# Shallow Water Wells and Groundwater
# Port Aransas, Mustang Island, Texas

Prepared for The City of Port Aransas, TX
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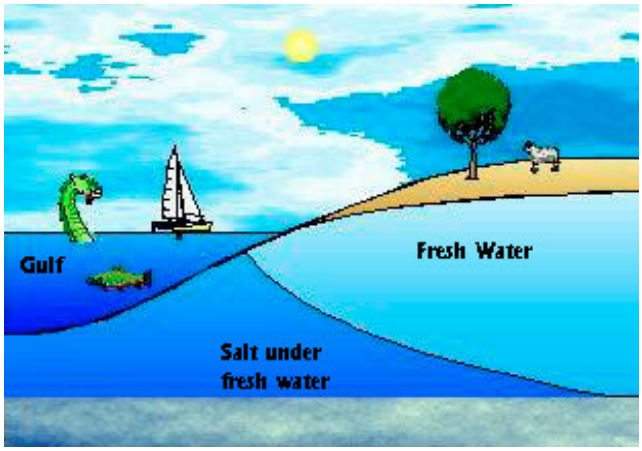


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# Executive Summary

Groundwater in the Mustang Island aquifer, which is the sand body of Mustang Island, is a valuable resource for the citizens of Port Aransas and Mustang Island. This aquifer is recharged only from rain falling directly on Mustang Island and by surface runoff from that rain. The aquifer has a maximum thickness of between 75-150 feet. It is thickest in the vicinity of the dune line, and thins to almost nothing at the boundary with Corpus Christi Bay.

Water quality in wells within 1500 to 2000 feet of the Gulf beach should be good, while salinity will increase and quality decrease closer to the bay, and near channels such as channels at Island Moorings and the ship channel.

Subsidence (sinking of the land due to compaction of underlying sediments) has been a major problem in some Texas locations due to withdrawal of groundwater. This will not be a problem at Port Aransas because the wells are shallow; there is little clay in the body of Mustang Island to compact, due to de-watering, and the surrounding Gulf and bay will prevent the ground water level being significantly lowered below sea level.

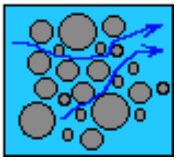
Salt water intrusion into the aquifer could become a problem if water withdrawal is excessive. This is most likely to be a problem if there is heavy pumping on only a few wells, rather than lighter pumping on many wells. Since most of the usage is by individual homeowners for landscape watering, the pumping is from many scattered wells, reducing the probability of serious draw down and salt water intrusion. That is more likely to become a problem if the usage is for a major user, such as a golf course. In that case, many wells should be used so as to not draw too much from any single well. For such heavy use, monitoring wells should be installed to track any changes in the level of the water table and stop withdrawing water if the water table is being drawn down to near sea level.

# Introduction

The groundwater system of Port Aransas and Mustang Island is a valuable resource to both the individual owners of shallow water wells and to the community as a whole. A considerable savings can be realized by homeowners using the water provided from a shallow well for landscape watering. At the same time, this reduces the water consumption of the City as a whole and reduces the drain on our regional water supply. Additionally, in time of emergency, such as after a storm or other major disaster, individually owned shallow wells can provide fresh water for bathing, and general cleaning, etc. Some of the wells probably provide water of adequate quality for human consumption, but they should not be used for that purpose without regular testing for quality.

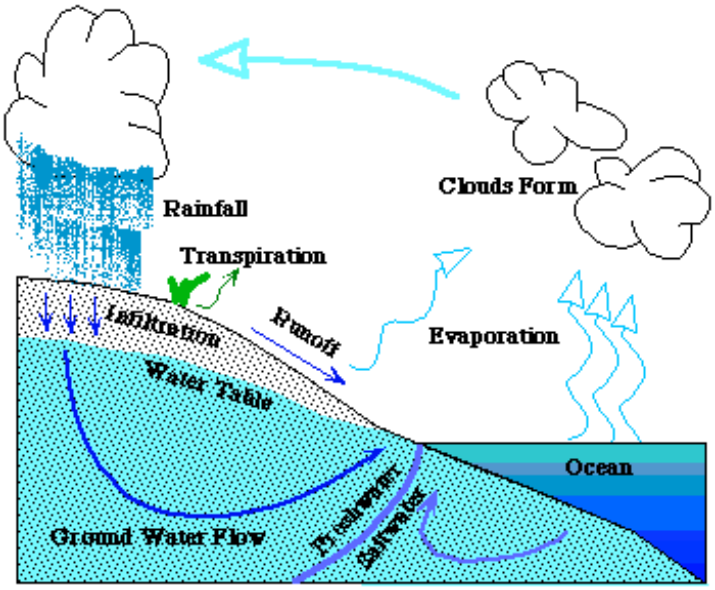
Prior to the construction of the two pipelines which bring water from the Corpus Christi regional system, all of the water supply for Port Aransas was from individual wells and a community well field in the dune area . Increased usage of this groundwater resource by individual property owners has raised concerns about whether or not construction of the shallow well should require a City permit.

# Ground Water and the Water Cycle



Ground water is water that is below the surface of the ground. It only rarely flows in underground rivers and then only for short distances in cavernous limestone terrain. Here on Mustang Island ground water behaves in the much more normal fashion of flowing between individual grains of sand. Surprisingly this flow rate can be as much as fifty feet per day. The top surface of the groundwater is called the water table. In general, the groundwater flows from areas where the elevation of the water table is high to areas where it is lower. The surface of a pond or a lake is the exposed surface of the water table at that location. On Mustang Island, when there is water standing in the roadside ditches for a long time, that is the level of the surface of the water table at that location. However, the actual surface of the water table is not flat. The water table rises under higher topography like the dunes and is lower under areas with lower land surface elevations.

The source for all of the fresh groundwater on Mustang Island is rain and surface runoff from rain sinking into the ground. This diagram of the water cycle shows how the groundwater is replenished. The portion of the rain which does not evaporate, run off, or return to the atmosphere by transpiration by plants, flows downward into the sand of the Mustang Island aquifer and slowly flows into the sea, into the ship channel and into Corpus Christi Bay. You may have noticed areas of cold water when swimming in the surf. Those are cool fresh water springs where the groundwater is flowing into the sea and coming up from the sea floor. Channels, such as the channels at Island Moorings, can accelerate the loss of fresh groundwater into the surrounding seawater, because they provide a closer escape route for the fresh water into the surrounding salt water.

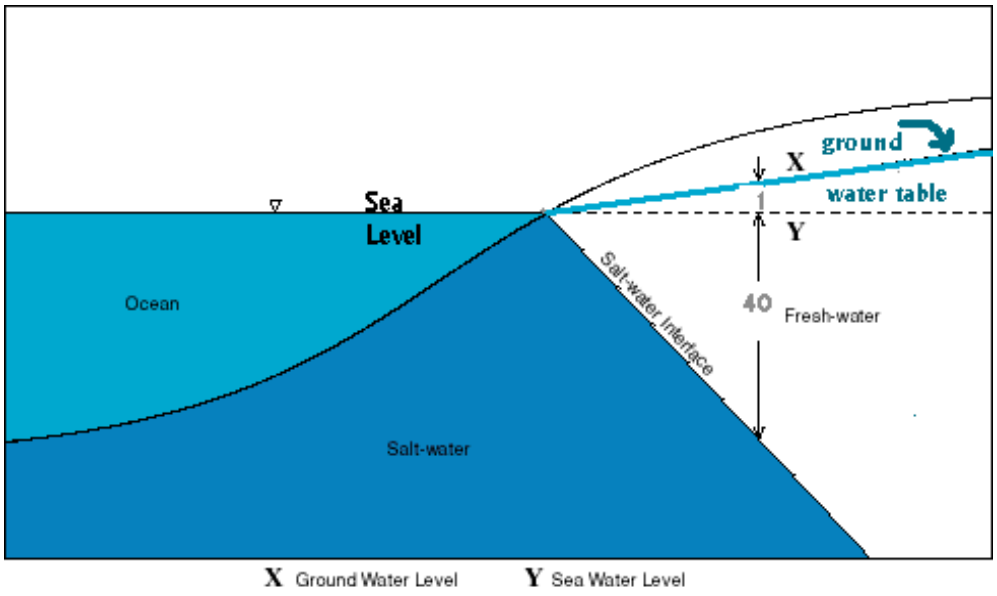



## The Mustang Island Aquifer

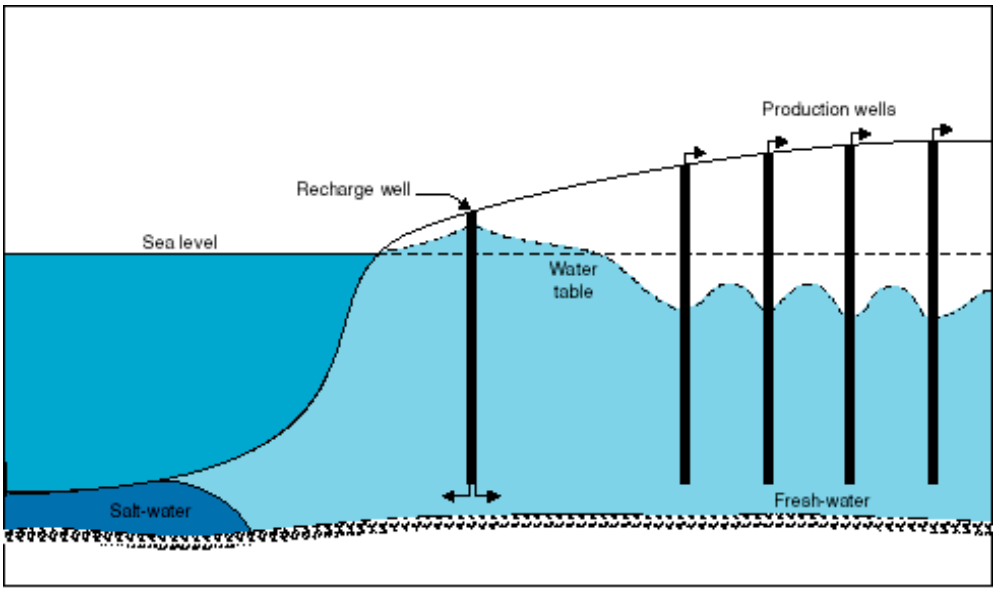
Materials which provide storage for groundwater are called aquifers. Lets take a closer look at the size and the shape of the aquifer on Mustang Island. Mustang Island is composed of a long narrow body of sand. Its maximum thickness is probably about 75 to 150 feet thick and it extends from a short distance seaward of the beach to about the bay shoreline. Most of the aquifer will be considerably thinner than 100 feet. Mustang Island, and thus the aquifer, is thickest in the vicinity of the main line of vegetated dunes and thins to almost nothing near the Corpus Christi Bay shoreline. This sand body is full of either fresh water or salt water below the level of the water table.

Coastal aquifers in isolated sand bodies which are surrounded by seawater, such as Mustang Island, are special in that the fresh water is actually floating on top of the seawater within the sand body. This is very similar to the way that ice floats in water. In the case of ice, the ice floats so that about 7/8 of it is submerged and only 1/8 is above the surface of the water. This is because ice is quite a bit lighter than the same volume of water. In the case of our coastal aquifer, the fresh water is only a tiny bit lighter than the surrounding salt water so it barely floats on it. In fact, only the top one fortieth of the fresh water is above the level of the surrounding seawater. If the fresh water is 41 feet deep from the top of the water table to the underlying seawater on which it is floating, the fresh water will extend only 1 foot above sea level, while it extends 40 feet below sea level.

In the following diagram note that the fresh water in the aquifer goes below sea level 40 times the distance that the fresh water exists above sea level. This is very important. If a well draws the surface of the water table down only one foot, the seawater that the fresh water is floating on rises 40 feet. *If the well draws the surface of the water table down below sea level, the seawater rises to sea level and the well becomes salt.*



Each well draws the water down in its vicinity in cone, called a cone of depression. The diagram below shows several wells and how they work together to draw down the surface of the water table. Remember that they raise the level of the underlying salt water 40 times as high as they draw down the water table.




**Deep recharge well creates groundwater ridge.**

This particular diagram shows a deep recharge well on the left which is used to inject fresh water, such as treated sewage effluent, to create a barrier so that the many wells do not draw in salt water due to lowering the water table below sea level in the aquifer. In this example, the entire aquifer would have become salt in the absence of the recharge well providing a fresh water barrier. We will not have this problem on Mustang Island if we do not over pump our wells.

In a study on Padre Island, Berkebile and Hay found that wells near the dune line had extremely low salinities often lower than 1 part per thousand and not exceeding 3 parts per thousand salinity. Wells in the center of the island rarely exceeded 5 parts per thousand. Normal seawater salinity is 35 parts per thousand. They found very high salinities on the back of Padre Island near Laguna Madre ranging to a high of 96 parts per thousand. Our experience on Mustang Island is similar. Wells near the dunes and in the higher vegetated parts of the island produce excellent fresh water. Wells further toward the bay, the channels and the flats are of higher salinity and lower quality. The wells in the thinner parts of the aquifer (toward the bay and flats) are also not able to produce large quantities of water without drawing the water table down to salt. The best location for water wells is within 1500 to 2000 feet of the beach.

# Subsidence

Galveston Island and some areas around Baytown, Texas have experienced severe subsidence (sinking of the land relative to sea level) due to groundwater withdrawal. In some cases, the ground level has subsided over 15 feet and areas that were dry land are now submerged. Fortunately, we do not have to worry about subsidence due to withdrawing groundwater from the Mustang Island aquifer. The problem areas which I have just described drew subsurface water from deep wells in which the water bearing sands were layered with watery clays. The subsidence occurred due to compaction and de-watering of the clays when the supporting water was withdrawn. This is permanent subsidence and cannot be remedied by injection of new water (Brown, L.F., Jr. Et al., 1974).

The Mustang Island aquifer is nearly pure sand and the sand grains are self supporting much like a big pile of bowling balls with the water in the pore spaces between the sand grains. Removal of the water causes no compaction. Further, the water can effectively be lowered only to about sea level as it will be maintained from below and from the sides by inflow of seawater. We do not have to worry about compactional subsidence due to groundwater withdrawal from shallow 8 to 25 foot deep wells in sand.

# Seawater Intrusion

There are two ways that the Mustang Island Aquifer can be degraded by seawater intrusion. Flooding of the low lying areas of the island during hurricanes can cause direct inflow of salt water down from the surface. Secondly over pumping of individual wells can cause localized seawater intrusion from below. This is most likely to be a problem on the low lying parts of the island (west of Alister St. and Highway 361 where the sand body is thin and the top of the water table may be lower relative to sea level than nearer to the dunes. This problem is partially self controlling since few users wish to pump salty water onto their lawns. Furthermore, the usage is by individual home owners, so the wells are already widely spaced.

A larger problem is a major user such as a golf course extensively watering a large area from only a few wells. This problem can be greatly reduced is such a user uses a large number of individual widely spaced wells so that the draw from each individual well is relatively small. This draws the water table uniformly down a small amount over a wide area rather than a deep draw down over a small area. Remember that the bottom of the fresh water body is raised 40 feet for every foot that the top is lowered toward sea level.

Most of the water drawn from wells is used for landscape watering, so whatever portion of that that is not evaporated and lost by plant transpiration may be returned to the water table.

Fresh ground water is continually flowing downward and laterally into the sea and in some cases at rates up to 50 ft. per day. This means that during droughts, we are continually losing our ground water to the sea whether we pump it or not. The natural variations in the level of the ground water on Mustang Island are large. At times, the road ditches and ephemeral ponds and marshes are full. After extended periods of little rain, the water table is lowered by flow into the sea and the marshes and ponds dry up. We do not know the relative importance of withdrawal of fresh water from wells and the natural flow into the sea. We do know that the marshes and ponds in the unoccupied parts of the island dry up during dry periods, so the natural loss is large.

It seems that recovery of the ground water system in the Mustang Island Aquifer is rapid during periods of abundant rainfall, even if the aquifer has been saturated with seawater by a hurricane. I personally showered for a month at a backyard well on 11$^{th}$ street after hurricane Celia. The water was fresh.

# Resource Management and Monitoring

The only problem due to increased withdrawal of water from the Mustang Island aquifer within Port Aransas is the possibility of salt water intrusion due to excessive pumping from individual wells or closely spaced wells. I do not believe this has been a problem so far. This could be investigated by measuring salinity at existing wells. Monitoring is most important during drought periods when the aquifer is not being recharged with rain water. It may also be valuable to monitor the groundwater after flooding due to hurricanes

The water table can be easily monitored for salinity levels and water table elevation if the City wishes to do that in the future. All that is necessary is to place shallow wells on a series of transects across the island. These are simply PVC pipe which has been perforated to let the water in and screened to keep the sand out. These wells are not for pumping, but merely to take water samples and to measure the level of the groundwater in the well, and thus the level of the water table. The water table level can also be measured at production wells if they have not been pumped for several days. All that is necessary is to cap them with a pipe tee with a plug in the top, so that a probe can be lowered straight down the pipe to measure the water level. The pump is attached to the side of the pipe tee.

As long as the water table remains above sea level the aquifer is in good shape. However, we must remember that for each foot that the water table falls, *the underlying seawater rises 40 ft.*

# Permits for Wells

I do not know if permits for wells for individual home use will serve any useful purpose at the present time. We do not have a problem It might be a good idea, however, for the City to provide general information such as in this report as well as plans and methods to install a successful shallow well in Port Aransas. It may be a good idea to provide a permitting and monitoring program for major users such as golf courses. It will certainly also be to their benefit to make sure that they do not over pump and contaminate their groundwater with salt water. It is easy to determine the water level in a monitoring well and to measure the salinity in a production well.

# Conclusions

Groundwater in the Mustang Island aquifer, which is the sand body of Mustang Island, is a valuable resource for the citizens of Port Aransas and Mustang Island. This aquifer is recharged only from rain falling directly on Mustang Island and by surface runoff from that rain. The aquifer has a maximum thickness of between 75-150 feet. It is thickest in the vicinity of the dune line, and thins to almost nothing at the boundary with Corpus Christi Bay.

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