Analysis of Impaired Waters in Zone H of Texas

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Introduction

About 85% of the drinking water in Houston is from surface water sources, with Lake Houston, Lake Conroe, and Lake Livingston being the main suppliers. Houston is the largest city in Texas with a population of approximately 2.31 million, so this project is aimed at assessing the quality of the surface water in the greater Houston area (Regional Water Planning Zone H). As the population of Houston continues to grow, its water supply steadily decreases, and although contamination levels are usually low in the drinking water, surface water contamination can be devastating for the wildlife and expensive to fix. In fact, most of the streams in Houston are unsafe for human exposure, with industrial pollution as well as waste management being mostly responsible for the contamination in the area. Lake Houston is recharged by the San Jacinto River, which was polluted after Hurricane Harvey caused a Superfund site with high levels of Dioxin to sill into the river. Furthermore, testing Houston's drinking water has revealed levels of Arsenic and Lead that are several parts per billion (ppb) above the EPA's recommended limit. PFAS, a category of chemicals found in non-stick pans and other products, have proliferated across the globe, breaking down into microscopic particles and residing in nearly every individual on the planet. The EPA still doesn't test for PFAs, and they are considered an "emerging contaminant," but elevated levels have been found in the San Jacinto River. In order to assess Houston's surface waters and the extent of contamination, data was accumulated from the EPA and the TWDB to visualize and analyze the problem.

Data Collection

The data used to assess contamination near Houston are shown below, with links to their sources as well as a general classification of the data type.

Regional Water Planning Areas (shapefile)
https://www.twdb.texas.gov/mapping/gisdata

Major River Basins (shapefile)
https://www.twdb.texas.gov/mapping/gisdata

Major Rivers (shapefile)

https://www.twdb.texas.gov/mapping/gisdata

Lakes- Medium Resolution (shapefile)

file://\\cgstdb\CGSTGeognet\Geognet\Geognet2014\TxStateLayers2014\Tx_Hydrology\Tx_Lakes.gdb

Land Use-Regional; (raster)

https://www.arcgis.com/home/item.html?id=1a46e6bca2fc4b0cbb2b863b17 72c421

303(d) Listed Impaired Waters NHD Plus Indexed Dataset with Program Attributes: (shapefile)

https://www.epa.gov/waterdata/waters-geospatial-data-downloads

Public Water System (point data)

https://www.arcgis.com/home/item.html?id=09074e983533475e986b8f551a442e54

Texas Cities (point data)

https://www.arcgis.com/home/item.html?id=993d420b9f0742b9afa06622d27a37e0

Preprocessing

To start organizing data, two folders labeled “Rasters” and “Shapefiles” were loaded into a separate project folder. This was done so that clipping or extracting data would be made easier later. Since the layers from TWDB were in GCS NAD83, the other layers were converted to the geographic coordinate system by using the “Project” tool under Data Management in the ArcToolbox.

All the shapefiles downloaded encompassed the state of Texas or the entire United States. The study area was narrowed down to the Regional Water Planning Zone H, which includes Galveston, Harris, Liberty, Montgomery, San Jacinto, Trinity, and Walker counties, so the shapefile containing all the zones in Texas was loaded first, and the polygon of interest was isolated and saved as its own layer. Next, the remaining shapefiles were clipped (Analysis Tools→Extract→Clip) to the shape of the zone. For the land use raster, the “Extract by Mask” tool was used, with the input raster being the Land Use

data, and the mask was set to the zone outline. In order to simplify the land use dataset, a new field was created in the attribute table- "CLASS"- which was a text field. The 16 previous categories (Fig **) were reduced to 7 (Wetlands, Open Water, Grassland, Forest, Developed, Barren, Agriculture) (Fig 1). After this, the basemap for the study area was established, so it was ready for data to be added on top.

Figure 1: Attribute tables for the land use raster before and after reclassification.

Rowid	VALUE	COUNT	CLASS
0	0	99	Perennial Ice
1	11	1364331	Open Water
2	21	3446883	Developed, Open
3	22	2624862	Developed, Low
4	23	1856654	Developed, Medium
5	24	781481	Developed, High
6	31	317970	Barren
7	41	1451170	Deciduous Forest
8	42	4653429	Evergreen Forest
9	43	2486826	Mixed Forest
10	52	2835716	Shrub/ Scrub
11	71	2197511	Grassland
12	81	11979457	Pasture
13	82	2740190	Cultivated Crops
14	90	7141747	Woody Wetlands
15	95	2145329	Herbaceous Wetland

Rowid	VALUE	COUNT	CLASS
0	1	1364430	Open Water
1	2	8709880	Developed
2	3	3153686	Barren
3	4	8591425	Forest
4	5	2197511	Grassland
5	6	14719647	Agriculture
6	7	9287076	Wetlands

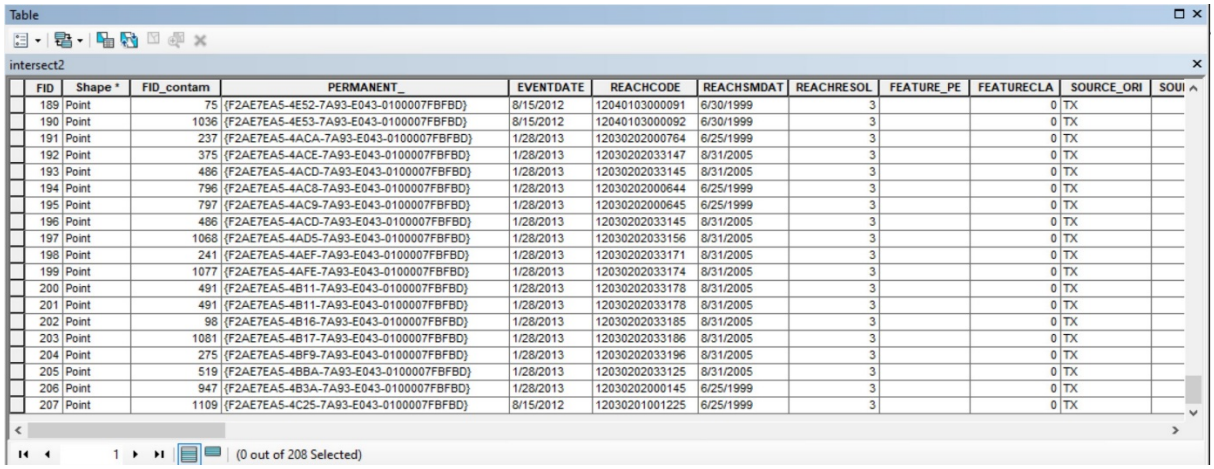
Data for water contamination came from the EPA with a shapefile containing 303(d) impaired waters from a 2014 survey. This dataset included waters with contaminants over the EPA regulations as defined in Section 303(d) of the Clean Water Act, and this was contrasted with surface water intake areas provided by the TCEQ. A shapefile of Texas cities was also used, and an SQL query was done (population>200,000) in order to isolate Houston on the map.

Data Processing and Analysis

After the surface water intake areas were identified on the map, the next step was to identify public wells that intersected the impaired water zones. To do this, a buffer region was created around the EPA contamination data because the line data didn't leave room for intersection with points. In ArcMap, the buffer tool was used, and a buffer length of 100 meters was established on each side of the contaminated streams. This resulting shapefile was then inputted alongside the Public Well data from the TWDB into ArcMap's "Intersect" tool. The end product of the tool is a layer that includes all of the

public wells in Texas that intersect an area of impaired water. As shown in the attribute table for the intersected values, out of the 10,976 public wells in Texas, 208 were within 100 meters of the impaired water lines defined by the EPA (Figure 2).

Figure 2: Attribute table of TWDB Public Wells intersected with impaired water 100m buffer zone.



Table

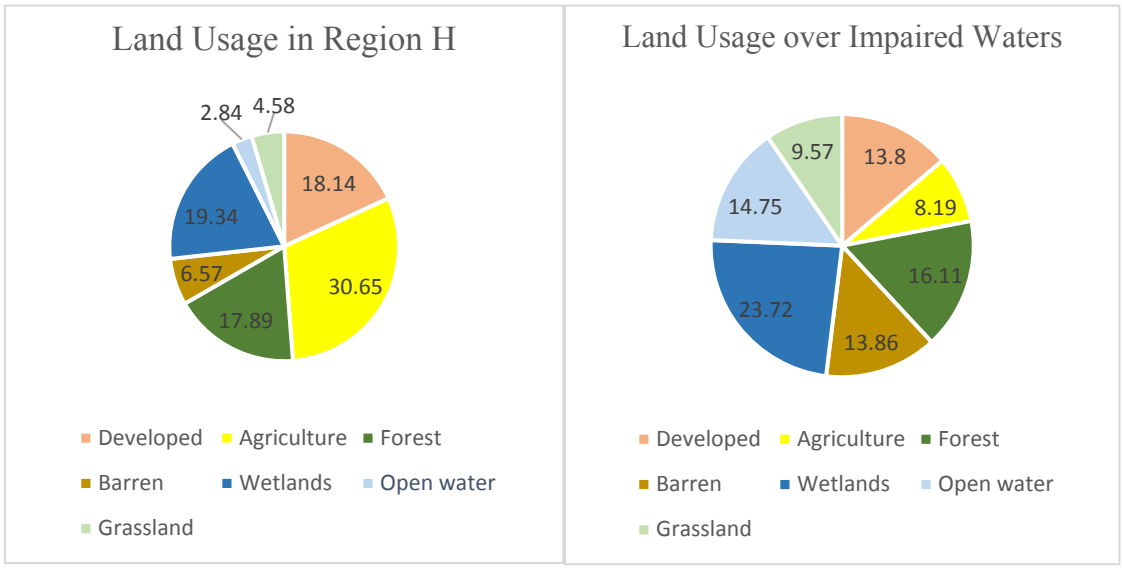
intersect2

FID	Shape *	FID_contam	PERMANENT_	EVENTDATE	REACHCODE	REACHSMDAT	REACHRESOL	FEATURE_PE	FEATURECLA	SOURCE_ORI	SOUI
189	Point	75	{F2AE7EA5-4E52-7A93-E043-0100007FBFBD}	8/15/2012	12040103000091	6/30/1999	3		0	TX	
190	Point	1036	{F2AE7EA5-4E53-7A93-E043-0100007FBFBD}	8/15/2012	12040103000092	6/30/1999	3		0	TX	
191	Point	237	{F2AE7EA5-4ACA-7A93-E043-0100007FBFBD}	1/28/2013	12030202000764	6/25/1999	3		0	TX	
192	Point	375	{F2AE7EA5-4ACE-7A93-E043-0100007FBFBD}	1/28/2013	12030202033147	8/31/2005	3		0	TX	
193	Point	486	{F2AE7EA5-4ACD-7A93-E043-0100007FBFBD}	1/28/2013	12030202033145	8/31/2005	3		0	TX	
194	Point	796	{F2AE7EA5-4AC8-7A93-E043-0100007FBFBD}	1/28/2013	12030202000644	6/25/1999	3		0	TX	
195	Point	797	{F2AE7EA5-4AC9-7A93-E043-0100007FBFBD}	1/28/2013	12030202000645	6/25/1999	3		0	TX	
196	Point	486	{F2AE7EA5-4ACD-7A93-E043-0100007FBFBD}	1/28/2013	12030202033145	8/31/2005	3		0	TX	
197	Point	1068	{F2AE7EA5-4AD5-7A93-E043-0100007FBFBD}	1/28/2013	12030202033156	8/31/2005	3		0	TX	
198	Point	241	{F2AE7EA5-4AEF-7A93-E043-0100007FBFBD}	1/28/2013	12030202033171	8/31/2005	3		0	TX	
199	Point	1077	{F2AE7EA5-4AFE-7A93-E043-0100007FBFBD}	1/28/2013	12030202033174	8/31/2005	3		0	TX	
200	Point	491	{F2AE7EA5-4B11-7A93-E043-0100007FBFBD}	1/28/2013	12030202033178	8/31/2005	3		0	TX	
201	Point	491	{F2AE7EA5-4B11-7A93-E043-0100007FBFBD}	1/28/2013	12030202033178	8/31/2005	3		0	TX	
202	Point	98	{F2AE7EA5-4B16-7A93-E043-0100007FBFBD}	1/28/2013	12030202033185	8/31/2005	3		0	TX	
203	Point	1081	{F2AE7EA5-4B17-7A93-E043-0100007FBFBD}	1/28/2013	12030202033186	8/31/2005	3		0	TX	
204	Point	275	{F2AE7EA5-4BF9-7A93-E043-0100007FBFBD}	1/28/2013	12030202033196	8/31/2005	3		0	TX	
205	Point	519	{F2AE7EA5-4BBA-7A93-E043-0100007FBFBD}	1/28/2013	12030202033125	8/31/2005	3		0	TX	
206	Point	947	{F2AE7EA5-4B3A-7A93-E043-0100007FBFBD}	1/28/2013	12030202000145	6/25/1999	3		0	TX	
207	Point	1109	{F2AE7EA5-4C25-7A93-E043-0100007FBFBD}	8/15/2012	12030201001225	6/25/1999	3		0	TX	

1 (0 out of 208 Selected)

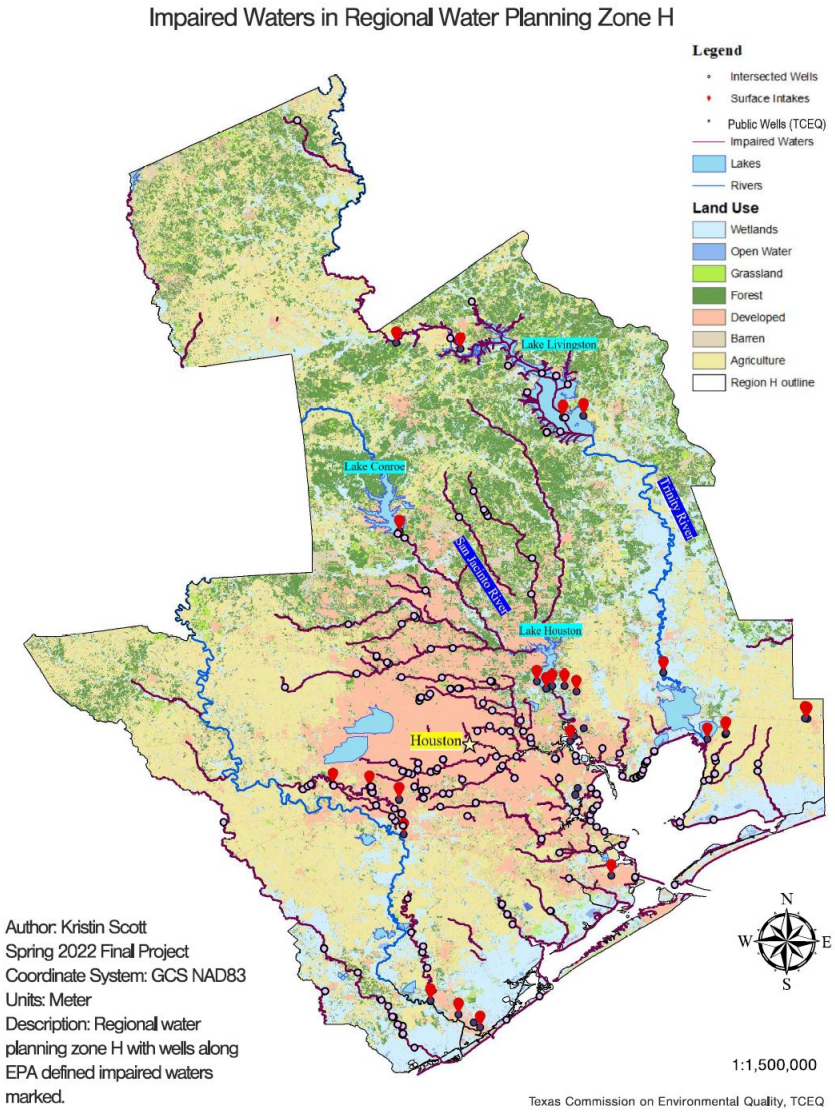
To determine any possible correlation between land use and contamination, with a focus on contamination in areas classified as "Developed," the land use raster was converted into vector data and then intersected with the EPA water data to form a new shapefile. The resulting data was sorted by land use category in the attribute table and transferred to excel.

Figure 3: Comparison of land usage over entire study area versus land usage over buffer zone of impaired waters.



While the study area had an unequal distribution of land usage, with agriculture, developed land, forested areas and wetlands dominating, the land around impaired waters was distributed far more evenly. Besides wetland zones, which is to be expected with impaired waters, there wasn't one type of land use that dominated the contaminated areas. Most of the pollutants in Houston surface waters are from industrial plants, but contaminants aren't restricted only to highly developed areas. Since Houston gets its water from multiple surface water sources, it was important to compare the source areas and surface intakes with the EPA defined contamination, which is shown below in the final map created (Fig 4).

Figure 4: Map of public wells and surface intakes along impaired waters in Texas' regional water planning Zone H.

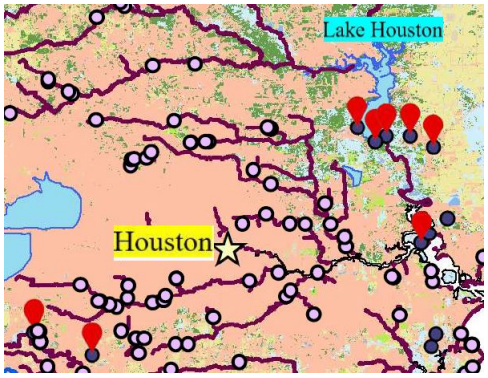


It can be seen from the map above that the majority of the San Jacinto River near Houston is classified as impaired. The three lakes that provide drinking water for Houston, Lake Conroe, Lake Houston, and Lake Livingston, all show contamination either in the lake itself or in the waters recharging the lakes. Upstream from the San Jacinto, Lake Conroe is not classified as impaired itself, but the water it discharges is contaminated downstream. Pits of toxic waste from an old paper mill were flooded during Hurricane Harvey, and the dioxins released into the water are carcinogens, causing cancer.

Conclusions

With such a high proportion of Houston's water supply coming from surface water sources, a risk assessment was conducted to visualize the extent of Houston's impaired waters as well as the proportion of wells that reside along the contaminated flow paths. Only about 2% of the wells in Houston were within 100m of the impaired zones, but there were approximately 30 surface intake zones in the areas of contamination. All of the municipal water is treated at a water treatment plant, but increased levels of Arsenic, Lead, microplastics and other chemicals are present in some Houston drinking water, and increased contaminants poses a health risk as well as economic risk. About 67% of Houston's streams are contaminated, exemplified by Figure 5 below (impaired waters in purple). EPA violations usually occur from bacteria in the water caused by malfunctioning sewage or wastewater treatment plants, but groundwater is most commonly polluted by petroleum storage tanks in Houston.

Figure 5: Zoomed in map of San Jacinto River in Houston with wells along it marked in pink.



There are several dozen Superfund sites in Houston like the San Jacinto Waste Pits, and previous events have shown that the infrastructure is not suitable to withstand extreme weather events. Another hurricane is a "when, not if-" scenario, so we must be prepared for future industrial waste leakages and increased microplastic content in the surface water. Municipal water is successfully treated in Houston, with no widespread areas of unusable or contaminated water, but Figure 5 shows that Houston is at a higher risk of having compromised water. All 3 of the surface water sources, which account for 85% of the city's water, show some amount of impairment. Furthermore, the untreated surface waters are detrimental to the fragile ecosystems that reside there. Increased levels of algal blooms in Houston lakes and rivers result in depleted nutrient and oxygen levels in the water, reducing photosynthetic activity. The full extent of damage caused by Harvey is still unknown, but future flooding poses a serious contamination risk for Houston waterways, as pollution from vehicles, industrial discharge, wastewater, and polluted stormwater runoff is absorbed and mixed with surface water. Houston has a serious risk of disaster when future extreme weather events increase in intensity and frequency.