

## **Subsidence in Terrebonne Parish may be Slowing Down**

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**Abstract:** The starting point for this investigation was the elevation bench mark data presented in the US Army Engineers Houma Quadrangle Bulletin of 1942. The elevations presented therein were from the mid to late 1930's to the early 1940's. These elevations represent the relatively stable conditions that existed before the accelerated surface subsidence occurred, due to the withdrawal of hydrocarbons and connate water.

The methods and concepts used in this presentation were fairly simple. Crude oil and natural gas production data was compared to bench mark elevations over the same time span up to the present. When plotted and displayed by bar graphs, the results clearly show an interaction indicating accelerated subsidence during peak production years, and a decrease in surface subsidence coinciding with diminishing hydrocarbon production.

**Introduction:** Natural subsidence across the gulf coast and elsewhere is brought about mainly by regional synclinal down warping, sediment compaction, and faulting. The rate of this type subsidence may be on the order of inches over hundreds of years. However, recently the rate of subsidence in coastal Louisiana has escalated to inches over decades rather than hundreds of years. It is widely accepted by many geologists and environmental scientists that this accelerated subsidence in South Louisiana over the last several decades is due, at least in part, to the withdrawal of hydrocarbons and connate water from the subsurface (Chan and Zoback, 2007; Holzer and Galloway, 2005).

**Methods:** We conducted a preliminary investigation of this relationship in Terrebonne Parish. The methods and concepts used in this presentation were fairly simple. The starting point for this investigation was the elevation bench mark data presented in the U.S Army Chief of Engineers Houma Quadrangle Bulletin (1942). The elevations presented therein were from the mid to late 1930's to the early 1940's. These elevations represent the relatively stable conditions that existed before the accelerated surface subsidence occurred, which coincided with the withdrawal of hydrocarbons and connate water. Crude oil and natural gas production data were obtained from the LA Department of Natural Resources (1940- 2008) and compared to bench mark elevations over the same time span up to the present (Rembert, 1950-2006). It is important to note that condensate and casinghead gas were not entered in our observation because some of the older production data were for crude oil and natural gas only. Also, no data on ground water withdrawal was available.

**Results:** Land elevation in Terrebonne Parish demonstrated a steady decline from 1935 to 2006 (Table 1). In 1941 land elevation in Houma was 12.60 feet (3.84 meters) above sea level and declined to 9.30 feet (2.85 meters) in 1968, with a further reduction to 8.70 feet (2.65 meters) in 1983 (Figure 1). The rate of decline, however, slowed to only 8.02 feet (2.54 meters) in 1997 (Figure 1). As shown in Figure 5, land elevation in Bourg was 7.1 feet (2.16 meters) in 1934, declined to 4.92 feet (1.50 meters) in 1995 and leveled off to 4.41 feet (1.34

meters) in 2006. A similar pattern was observed in Chauvin (Figure 2), Grand Caillou (Figure 3), and Savoie (Bayou Blue [Figure 4]). Conversely, as demonstrated in Table 2, crude oil production in Terrebonne Parish increased steadily from 5.3 million barrels per year (bbls/yr [842.7 million liters/yr]) in 1940 to 20.5 million bbls/yr (3.3 billion liters/yr) in 1953, peaking at 39.0 million bbls/yr (6.2 billion liters/yr) in 1960. Production declined to 13.0 bbls/yr (2.1 billion liters/yr) in 1980 and by 2008 was reduced to only 2.3 bbls/yr (365.7 million liters/yr). Natural gas rates of increase and decline were similar (Table 2). When compared with pre-existing and present elevations over this same period, there appears to be a reduction in the rate of subsidence that correlates with the diminishing rate of crude oil and natural gas production in Terrebonne Parish (Figures 1-5).

The subsidence induced by hydrocarbon and groundwater withdrawal appears to be approximately three feet (0.914 meters) over the past sixty years in Terrebonne Parish (Table 1, Figures 1-5). When compared with pre-existing and present elevations over this same period, there appears to be a reduction in the rate of subsidence that correlates with the diminishing rate of crude oil and natural gas production in Terrebonne Parish (Figures 1-5). Results show an interaction indicating accelerated subsidence during peak production years, and a decrease in surface subsidence coinciding with diminishing hydro carbon production.

Conclusion: This preliminary investigation suggests that land subsidence in Terrebonne Parish may be inversely related to oil and natural gas production. However, more data is needed to determine whether this is a statistically significant relationship. Regardless, land subsidence in Terrebonne Parish over the past decade appears to be slowing down. Therefore, it follows that these events will give impetus for funding and implementation for coastal and wetlands restoration.

#### Acknowledgements:

Robert R. Wright, retired Civil Engineer and Land Surveyor, and his wife Ruth allowed me to browse around in the building housing years of documents, books and map collections where I came across the U.S. Army Engineers bulletin listed above. They graciously allowed me to borrow the bulletin for the duration of my research.

Kenneth L. Rembert, Land Surveyor, helped me to locate more recent elevation benchmarks at or near the older ones listed in the above U.S. Army Bulletin.

Melinda S. Sothern, PhD. CEP, Louisiana State University Health Sciences Center, School of Public Health. Melinda (my daughter) produced all of the bar and line graphs in this presentation.

#### References:

Chan, A., and Zoback, M. 2007, The role of hydrocarbon production on land subsidence and fault reactivation in the Louisiana coastal zone. *Journal of Coastal Research*, v. 23, no. 4, p.771-786.

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Rembert, Kenneth L. - land surveyors elevation files, 1950-2006, Terrebonne Parish Consolidated Government elevation benchmark files.

U.S. Army, Chief of Engineers, 1942, Bulletin (formerly restricted document) Houma Quadrangle, horizontal and vertical control data: elevation benchmarks, Washington, DC

Table 1: Historic and current elevations (elevations in ft. above mean sea level)	
Houma – El Paso Dr.USC&GS benchmark “Y227” center of median	
1941	– 12.6
1968	– 9.259
1983	– 8.683
1997	– 8.015
Chauvin - Benchmark 1,100 ‘ S of Moses st.	
1940	– 5,6 (estimated from proximal benchmark)
1968	– 3.038
1983	– 2,142
2006	- 1.7
Grand Caillou – shoulder of LA 57 opposite old Combon bridge	
1935	– 5.6 (bronze marker set in concrete, destroyed)
1995	– 3.39
2006	– 2.87
Savoie (Bayou Blue)	
1934	– 9.349
1967	– 8.757
1995	– 7.51
2006	– 6.94
Bourg	
1934	– 7.104
1995	– 4.92
2006	– 4.41

Table 2.Crude oil and natural gas production amounts over a sixty eight year period, beginning in 1940 and ending in 2008.		
Year	Crude oil production (bbls)	Natural gas production (mcf)
1940	5,319,775	2,165,585
1947	8,460,672	37,377,475
1950	12,916,661	45,135.503

1953	20,537,922	113,525,635
1960	38,954,597	261,810,976
1970	not available	not available
1980	12,946,340	356,740,984
1990	5,144,761	138,395,721
2000	4,876,464	133,599,972
2008	2,255,574	84,142,879

### Land Elevation of Houma, Louisiana and Crude Oil Production

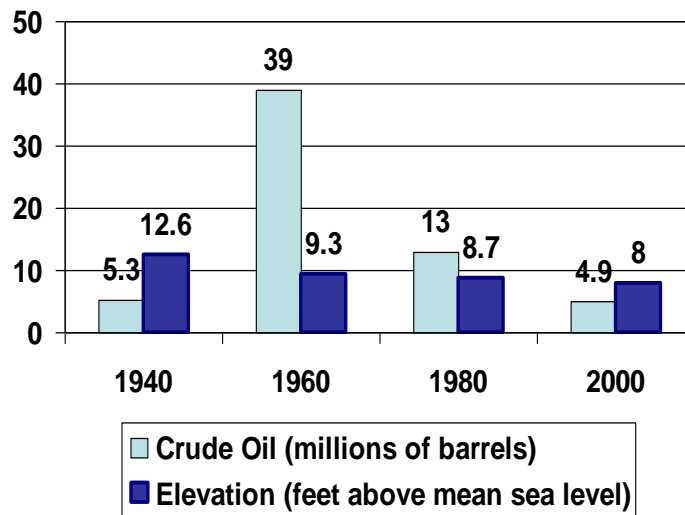


Figure 1: Land elevation of Houma Louisiana in comparison to crude oil production rates in Terrebonne Parish, Louisiana.

### Land Elevation of Chauvin, Louisiana and Crude Oil Production

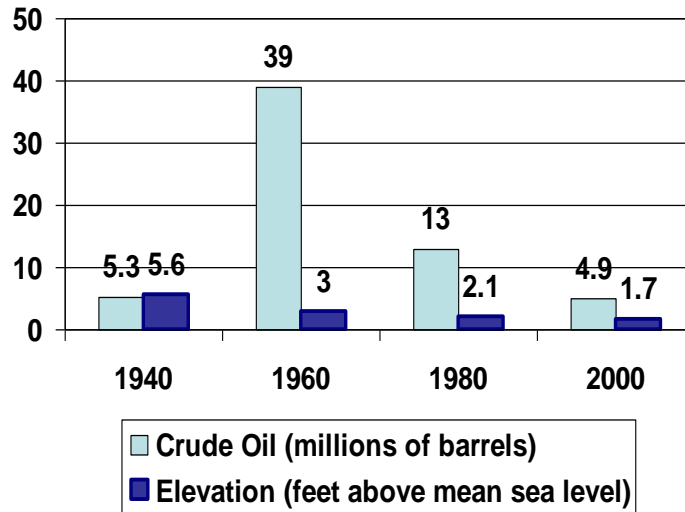


Figure 2: Land elevation of Chauvin, Louisiana in comparison to crude oil production rates in Terrebonne Parish, Louisiana.

### Land Elevation of Grand Caillou, Louisiana and Crude Oil Production

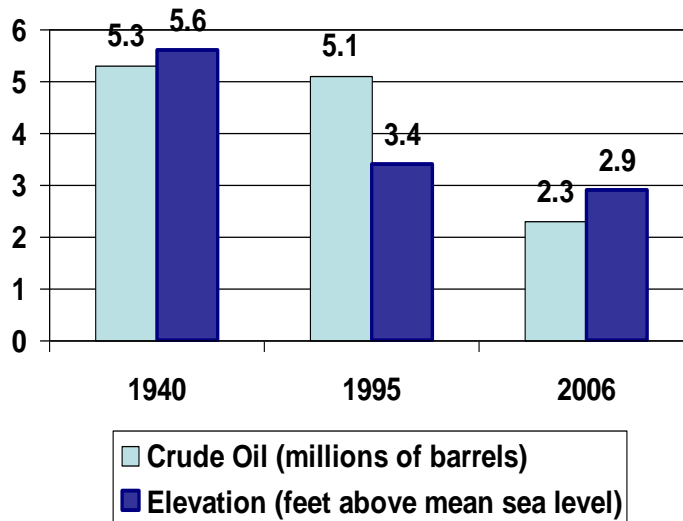


Figure 3: Land elevation of Grand Caillou, Louisiana in comparison to crude oil production rates in Terrebonne Parish, Louisiana.

**Land Elevation of Savoie (Bayou Blue) Louisiana  
and Crude Oil Production**

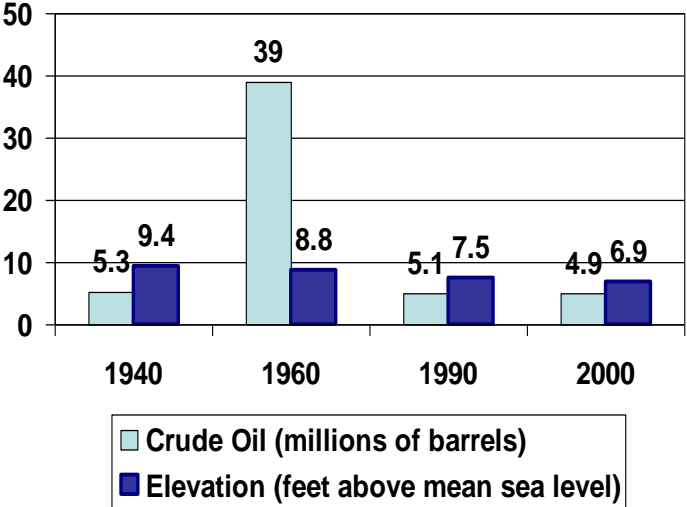


Figure 4: Land elevation of Savoie (Bayou Blue), Louisiana in comparison to crude oil production rates in Terrebonne Parish, Louisiana.

**Land Elevation of Bourg Louisiana  
and Crude Oil Production**

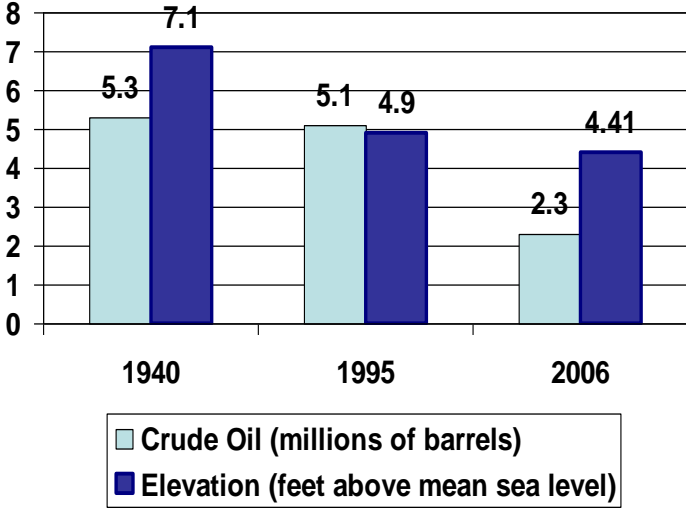


Figure 5: Land elevation of Bourg, Louisiana in comparison to crude oil production rates in Terrebonne Parish, Louisiana.