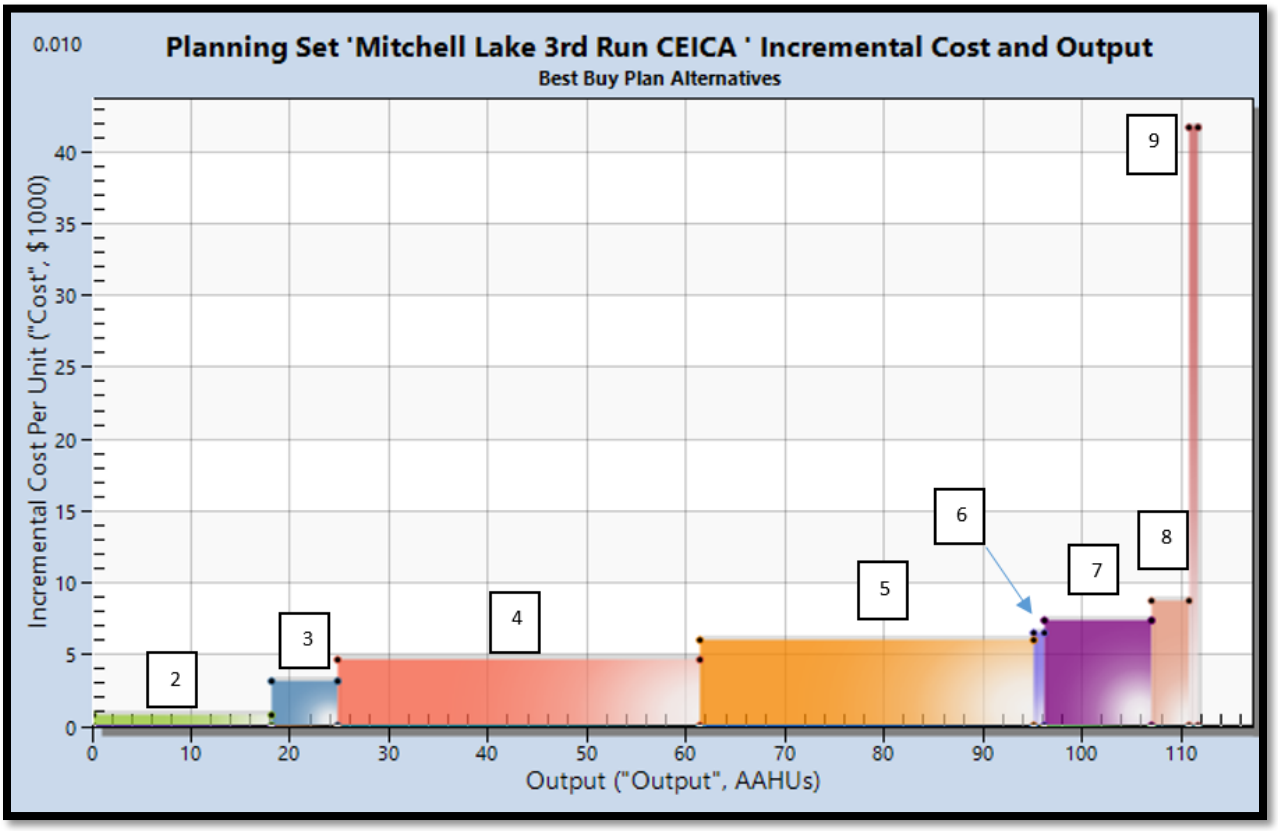

Figure 3-2. Incremental Cost Analysis Result

Table 3-4. Best Buy Plans

No.	Plan	Output (AAHU)	Annual Cost ($1000)	Average Annual Cost ($1000/AAHU)	Incremental Cost ($1000)	Incremental Output (AAHU)	Incremental Annual Cost per Output	Plan First Cost
1	No Action	0	0	-	-	-	-	-
2	Polders	18.140	13.680	0.754	13.680	18.140	0.754	$ 144,780
3	Polders + Cove 3	24.740	34.700	1.403	21.020	6.600	3.185	$ 336,300
4	Polders, Cove 3, Downstream Wetlands	61.470	207.770	3.380	173.070	36.730	4.712	$ 1,851,969
5	Polders, Coves 1,2,and 3; Downstream Wetlands	95.180	409.130	4.298	201.360	33.710	5.973	$ 3,686,529
6	Plan 5 + Skip's Pond	96.230	416.030	4.323	6.900	1.050	6.571	$ 3,749,480
7	Plan 6 + Central Wetlands (2B)	106.920	495.250	4.632	79.220	10.690	7.411	$ 4,643,224
8	Plan 7 + Bird Pond Wetlands (1B)	110.770	529.080	4.776	33.830	3.850	8.787	$ 5,115,007
9	Plan 8 + Dam Forested Wetlands	111.600	563.670	5.051	34.590	0.830	41.675	$ 5,762,219

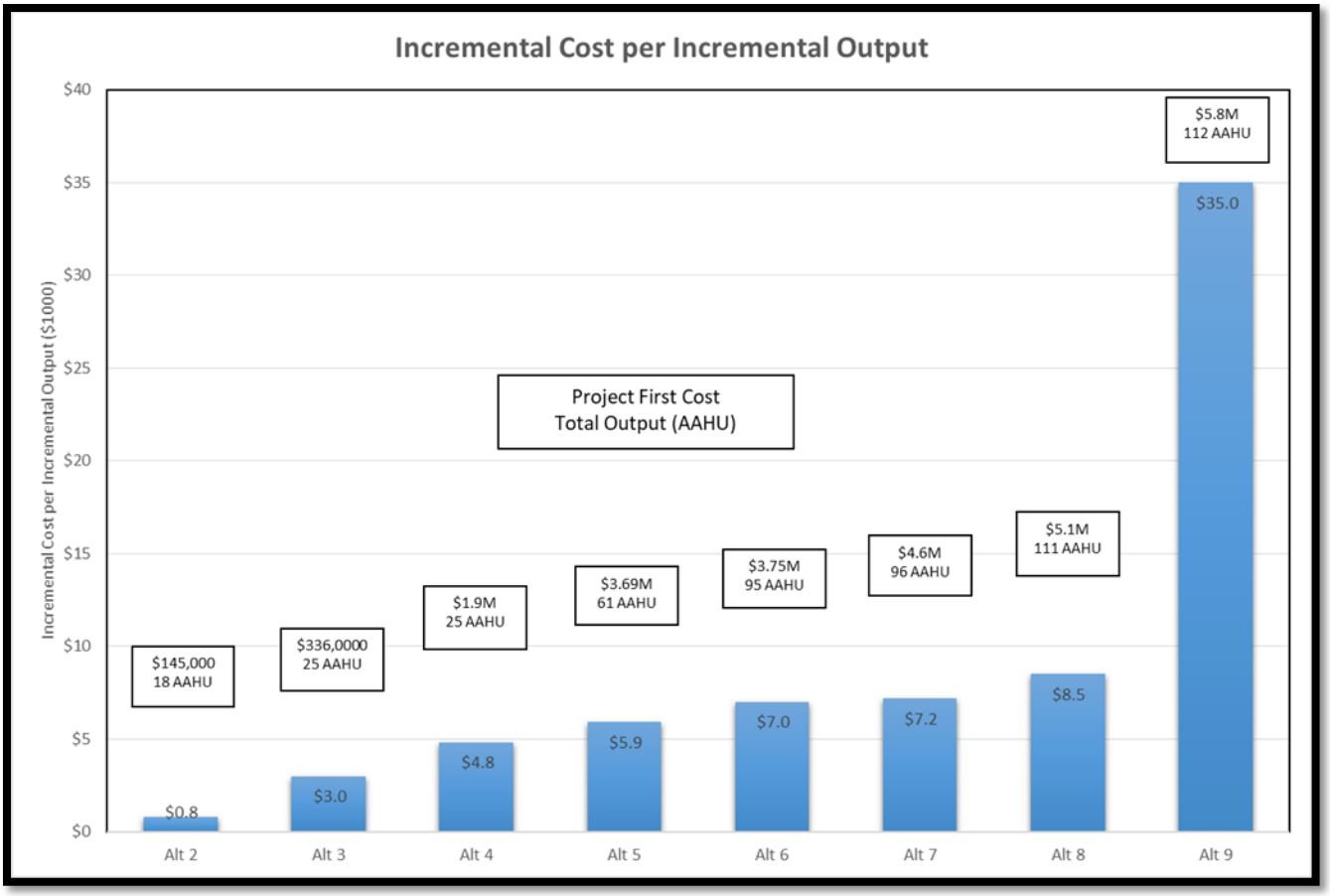

Figure 3-3. Comparison of Final Array of Plans

4 Is It Worth It Analysis on the Final Array of Plans

4.1 Plan 1 (No Action)

The No Action plan would leave the Mitchell Lake study area in its existing condition and would not address the study objectives of restoring habitats that would benefit migratory, breeding, and wintering neotropical birds, waterbirds, shorebirds, and water fowl. The significant national loss of habitats that is occurring for these species would continue and no efforts to offset the magnitude of these losses would occur for the study area. Migratory birds key in on aquatic habitats such as Mitchell Lake when identifying resting and refueling areas during their annual migrations, especially in the more arid regions of the western U.S. This is an evolutionary response for these species as riparian and aquatic habitats generally have higher biodiversity and biomass than upland habitats. These resources are especially important during times of high energy demands such as migration and preparation for the breeding season. Although the Mitchell Lake study area continues to attract a large number of migratory birds due to its attractive aquatic environments, the low quality habitat and low habitat diversity cannot adequately support the energy needs of the migratory birds the lake attracts. Therefore, migratory birds must expend additional, limited energy resource in search of food resources elsewhere. Therefore Plan 1 is not an acceptable Plan to improve habitat for the nationally significant migratory bird populations at Mitchell Lake.

4.2 Plan 2 (Polders)

Plan 2 entails the restoration of mud flats habitats that would have been interspersed throughout the historical wetland complex prior to the impoundment of Mitchell Lake. The Plan would result in the restoration of five mudflat cells within the existing polder complex comprising a total of 49.52 acres of mudflat habitat from Alternative 6 (Figure 4-1). Details of the ecological benefits of the mudflat restoration are provided in Chapter 5 of the Environmental Appendix (Appendix C).

Under the existing condition, the polders are managed for open water and provide essentially no foraging habitat for migrating shorebirds. Due to the larger size of the East and West Polders in comparison to the basins, berms will be installed to create more equal sized cells. This measure will allow better manageability of the water levels within this area, which will assist in waterbird, waterfowl, and shorebird management overall. Therefore, the creation of the mudflats would create a total of 18.1 AAHU for migratory shorebirds with an incremental cost per incremental output of $750. The Plan has a first cost of $144,780 and an average annual cost of $13,680. Plan 2 encompasses 24.1%% of the total area identified for restoration under this study. Because this Plan would provide critical habitat for migrating shorebirds, a nationally significant resource with population numbers that are in decline primarily due to habitat loss, Plan 2 is worth the Federal and local investment.

Figure 4-1. Plan 2 Restoration Area

4.3 Plan 3 (Polders and Cove 3)

Plan 3 includes the mudflat restoration defined in Plan 2 and adds the restoration of 6.84 acres of emergent and submerged aquatic vegetation within Cove 3 of Mitchell Lake from Alternative 7C (Figure 4-2). The restoration of the fringe wetlands along the shoreline and shallows of the cove provides significant resting and foraging habitat for migrating waterbirds and waterfowl. Details of the ecological benefits of the emergent/submergent wetland habitats are provided in Chapter 5 of the Environmental Appendix (Appendix C).

Plan 3 adds 3.81 AAHUs of emergent and submergent wetland habitat to the 18.1 AAHU of mudflat habitat. Because the mudflat and emergent/submergent wetlands are entirely different habitats and the habitat quality for each area was calculated using two different sets of habitat models, the AAHUs for each habitat are not directly comparable or additive. With that caveat, Plan 3 would provide a total of 21.95 AAHUs; this comprises 16.25% of the output of that captured by the largest Plan (Plan 9). The incremental cost per incremental output of Plan 3 is $3,190 with a first cost of $336,300. Plan 3 would restore 27.5% of the total area identified for restoration under this study.

Plan 3 includes the restoration of shorebird habitat attributed to the polders and adds habitat for waterbirds (another group of birds experiencing significant declines in population sizes) and waterfowl (a nationally managed resource). Because Plan 3 increases the habitat value for two additional groups of migratory bird species with a relatively minor incremental cost to incremental output ratio, the selection of this Plan as a Federal and local investment is justified.

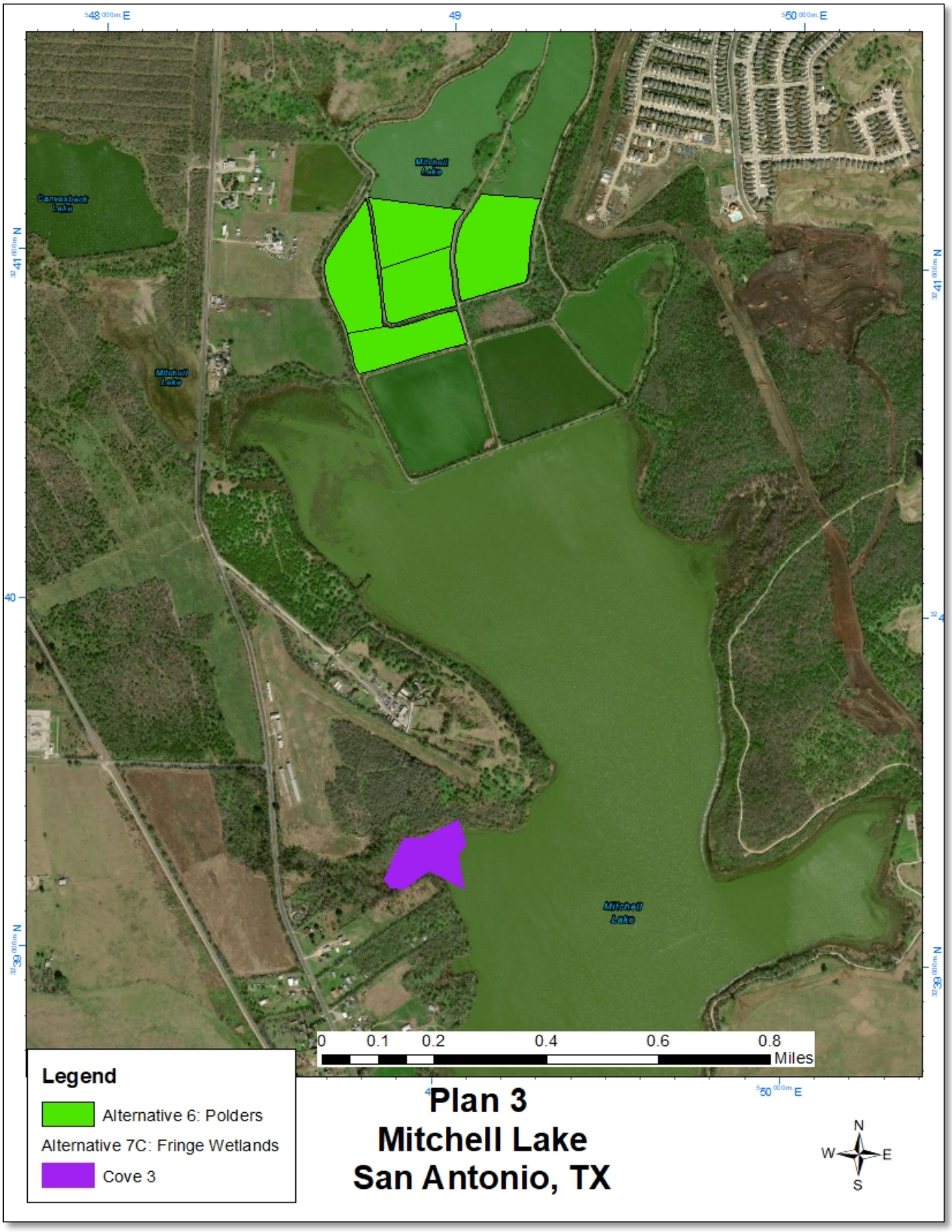

Figure 4-2. Plan 3 Restoration Areas

4.4 Plan 4 (Polders, Cove 3, and the Downstream Wetlands)

Plan 4 includes the restoration of the mud flats and emergent/submergent wetlands that were defined in Plan 3 and adds the restoration of 51.32 acres of emergent wetlands located downstream of the Mitchell Lake Dam from Alternative 10. The downstream emergent wetlands provide cover and foraging habitat for temperate and neotropical migrant songbirds and waterbirds. Neotropical migrant songbirds attracted to emergent wetlands include the Marsh Wren (*Cistothorus palustris*), Sedge Wren (*C. platensis*), Bobolink (*Dolichonyx oryzivorus*), rails, egrets, and herons. Similar to shorebirds and waterbirds, the population trends for neotropical migrant songbirds are also in decline.

Plan 4 adds 36.7 AAHUs of emergent wetland habitat to the 18.1 AAHU of mudflat and 3.81 AAHUs of emergent/submergent wetland habitats. Keeping the caveat identified above regarding combination of AAHUs from different habitat types quantified using different habitat models model in mind, Plan 4 would result in a total 58.68 AAHUs or 52.6% of the total potential AAHUs available for the study. The incremental cost per incremental output for Plan 4 is $4,710 with a first cost of $1,851,969. Plan 4 would restore 52.5% of the total area identified for restoration under this study.

The addition of the downstream wetlands associated with Plan 4 increases the number of ecological guilds and niches that would benefit from the Mitchell Lake restoration efforts. The creation of mudflat habitat specifically benefits shorebirds, the emergent/submergent wetlands benefit waterfowl and waterbirds, and the emergent wetlands benefit waterbirds and temperate and neotropical migrant songbirds. Because Plan 4 adds habitat features that provide increased benefits to for additional bird guilds and is economically justified, the Plan is worth the Federal and local investment.

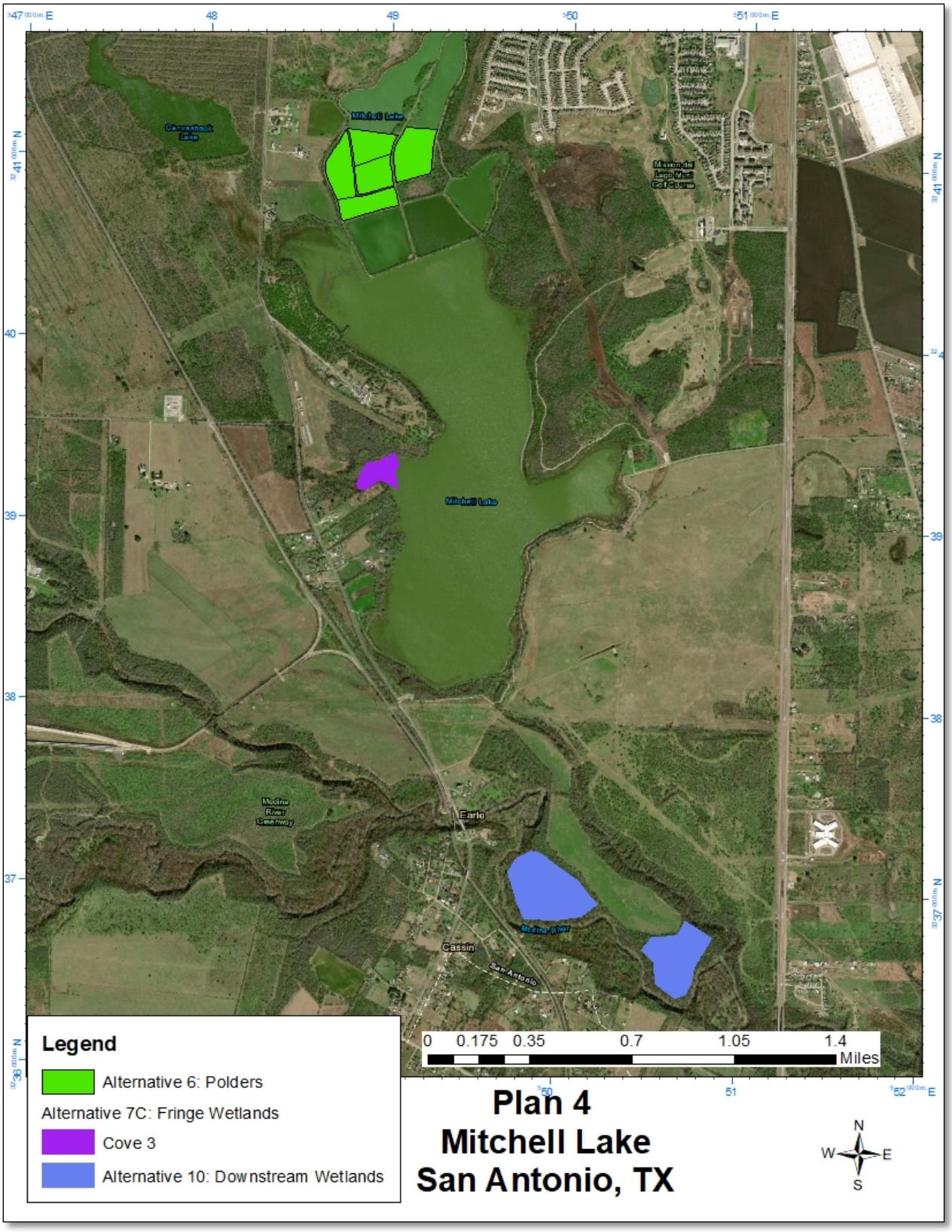

Figure 4-3. Plan 4 Restoration Areas

4.5 Plan 5 (Polders; Coves 1, 2, and 3, and the Downstream Wetlands)

Plan 5 adds the restoration of emergent and submergent wetlands in Coves 1 and 2 from Alternative 7G to those restoration features included in Plan 4. In addition to the restoration of 49.52 acres of mudflats associated with the polders, 6.84 acres of emergent/submergent wetlands associated with Cove 3, and 51.32 acres of emergent wetlands associated with the downstream wetlands, Plan 5 adds emergent/submergent wetland habitat restoration in two additional coves of Mitchell Lake (Figure 4-4). Restoration would include 53.68 acres of restoration in Cove 1 located at the northwest end of the lake and 11.84 acres of restoration in a cove at the eastern edge of the lake. The additional 65.52 acres of emergent/submergent wetland provided by Plan 5 would result in a total of 72.36 total acres of restoration in the coves of Mitchell Lake.

Plan 5 adds 36.5 AAHUs of emergent/submergent wetland habitat to the previous 3.81 AAHUs of emergent/submergent wetlands, 18.1 AAHUs of mudflat, and 36.7 AAHUs of emergent wetland habitats. The 95.2 total AAHUs captured by this Plan can be broken down for each habitat type:

- 49.52 acres and 18.1 AAHUs of mudflat habitat
- 72.36 acres and 40.3 AAHUs of emergent/submergent wetland habitat
- 51.32 acres and 36.7 AAHUs of emergent wetland habitat

The incremental cost per incremental output for Plan 5 is $5,973 with a first cost of $3,686,529. Plan 5 would restore 84.6% of the total area identified for restoration under this study.

Plan 5 would increase the area of emergent/submergent wetlands restored by an order of magnitude. The larger areal extent of Coves 1 and 2 result in exponentially longer habitat edge. The edge habitats provide significant habitat for birds that require shallower habitats for foraging and resting. The result of the larger restored area and longer edge habitat significantly increase waterbird and waterfowl habitat in Mitchell Lake. As previously mentioned, this habitat is highly valuable for nationally significant resources such as waterbirds and waterfowl. Each year, these birds migrate through the area and settle on Mitchell Lake. The addition of two larger coves to the restoration Plan would spread the bird population over a larger area and accommodate more birds that would otherwise have been forced to expend energy in search of additional habitat. The addition of the two larger coves creates “patch” habitat that is utilized by different species of waterfowl and waterbirds. Patch habitats are a component of the island biogeography concept. The island biogeography theory considers the benefits of habitat connectivity in relation to habitat patch sizes and distances between the habitat patches. The restoration of separate patches provides resiliency as natural stresses such as drought or flooding may adversely impact one patch more than another. These stressors are anticipated to increase over time as the effects of climate change manifest. The incremental cost per incremental output of including the Cove 3 wetlands into Plan 3 was $3,190 compared to the $5,973 incremental cost per incremental output for the Cove 1 and Cove 2 wetlands. Because of the value of these wetlands, the expenditure of the additional incremental cost per incremental output is worth the Federal and local investment.

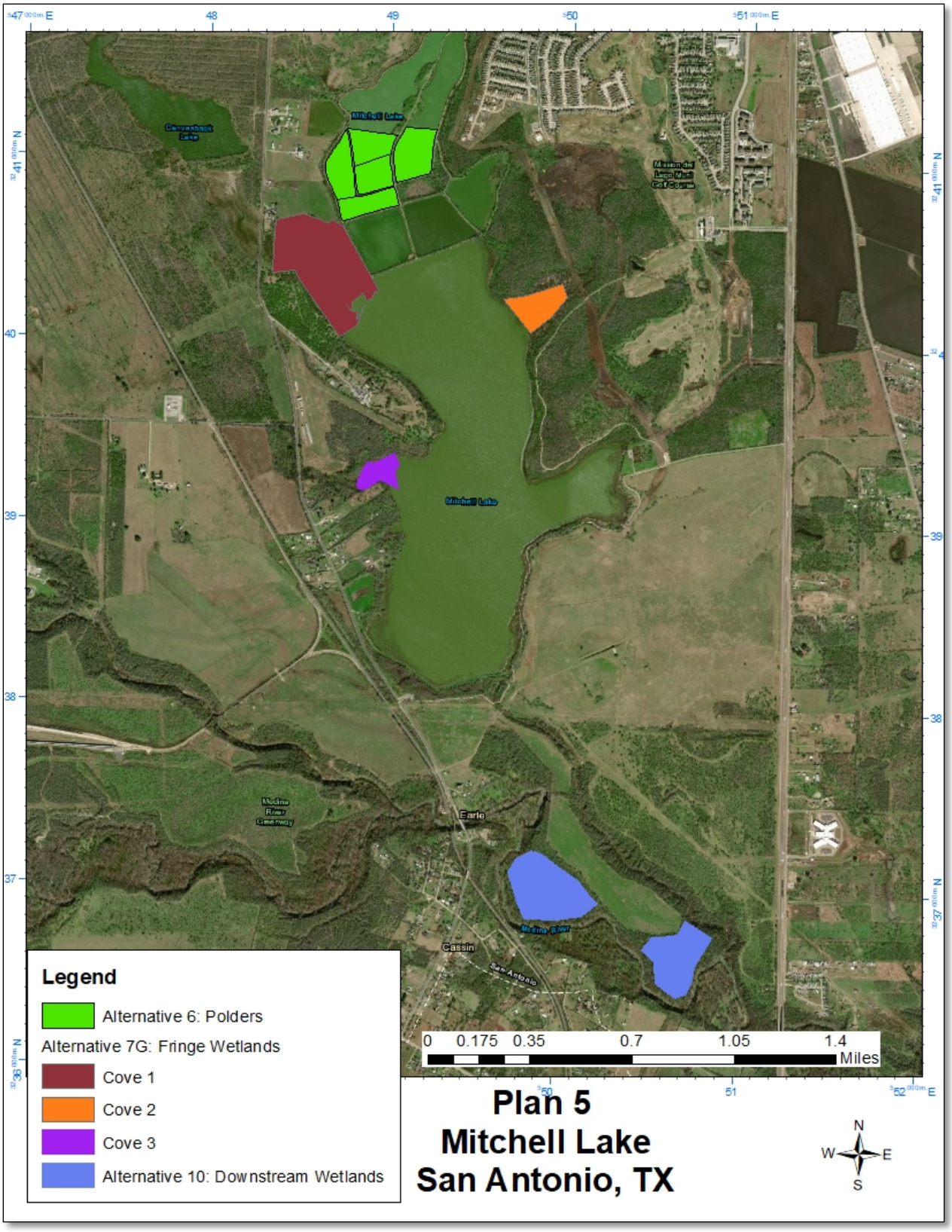

Figure 4-4. Plan 5 Restoration Areas

4.6 Plan 6 (Polders; Coves 1, 2, and 3, the Downstream Wetlands, and Skip's Pond)

In addition to the restoration features included in Plan 5, Plan 6 adds restoration measures to improve the habitat quality of Skip's Pond from Alternative 3. Skip's Pond is an existing submergent/emergent wetland with areas of open water. The restoration would increase the topographic diversity of the pond, create emergent vegetation on the margins of the pond, and control non-native, invasive species. The Skip's Pond restoration would add 2.18 acres of submergent/emergent wetlands and 1.0 AAHUs to the previous Plan (Figure 4-5).

A total of 96.2 AAHUs are provided by Plan 6; the allocation of the AAHUs are provide below:

- 49.52 acres and 18.1 AAHUs of mudflat habitat
- 74.54 acres and 41.3 AAHUs of emergent/submergent wetland habitat
- 51.32 acres and 36.7 AAHUs of emergent wetland habitat

The incremental cost per incremental output for Plan 6 is $6,571 with a first cost of $3,749,480, a first cost increase of approximately $63,000 over Plan 5. Plan 6 would restore 85.7% of the total area identified for restoration under this study.

Although Skip's Pond adds submergent/emergent wetland habitat to the proposed restoration and increases the total acreage of submergent/emergent for this Plan to 74.54 acres, the Skip's Pond wetlands are significantly different than the cove wetlands. The cove wetlands border the deeper open water habitats of Mitchell Lake with the wetlands gradating from submergent to emergent vegetation towards the shoreline. The deeper wetland areas associated with the cove primarily attract diving ducks such as Canvasbacks (*Aythya valisineria*), Redheads (*A. americana*), and Greater and Lesser Scaup (*A. marila and A. affinis*). The Skip's Pond wetlands provide smaller patches of shallower open water surrounded by more tussocks of emergent vegetation. These smaller wetlands provide high quality habitat for migrating dabbling ducks such as Mallard (*Anas platyrhynchos*), Northern Pintail (*Anas acuta*), Gadwall (*Mareca streptera*), and teal (*Spatula discors, Spatula cyanoptera, and Anas crecca*). Because the addition of the Skip's Pond wetlands provides habitat that has not been included in the previous Plans and that habitat provides resources for another distinct group/guild of birds; absorbing the increased incremental cost to incremental output ratio resulting from moving from Plan 5 to Plan 6 and the marginal increase in the first cost, Plan 6 is worth the Federal and local investment.

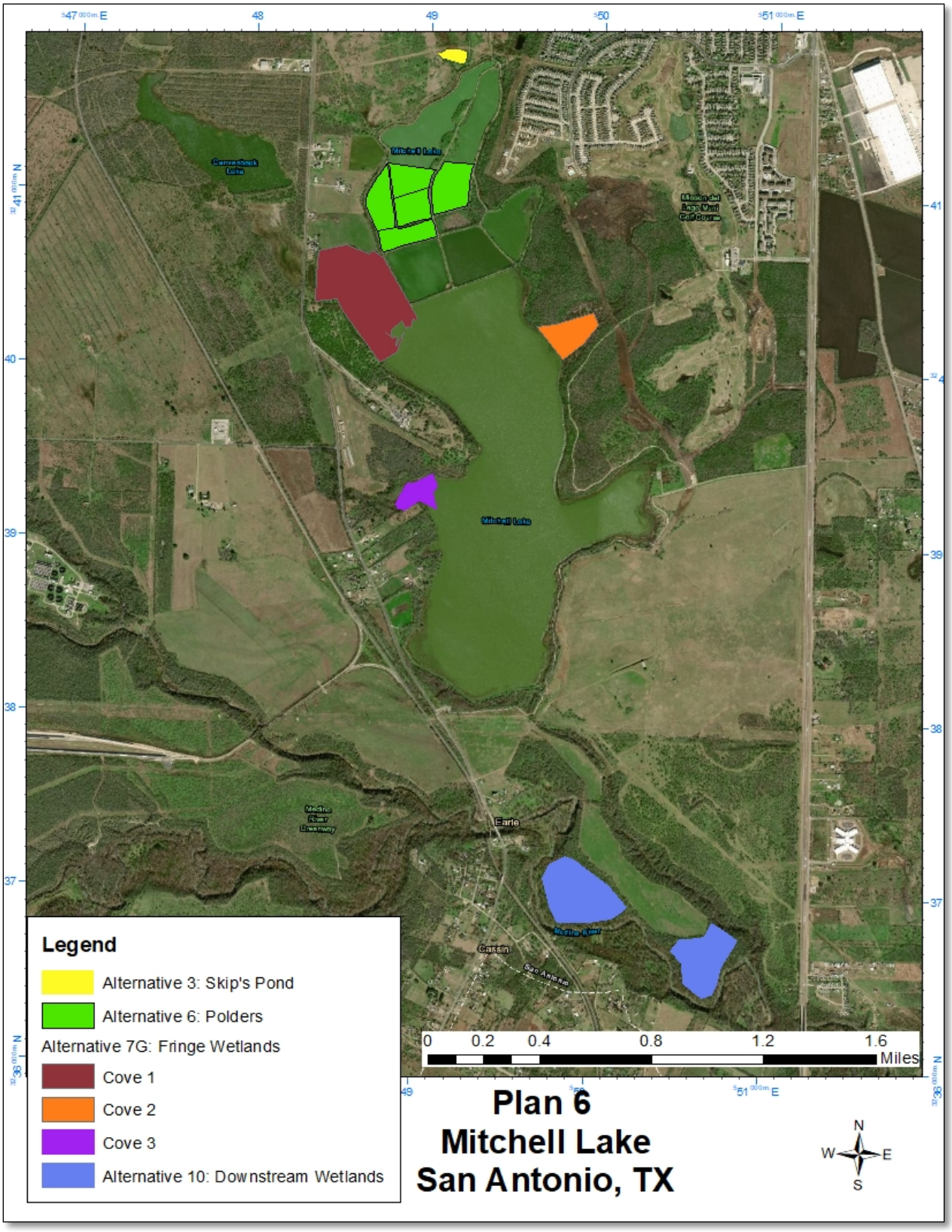

Figure 4-5. Plan 6 Restoration Areas

4.7 Plan 7 (Polders; Coves 1, 2, and 3, the Downstream Wetlands, Skip's Pond, and the Central Wetlands)

Plan 7 includes the restoration features included in Plan 6 and adds the restoration the expansion of the Central Wetlands from Alternative 2B (Figure 4-6). The Central Wetlands is a complex of emergent wetlands located immediately north of Skip's Pond. The existing wetlands are dominated by noxious species such as willow baccharis, palo verde, and cattails. The restoration measures would improve the plant diversity and expand the wetland complex. The Central Wetland restoration would add 18.37 acres of emergent wetlands and 10.7 AAHUs to the previous Plan.

A total of 106.9 AAHUs are provided by Plan 7; the allocation of the AAHUs are provide below:

- 49.52 acres and 18.1 AAHUs of mudflat habitat
- 74.54 acres and 41.4 AAHUs of emergent/submergent wetland habitat
- 69.69 acres and 47.4 AAHUs of emergent wetland habitat

The incremental cost per incremental output for Plan 7 is $7,411 with a first cost of $4,643,224, a first cost increase of approximately $894,000 over Plan 6. Plan 7 would restore 94.6% of the total area identified for restoration under this study.

Thus far, Plans 2 through 6 have included restoration areas that realize benefits in isolation, albeit with cumulative benefits across the spread of the study area. With the addition of the Central Wetlands, Plan 7 begins linking restoration areas from the previous Plans resulting in synergistic benefits to fish and wildlife habitat. Plan 7 also provides significant ancillary water quality benefits that are not captured or included in the plan formulation of the study.

One of the key components of the Central Wetland restoration is the pipeline from the existing pump station at the southwest corner of the polders to the northern end of the Central wetland complex. This pipeline provides the capability of managing the water levels of the wetlands, extracting low quality water from Mitchell Lake and releasing it into the Central Wetlands. Wetland habitats provide water quality benefits as the wetland vegetation captures nutrients as the water passes through them. The water exiting the wetlands has a lower nutrient load and is of a higher quality than the water entering them. Once the water is filtered through the Central Wetlands, the water flows through Skip's Pond further filtering out the nutrients. Skip's Pond empties into a long linear wetland/drainage feature that borders the polders. This linear wetland continues along the northern and western boundary of the polders until it empties into Cove 1 of Mitchell Lake. Therefore, once leaving Skip's Pond, the water is "polished" further as it flows approximately 4,635 feet through the linear wetland and Cove 1 of Mitchell Lake.

Although the incremental cost per incremental output for restoring the Central Wetlands is slightly higher than the incremental ratio of the Downstream Wetlands, the Central Wetlands complex has a relatively flat topography and supports an extensive ecotone with transitional habitats between the wetland and upland prairie areas. Because the Downstream Wetlands would be excavated from an upland area, the transitional areas between the resultant wetland and upland would be more severe and constrained. In effect, the Central Wetlands would have proportionately larger areas of transitional habitat than the Downstream Wetlands. Although the modeled target year benefits of the habitat quality between the two wetlands is projected to be equal, the uncaptured benefits of the ecologically significant transitional habitats was not captured in the analysis. Although the captured benefits more than justifies each of these emergent wetland areas, the cumulative captured and uncaptured benefits of the Central Wetlands is significantly higher than the Downstream Wetlands.

Because of the connectivity the Central Wetlands provide to Skip's Pond, the linear wetlands, and Cove 1; the synergistic captured and uncaptured benefits attributed resulting from the connected system; and the connection of the existing transitional habitats to the Central Wetlands, the increased incremental cost to incremental output ratio resulting from moving Plan 6 to Plan 7 and the marginal increase in the first cost, Plan 7 is worth the Federal and local investment.

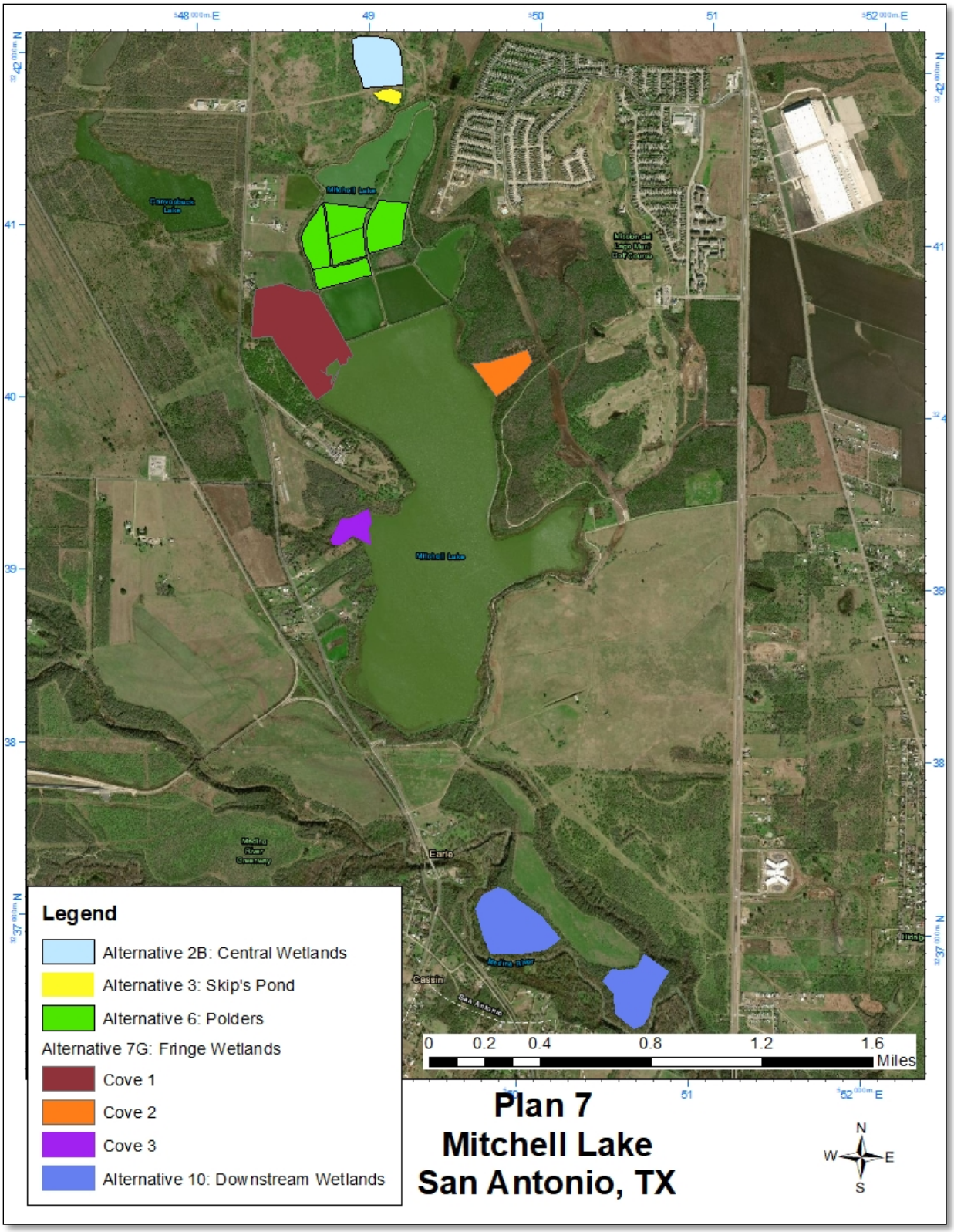

Figure 4-6. Plan 7 Restoration Areas

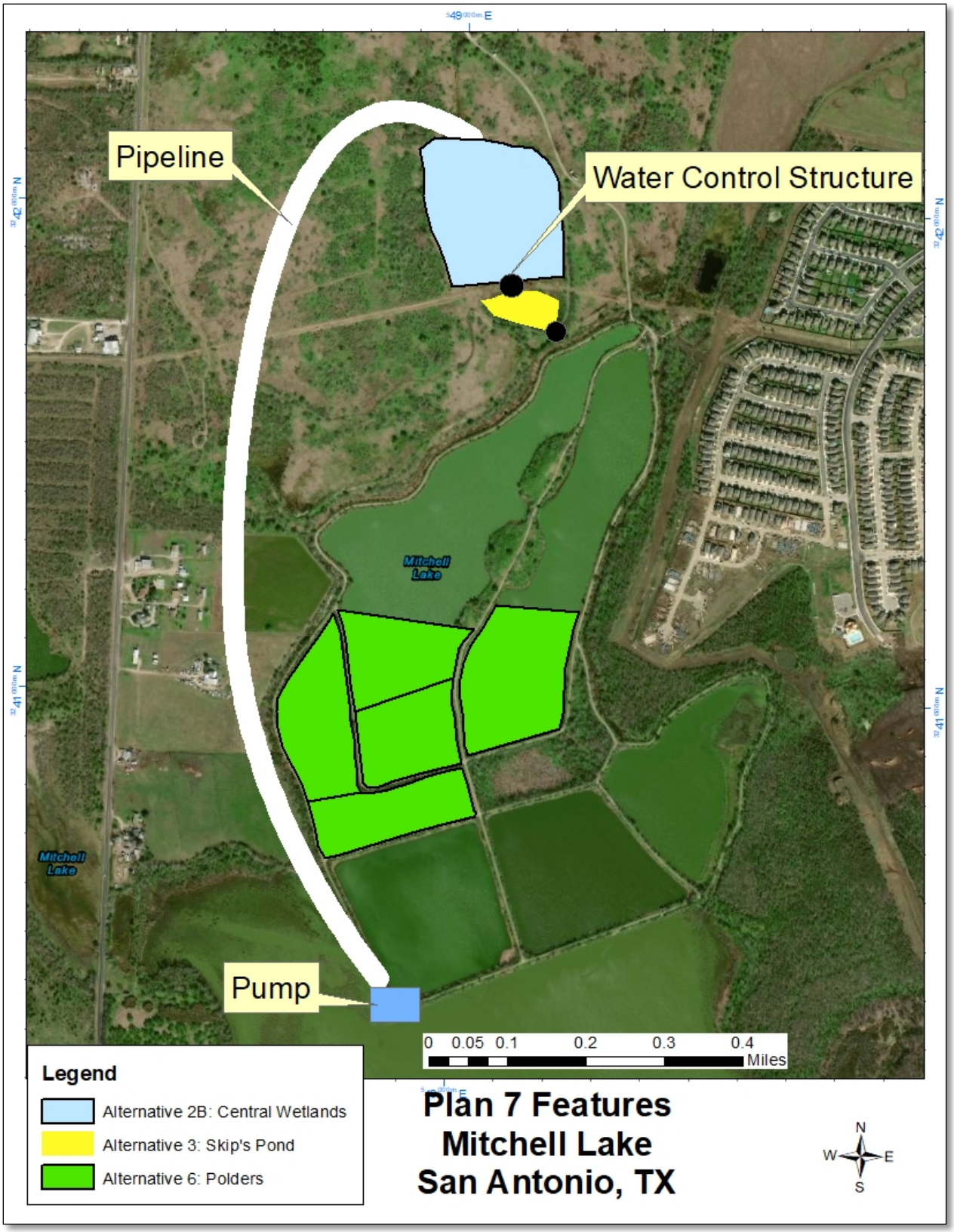

Figure 4-7. Plan 7 Restoration Features

4.8 Plan 8 (Polders; Coves 1, 2, and 3, the Downstream Wetlands, Skip's Pond, the Central Wetlands, and the Bird Pond Wetlands)

Plan 8 includes the restoration features included in Plan 7 and adds the restoration and expansion of the Bird Pond Wetland from Alternative 1B (Figure 4-8). The Bird Pond Wetland is an existing wetland located east of Bird Pond and upslope of the Central Wetlands. The existing wetlands are dominated by cattails with little herbaceous diversity. An indistinct drainage comprised of a swale of wetlands with intermittent sections of distinct channels connects the Bird Pond and Central Wetlands. Instead of placing the pipeline outfall structure at the north end of the Central Wetlands (Plan 7), the pipeline would be moved to the north end of the Bird Pond Wetland. The restoration measures would improve the plant diversity and expand the wetland complex. The Bird Pond Wetland restoration would add 6.42 acres of emergent wetlands and 3.9 AAHUs to the previous Plan.

A total of 110.8 AAHUs are provided by Plan 8; the allocation of the AAHUs are provide below:

- 49.52 acres and 18.1 AAHUs of mudflat habitat
- 74.54 acres and 41.4 AAHUs of emergent/submergent wetland habitat
- 76.11 acres and 51.3 AAHUs of emergent wetland habitat

The incremental cost per incremental output for Plan 8 is $8,787 with a first cost of $5,115,007, a first cost increase of approximately $472,000 over Plan 7. Plan 8 would restore 97.8% of the total area identified for restoration under this study.

Plan 8 increases the synergistic water quality benefits of the previous Plan by adding the nutrient filtering function of the Bird Pond Wetlands and approximately 591-foot channel to the Central Wetland/Skip's Pond/Linear Wetland/Cove 1 system (Figure 4-9).

The Bird Pond Wetlands provide the same core target habitat benefits as the Central Wetlands and Downstream Wetlands and provide the same uncaptured benefits as the Central Wetlands associated with the surrounding transitional habitats. However, the Bird Pond Wetlands are located adjacent to the aquatic habitat of Bird Pond and the associated forested habitat that surrounds the pond. The proximity of the forested habitats to the Bird Pond Wetlands provide significant resources for specific neotropical migratory birds that utilize edge habitats along wetland/woodland boundaries such as the Common Yellowthroat (*Geothlypis trichas*), Yellow Warbler (*Setophaga petchia*), Swamp Sparrow (*Melospiza georgiana*), and Song Sparrow (*M. melodia*). The Bird Pond Wetland also provides optional foraging opportunities for pond dependent species utilizing the Bird Pond habitats such as egrets and herons.

Although the incremental cost per incremental output for restoring the Bird Pond Wetland is slightly higher than the incremental ratio of the Central Wetlands, the Bird Pond Wetland provides habitat for an additional bird guild and increasing the water quality treatment of the Mitchell Lake water flowing through the system. Because of the increased diversity of bird species benefiting from the restoration, the increased water quality function resulting from adding the Bird Pond Wetland to the Plan, and the relatively small increase in incremental cost to incremental output ratio and increase in first cost resulting from moving from Plan 7 to Plan 8, Plan 8 is worth the Federal and local investment.

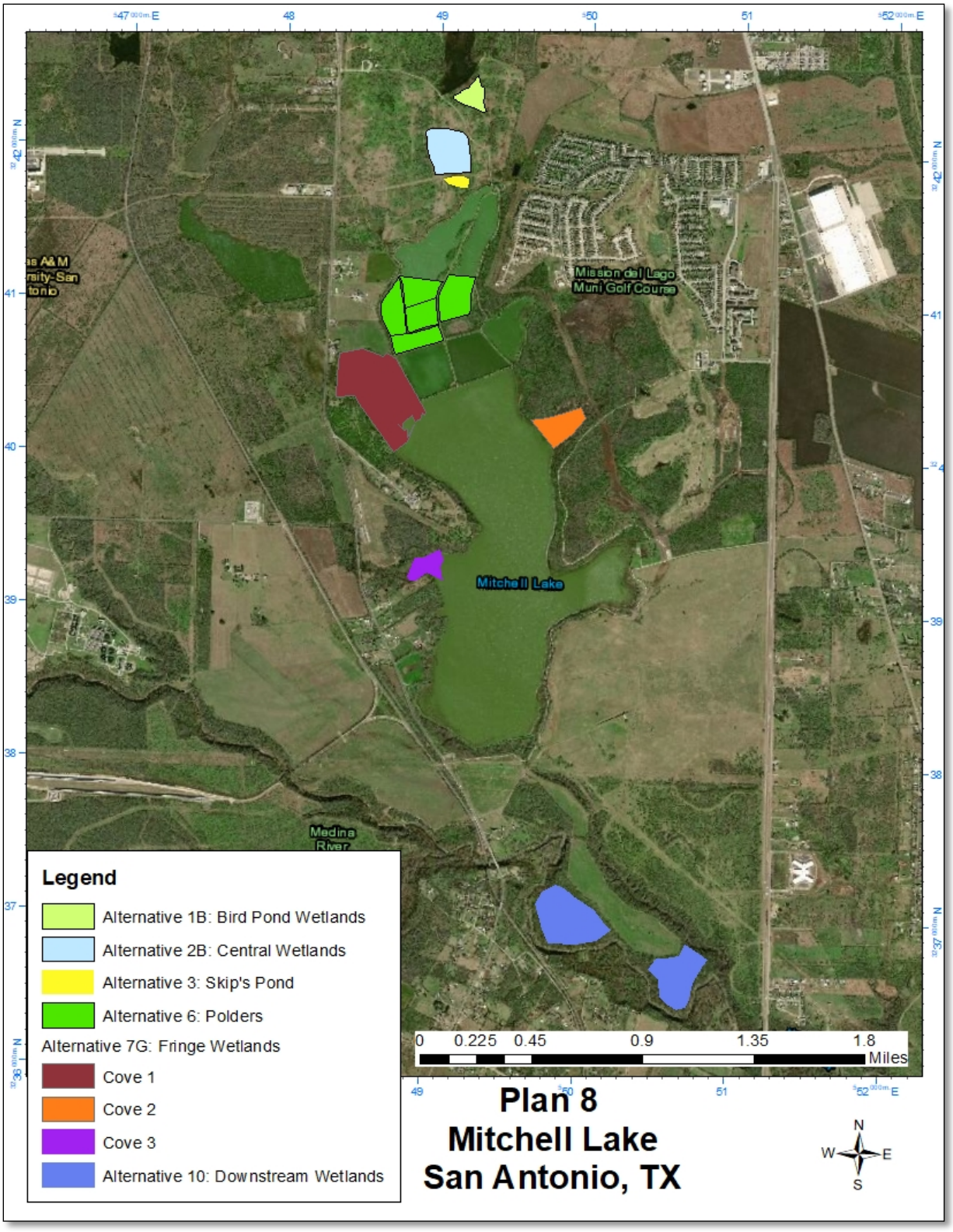

Figure 4-8. Plan 8 Restoration Areas

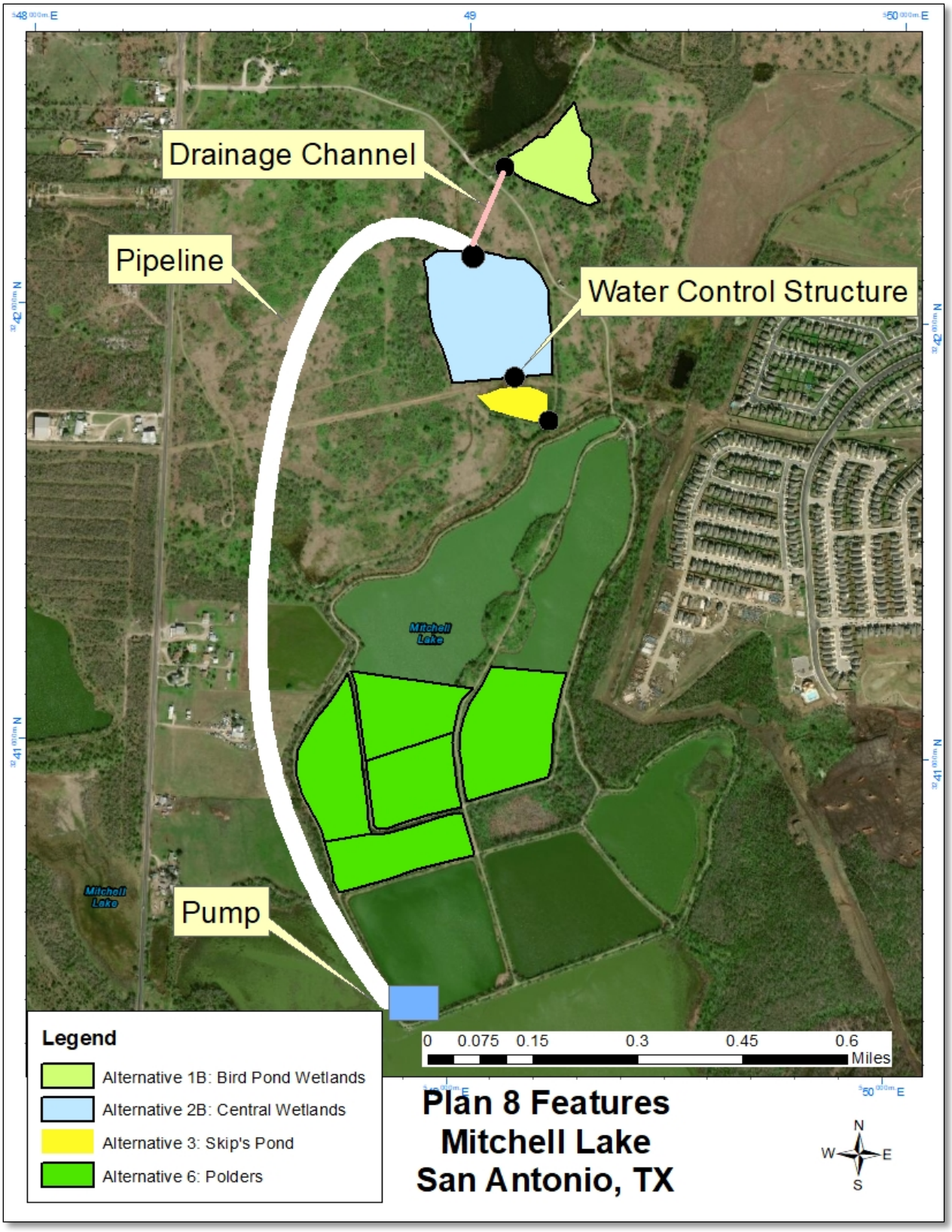

Figure 4-9. Plan 8 Restoration Features

4.9 Plan 9 (Polders; Coves 1, 2, and 3, the Downstream Wetlands, Skip's Pond, the Central Wetlands, the Bird Pond Wetlands, and the Dam Forested Wetlands)

Plan 9 includes the restoration features included in Plan 8 and adds the restoration of a forested wetland complex south of the Mitchell Lake Dam from Alternative 9B (Figure 4-10). Although the existing Dam Forested Wetlands have an extremely low plant species diversity, the structural diversity of the wetlands is appropriate for that system. The restoration strategy for the Dam Forested Wetlands would be to thin the dominant tree species and replant with a more diverse palette of native tree species to increase the diversity. The Dam Forested Wetland restoration would add 4.48 acres of forested wetlands and 0.8 AAHUs to the previous Plan. The small increase in AAHUs is attributed to the fact that the habitat quality models key in on structural habitat features and not on species diversity.

A total of 111.6 AAHUs are provided by Plan 9; the allocation of the AAHUs are provide below:

- 49.52 acres and 18.1 AAHUs of mudflat habitat
- 74.54 acres and 41.4 AAHUs of emergent/submergent wetland habitat
- 76.11 acres and 51.3 AAHUs of emergent wetland habitat
- 4.48 acres and 0.8 AAHUs of forested wetland habitat

The incremental cost per incremental output for Plan 9 is $41,675 with a first cost of $5,762,219, a first cost increase of approximately $647,000 over Plan 8. Plan 9 would restore all areas identified for restoration under this study.

Plan 9 would introduce a fourth habitat type into the proposed restoration Plans – forested wetlands. Forested wetlands provide for additional guilds of Neotropical migrant songbirds including the Barred Owl (*Strix varia*), Northern Parula (*Setophaga americana*), Vermilion Flycatcher (*Pyrocephalus rubinus*), Louisiana Waterthrush (*Parkesia motacilla*), and Prothonotary Warbler (*Protonotaria citrea*). The forested wetlands also provide for species of reptiles, amphibians, and mammals that are not found in the grassland and savannah wetlands associated with the previous Plans. In spite of the ecological value that the addition of the Dam Forested Wetlands provide for the restoration plan, the high incremental cost per incremental output is significantly higher than the rest of the Plans combined. Therefore, the expenditure of Federal and local funds to implement Plan 9 is not justified.

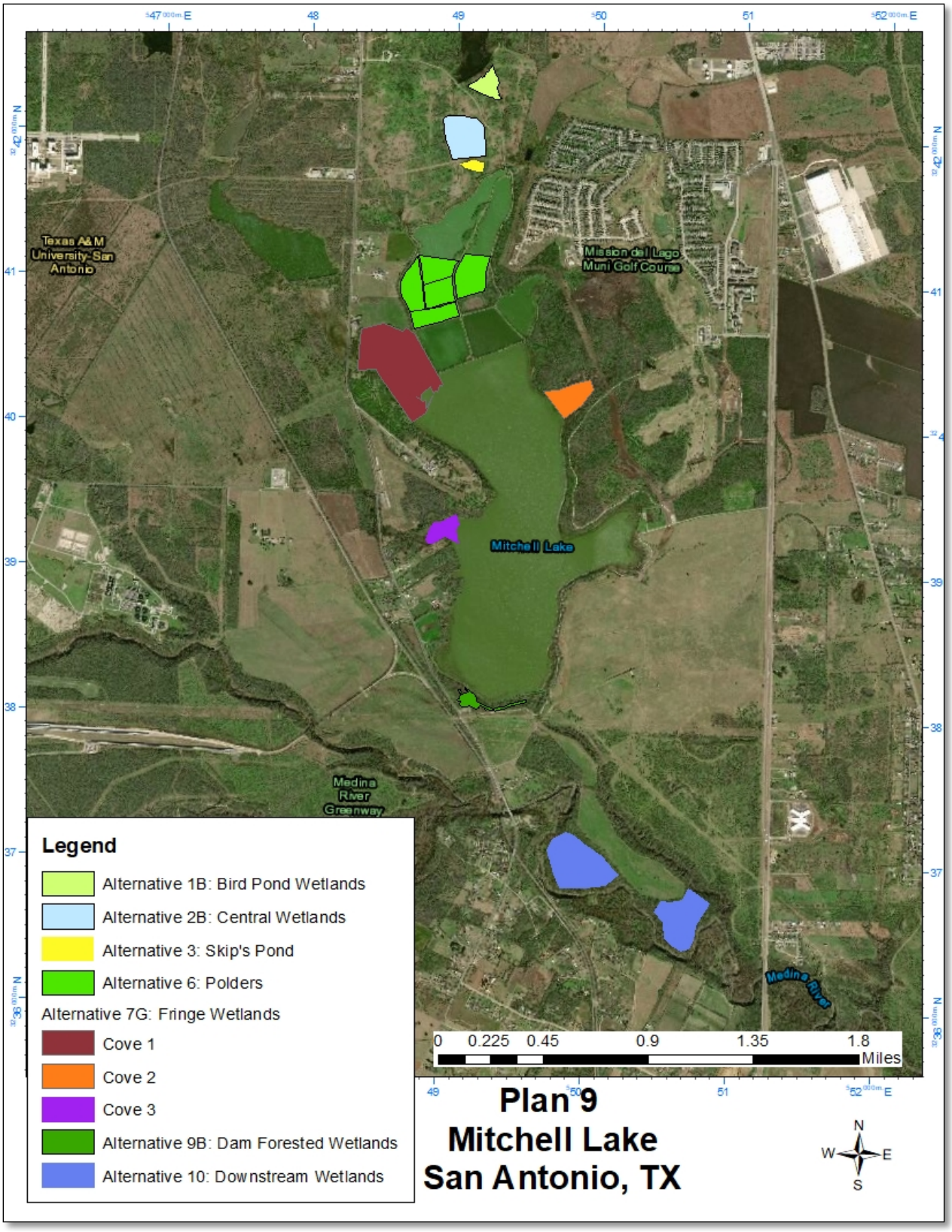

Figure 4-10. Plan 9 Restoration Areas

5 National Ecosystem Restoration Plan

Migratory birds are the primary resource of national significance identified within the study area. Based on historical descriptions, the large wetland complex that occupied the study area prior to the impoundment of Mitchell Lake would have acted as extremely valuable stopover habitat for migrating birds. The recreation of the emergent, submergent, and forested wetlands along with the associated mudflat and prairie habitats are critical to improving vital migratory habitat for migratory birds and help stem the systemic decline in population sizes for these species.

Plan 8 is the recommended National Ecosystem Restoration (NER) plan. This Plan provides:

- Three distinct habitat types (emergent wetlands, submergent/emergent wetlands, and mudflats) out of the four targeted habitat types;
- Resilient habitat for migratory birds;
- The creation of a complex of wetlands that can be managed to improve water quality as an ancillary benefit;
- The restoration of 97.8% of the proposed restoration areas;
- An incremental cost per incremental output of $8,787 over Plan 7;
- An approximate first cost of $5.2 million.

6 *References

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