

Culebrinas River Flood Control Project

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Executive Summary

The U.S. Army Corps of Engineers, Jacksonville District, is planning a flood control project for an associated river mouth drainage of the Culebrinas River, Caño Madre Vieja. During high flood events, the Culebrinas River overflows its channel upstream of highway PR-2 and at the first meander curve just downstream of PR-2. The flood waters enter Caño Madre Vieja flooding out the southwestern sectors of Aguadilla and the northeastern portion of the community of Espinar.

The preferred alternative would place two dikes east and west of the Caño to maintain the flood waters within this floodway. To accommodate the eastern levee, a double meander of flowing stream in the Caño would be eliminated via a cut-off channel. The western levee would cross a mangrove forest and channel near the mouth of the Caño, directly impacting some mangroves and indirectly affecting the existing hydrology that supplies tidal flow to the mangrove forest that would be left outside the flood dikes.

The Service's major concern centers around the potential indirect and secondary impacts for the mangrove forest and other wetlands that would remain outside the flood levee. The section of the mangrove forest where the west levee would pass through lies within Coastal Barrier unit PR-75. Our understanding is that this precludes the use of Federal funds for projects, including flood control projects authorized after the date of the inclusion of the Coastal Barrier unit. Another concern is for the section of river to be eliminated. The Service believes that ample opportunities exist in the area for appropriate mitigation, however, there has been no specific mitigation plan discussed to this point.

Introduction

The Río Culebrinas is the fifth largest watershed in Puerto Rico with a total drainage area of approximately 103 square miles. The river flows at a relatively low gradient out of the central mountain region in a northwesterly direction, emptying into Aguadilla Bay southwest of the town of Aguadilla. Historically the river has meandered throughout the valley (C type meandering stream, Rosgen hydrogeomorphic classification), and the mouth of the river has periodically migrated. Caño Madre Vieja, to the north of the Culebrinas River, is considered to be an abandoned river mouth that now carries only localized drainage except during flood stages on the Culebrinas. The beach in this area receives moderate to high energy sea conditions, and the coastline is subject to erosion. The beach between the Culebrinas River and Caño Madre Vieja has a low berm, and is backed by herbaceous and mangrove forest wetlands with a direct hydrological connection to the Caño.

One of the major island highways, PR-2, crosses the Culebrinas River in a north/south direction. The highway is elevated above the surrounding floodplain, although the river is capable of going over the highway during flood stage (Figure 1). The highway bridges the Culebrinas River and culverts maintain flow in the upper part of Caño Madre Vieja. When the Culebrinas exceeds bank-full flows, it floods over the first large meander below PR-2, and into the drainage for Caño Madre Vieja, flooding both the Espinar Community and the southwestern low-lying portions of Aguadilla. In higher flood stages, it overflows above PR-2, also draining towards the Caño.

The river has no major impoundments, but does have a small low head dam (Photos 1 and 2) built in the early part of the century to provide a water diversion for the Coloso Sugar Mill. This diversion is still used to provide process water for the mill. In 1998, the Puerto Rico Aqueducts and Sewers Authority (PRASA) along with the Commonwealth Infrastructure Agency (AFI) developed a surface water intake for potable water using the impoundment from this dam. The dam is located several hundred meters upstream of PR-2, and the pump house is located on an elevated stand next to the diversion dam (presumably above the 100 year flood stage). The raw water is currently pumped up to the Aguadilla treatment plant, but AFI is considering the creation of an off-river reservoir/ sedimentation lake near the damsite to supply additional firm yield and reduce the very high sediment load in the raw water extracted from the river. Because of its narrow design, it is likely that the existing dam serves as a constriction creating overflow into the floodplain above PR-2 during flood stage.

The dam acts as a partial barrier for fish and shrimp migration upstream, and juvenile shrimp can generally be seen migrating upstream on the cement bulkhead of the weir in the wetted zone above the water flow (Photo 3). Native fish (approximately 6 species) and shrimp (as many as 14 species) are compulsory migrators, requiring a portion of their life cycles in estuarine or marine waters. At least six species of shrimps are large enough to be fished for human consumption, one species reaching very large sizes (Photo 4). Most of these species are also likely to occur in Caño Madre Vieja along with estuarine fish such as snook, tarpon, mullet, mojarra, and jacks; and crustaceans such as blue crabs and land crabs. Fishermen of the area

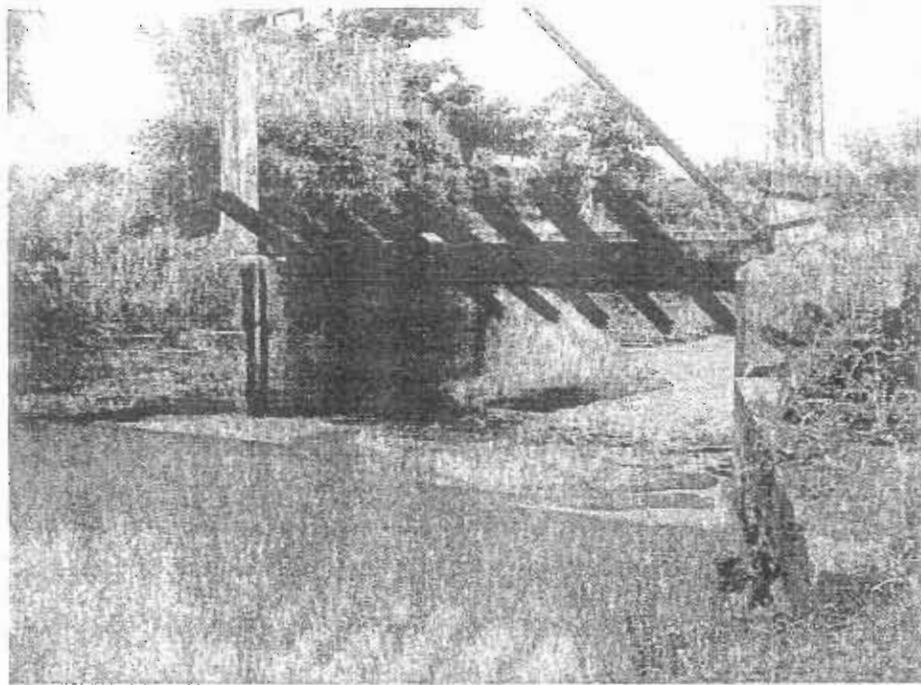


Photo 1. Coloso diversion dam from the upstream side. Note that the opening is very narrow and topped by a road.

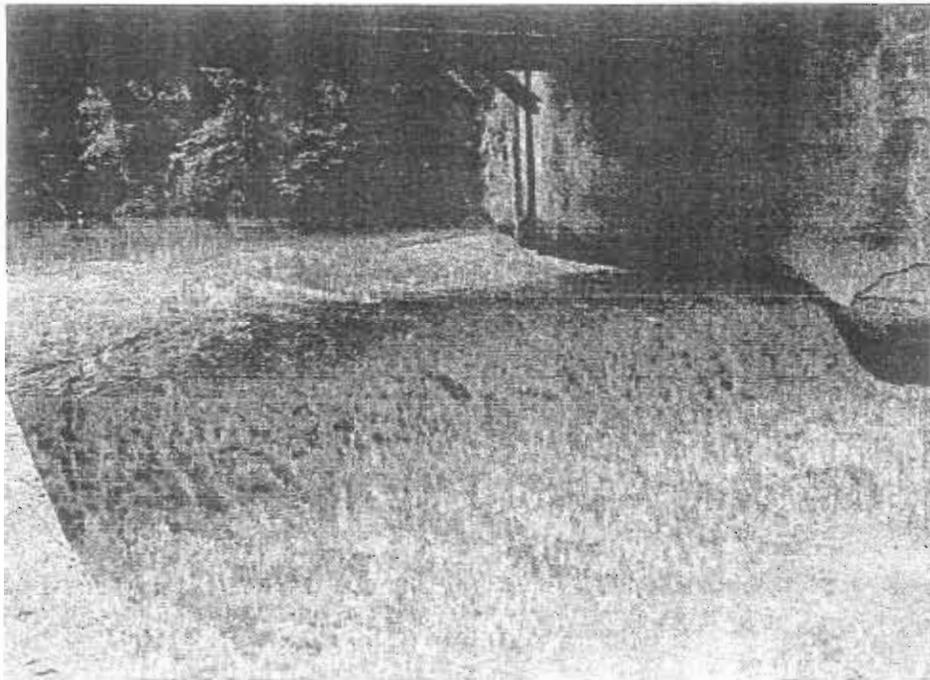


Photo 2. Downstream side of the Coloso dam. Drop during lower flows (photo condition) approximately 2 meters including a lower step not shown in the photo. Note that the vertical sidewalls have a wetted zone.

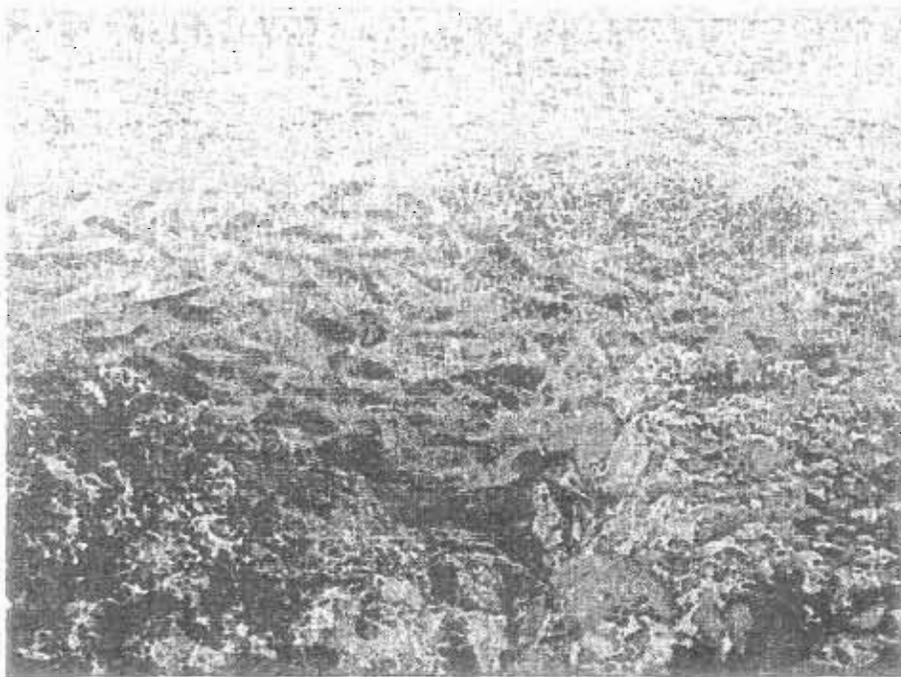


Photo 3. Juvenile shrimps, approximately 1 cm long, migrating upstream in the wetted (splash zone of the dam side walls.

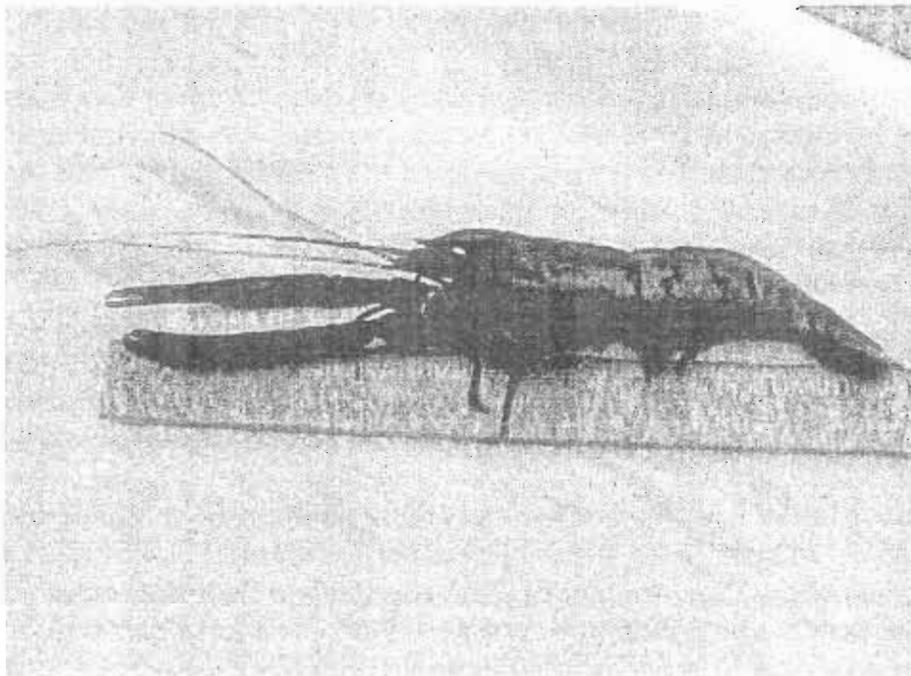


Photo 4. A specimen of *Macrobrachium carcinus*, the largest species of freshwater shrimp. This species can reach overall lengths of 18 inches and a pound in weight. This, and four other species of shrimp are actively fished.

have commented that they catch fish and the larger species of shrimp from both the Culebrinas and the Caño and its canals for consumption. The Service is participating in a fishway project for the Coloso Mill dam with AFI and PRASA.

A large wetland area, the Cayures marsh, lies south of the Culebrinas River near the Coloso sugar mill. This wetland area is a DNER designated Critical Coastal Wildlife Area providing habitat for a number of waterfowl species. The marsh consists of some interconnected ponding areas associated with overflow from the river. This wetland area will not be discussed further as the preferred alternative would not impact this marsh. In addition to the Cayures marsh, herbaceous wetlands occur on the south side of the Culebrinas River and are directly associated with the river.

From documents provided by the Corps, we understand that a number of alternatives have been considered to provide some Flood Hazard Mitigation for already developed portions of the community of Espinar and the southwestern communities of Aguadilla. The first alternative proposed was to construct a single flood levee from PR-2, just southwest of Caño Madre Vieja extending along the south side of Espinar, tying into a hill to the west to isolate the Caño from the floodwaters of the Culebrinas River (Figure 2). This would have provided flood protection for the western communities of Aguadilla, greatly reduced the floodplain of Caño Madre Vieja, and protected portions of the Espinar community. It would have raised flood levels in the Culebrinas River, however, thus affecting other portions of the Espinar community along the Culebrinas River. It also would have reduced the frequency of high flows that help maintain the channel and mouth of Caño Madre Vieja and encouraged development in much of the currently uninhabited floodplain along the Caño, violating E.O. 11888 for the protection of floodplains. To be effective, this plan would have to include channelization of the lower Culebrinas River to minimize the flood levels on its course, eliminating the river meanders and associated wetlands, and increasing maintenance costs for the floodway channel. Channelization of the lower Culebrinas River would have been likely to affect hydrology in the neighboring associated Cayures marsh. Our understanding is that this alternative has been discarded due to high costs and environmental considerations.

Alternative 2 from the original Reconnaissance Report (Figure 3) would provide two flood levees: one along the eastern side of Caño Madre Vieja north of PR-2 to protect southern Aguadilla, and a flood ring levee on the west side of the Caño. The original design would also have included a continuation of this levee on the north side of Espinar. Various permutations of Alternative 2 have been considered by the Corps as additional alternatives, mostly as variations to the western levee. In addition to the levees, the various permutations of this alternative also require the elimination of a double meander of Caño Madre Vieja via a short cut-off channel to accommodate the eastern levee. A modified version of Alternative 2 is the currently preferred alternative described as "Plan 1" in the Detailed Project Report (Figure 4). The western levee of this plan was altered to include the Iglesia de Espinar, a historic church for that community, in the protected area. The portion of the levee behind the beach berm and just north of Espinar community was eliminated, and the end of the levee was tied into the beach berm on the west side of the mouth of the Caño. One-way drainage structures are to be incorporated into the levee at strategic points. This last alternative has been further modified to include a two-way culvert

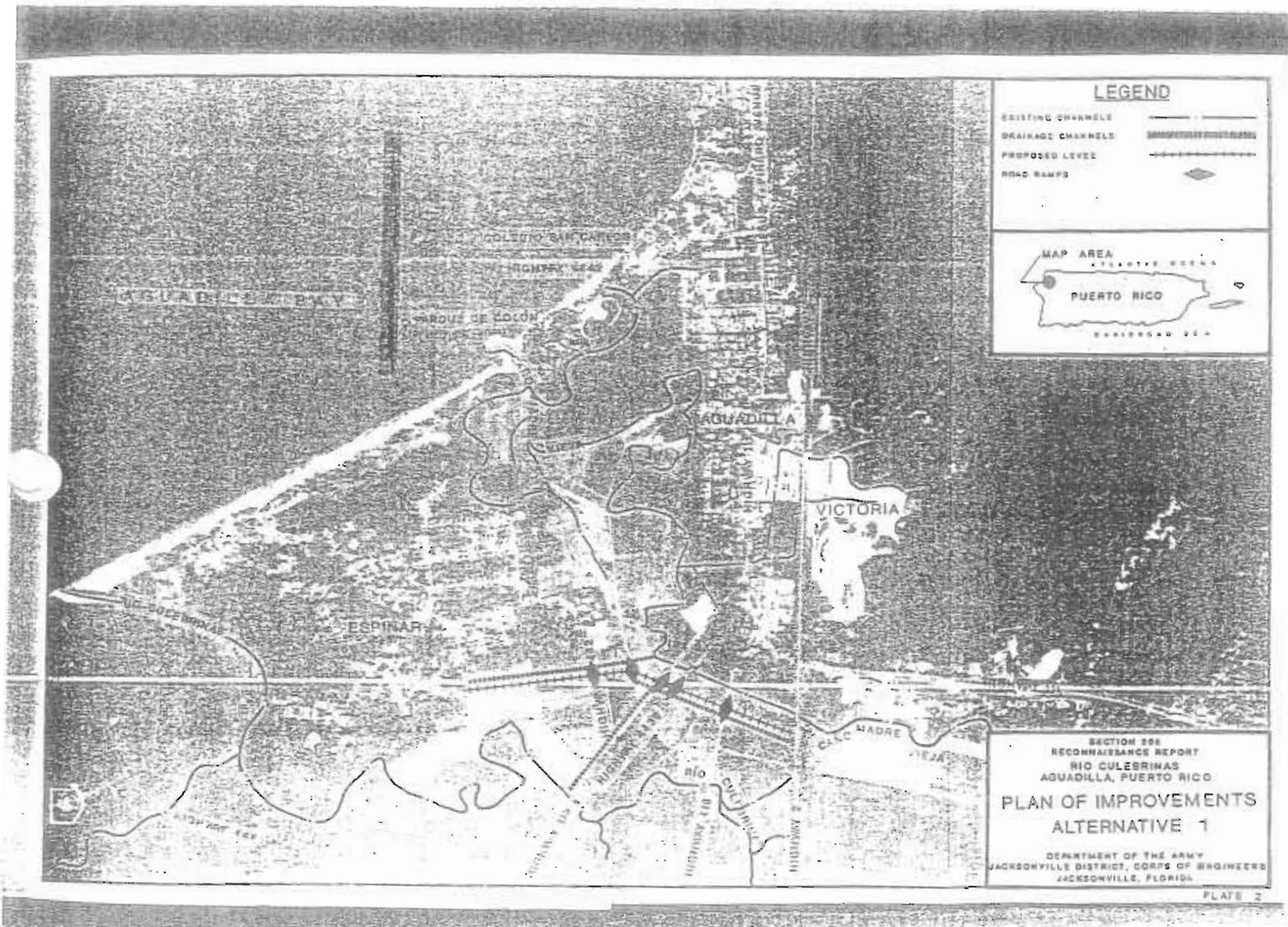


Figure 2. Original alternative 1 from Section 205 Reconnaissance Report, 1992.

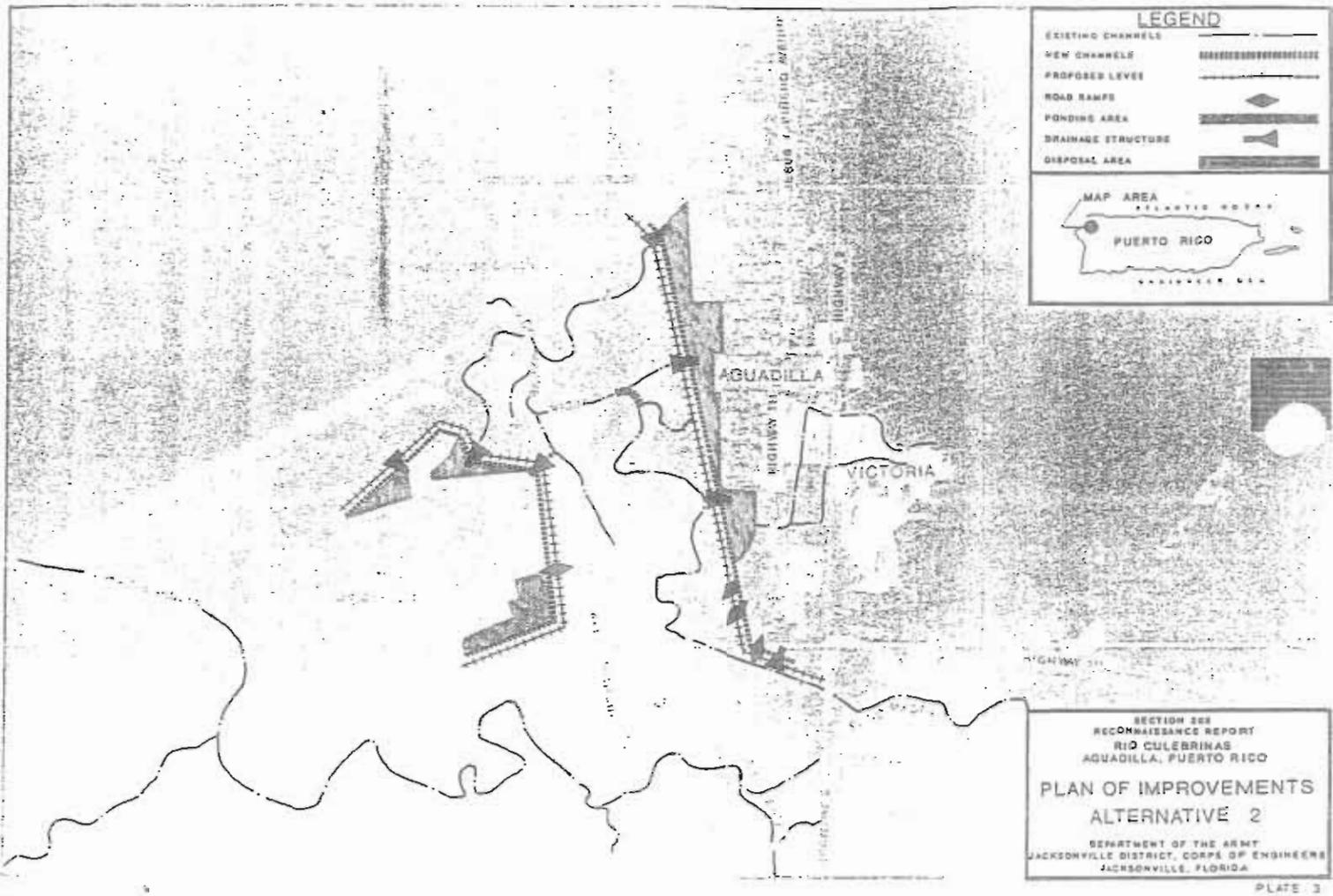


Figure 3. Original Alternative 2 from Section 205 Reconnaissance Report, 1992.



Figure 4. Currently favored alternative with the modified west levee.

to provide hydrology to the mangrove forest channel that runs on the north and east sides of the Espinar community.

Fish and Wildlife Trust Resources

Evaluation of the fish and wildlife trust resources for this CAR focus strictly on the Caño Madre Vieja area that would be affected by the currently favored alternative. Both the Cayures marsh and the low-head dam discussed above are outside of the immediate project area, but should be evaluated if further alternatives outside the lower Caño Madre Vieja area are considered. The lower Culebrinas River valley includes areas of herbaceous and forested (mostly mangrove) wetlands. Most of the forested wetlands in the immediate project area are located near the mouth of Caño Madre Vieja.

On the east side of the Caño, Aguadilla developed a public park with recreational facilities, a boat ramp, and an athletic field and track. The beach front road on the west side from the town to the park is protected in most areas by rip-rap. The mouth of the Caño is protected by breakwater/groins, the larger one lying on the east side of the mouth (Photos 5 and 6). These help maintain the mouth open and provide some protection for small boats entering and leaving the mouth. Our understanding is that the municipality of Aguadilla may also periodically provide maintenance to keep the mouth open, and that no new alterations are planned for the mouth the the Caño. The eastern side of the Caño mouth lies within Coastal Barrier unit PR-75P, while the western side of the mouth lies within Coastal Barrier PR-75 (Figure 5). On the west side of the Caño mouth is a small groin, but the beach berm is otherwise in a relatively natural condition. The western levee would tie into the beach berm within PR-75. According to the information available in our office on CBRA, the use of Federal funds is prohibited, and exempt activities do not include flood control work authorized after the date the relevant unit was included in the CBRA (in this case 1990).

While the Service has no ongoing beach monitoring projects in the area, a previous site inspection revealed the beach between Caño Madre Vieja and the Espinar community is likely to be suitable nesting habitat for the endangered hawksbill sea turtle (*Eretmochelys imbricata*) and the leatherback sea turtle (*Dermochelys coriacea*). While the project does not contemplate any alterations to the beach area, project changes that would require alterations to this beach should require consultation under Section 7 of the Endangered Species Act. This section of the beach also lies within Coastal Barrier Unit PR-75.

Soils

Caño Madre Vieja and the lower Culebrinas River lie within two major soil associations: the Coloso-Toa Association described as nearly level porous loamy soils, and the Bejucos-Jobos Association consisting of strongly leached soils with a very tight, clayey subsoil. Caño Madre Vieja lies mostly within the intersection of these two major associations. Soils in the project area are all either considered to be hydric soils or non-hydric soils with hydric inclusions (Figure 6). Those considered to be hydric soils include Bajura clay (Ba), Iguadad clay (Ig), and Tidal swamp (Td). The non hydric soils with hydric inclusions include Toa silty clay-loam (ToA),



Photo 5. A view of southwestern Aguadilla from PR-2 above the town. The jetty visible in the middle of the coastline is the eastern jetty of Caño Madre Vieja.

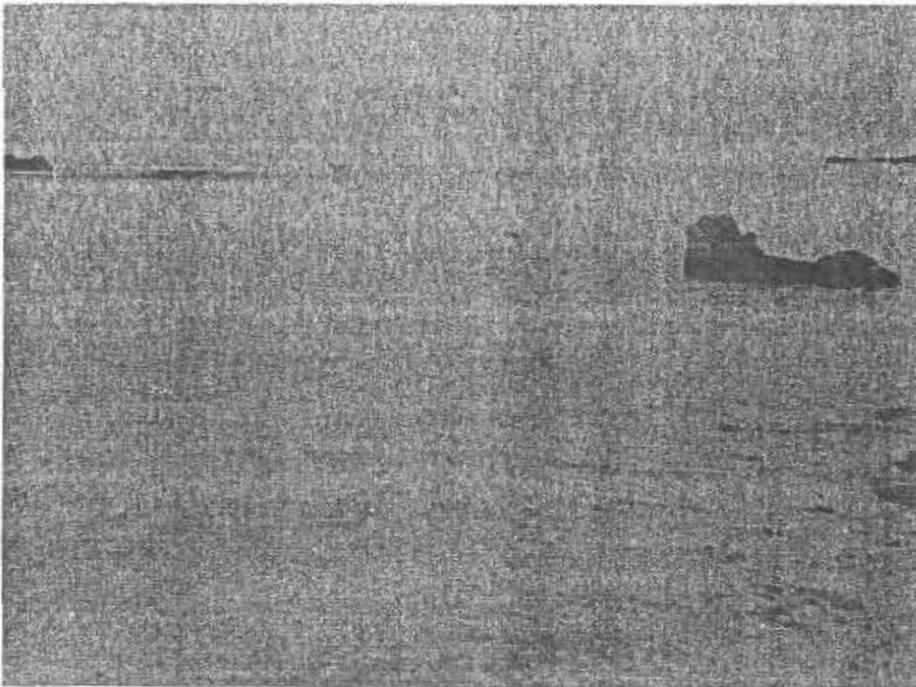


Photo 6. Open mouth of Caño Madre Vieja from Parque Colón on the east side. The tip of the small western jetty is visible on the left side of the picture.



Figure 5. Showing Coastal Barrier Resource Units PR-75 and PR-75P.



Figure 6. Enlarged soil map showing Caño Madre Vieja.

Coloso silty clay-loam (Cn), Cataño sandy clay-loam (Ce), and Cataño sand (Cd). In general, the unmapped inclusions may be small units of the above listed known hydric soils, or would be described as “unnamed inclusions”. These unnamed inclusions generally have a lot of the characteristics of the surrounding soils and may lack obvious hydric indicators, but are often ponded. In the case of soils with heavy clay content, hydric indicators may not be obvious, and inclusions are usually within depressional wetland areas where the hydrology is maintained by ponding rather than flooding. NRCS has noted that the hydric soil indicators in such soils are good for saturation only and may not be present in ponding situations. Drainage channels have been dug on both sides of the Caño in various places, and while some have been maintained others have not, making the hydrology of the area complex.

Existing Conditions

The National Wetland Inventory Map (Figure 7) of the area indicates relatively extensive wetlands in the Caño Madre Vieja area. While wetlands east of Caño Madre Vieja may be over-estimated in the maps, some areas marked as uplands within the proposed levees may be in the process of reverting to wetlands. The mouth of Caño Madre Vieja is mapped as Cd on the soil map, and is a classic small stream opening on a dynamic beach. The beach berms, while considered to be uplands are relatively narrow. On the eastern side of the Caño, as mentioned above, the beach berm has been elevated for the coastal road and further altered with groins and rip-rap to protect the park development, the public road, and the school. The beach berm on the western side of the Caño mouth has retained more natural characteristics with some forest of coconut palms and portia tree (*Thespesia populnea*), and West-Indian almond (*Terminalia catappa*).

Typically small rivers form sand bar sills in the river mouths during low flows and may even close during very low flows. As mentioned above, this channel is generally maintained open by the groins and occasional maintenance. Both east and west of the mouth, the beach berm is backed by the two side drainages that enter into the Caño near the mouth. These drainages are mapped as Tidal swamp (Td) and contain the riverine mangrove associations commonly found in small drainages where water accumulates behind the river mouth bar. Red mangroves (*Rhizophora mangle*) generally occur as fringes immediately adjacent to the channels, while black mangroves (*Avicennia germinans*) dominate in the saturated areas away from the open channel. On the beach side of this channel, red mangrove on the channel is backed by white mangrove (*Laguncularia racemosa*), and indication that soils are not hypersaline in this area. Leather ferns (*Achrosticum* spp.) are also commonly found in this association.

The eastern forested wetlands have been reduced since the NWI maps were made by the park development, particularly the athletic track and by the western edge of the school (Colegio San Carlos). The remaining wetlands still retain mangroves and other wet tolerant trees such as west-indian almond (*Terminalia catappa*), and palms (Photos 7 and 8). The seaward edge of the east dike would pass through the edge of the school yard, possibly cutting off a small segment of this drainage and wetland forest.

The western drainage divides with one arm passing just behind the beach berm directly west,



Figure 7. NW1 map of the project with the dike layout and rough approximation of wetland types

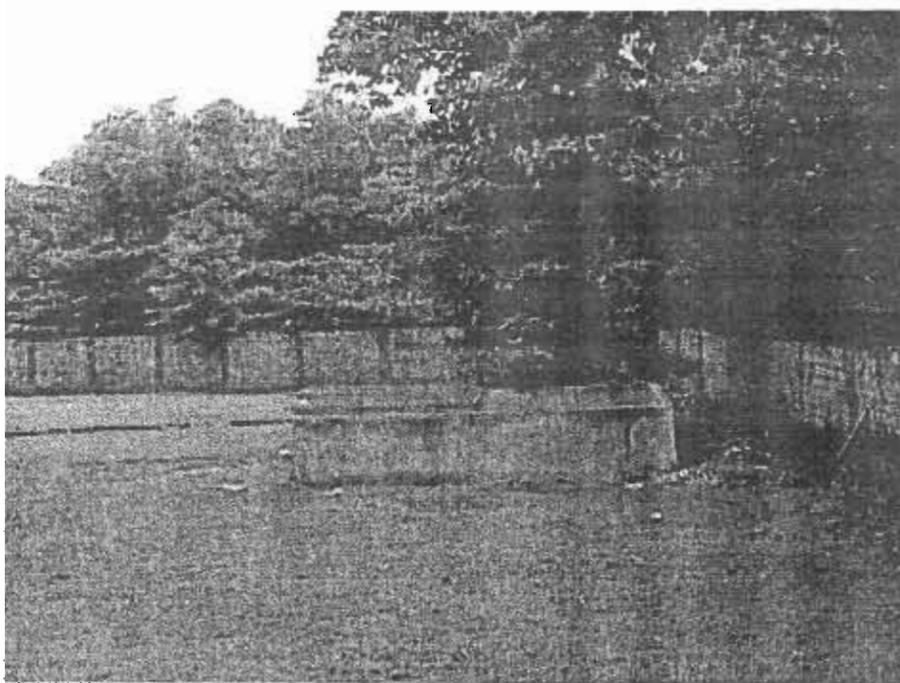


Photo 7. Colegio San Carlos school yard with the forested drainage behind it. The eastern levee would pass through part of the school yard and forest.



Photo 8. The forested drainage from the road just west of the school. Upland trees are in the foreground on the road levee and mangroves are in the background.

and the other arm meandering south on the edge of Espinar community. The mangrove forest along the southern portion of this drainage next to the Espinar community is well developed with some trees exceeding 30 feet in height. The channel is also connected to an intermittent drainage lying on the north side of Espinar, just behind the beach berm. The wetlands behind the beach berm are dominated by cattail (*Typha domingensis*) and other herbaceous vegetation to the west, probably a result of past (and current) land clearing and sand extraction. A previous wetland violation was noted in that area, and these wetlands were recently disturbed by land clearing activities (Photos 9 and 10). It appears that most of the cleared wetlands consisted of cattail (*Typha domingensis*) mixed with sedges and salt grass. The western dike would cut across the mangrove channel to tie into the existing beach berm just to the west of the mouth of Caño Madre Vieja. While the current plan calls for a two-way culvert to maintain tidal flow into this channel, the size of the culvert is critical in maintaining the hydraulic capacity of this channel. At the narrowest point in the vicinity of the proposed dike, the channel is approximately five feet in width and at least a foot in depth (Photos 11 and 12). Our understanding is that the Corps is currently considering a 2' diameter two-way culvert which appears to be considerably below the existing hydraulic capacity of the channel.

The east side of the Caño, south of the mangrove channel and park, lies between the side channel and a large curve in the main channel. It is mapped as Cataño sandy clay-loam (Ce) just south of the channel, shifting to Coloso silty clay-loam (Cn) and Igualdad clay (Ig) to the east. Probably reflecting these mixed soil associations, the plant community is patchy, varying between FACU and FACW herbaceous plant species. Most of the area is in grasses classified as FACU (*Panicum maximum*) with patches including sedges and FACW grasses such as *Brachiaria purpurascens*. The plant association shifts to cyperids and leather fern as the wetland forest is approached to the north, and the soils shift to Cataño sandy clay-loam. Much of the area on the eastern side of the Caño near the existing community could be considered as uplands, however, small changes in topography promote the wetland plant species in shallow depressions. The area is complex, and should be considered to be a mixture of wetlands and uplands that perform a number of wetland functions including filtration and sedimentation.

On the west side of Caño Madre Vieja, south of the mangrove channel, the soils are mapped as Cataño sandy clay-loam (Ce), grading into Bajuras clay. The plant community in this area strongly reflects the hydric soils, being dominated by wetland grasses and sedges (Photos 13 and 14). The ground in this area was completely saturated, with ponded water in places during the October 12 site visit. This area is bordered on the west by the mangrove lined channel adjacent to Espinar community. The dike would pass through this area.

Further south, in the vicinity of the double meander that would be impacted by the project (see below), the soils shift from Coloso silty clay-loam (Cn) on the east bank and within the meander area to Toa silty clay-loam (ToA) further west. Some small forest stands of geno-geno (*Lonchocarpus domingensis*) lie on or near the Caño meanders to be cut off by the levee (Photo 15 and 16). This tree is often found associated with drainages in drier areas and is considered to be a FACW tree. Some of the trees lie within a meander channel below bankfull levels, and fiddler crabs were abundant in the area indicating the likelihood of occasional estuarine conditions. Otherwise, the east bank area is dominated by guinea grass (*Panicum maximum*,

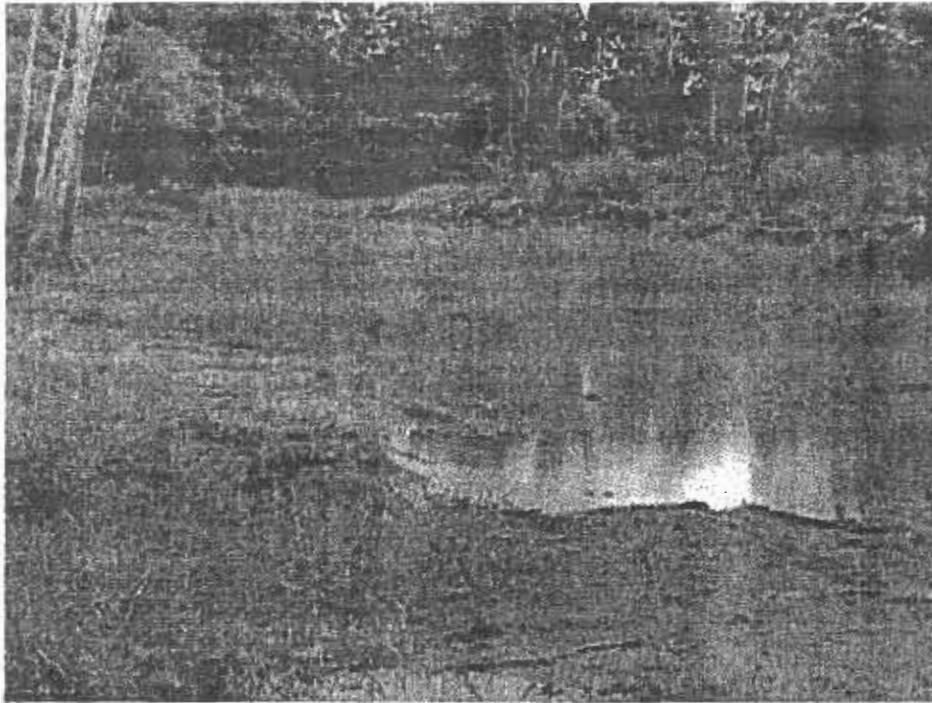


Photo 9. Recently disturbed wetland area behind the beach berm to the west of Caño Madre Vieja. Note the piles of cleared vegetation and soil deposited in wetlands towards the mangrove forest.



Photo 10. Cleared wetland area behind beach berm west of the Caño showing piled debris that includes some trees.

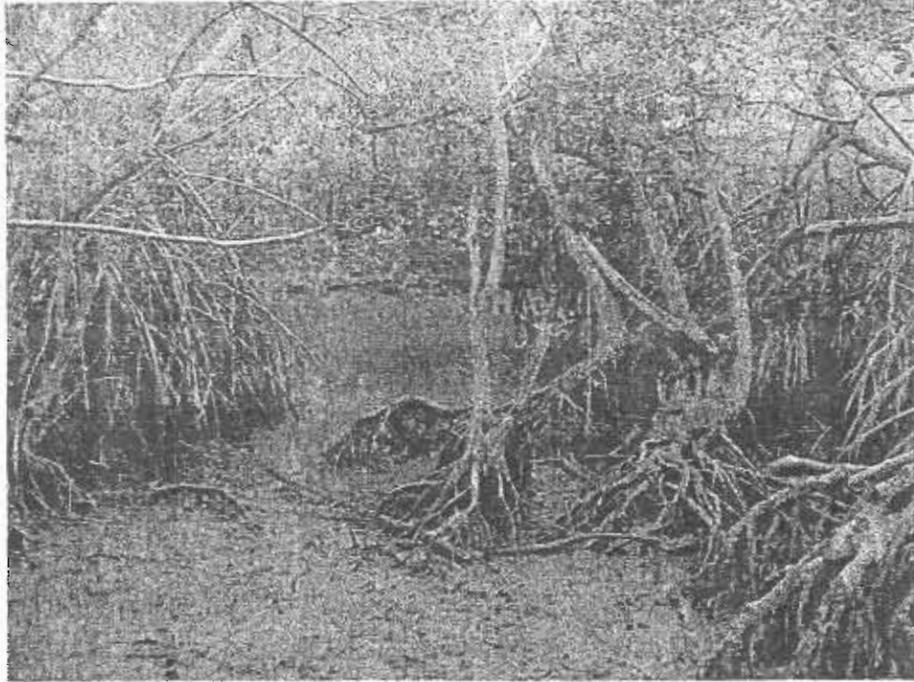


Photo 11. Predominantly red mangrove forest in the area where the western dike would cross and near the narrow point of the channel. The tide was moving out and at low stage.



Photo 12. Mixed red and white mangroves along the mangrove channel area behind the beach berm west of the Caño.

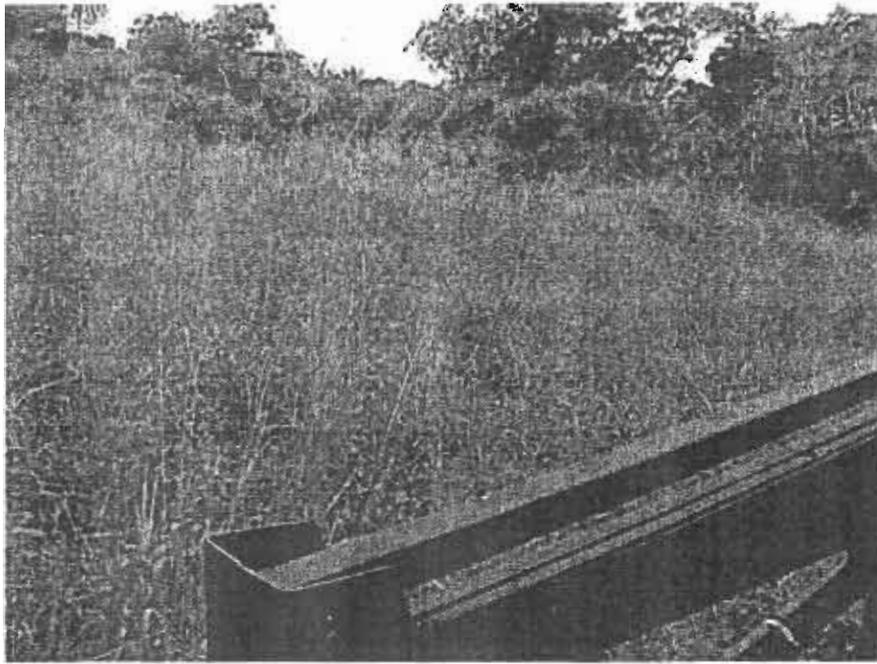


Photo 13. Sedge dominated wetlands on the west side of the Caño, south of the mangrove channel (visible in background). The ground was ponded with several inches of water during this visit.

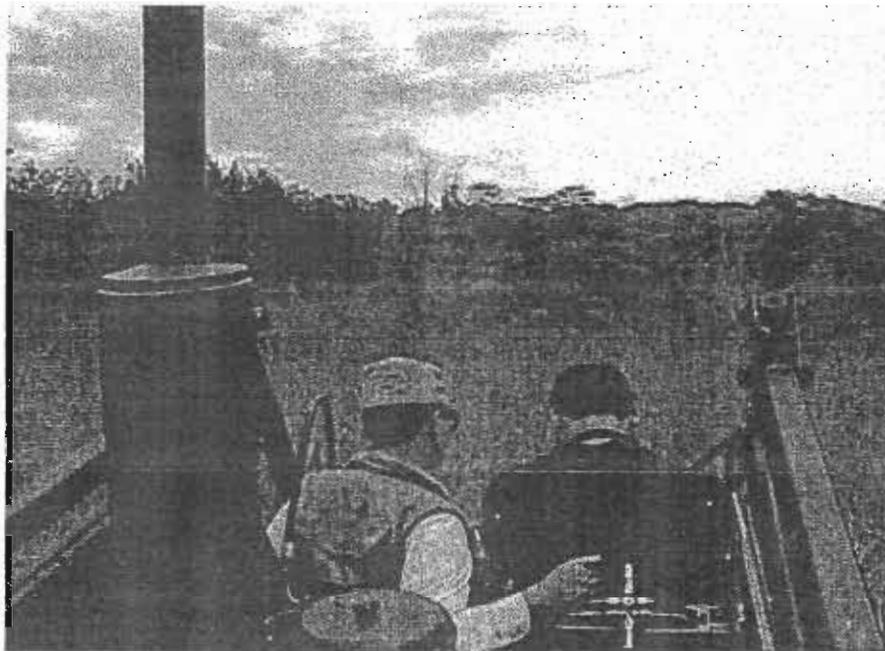


Photo 14. Another view of sedge/wetland grass dominated area. The entire area on the west side of the channel was too wet to enter with conventional 4 wheel drive vehicles and could only be accessed on foot or by tractor.

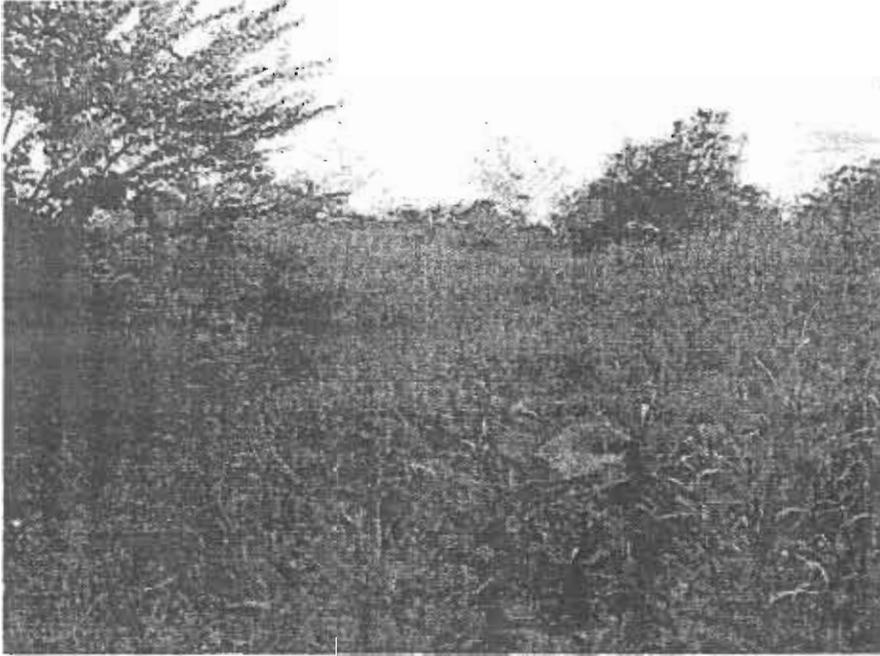


Photo 15. Mixed uplands and wet prairie area on the eastern side of the Caño, near the meanders that would be impacted. The larger trees are geno-geno (*Lonchocarpus domingensis*), and the herbaceous plants are mostly guinea grass (*Panicum maximum*) mixed with cyperids and *Brachiaria purpurascens*.



Photo 16. Geno-geno trees next to the river. Fiddler crabs were in abundance around the roots of the trees in this area.

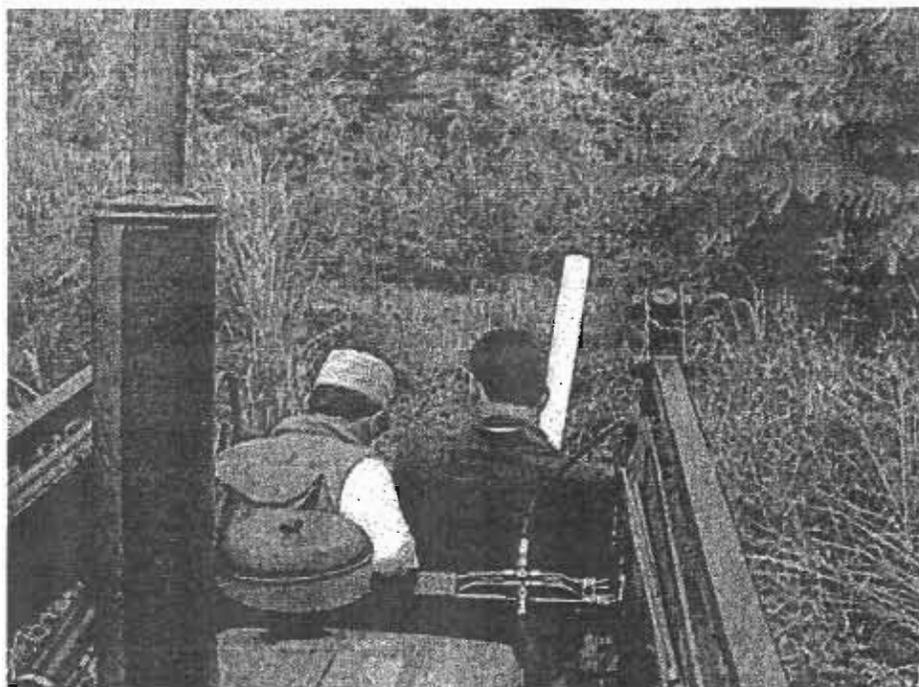


Photo 17. Western side of the Caño, approaching the edge. Note upland trees on the top of the river bank. Many of the grasses are FACW such as *Brachiaria purpurascens* and *Paspalum millegrana*.

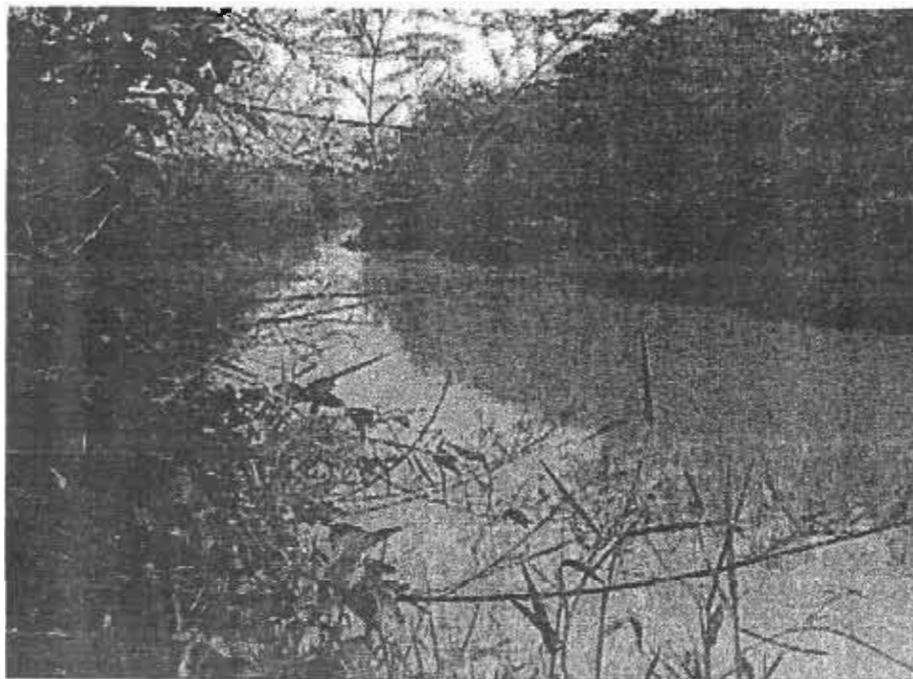


Photo 18. View downstream of the Caño from the west bank just downstream of the meanders. Trees near the water-line are mangroves (red and some white). Most are under 10 feet in height.

FACU), and the southern Aguadilla communities have developed up to the edges of the meanders at some points. The west bank is still largely in sugarcane production, with very deep furrows made to help drain the soils. Depressional areas have sedges and FACW grasses moving in. A drainage channel coming from the edge of Espinar community divides this area from the sedge dominated areas further north.

Small mangroves still occur on the Caño banks just downstream of the double meander (Photos 17 and 18). The size of the mangroves probably reflect the last time this Caño was mechanically cleaned out. While the Corps does not intend further alteration to the cut-off meander, the hydrology would be highly altered from an estuarine to a fresh-water ponding condition. Some of the trees would be eliminated, though it appears that most would be outside the immediate footprint of the levee.

Further upstream, to the southeast, the eastern dike would pass through a forested area and over two roads (Figure 4). The forest in this area has some mature mango trees, but is heavily dominated by *Albizia procera*, an introduced legume that colonizes old cane fields and disturbed areas. *Albizia* tends to form monocultures and provides little wildlife habitat value. While this species is often found in relatively wet soils on the edges of wetlands, it is considered to be an upland species.

Wildlife seen in the Caño Madre Vieja included a number of herons and egrets, smooth-billed anis (*Crotophaga ani*), and the red bishop (*Euplectes orix*). The presence of fiddler crabs in the vicinity of the double meander indicates that estuarine conditions occur at least that far upstream. Other likely fauna would include mongoose, rats, the cane toad (*Bufo marinus*), and other common amphibians, reptiles, and birds in the less disturbed areas with trees. The aquatic freshwater species of fishes and shrimps should occur in the Caño as well as the Culebrinas River.

Potential Project Impacts and Recommendations

The draft Environmental Assessment for the project estimates a wetland loss of approximately 0.5 acres of mangroves (under worst case scenario), and approximately 1.5 acres of wet prairie. It would also eliminate approximately 980 meters of active stream (meander to be cut off). The EA emphasizes that these are strictly estimates of direct impacts from the footprint of the levee, and do not include indirect or secondary impacts likely to occur in wetlands outside of the flood levees. The EA does not consider the fragmentation of wetlands by the dike and associated construction (including the small pilot channel and land to be disturbed during the construction phase). Estimated impact width for the levee footprint includes: a side access on the inside of the levee (5m), the levee footprint (approximately 21m with side slopes), access between the levee and small pilot channel (9m), pilot channel on the outside of levee (7m), and 4m of disturbed area outside of the pilot channel. The total width of the disturbed area would be approximately 46m or 150 feet. Permanent impacts would likely be less, but should include at least the levee footprint to the pilot channel (approximately 21 m).

Indirect and secondary impacts should receive careful consideration as they are likely to be

greater and have longer term impacts on the Caño's wetlands than the direct impacts. Indirect effects would be likely to include hydrology modifications to wetlands lying outside the flood levee and meander wetlands to be cut off by the diversion channel within the flood levees. Secondary impacts would include the likelihood that wetlands remaining outside of the levees would be filled for urban expansion.

Much of the alignment of the eastern levee would lie within uplands, except where it passes in the vicinity of the mangrove wetlands near the school and where it cuts off the Caño meanders. The eastern levee would impinge on the edge of the mangrove fringed channel between the track and Colegio San Carlos, and the impact area is likely to be small as this is a much more restricted forested wetland area than the mangrove channel next to Espinar. The major impact to the meander to be cut off would be due to the cut-off channel within the levee. The tendency over time should be for this meander to fill with sediment since the only hydrology would be provided by the one-way drainage structure through the dike. At the least, the character of the channel and any associated wetlands would change.

The western dike, as currently contemplated cuts across a small portion of the mangrove forest and channel near Espinar and bisects the relatively large herbaceous (sedge dominated) wetland south of the mangroves. The hydrology currently supporting the mangroves is likely to be altered. As mentioned above, the seaward end of the dike, including the mangrove channel crossing, lies within Coastal Barrier PR-75. The two-way culvert being proposed for maintaining hydrology to the Espinar mangrove channel is only 2 feet in diameter. Heavy flood waters moving down this channel would be drained through additional one way drainage structures. Our understanding is that the sizing of the two-way culvert was based on a need to prevent back-flow flooding into the side channel as the flood stage rises on the main channel within the dikes. Apparently this is also based on the assumption of continued partial closing of the Caño, forcing flood levels to as high as 2 meter near the mouth of the Caño. Heavy flooding has traditionally opened this mouth, and the mouth rarely closes now due to the groin/breakwater modifications and periodic maintenance by the municipality.

The original version of the two-levee alternative (Figure 3) included a flood ring levee immediately adjacent to the south, east and north sides of Espinar community. The variation to include the church could still be used within this alternative. That alternative would have impinged on the mangrove channel immediately adjacent to the northeast part of Espinar community, but would have remained south of the back-berm herbaceous and forested wetlands and Coastal Barrier Unit PR-75 and it would have avoided impacts to the sedge dominated wetlands south of the mangroves. The mangroves that would be impacted could be mitigated by relocating the portion of the channel to be impacted slightly eastward and replanting mangroves.

If the currently favored alternative can still be developed under the Coastal Barriers Resources Act, we strongly recommend that the Corps consider installing a larger two-way culvert to maintain tidal flows in the mangrove channel. Reducing the hydraulic capacity of this channel would be likely to encourage sedimentation upstream of the culvert. While the general tendency of flows in the existing mangrove channel is seaward, the persistence of mangroves far upstream along this channel indicates that seawater moves in as a tidal salinity wedge, at least during

spring tides (or normal tides in low rainfall periods). Maintaining adequate two-way flow may be critical to maintaining this system. The additional one-way flood-plain culverts should be slightly elevated above the two-way culvert to encourage the normal flows to continue passing through the principal two-way culvert, and to maintain the existing hydrology in the wetlands upstream.

Wetlands outside of the dike are supposed to be maintained as ponding areas to reduce community flooding, and allow these areas to drain out as flood levels recede within the flood dikes. The Corps should stipulate how these ponding areas would be maintained. Considerations for maintaining these areas as wetlands should include careful evaluation of the elevations of the one-way drainage structures through the dikes. If these ponding areas are not protected through acquisition and posting, they are likely to be developed in a piece-meal fashion through incidental filling and should be considered as part of the secondary impacts of the project.

For wetland impacts that cannot be avoided, we believe that significant opportunities exist within the flood levee dikes for wetland restoration, and possibly some creation. The presence of young mangroves far up the channel of Caño Madre Vieja indicates that the area has probably been periodically altered through channel clearing. Mangroves could be planted, and to some degree, allowed to naturally colonize the Caño margins. Post-project conditions within the dike floodway area may preclude the little agricultural use currently occurring there. Without maintenance of existing drainage channels, more of the area would be likely to revert to wetlands. This obviously depends on the future plans for agricultural use and sand/earth extraction in the area.

The sedge dominated area on the west side of the Caño near the mangrove forest would be particularly suitable for estuarine and freshwater forested wetland restoration. Since this area would lie mostly outside the flood levee, protection of this area from future development would be critical. If no use restrictions are put on these wetlands, they should be considered to be part of secondary project impacts. The upstream portions of this area may be capable of supporting fresh-water wetland trees such as swamp apple (*Annona glabra*), (*Machaerium lunatum*), and swamp bloodwood (*Pterocarpus officinalis*). Freshwater forested wetlands in similar positions on the landscape used to be quite abundant in Puerto Rico, but were largely eliminated by clearing for agriculture early in this century. A *Pterocarpus officinalis* forest (Caño Boquilla) occurs on a similar small drainage associated with the Añasco River to the south and is in the process of becoming a Natural Reserve.

In summary, we recommend that the preferred alternative be re-evaluated to avoid impacts within Coastal Barrier PR-75. If the Corps determines that the project can still proceed as proposed under CBRA, careful consideration should be given to the capacity of the two-way culvert to maintain hydrology to the mangrove channel. The wetland areas outside of the flood dikes would also have to be protected in some manner and the drainage culvert elevations would be critical to maintaining these wetlands. Mitigation needs could be met through development of additional estuarine and freshwater forested wetlands within the flood levees.