

Briefing Paper on Galveston Bay Plan Action Items
Freshwater Inflow and Bay Circulation
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Overview

Goals of the Galveston Bay Plan

- Ensure freshwater beneficial inflows necessary for salinity, nutrient, and sediment loading regime adequate to maintain productivity of economically important and ecologically characteristic species.
- Ensure that alterations to circulation do not negatively affect productivity and ecosystem health.

The Galveston Bay Estuary Program (GBEP) is a program of the Texas Commission on Environmental Quality (TCEQ). GBEP successfully works with a variety of partners and stakeholders to facilitate implementation of goals and objectives outlined in The Galveston Bay Plan (The Plan). The Plan is a Comprehensive Conservation and Management Plan (CCMP) for the Galveston Bay ecosystem, developed as a part of the National Estuary Program process. The Plan was developed by building consensus among citizens, industry, business, development, academia, and government. The Plan places a high priority on freshwater inflows and circulation of waters within the Galveston Bay estuary. Goals of The Plan focus on ensuring that 1) freshwater inflows into the Galveston Bay estuary are adequate to maintain salinity gradients and nutrient and sediment loading necessary to sustain bay productivity and 2) alterations to bay circulation do not negatively impact bay productivity and overall health of the ecosystem.

The amount of available fresh surface water is finite. Many pressures are placed on this resource by competing interests including agricultural irrigation, municipal water consumption, and industrial water use. Under the current regulatory structure, after human water demand is satisfied, the waters remaining in the tributaries to Galveston Bay are made available as environmental flows or freshwater inflows to the bay. Problems caused by the over-consumption of freshwater by municipal, agricultural and industrial users can be exacerbated by human-built structures (e.g. channels and dikes) that alter natural bay circulation. Inadequate freshwater inflows and altered circulation of water within the estuary can have a profound impact on the estuary by impacting populations of commercially and recreationally important shellfish and finfish and the location of survivability of important habitats such as oyster reefs and estuarine marshes.

Freshwater Inflows

An estuary is, by nature, a transitional environment between freshwater from the land and the saline open ocean. Naturally, among the most important factors governing the health of an estuary will be the volume, timing, and quality of freshwater inflows. This inflow helps determine bay circulation patterns and the salinity regime of the estuary. The salinity regime in

any estuary influences important aspects of the ecology. Thus, resource managers and others responsible for managing Galveston Bay's natural resources are concerned with changes in the volume, timing and spatial distribution of freshwater inflows into Galveston Bay.

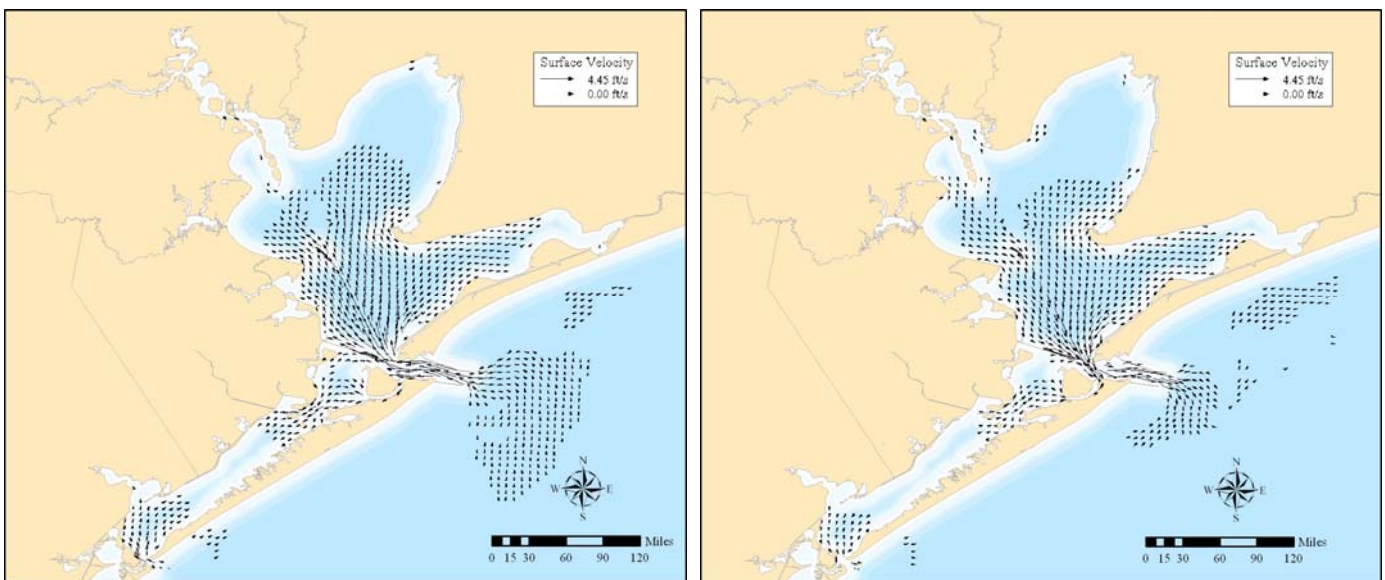
The Galveston Bay Estuary is a mix of saltwater from the Gulf of Mexico and freshwater from rain, land runoff, large rivers, and local bayous. Saltwater enters the Galveston Bay system with the tides through the Bolivar Roads (the entrance into the bay between Galveston Island and the Bolivar Peninsula), San Luis Pass at the western end of Galveston Island, and to a lesser degree through Rollover Pass at the east end of the bay on Bolivar Peninsula.

Most of the freshwater entering the Galveston Bay system does so through two large rivers: the Trinity River and the San Jacinto River. The Trinity River extends from Dallas-Fort Worth south to Galveston Bay. Its watershed encompasses nearly 18 thousand square miles of land in 37 counties. The river's mouth is located on the north shore of Trinity Bay west of Lake Anahuac. In contrast, the San Jacinto River basin is nearly 4 thousand square miles with its headwaters originating in the northern portion of Southeast Texas. The river then flows to Lake Houston and south into the Houston Ship Channel where inflows enter Upper Galveston Bay.

Bay Circulation

The circulation of water in Galveston Bay is influenced by many factors, including freshwater inflow, salinity changes, winds and tides. In turn, circulation is a major force affecting the distribution of sediments, oyster reefs, wetlands and other features of the bay. Typical circulation patterns are shown in Figure 1. On incoming and outgoing tides, the water flows rapidly through the Bolivar Roads between Galveston Island and Bolivar Peninsula. In addition to being influenced by the tides, circulation patterns are also altered by built structures such as the Texas City Dike, which limits flows into West Bay, and dredged channels such as the Houston Ship Channel, which acts as a conduit for seawater from the Gulf through the middle of Galveston Bay.

Figure 1. Typical Galveston Bay circulation pattern during incoming (left) and outgoing (right) tides. Maps created by the Galveston Bay Status and Trends Project, Houston Advanced Research Center. Data source: Carillo and Berger (2001).



Salinity, one of the essential properties of estuarine waters, is determined by the intermixing of fresh and oceanic waters. It is an excellent indicator of circulation and flushing in an estuary. Salinity also affects the suitability of habitats because a given species typically survives in a particular salinity regime. Salinity gradients from the upper to lower bay are a normal feature. Salinity measured near the principal points of inflow such as the Trinity River may be as low as three parts per thousand (ppt) while values as high as 30 ppt may occur at Gulf inlets. Trinity Bay is particularly sensitive to the effects of freshwater inflow from the Trinity River. Galveston Bay, which receives runoff from urban bayous in addition to San Jacinto River inflow, also experiences lower average salinity. The higher salinities of East and West Bays are caused by high salinity gulf water, which enters the bays through the tidal passes. West Bay experiences the highest average salinities due to the influence of both more saline gulf waters and the presence of the Texas City Dike which limits circulation of water between Lower Galveston Bay and West Bay.

Historical Data Trends

Freshwater Inflow

The Trinity River basin is responsible for the majority of freshwater inflows into Galveston Bay while the San Jacinto River and runoff from coastal urban watersheds contributes the remainder (See Figure 2). The inflow from all sources is quite variable over time with freshets (periods of sudden, large inflows) typically occurring in winter and spring months (see Figure 3). Peak inflows usually occur in May while the lowest volumes of inflows to the bay usually occur in August.

Figure 2. Average Percent Contribution of Inflowing River and Coastal Basins to the Galveston Bay Estuary; 1941-1990 Maps created by the Galveston Bay Status and Trends Project, Houston Advanced Research Center. Data source: Texas Water Development Board.

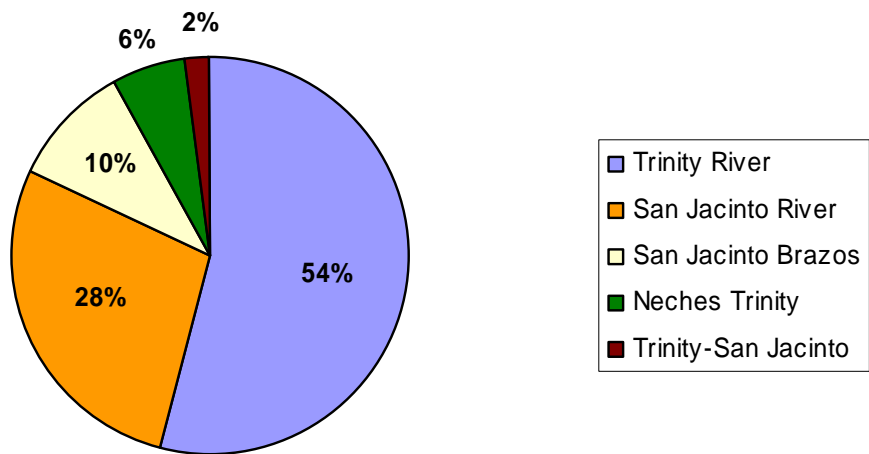
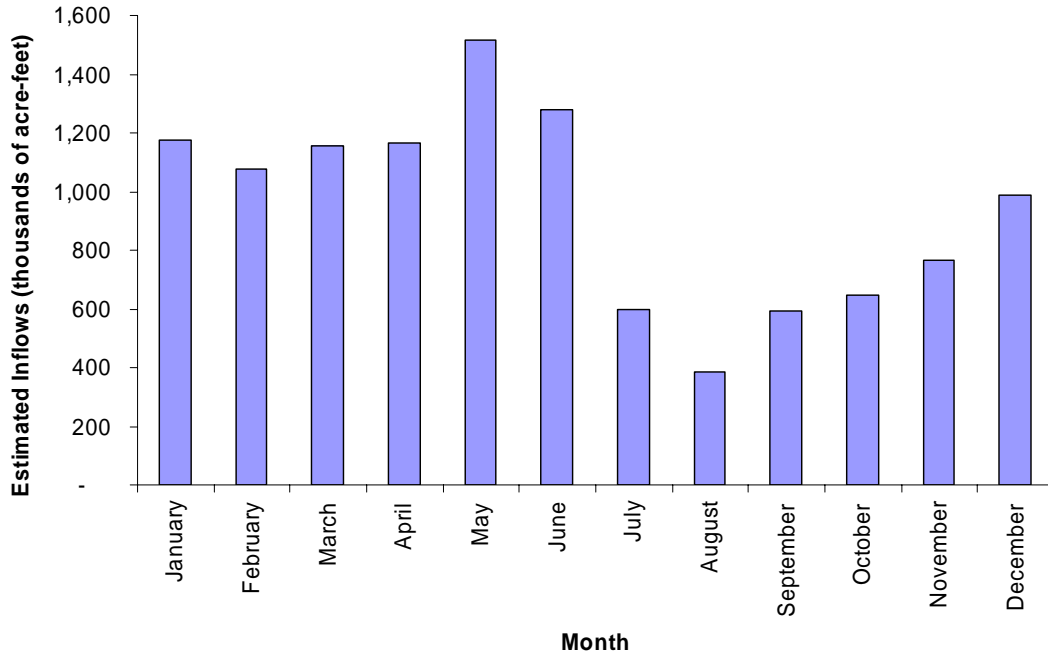
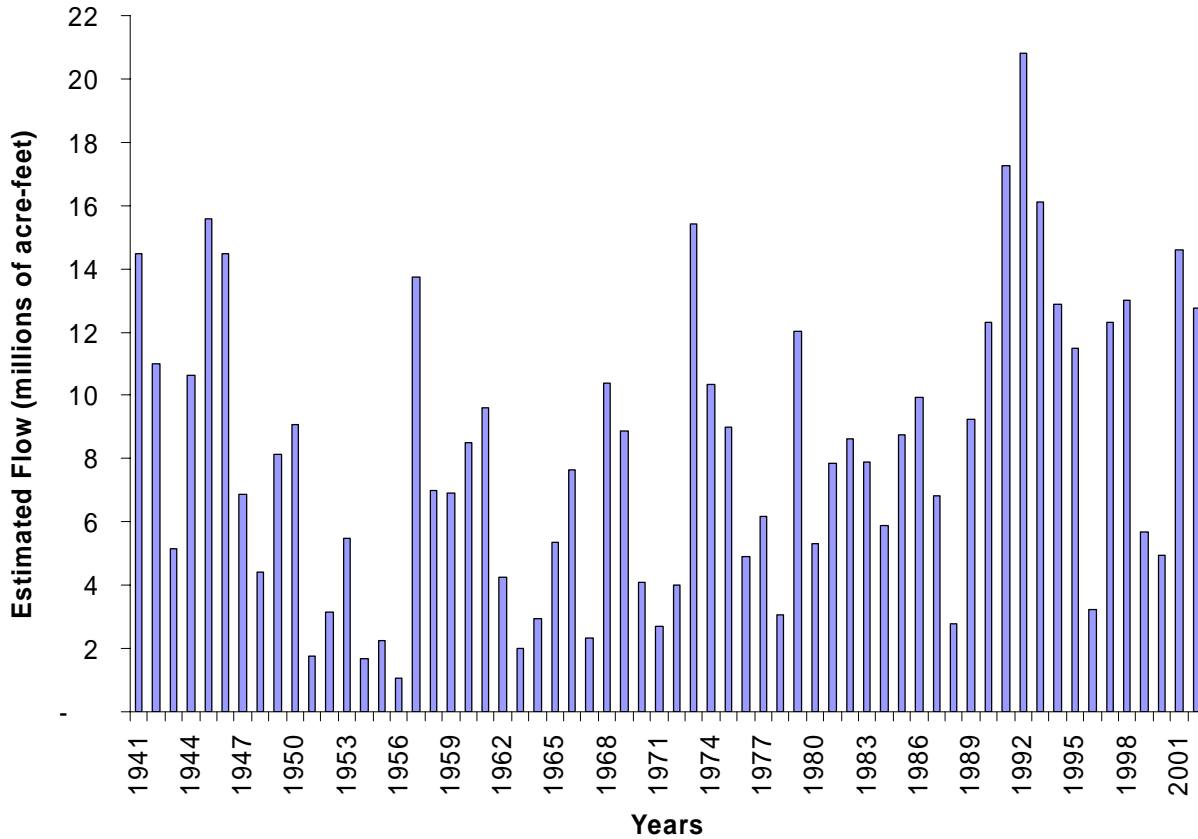


Figure 3. Average monthly freshwater inflows into Galveston Bay for the period 1941-2002. Figure created by the Galveston Bay Status and Trends Project, Houston Advanced Research Center. Data source: Texas Water Development Board.



Variability in inflows also occurs annually as some years are characterized by much rainfall and others by drought conditions. Figure 4 shows the annual volume of freshwater inflows into Galveston Bay as estimated by the Texas Water Development Board (TWDB) for the period 1941-2002.

Figure 4. Total annual volume of freshwater inflows into Galveston Bay for the period 1941-2002. Figure created by the Galveston Bay Status and Trends Project, Houston Advanced Research Center. Data source: Texas Water Development Board.

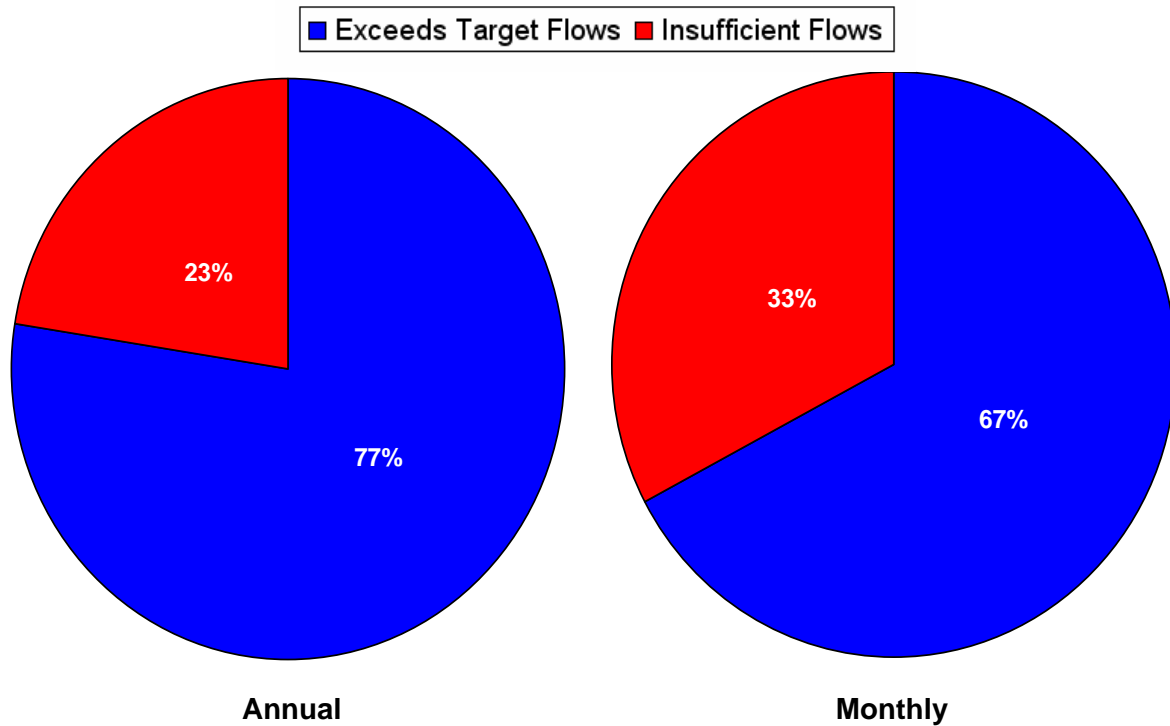


While natural variability in freshwater inflows is necessary to maintain the health of the system, human alterations can have negative impacts. Examples of potentially harmful alterations include changes in the: volume of flow (exacerbating low flow periods through high rates of human water consumption during periods of drought); timing of flows (regulating releases of river flows with dams and reservoirs); and location of flows (transferring water from one river basin and discharging unconsumed water into another).

An analysis conducted by the Galveston Bay Indicators Project compared historical freshwater inflows for the Galveston Bay Estuary for the years 1941-2002 to annual and monthly Min Q values; one of three freshwater inflow targets, which is defined as the minimum annual inflow required to maintain bay and estuary fisheries harvest. As seen in Figure 5, nearly one quarter of all years and one third of all months has likely had insufficient freshwater inflows to maintain bay fisheries harvests during the 62 years for which data are available. Variability in the timing and spatial distribution of inflows along with the resiliency of natural systems has allowed Galveston Bay to maintain its productivity over the years. However, as population, municipal, industrial, and agricultural water demand, water diversions, and water re-use increase, a resulting

increase in the frequency and duration of periods of inadequate freshwater inflows to the estuary could have devastating effects.

Figure 5. Indicator showing annual (left) and monthly (right) percentages of time that modeled Galveston Bay inflows exceeded the minimum annual inflow required to maintain bay and estuary fisheries harvest. Figure created by the Galveston Bay Indicators Project, Houston Advanced Research Center. Data source: Texas Water Development Board.



Bay Circulation

Human alterations in the Bay have likely exerted more profound influence on bay circulation than natural processes. The Houston Ship Channel has caused the most pervasive change to circulation by greatly increasing the flow of Gulf water into the bay. Unfortunately, there are no direct measurements of bay circulation prior to 1900 before large-scale navigation channel expansion began. However, it is likely that the channel has directly altered circulation by providing a larger cross section for north to south water movement on the main axis of the Bay and by breaching Redfish Bar, which limited water exchange between the upper and lower bay. The Houston Ship Channel serves as a conduit for Gulf water to intrude into the upper bay system.

The disposals of dredged material at sites parallel to the ship channel, such as Atkinson Island, create barriers to flow across the bay. The upper Houston Ship Channel is a major contributor of freshwater coming from industrial processing. This less-dense, freshwater moves into the Bay above the more-dense saltwater moving along the open bay reaches of the ship channel. Additional human activities that have altered circulation patterns in the Bay are the Texas City

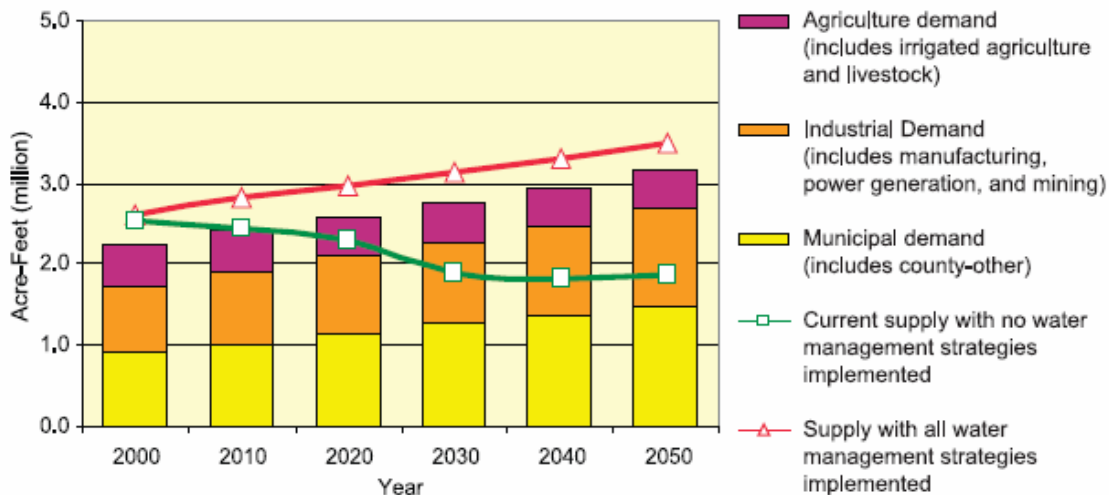
Dike and the interbasin transfer of water from the Trinity River to the upper Houston Ship Channel and San Jacinto River. Construction of the Texas City Dike has had a profound influence on the circulation in the lower bay by essentially preventing fresher upper bay waters from entering West Bay while interbasin transfers change the location of freshwater inflows in the bay system.

Status of Freshwater Inflows in Lower Galveston Bay watershed

It is generally agreed for the Houston-Galveston region that current supplies of freshwater are adequate to meet the current human demands placed the resource (see Figure 6). Periodic drought conditions do occur and impact the salinity regime of the Galveston Bay Estuary. However, these conditions are relatively short-lived and are reversed by periods of intense rainfall such as those caused by tropical weather systems.

Concerns arise when future conditions are contemplated. As the Houston-Galveston population increases to an estimated 10,000,000 people by the year 2050, demands for freshwater for use in homes, agriculture and industry are projected to increase to a level that cannot be met by the available supplies of freshwater. If current trends continue, there may come a time when there is not enough freshwater available to satisfy all demands placed on the resource. If water management strategies are not implemented, water demand could exceed available supplies within the next five to ten years. If water management strategies are implemented, water supplies could satisfy water demand. Whether this is enough to sustain the ecological resources of the Galveston Bay estuary remains to be seen and is a subject of great debate.

Figure 6. Comparison of projected water supplies and demands for Region H, 2000-2050. Source: Texas State Water Plan, 2002.



Managing the Resource

The supply of freshwater consists of both surface water and groundwater. Surface water or water that flows in rivers, streams, and bayous is considered property of the state of Texas. In general, there are two types of surface water law: *Riparian Doctrine* and *Prior Appropriations Doctrine*. Texas uses a combination of both. In some instances, Riparian Doctrine is applied which gives

the right to use surface water to those households and livestock operations that exist directly adjacent to a stream or river. In other instances Prior Appropriations or “first in time, first in right” rules apply. Under this structure the state regulates the use of surface water through a permitting system that grants senior and junior water permit holders the right to use specified volumes of water. Another technique for surface water rights management in Texas includes the issuance of *Certificates of Adjudication* by the Texas Commission on Environmental Quality (TCEQ) to settle conflicting water rights claims. In Texas, groundwater or water that exists in aquifers below the earth’s surface is managed by the *Rule of Capture* which grants landowners the right to pump the available groundwater that lies beneath their property.

While the TCEQ regulates the use of Texas water resources, Texas Senate Bill 1, approved by the Texas Legislature in 1997, directs the Texas Water Development Board (TWDB) to plan for future water needs. The TWDB was directed by Senate Bill 1 to develop a Texas State Water Plan and 16 regional water plans to be revised every five years. The Texas State Water Planning process assesses historical data, current water supply and demand, and future projections of population, water demand, and water supply.

Region H includes the Lower Galveston Bay watershed while Region C encompasses the Upper Galveston Bay watershed including Dallas-Fort Worth. The first Region H Water Plan was approved in 2001. The 2006 Region H Water Plan is under development. In addition to considering human demands for water, the Region H Plan also takes environmental flow requirements into consideration. The Galveston Bay Freshwater Inflows Group (GBFIG) has been meeting since 1996 to devise strategies to maintain adequate freshwater inflows to Galveston Bay. GBFIG includes representatives from natural resource agencies, environmental groups, fisheries and agricultural interests, and water district managers from Region H and Region C. GBFIG members review relevant scientific and technical information, and are tasked with developing potential management strategies to ensure that Galveston Bay continues to receive adequate fresh water while protecting the interests of citizens living in the surrounding watersheds.

Proposed strategies to ensure future water supplies include the construction of additional water supply reservoirs, increased municipal and irrigation water conservation, and increased interbasin transfers (transfer of water from river basin to another). Expansion of interbasin transfers is also recommended in the upper Trinity watershed (Region C) regional plan. As the Dallas-Fort Worth metroplex acquires more water from sources outside the watershed and returns it by municipal and industrial treatment, upper Trinity River flow may increase. Whether interbasin transfers will result in more water entering the Bay will depend on management decisions of water users. While large scale water management strategies are needed, there is much that the public can do to conserve water in the home. Water conservation can be achieved in a number of ways such as installing low flow water fixtures in the home, planting water smart landscaping, and watering lawns less often.

Conclusion

Successful management of inflows to Galveston Bay must consider quantity, quality, seasonality, and location of inflows. The issue of freshwater inflow needs of bays and estuaries has been studied extensively and is the focus of great policy debate in Texas. The debate is only likely to increase as the human population surrounding Galveston Bay is projected to double to nearly ten million people in the coming decades. While the circulation of water in Galveston Bay is influenced by many factors, including freshwater inflow, salinity changes, winds and tides; human alterations including structures and dredging in the bay have likely exerted more influence on bay circulation than natural processes. Through its sponsorship of the Galveston Bay Freshwater Inflows Group, GBEP is active in regional efforts to adequate freshwater inflows to the Galveston Bay Estuary. While large scale water management efforts are necessary to ensure future adequate inflows, there is much that individuals can do through water conservation in the home and workplace. Additional water conservation education programs are required to promote water conservation by the public.

References

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