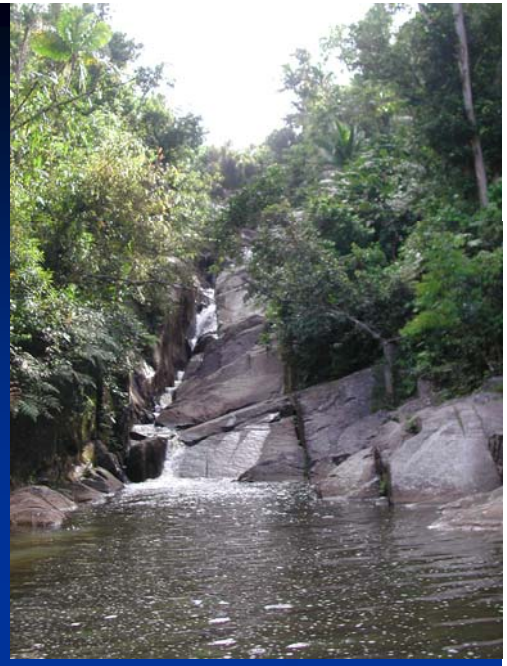
# A View from the Watershed

**Beverly Yoshioka, US Fish and Wildlife Service**



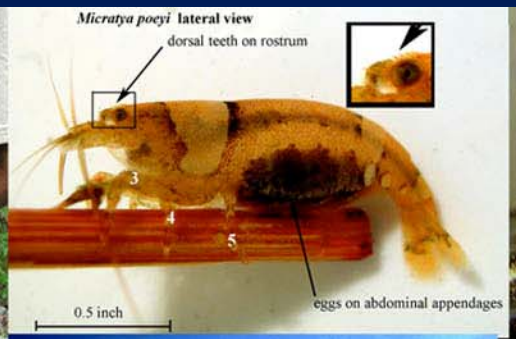
## From the Mountains to the Sea

- >60  watersheds in Puerto Rico
- Range from > 200 sq mi to < 5 sq mi
- Unit for water availability & many ecological considerations

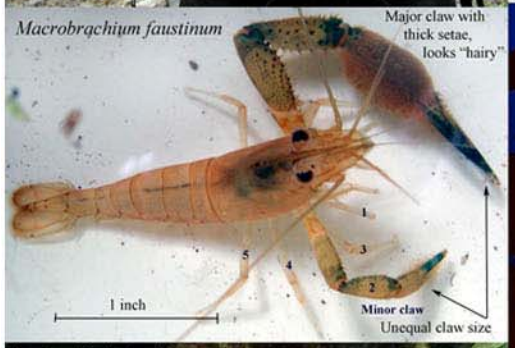
# River Functions and Values

- Moves water and sediments
  - Cleans land and stream habitat
  - Redistributes and sorts sediments
  - Replenishes clean water - removes and dilutes pollutants
  - Provides water for drinking, household use, and irrigation
  - Delivers freshwater to estuaries
- Dynamic interaction with groundwater (discharge and recharge)
- Renourishes and deposits floodplain soils during flood events
- Provides riparian and aquatic habitat
  - Riparian habitat (often the only forest left in agricultural or urban landscapes)
  - Creates a variety of lotic (stream) habitats
- Connectivity
  - Provides pathways between coastal and mountain habitats for a variety of terrestrial fauna (birds, reptiles, amphibians, mammals)
  - Distributes seeds of many plants downstream
  - Provides up and down stream migratory pathways for aquatic species (crustaceans, fish, molluscs), especially catadromous or amphidromous species

# Puerto Rican Stream Fauna

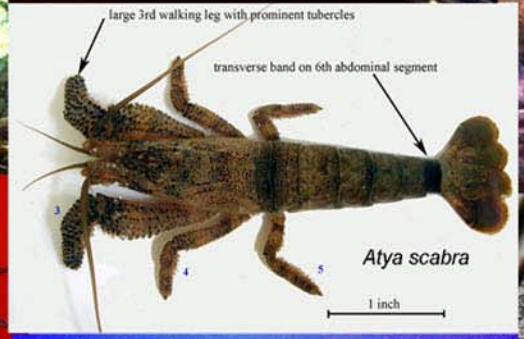





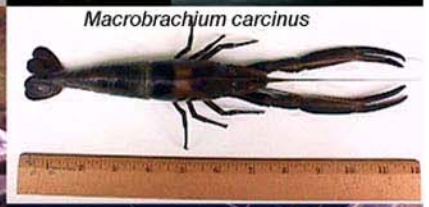








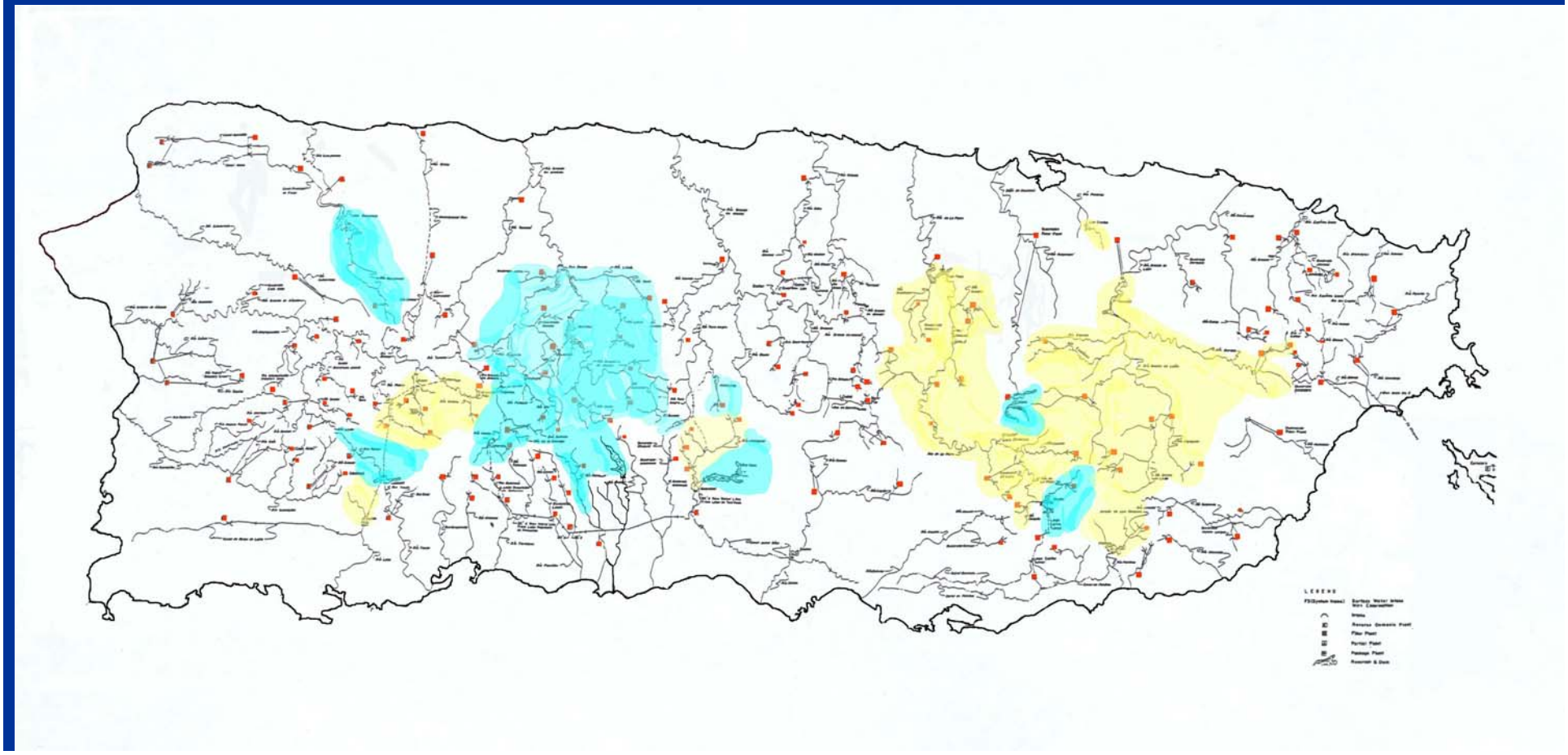






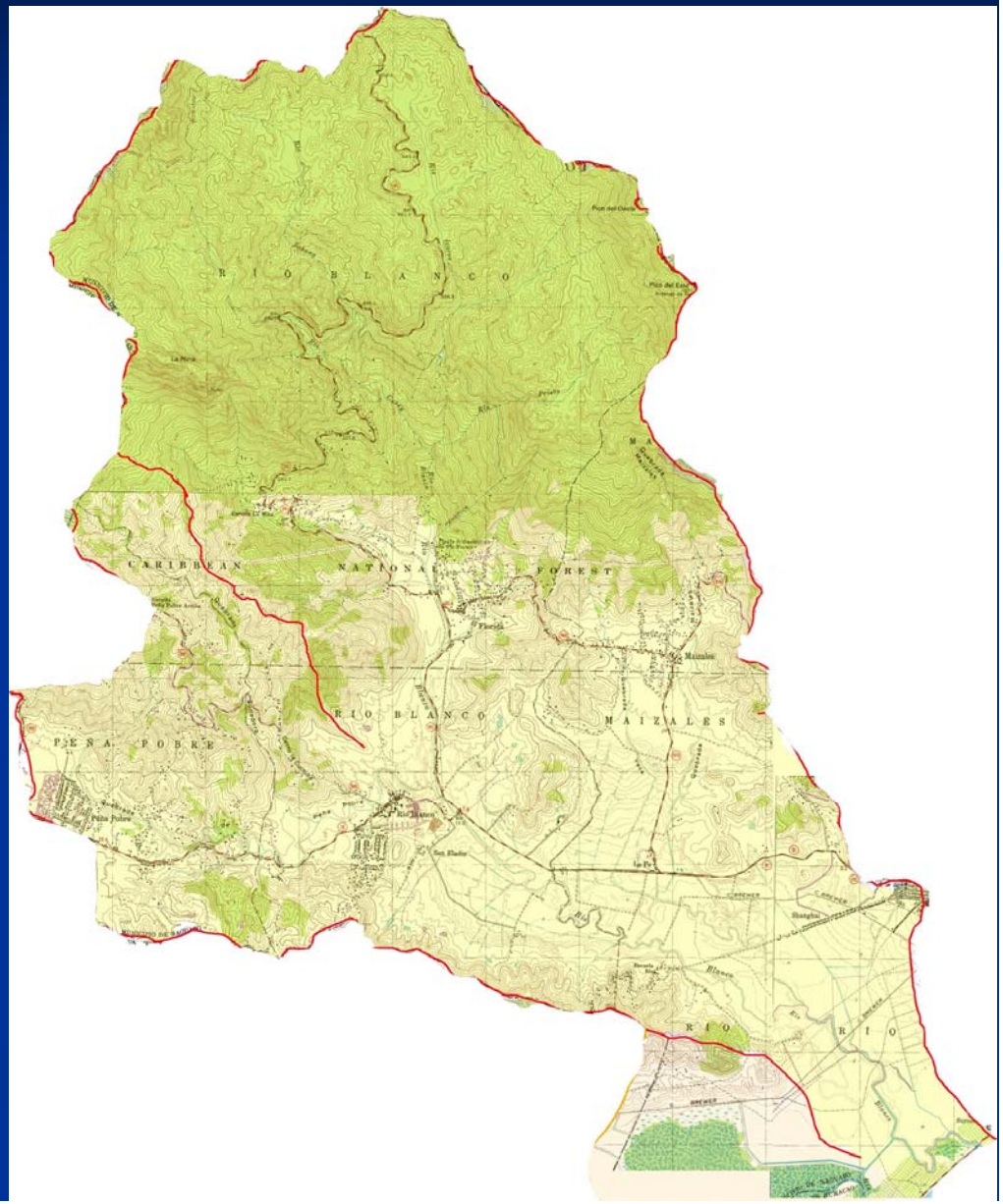


# High dams and Water Intakes in Puerto Rico



# Rio Blanco Watershed


- Small watershed ≃ 14 sq mi
- Important for human and ecological needs
- Has many different activities within watershed
- Variety of habitats within the drainage basin
- Presence of native stream fauna

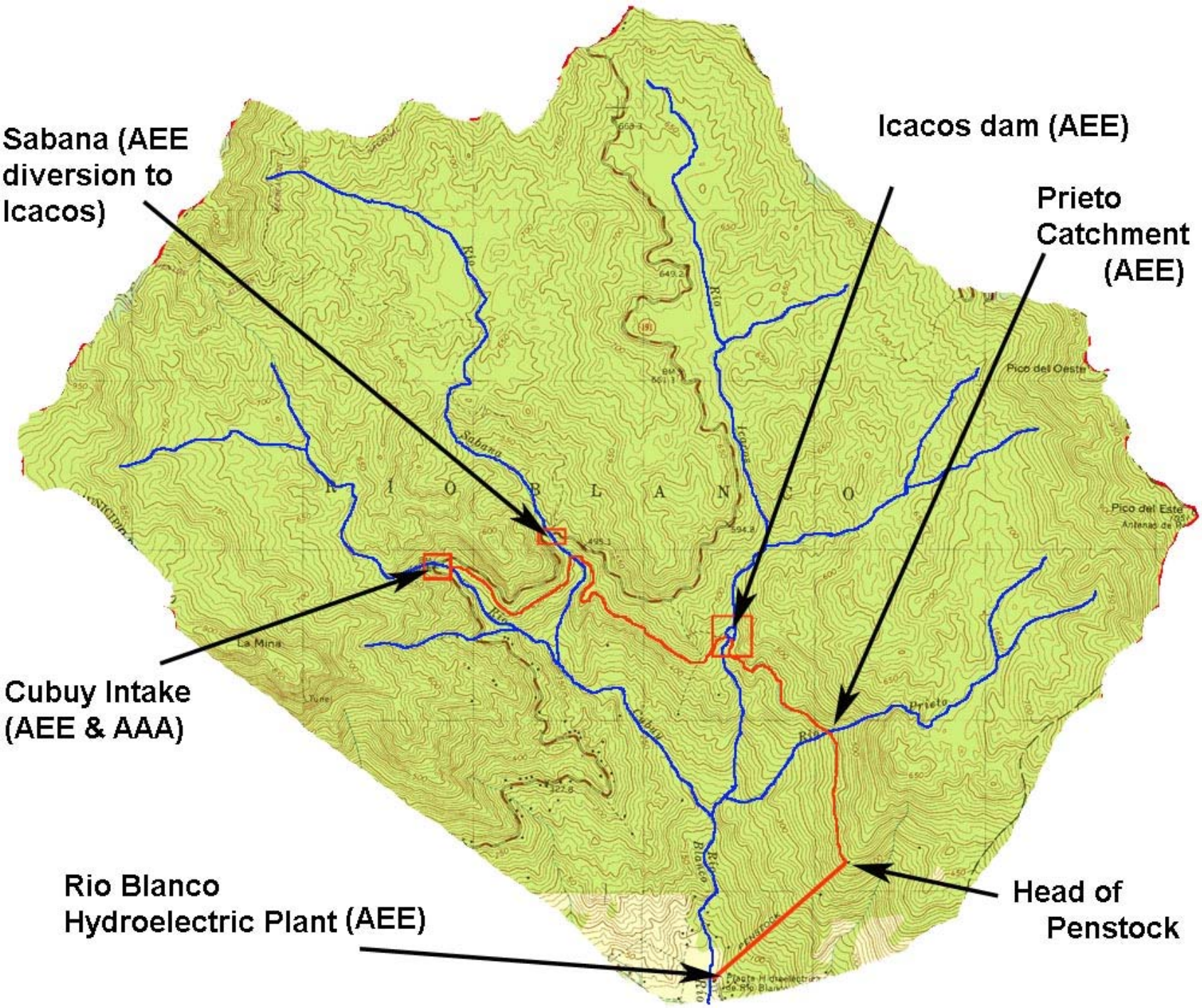


# Rio Blanco

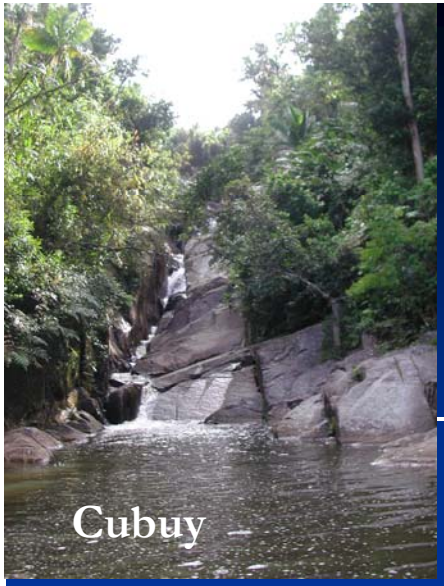

- Upper Watershed in El Yunque National Forest
  - Forest Cover
  - Very steep
- Rapid transition from colluvial to alluvial
- Lower watershed agricultural converting to suburban
- Estuarine wetlands at mouth and channel to Anton Ruiz wetlands to the south

# Upper watershed - low order streams

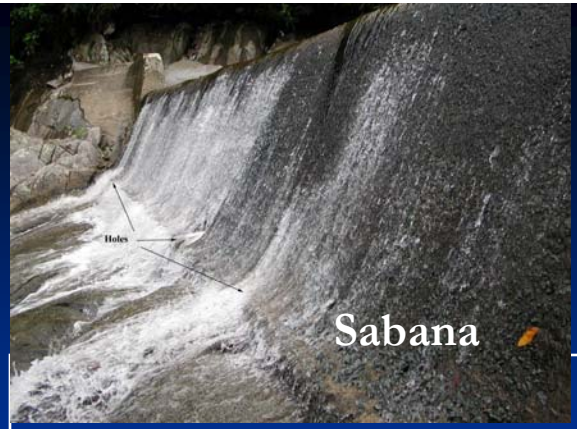
- Usually steep drops and pools
- High channel surface area to water volume
  - Facilitates aerobic water treatment
  - Facilitates biological and chemical treatment (nutrient removal)
- Recharge & discharge sites
- Provides drainage for forest
- Refuge habitat for aquatic species capable of ascending steep passes

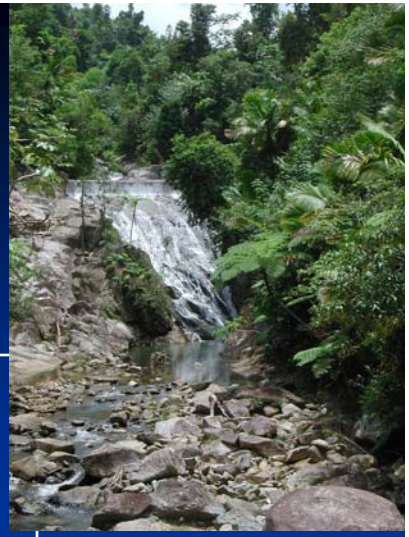

Sabana (AEE diversion to Icacos)
Icacos dam (AEE)
Prieto Catchment (AEE)
Cubuy Intake (AEE & AAA)
Rio Blanco Hydroelectric Plant (AEE)
Head of Penstock
R I O B L A N C O
Pico del Oeste
Pico del Este
La Mina
Sabana
Cubuy
Prieto
Rio Blanco

# Rio Blanco Run-of-River Hydropower Plant







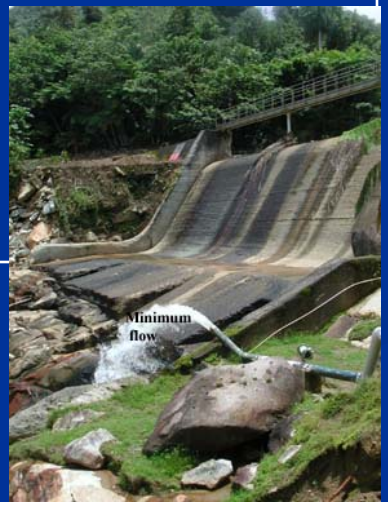



- Now AAA water supply
- Local recreation use

- Some water diverted to Icacos Dam
- Local recreation use
- Low flow holes in dam

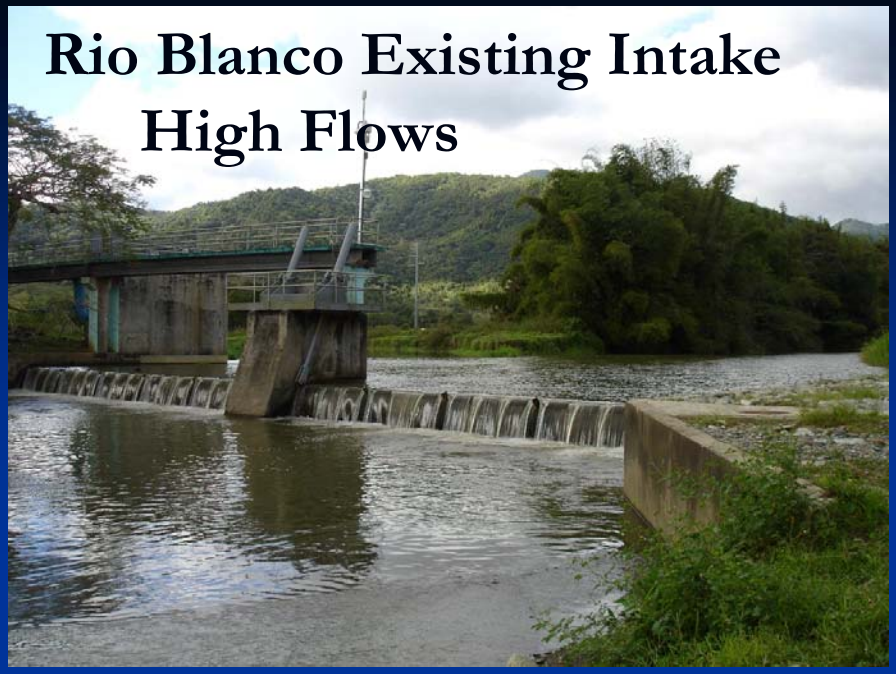
- Was a by-pass reach
- Must provide 4 cfs to stream (FERC license)
- Some local recreation (difficult to access)

- Penstock 1,300' drop to hydropower plant
- Through turbines
- Returns to Rio Blanco
- Exits to river at new water intake


# Mid-Watershed Alluvial area

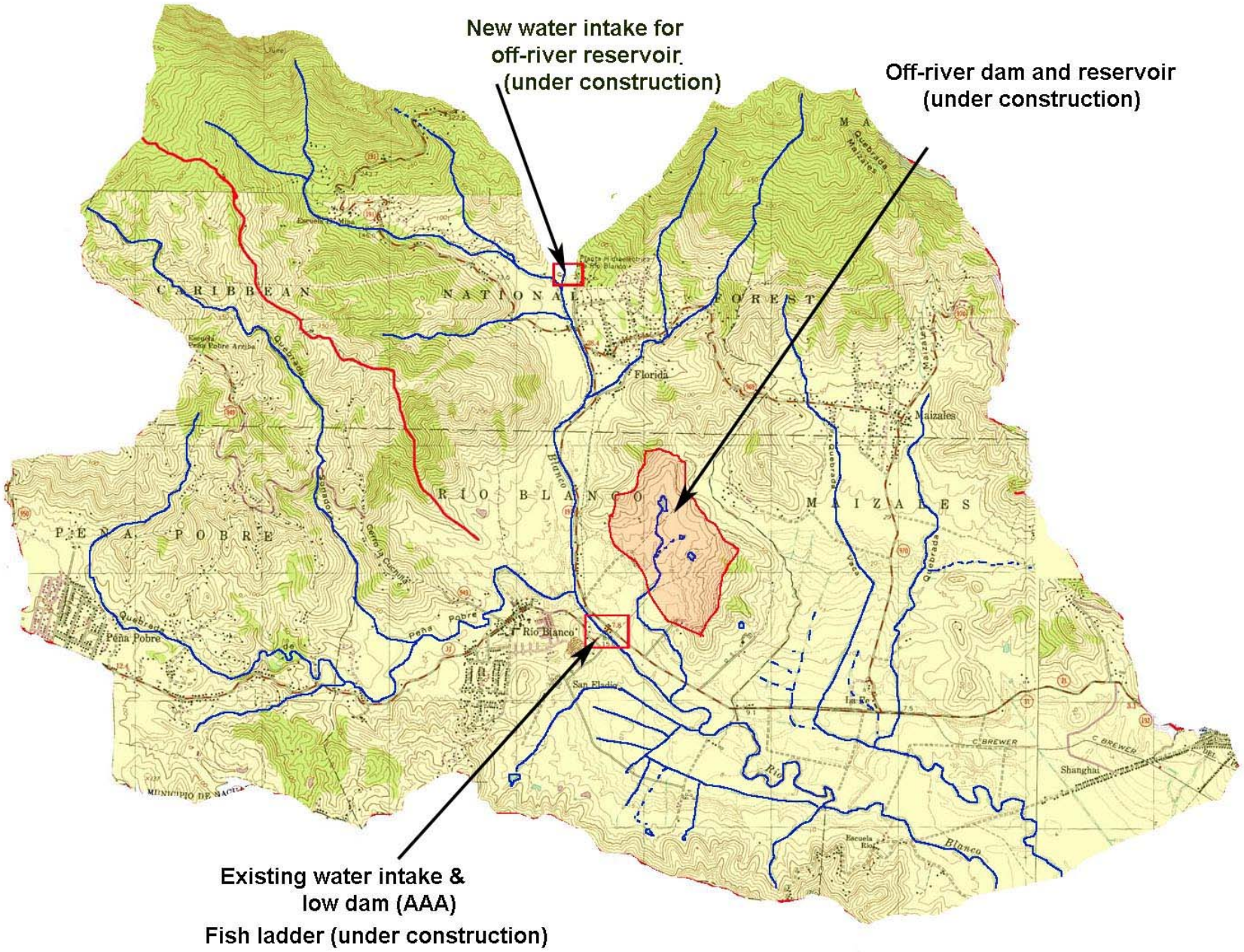
- Pasture
- Flood zone
- Uplands undergoing urbanization
- Large AAA water extraction for Naguabo, parts of Humacao and Ceiba, Vieques & Culebra



Rio Blanco Existing Intake
High Flows

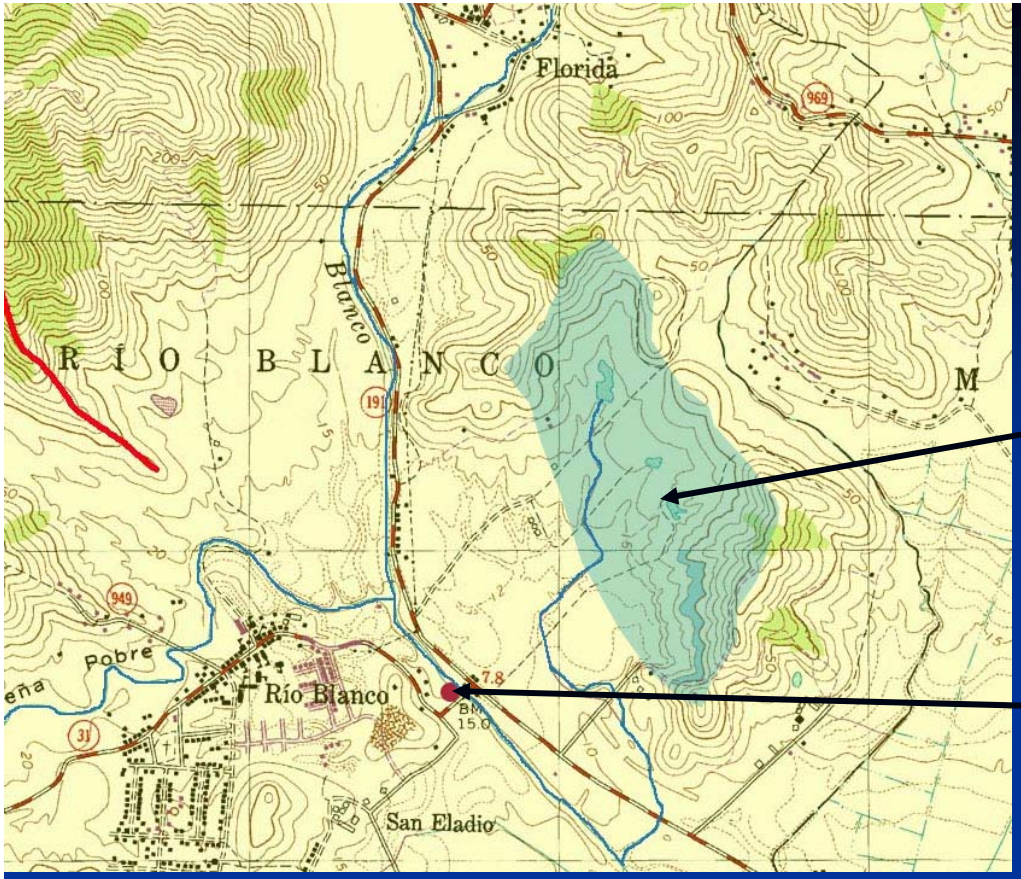
Rio Blanco- Low Flows &
Full Water Withdrawal

- At the point of extraction, river has a firm yield of 6-7 mgd.
- The actual extraction when water is available is up to 12 mgd
- Plant to be expanded to up to 20 mgd


New water intake for
off-river reservoir
(under construction)
Off-river dam and reservoir
(under construction)
Existing water intake &
low dam (AAA)
Fish ladder (under construction)
CARIBBEAN NATIONAL FOREST
RIO BLANCO
MAIZALES
PEÑA POBRE
Florida
Maizales
Río Blanco
Peña Pobre
San Eladio
Shanghai
C. BREWER
Blanco


Labyrinth weir
For new intake

# Rio Blanco Off-River Dam




Off-Stream Reservoir

Existing AAA Water Intake

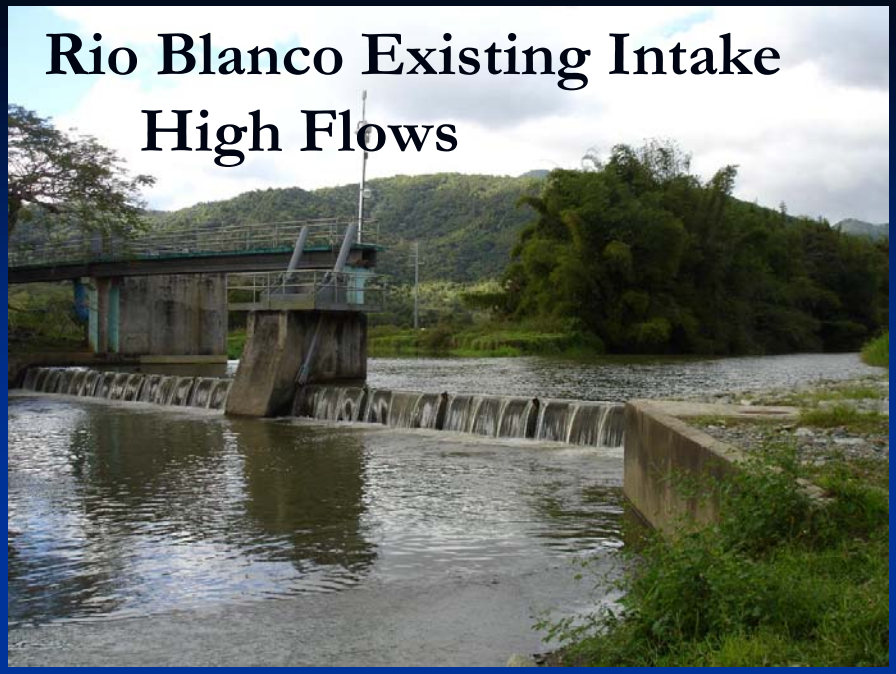
# Off-Stream Reservoirs

## Disadvantages

- Limited input - does not store flood flow waters
- Does not reduce floods (generally limited capability for water supply dams)
- Potential sites are very limited (often already developed)

## Advantages

- Leaves reasonable base flows
- Minimizes alterations to the patterns of flow (variation)
- Maintains natural sediment flows
- Maintains migratory pathways
- Increases reservoir lifespan (reduced sedimentation)
- More potential for protecting the limited watershed






Fish ladder
under
construction

# Fish ladders

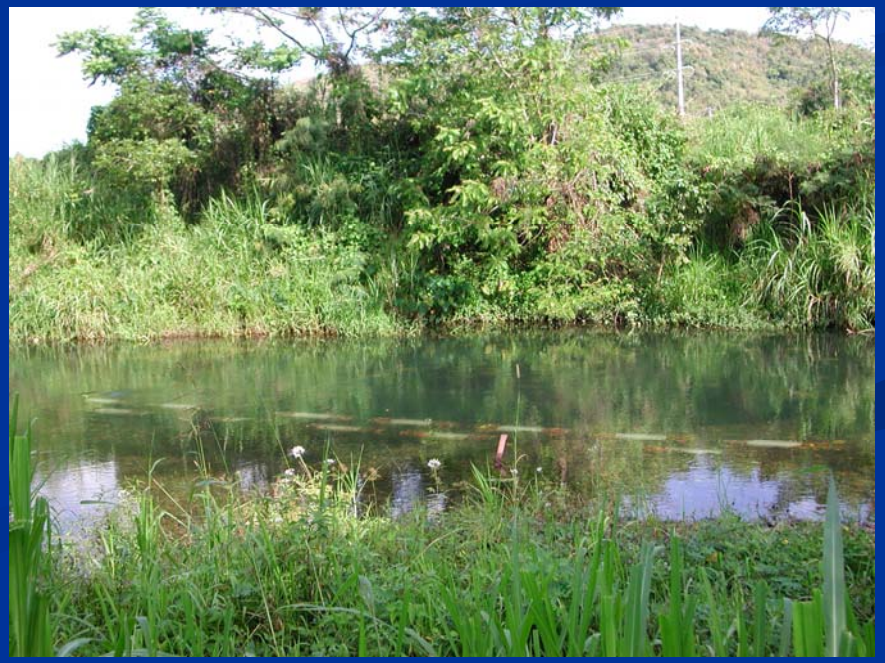
- Can be expensive (depending on height and other constraints)
- Will require maintenance (cleaning, repairs, etc.)
- Need to consider habitat to be restored (how much upstream habitat will be restored?)
- Are there existing natural or man-made obstructions downstream?
- What are the migratory needs and limitations of the aquatic species?
- What are the flow variations to consider?

## Generally, the best benefits will be for fish ladders low on the river system

- Helps fish with limited climbing or jumping abilities
- Restores more habitat
- Less chance of other unseen migration impediments

## Consider ways to avoid the need for fish ladder

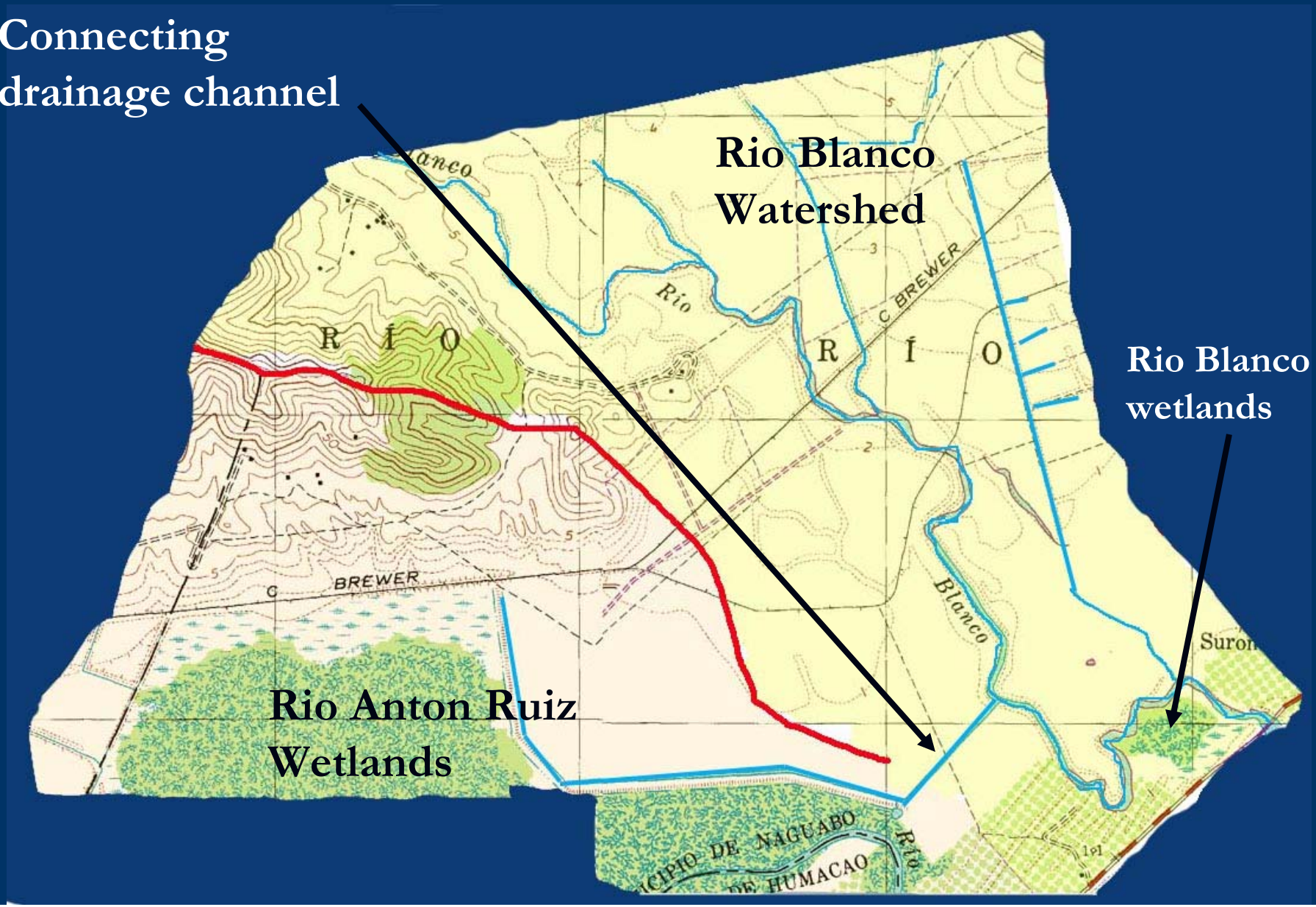
- Intake without dam (Mameyes)
- V-notch weir design




# Lower Watershed – Estuarine Reaches

- Usually very flat topography with depressions (often with wetlands)
- Saline wedge often intrudes far up from the river mouth and often vertically stratified (variable depending upon tides, etc)
- Fish and shellfish nursery (for freshwater and marine aquatics)
- Small river mouths often close during low flows

# Rio Blanco Lower Watershed



# River Estuaries

- Most estuaries in Puerto Rico are the lower portions of river watersheds
- Low flows maintain input of freshwater
- Low flows help dilute accumulating pollutants
- Low and moderate flows maintain wetlands
- High flows flush out and mix (de-stratify) the system

# Throughout River System

- Maintenance of base and moderate flows is important
  - Maintains stream migration continuity
  - Maintains pool habitats throughout the system
  - Recharges acquifer
  - Dilutes point and non-point source discharges
  - Nourishes river and estuarine wetlands
- Maintenance of flow variation is important
  - Creates variable habitats
  - Maintains stream channel
  - Provides needed variation to the estuary
  - Provides sediments to maintain stream channels and renourish beaches
  - Cleans system

# Reducing Impacts of Water Supply Projects

- Leaving reasonable environmental or base flows
  - What is reasonable?
  - Should they be variable?
  - How do you guarantee them?
- What should flows be based on?
  - Evaluation of the entire watershed and point specific firm yield
  - Needs for flow to the estuary
  - Need to maintain migratory aquatic fauna continuity
  - Need to maintain instream habitat
  - Site specific considerations
    - Distance to the nearest downstream tributary
    - Other intakes upstream and downstream
    - Downstream point source discharges that need dilution?

## What to do in extreme drought or existing excessive water withdrawal situations?

- Have levels of water rationing rules based on rainfall, reservoir stand, etc.
- Combine water supply sources (must have strict environmental flow rules at the points of withdrawal to avoid severe impacts)
- Consider night-time shut down hours for intake
  - Severe dissolved oxygen depletion occurs at night
  - Most aquatic fauna migration occurs at night
  - Maintains pools of water in otherwise dewatered channel
  - Maintains some freshwater input to stagnating estuaries