Rivers that support endangered species and represent significant opportunities for ecosystem restoration.

5.5.1 Land Area

Land use in the Nueces River Basin is predominately related to agriculture, with approximately 10 percent classified as cropland, 6 percent pastureland, and 84 percent rangeland with only a small fraction for urban area. There are primarily three natural eco-regions that make up the Nueces River Basin, namely the Edwards Plateau (Hill Country), the South Texas Plains (South Texas Brush Country), and the Gulf Coast Prairies and Marshes (Coastal Plains). One common trait among each of these regions is the ongoing problem of brush infestation that is replacing the native grasslands, and has been for hundreds of years since European settlers first moved into this area. Each of these eco-regions is described below.

5.5.1.1 Edwards Plateau (Hill Country)

In the South Central Texas Region, the Edwards Plateau area includes the northern portions of Uvalde, Medina, and Bandera Counties. This limestone-based area of the Edwards Plateau is characterized by spring fed, perennially flowing streams that originate in its interior and flow across the Edwards Aquifer recharge zone, which bounds it on the south and east. This area is also characterized by the occurrence of numerous ephemeral streams that are important conduits of storm runoff, which contributes to the recharge of the Edwards Aquifer. The soils are shallow, ranging from sands to clays, and are calcareous in reaction. This area is predominately rangeland, with cultivation confined to the deeper soils.

Noteworthy is the growth of Bald Cypress (*Taxodium distichum*) along the perennially flowing streams. Separated by many miles from the cypress growth of the moist Southern Forest Belt, they constitute one of Texas' several "islands" of vegetation. The principal grasses of the clay soils are several species of bluestem (*Schizachyrium* and *Andropogon* spp.), gramas (*Bouteloua* spp.), Indiangrass (*Sorghastrum nutans*), common curly mesquite (*Hiaria belangeri*), buffalograss (*Buchlow dactyloides*), and Canadian wild rye (*Elymus Canadensis*). The rocky areas support tall or mid-grasses with an overstory of live oak (*Quercus virginiana*) and other oaks (*Q. fusiformis, Q. buckleyi, Q. sinuatam* var. *breviloba*), cedar elm (*Ulmus crassifolia*) and mesquite (*Prosopis glandulosa*). The heavy clay soils have a mixture of buffalo grass (*Buchlow dactyloides*), sideoats grama (*Bouteloua curtipendula*) and mesquite (*Prosopis glandulosa*).

5.5.1.2 South Texas Plains (South Texas Brush Country)

Parts of Uvalde, Zavala, Dimmit, Medina, Frio, LaSalle, Atascosa, Wilson, and Karnes Counties, lies in the South Texas Plains area, which is characterized by subtropical dryland vegetation consisting of small trees, shrubs, cactus, weeds and grasses. Early settlers of this area called this the "Wild Horse" or "Mustang" Desert. Principal plants are honey mesquite (*Prosopis glandulosa*), live oak (*Quercus virginiana*), post oak, several members of the cactus family (Cactaceae), blackbrush acacia (*Acacia rigidula*), guajillo (*Acacia berlandieri*), huisache (*Acacia smallii*) and others that often grow very densely. The original vegetation was mainly perennial warm-season bunchgrass in post oak, live oak, and mesquite savannahs. Other brush species form dense thickets on the ridges and along streams. Long-continued grazing as well as the control of wild fires has contributed to the dense cover of brush. Most of the desirable grasses have persisted under the protection of brush and cacti.

There are distinct differences in the original plant communities on various soils. Dominant grasses on the sandy loam soils are seacoast bluestem (*Schizachyrium scoparium* var. *litoralis*), bristlegrasses (*Setaria* spp.), and silver bluestem (*Bothriochloa saccharoides*). Dominant grasses on the clay and clay loams are silver bluestem, Arizona cottontop (*Trichachne californica*), buffalograss (*Buchloe dactyloides*), common curlymesquite (*Hilaria belangeri*), bristlegrasses (*Setaria* spp.), gramas (*Bouteloua* spp.), and Texas wintergrass (*Stipa leucotricha*). Gulf cordgrass (*Spartina* spp.) and seashore saltgrass (*Distichlis spicata*) characterize low saline areas. In the post oak and live oak savannahs, the grasses are mainly seacoast bluestem (*S. scoparium* var. *litoralis*), Indiangrass (*Sorghastrum nutans*), and switchgrass (*Panicum virgatum*).

5.5.1.3 Gulf Prairies and Marshes (Coastal Plains)

The Gulf Prairies and Marshes area includes all or parts of San Patricio, Nueces, Jim Wells, Duval, and Live Oak Counties. There are two subunits: (1) the marsh and salt grasses immediately at tidewater and (2) a little farther inland, a strip of bluestems and tall grasses, with some gramas in the western part. Many of these grasses make excellent grazing. Oaks (*Quercus* spp.), elm, and other hardwoods grow to some extent, especially along streams, and the area has some post oak and brushy extensions along its borders. Much of the Gulf Prairies is fertile farmland.

Principal grasses of the Gulf Prairies are tall bunchgrasses, including big bluestem (*Andropogon gerardi*), little bluestem (*Schizachyrium scoparium*), seacoast bluestem (*S. scoparium* var. *litoralis*), Indiangrass (*Sorghastrum nutans*), eastern gamagrass (*Tripsacum dactyloides*), Texas wintergrass (*Stipa leucotricha*), switchgrass (*Panicum virgatum*) and gulf cordgrass (*Spartina* spp.). Seashore saltgrass (*Distichlis spicata*) occurs on most saline sites. Heavy grazing has changed the range vegetation in many cases so that the predominant grasses are less desirable broomsedge (*Andropogon virginicus*), smutgrass (*Sporobolus indicus*), threeawns (*Aristida* spp.) and many other inferior grasses. The other plants that have invaded the productive grasslands include oak underbrush, huisache (*Acacia smallii*), mesquite (*Prosopis glandulosa*), pricklypear (*Opuntia* spp.), ragweed (*Ambrosia psilostachya*), broomweed (*Xanthocephalum* spp.), and others.

5.5.2 Precipitation/Climate

Average annual rainfall in the semi-arid basin ranges from approximately 21 inches in the west to approximately 32 inches in the east. Early settlers once referred to the western portion of the basin as the “Wild Horse” or “Mustang” Desert. Rainfall in the basin is highly variable in magnitude and frequency, as most significant rainfall originates from localized convective thunderstorms or from tropical storms and hurricanes covering wider areas. The sporadic nature of rainfall in the basin results in short periods of high flows in the streams and rivers, followed by long periods of low or zero flows except in the Hill Country where moderate to high base flows are the normal condition, above the Edwards Aquifer recharge zone.

The area has a mild climate that ranges from sub-humid to semi-arid. Long, hot summers, warm falls, and short mild, winters characterize the Coastal Plain, while temperatures are somewhat lower in the Hill Country. The mean annual temperature is approximately 70 degrees Fahrenheit, decreasing from about 73 degrees in the southern part of the Coastal Bend area to about 67 degrees at the northern end of the basin. Periods of extreme heat occur during the summer, but they are moderated by Gulf breezes, especially at night. High temperatures (Fahrenheit) in the summer average in the 90’s and often into the 100’s, and low temperatures (Fahrenheit) in the winter average in the mid to low 50’s. Mild temperatures normally prevail during the winter months, but subfreezing weather does occasionally occur as a result of cold fronts pushing down from the north. The average number of frost-free days ranges from 310 in the southern part of the basin to 230 in the northern end. Prevailing winds are typically from the east to southeast, except in the winter when they periodically shift to the north.

5.5.3 Physiography and Geology

Topography varies from steep slopes in the Hill Country upstream of the Edwards Aquifer recharge zone to generally mild or flat as the streams and rivers traverse the Brush Country and Coastal Plains approaching the Gulf of Mexico. The steep slopes and characteristically thin soils of the Hill Country result in this area producing the greatest runoff per unit rainfall in the basin. In the Hill Country portion of the basin upstream of the Edwards Aquifer recharge zone, an annual average of about 13 percent of precipitation appears as runoff or gaged streamflow with the other 87% being lost to predominately evapotranspiration. This differs from the lower basin where flat, sandy soils reduce average annual runoff volumes to between 2 and 5 percent of average annual precipitation. The remaining water in this part of the basin is lost to evapotranspiration, aquifer recharge and channel losses. Overall, about 3 percent of the average annual basin-wide precipitation appears as runoff flowing into Lake Corpus Christi in the lower basin, with the other 97 percent being lost to evapotranspiration, channel losses and aquifer recharge.

5.5.4 Edwards Aquifer / Guadalupe – San Antonio Basin Springflows

The Edwards Aquifer itself, together with the karst geology of its recharge zone and the major perennial springs, constitute a unique set of habitats in which a significant concentration of isolated, endemic species have developed. The porous to cavernous formation making up the Edwards and associated limestones constitute the Edwards Aquifer, the ground water source that presently supplies the City of San Antonio, numerous other cities, several military installations, and which is critical to maintenance of spring habitats containing several endemic, endangered species. The Edwards Aquifer is the only important aquifer habitat in Texas in which vertebrate species live[2] and it supports a surprisingly diverse ecosystem.

The Edwards Aquifer is primarily composed of Edwards Limestone, and is one of the most permeable and productive aquifers in the Unites States. The Edwards Aquifer serves as the primary drinking water source for over 1.7 million people located in and around San Antonio,

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[2] Edwards, Robert J., Glen Longley, Randy Moss, John Ward, Ray Mathews, and Bruce Stewart, "A Classification of Texas Aquatic Communities with Special Consideration Toward the Conservation of Endangered and Threatened Taxa," Vol. 41, No. 3, The Texas Journal of Science, University of Texas at Austin, Austin, Texas, 1989.

Texas. This is the largest population in the United States that relies so heavily on groundwater to meet their municipal demands.

There are three parts to the aquifer, drainage area, recharge zone and artesian zone. The drainage area is comprised of the area north and west of the aquifer in the Texas Hill Country, primarily in the Nueces River Basin. Covering approximately 4,400 square miles, this area serves as the collection area for precipitation and channeling water in the form of runoff through many streams that lie on older, less permeable formations, delivering the water to the recharge zone. Geologically the recharge zone is known as the Balcones Fault Zone, and consists of exposed, porous Edwards Limestone on the surface that serves as a conduit that funnels the water underground into the artesian zone. The recharge enters the aquifer from streams flowing across the outcrop which contains fractures, sinkholes and caves. Once the water is underground it flows into the part of the aquifer referred to as the artesian zone. The Edwards Aquifer has a tremendous capacity for moving and storing water via its many intricate interconnecting spaces ranging in size from small pores to large caverns. This zone is located between two impermeable layers, which confines the water and in some instances allows the water to flow to the surface through faults discharging in springs, or through artesian wells. All water discharged from the aquifer is from wells or springs, and approximately half of all discharge is through the springs associated with the aquifer system.

A significant Federal interest has been established through several court actions relating to the Edwards Aquifer with respect to protection of minimum spring flows and underground species at Comal and San Marcos Springs.[3] These court actions resulted in the U.S. Fish and Wildlife Service establishing minimum flow limits necessary to protect the endangered species that rely upon flows from these springs. The Edwards Aquifer Authority (EAA) is the state agency responsible for regulating pumpage from the Edwards Aquifer. Under the act that created the EAA, the Authority is directed to reduce annual permitted withdrawals from the aquifer to no more than 450,000 acre-feet through the year 2007, and to 400,000 acre-feet by 2008, unless the EAA determines that additional aquifer supplies are available. Further, by the end of 2012, the EAA is required to implement and enforce water management procedures to ensure that continuous minimum spring flows at Comal Springs and San Marcos Springs are maintained to protect endangered and threatened species, as required by federal law. (Figure 5 -

[3] Sierra Club v. Babbitt, Cause No. MO-91-CU-069, in the U.S. District Court for Western Division of Texas, Midland/Odessa Division, January 30, 1993.

2) The recharge enhancement projects as discussed later in this report will significantly assist the EAA accomplish these goals by contributing to higher water levels in the aquifer, which will enhance the reliability of spring flows and the quantities of supply available for withdrawal from the Edwards Aquifer.

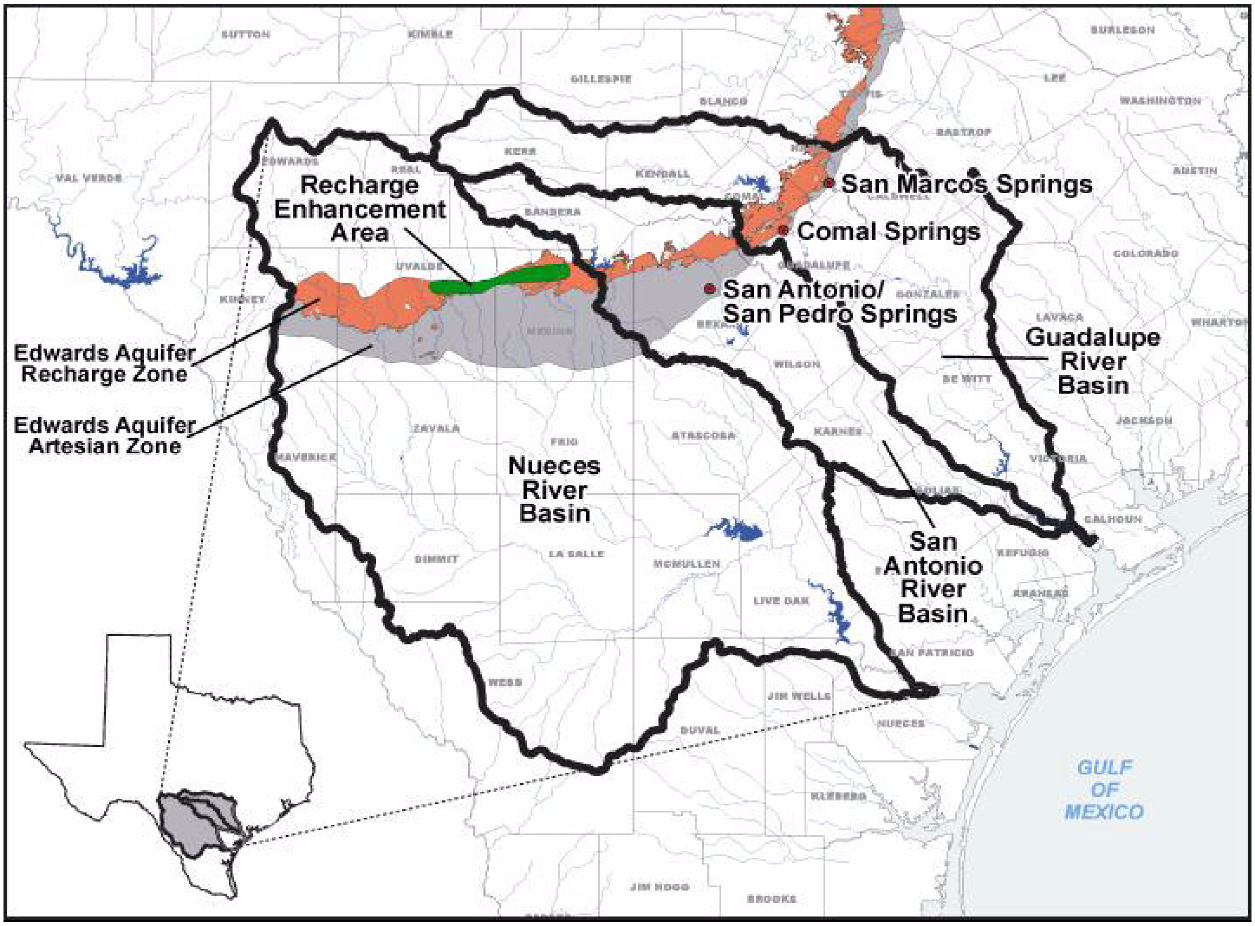

Figure 5-2 Location of Springs Outside Nueces River Basin

The Edwards Aquifer recharge zone is a unique feature that extends or lies across most of the major streams in the Nueces Basin just downstream of the Hill Country. A majority of the Edwards Aquifer recharge in the Nueces River Basin benefits ecosystems and water users located in the Guadalupe and San Antonio River Basins to the east, since the Edwards Aquifer extends eastward beneath these basins and conveys waters to wells and springs located in the San Antonio and Guadalupe River Basins. Particular ecosystems that have experienced reduced flows because of aquifer pumpage include the Comal and San Marcos Springs, the spring runs located just downstream of certain springs, the San Marcos and Guadalupe Rivers, and the

Guadalupe Estuary. Since a portion of the recharge that occurs in the Nueces River Basin emerges as springflows in these neighboring basins, both higher streamflows and higher baseflow will occur in these streams, which is beneficial to the terrestrial and aquatic species that inhabit these ecosystems. A total of seven plant, amphibian, insect, and fish species are Federally listed as endangered in the Edwards Aquifer system, and one is listed as threatened. The seven endangered species of the Edwards Aquifer system include the Texas Blind Salamander, Fountain Darter, San Marcos Gambusia, Texas Wild Rice, Comal Springs Riffle Beetle, Comal Springs Dryopid Beetle, and the Peck's Cave Amphipod.

Not only do the higher flows mentioned above contribute to the health of the species and the ecosystem in general, but also these higher flows reduce the likelihood that the springs would go dry. Glenn Longley, a Southwest Texas State University Biologist and authority on the Edwards Aquifer, was recently quoted as warning: "If we let the Comal Springs dry up, we are down the road to an ecological disaster."[4] Additionally recharge to the Edwards Aquifer in the Nueces River Basin contributes to the flow of Leona Springs located in Uvalde County. Leona Springs form the headwaters of the Leona River, which contributes to the flow into Choke Canyon Reservoir. Edwards Aquifer recharge projects located in the Nueces River Basin will increase the flow of Leona Springs and will, in part, serve to mitigate downstream flow reductions caused by the recharge structures themselves. There is additionally some opportunity to increase the aquatic habitat associated with Leona Springs by increasing the flow with the Edwards Recharge enhancement projects.

5.5.5 Reservoirs

The City of Corpus Christi operates two large reservoirs in the Nueces Basin for water supply: Choke Canyon Reservoir, built in 1982, (on the Frio River upstream of Three Rivers) with an authorized storage capacity of 700,000 acft and Lake Corpus Christi which was last expanded in 1958 (on the Nueces River near Mathis) with an authorized storage capacity of 300,000 acft. The City of Corpus Christi operates Choke Canyon Reservoir (CCR) and Lake Corpus Christi (LCC) as a system in order to supply water to municipal and industrial customers within its regional service area. The majority of the water supplied by these reservoirs is released and diverted downstream of Lake Corpus Christi at the Calallen Diversion Dam near

[4] Reid, Jan, "The Fount", Texas Parks and Wildlife Magazine, Page 40, July 2002.

Calallen. The next largest reservoir operated for water supply in the basin is the Upper Nueces Reservoir, owned by the Zavala-Dimmit Counties Water Improvement District No. 1, with a permitted capacity of 4,010 acft. Water diverted from this reservoir is used primarily for irrigation purposes. (See Figure 5.1A)

Both major reservoirs are owned and operated by the City of Corpus Christi to meet municipal and industrial water demands. The city operates the Choke Canyon Reservoir/Lake Corpus Christi (CCR/LCC) System in compliance with a Texas Natural Resource Conservation Commission (TNRCC) Agreed Order, a legal imperative. The Agreed Order, last amended and issued April 17, 2001, established an operating procedure pertaining to Special Condition 5.B., Certificate of Adjudication No. 21-3214 (the water right for Choke Canyon Reservoir), held by the City of Corpus Christi, the Nueces River Authority, and the City of Three Rivers. This order specifies monthly inflow targets for the Nueces Bay that must be met by allowing reservoir inflows to pass through the reservoirs to the Nueces Bay and Estuary based on total system storage of the reservoirs. The annual amount has monthly targets that were developed by the Texas Water Development Board and the Texas Parks and Wildlife Department to maximize the biological benefit to the species that inhabit the estuary.

To address concerns about the health of the Nueces Estuary, a Technical Advisory Committee (Nueces Estuary Advisory Council, NEAC) chaired by the TNRCC was formed in 1990 to establish operational guidelines for the CCR/LCC System and desired monthly freshwater inflows to the Nueces Estuary (in accordance with Special Condition 5.B. of Certificate of Adjudication No. 21-3214). These operational guidelines were first summarized in the 1992 Interim Order regarding freshwater inflow operations of the CCR/LCC System. This TNRCC Order has been amended several times over the last ten years and the current operating order was established April 17, 2001 (the 2001 Agreed Order).

The mechanics of the 2001 Agreed Order are shown graphically in the middle graphic of Figure 5-3. The 2001 Agreed Order established a monthly schedule of desired freshwater inflows to Nueces Bay to be satisfied by reservoir spills, return flows, runoff below Lake Corpus Christi, and/or pass throughs of system inflows. When the reservoir system is greater than or equal to 70-percent of full, annual Nueces Bay inflow target is 138,000 acft per year. Under the Agreed Order pass-throughs can be reduced based on inflow banking, low monthly salinity variation in the upper Nueces Bay, and implementation of drought contingency measures tied to CCR/LCC System storage. For example, when reservoir system capacity is below 70 percent but above 40 percent, the annual Nueces Bay inflow target is 97,000 acft per year. If system storage drops below 40 percent but is above 30 percent, the City automatically enacts drought contingency measures and the pass-through requirements drop to 1,200 acft per month (the monthly median inflow to Lake Corpus Christi during the drought of record). If the system storage drops to below 30 percent, the City automatically enacts more stringent drought contingency measures and pass-throughs from the reservoir system are suspended. A copy of the 2001 Agreed Order is included in Appendix D.

The Agreed Order between the city and the TNRCC provides a mechanism for ecosystem restoration in the Nueces Estuary. Any water supply project that either reduces demand on the reservoir system or increases the volume of water stored in the reservoirs creates additional opportunities for more freshwater to be passed to the estuary. The top two illustrations in Figure 5-3 graphically represent the process by which decreased demands on the reservoir system increase freshwater inflows to the bay on the basis of system storage. New projects that reduce overall demand on the CCR/LCC System have the added benefit of increasing freshwater inflows to the Nueces Estuary. In the case of reduced inflows in the Nueces River Basin, the impact to the CCR/LCC System will be a potential reduction in the firm yield of the system for water supply. In addition, reduced inflows to the reservoir system will potentially reduce freshwater pass-throughs to the Nueces Estuary. To the extent the City of Corpus Christi obtains additional water supply sources, and provided these new sources decrease the demand on the CCR/LCC System, the opportunity for greater pass-throughs to the Nueces Estuary will occur. In addition, the alternative sources will continue to provide return flows of wastewater effluent, which is the other major source of freshwater inflows to the Nueces Estuary system.

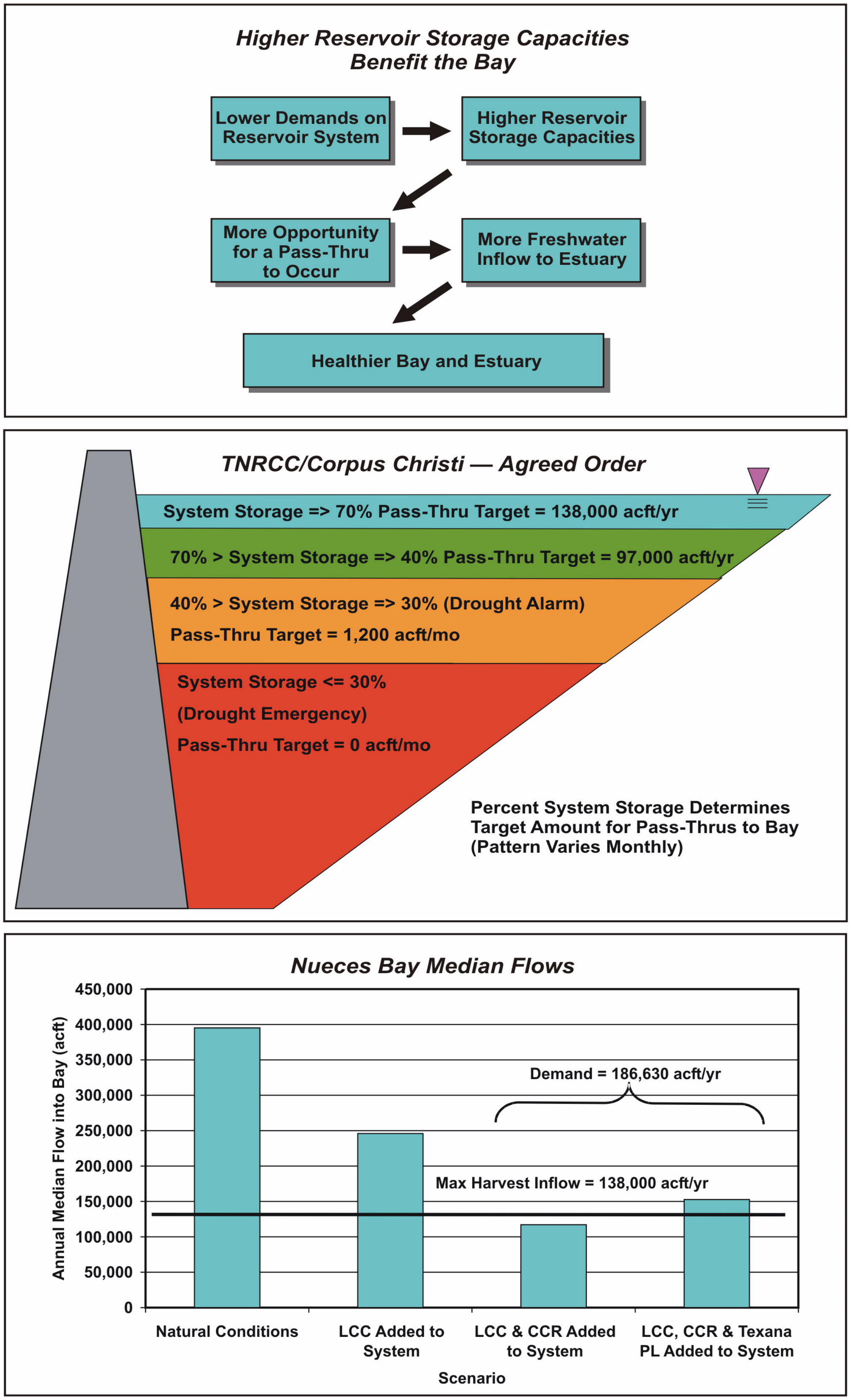

Figure 5-3 Explanation of Nueces Bay Inflow Methodology