



February 7, 2017

HONORABLE MAYOR AND CITY COUNCIL  
City of Long Beach  
California

RECOMMENDATION:

Receive and file the attached report, "Elevation Changes in the City of Long Beach, November 2015 through October 2016." (Citywide)

DISCUSSION

The City of Long Beach, through the Long Beach Gas and Oil Department (LBGO), supervises oil production and subsidence control operations in the Wilmington Oil Field. LBGO conducts elevation surveys every six months to monitor elevation changes in the oil fields and adjacent city areas. This report focuses on elevation changes that have occurred from November 2015 through October 2016. The LBGO survey includes the following areas: Civic Center, Central City, Alamitos Bay, Naples, Harbor District, and the offshore area encompassing the four oil islands.

The results of the last two six-month surveys indicate that elevations were stable in the Civic Center, Central City, Alamitos Bay, Naples, and the offshore area. The Harbor District was stable for the year with the exception of Pier D. Pier D experienced an elevation increase of up to 0.07 foot (0.8 inch) during the first six-month period of the year. The increase may have been due to increased injection in the area and did not continue during the second half of the year.

The LBGO survey uses a series of benchmarks to determine elevation changes. Studies by the Department's engineers and geologists show that the benchmarks may rise and fall in such a manner as to make a survey either optimistic (slightly up in elevation) or pessimistic (slightly down in elevation). These changes in elevations may be associated with tidal cycles, drought, temperature changes, deep earth tectonic changes and/or re-pressuring operations in the oil field. Surface elevations over the active Wilmington Oil Field can be expected to fluctuate under changing water flood conditions.

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This matter was reviewed by Deputy City Attorney Richard F. Anthony on January 12, 2017 and by Budget Analysis Officer Julissa José-Murray on January 17, 2017.

TIMING CONSIDERATIONS

City Council action on this matter is not time critical.

FISCAL IMPACT

There is no fiscal or local job impact associated with this recommendation.

SUGGESTED ACTION:

Approve recommendation.

Respectfully submitted,



ROBERT DOWELL  
DIRECTOR OF LONG BEACH GAS AND OIL

Attachment

APPROVED:



PATRICK H. WEST  
CITY MANAGER

**ELEVATION CHANGES  
IN THE  
CITY OF LONG BEACH**

**NOVEMBER 2015 THROUGH OCTOBER 2016**

**PREPARED**

**FOR**

**LONG BEACH CITY COUNCIL**

**BY THE**

**LONG BEACH GAS AND OIL  
DEPARTMENT**

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## ELEVATION SURVEY ANALYSIS

The City of Long Beach semi-annual elevation surveys of the Civic Center, Central City, Harbor District, Alamitos Bay, Naples, and offshore drilling islands were conducted during May 2016 and November 2016. Changes in elevation that have occurred since the last three surveys, November 2016, May 2016 and November 2015, are discussed in this report. The results in this report reflect elevation changes both within and beyond the scope of oil field operations. Some changes are due to natural geologic factors.

### **Elevation Change – November 2015 through April 2016**

**(Figure 1)**

Elevations throughout the Alamitos Bay, Naples, Central City, Civic Center and the offshore islands were stable during the six-month period.

The Piers in the Harbor District were also stable during the period, with the exception of Pier D. Pier D experienced an elevation increase of up to 0.07 foot (0.8 inch). The elevation increase was within normal limits and did not continue through the year.

Elevations in the City of Long Beach to the north of the boundaries of the Wilmington Oil Field indicate the region was slightly up during the six-month period.

### **Elevation Change – May 2016 through October 2016**

**(Figure 2)**

Elevations throughout the Alamitos Bay, Naples, Central City, Civic Center and the offshore islands remained stable during the six-month period. In the Harbor District, elevations of all of the piers were stable.

Elevations in the City of Long Beach beyond the boundaries of the Wilmington Oil Field indicate the region continue to be slightly up during the six-month period.

**Elevation Change – November 2015 through October 2016**

**(Figure 3)**

Elevations in the Alamitos Bay, Naples, Civic Center and the Central City were stable during the twelve-month period. The offshore drilling islands were stable during the period with the exception of Island Grissom and the adjacent shoreline which experienced an elevation increase of up to 0.07 foot (0.8 inch). The increase was within normal limits and may have resulted from increased water injection in the area. The elevation increase is not expected to continue.

Elevations of all the piers in the Harbor District were stable during the twelve-month period.

Mitigation measures implemented during the last year by LBGO were effective in halting elevation declines in the area.

**Use of Global Positioning System (GPS)**

This report is based solely upon computer processed data utilizing the Long Beach Deformation Network (LBDN). The LBDN consists of thirteen permanent, reference GPS base stations, communication equipment, computer server, monitoring software and five mobile GPS receivers. The LBGO Oil Operations and Public Works Bureau of Engineering surveyors use the mobile GPS receivers linked to the reference base stations to measure approximately 240 City and Harbor bench marks.

## APPENDIX

### Brief History of Long Beach Subsidence

Long Beach and the general vicinity have a history of regional subsidence (losses of elevation) since 1929. Elevation changes were minor, amounting to an average of about -0.036 foot (-0.43 inch) per year until about 1939. Geologic movement such as the Long Beach Earthquake of March 1933 altered this average rate at times. Contributing causes of the subsidence were groundwater withdrawal from aquifers in the Long Beach area, regional basin sediment compaction, and tectonic effects of local faulting.

Development of the Wilmington Oil Field began in 1936. Oil operations accelerated subsidence and within twenty years created a 29-foot deep subsidence bowl centered in the Wilmington-Long Beach Harbor area near Bench Mark 8772, at the Edison power plant. Development of the Ranger Zone west of Pine Avenue and its extension seaward in 1947 started the first definitive subsidence in the Central Business District that could be attributed to oil production.

Repressuring operations began in the 1950s. By 1965, subsidence stopped throughout the Long Beach portion of the Wilmington Oil Field. Several bench marks recovered over one foot in elevation, due to waterflood repressuring. As an example, from 1960 to 1970, Bench Mark 1735, near the corner of Ocean Boulevard and Magnolia Avenue, recovered approximately one foot of elevation. The recovery of bench mark elevations is known as rebound.

The Alamitos Bay and Naples area had losses in elevation prior to development of the adjacent oil operations. These original small losses were most likely due to the regional effects of basin sediment compaction and tectonic movements along the Newport-Inglewood Fault Zone. Later, the coastal strip from the Civic Center eastward to the Alamitos Bay Peninsula lost elevation due to oil and gas production from the West Wilmington Oil Field and possibly the adjacent oil fields. The coastal strip rebounded slightly due to water injection from the offshore Oil Islands that began in 1965.

## **Survey Accuracy**

The May 2002 Elevation Leveling Campaign marked the conversion from spirit, first and second order rod leveling, to GPS surveying of bench mark elevations.

Through statistical analysis of satellite, base station, and mobile instrument geometries, a coincident spirit leveling and GPS bench mark elevation survey, City surveyors estimate the relative accuracy of GPS elevations to be 8 to 10 millimeters (0.025 foot or 0.30 inch). Areas are considered to be stable where elevation change is less than 0.050 foot (0.60 inch) over a six-month survey period.

Studies by the City's subsidence control engineers, geologists, and consultants show that the bench marks may, at times, rise and fall somewhat concurrently city-wide in such a manner as to make an entire survey either optimistic or pessimistic. These elevation changes are random and can be due to a variety of factors. Repressuring operations and the resulting rebound can mask the rise or fall pattern. Surface elevations in a rebounded area can be expected to fluctuate under changing water flood conditions. Because of these fluctuations, conclusions based upon short-term survey data should be viewed with caution. Short-term survey data are useful for possible early detection and confirmation of subsidence trends or relative elevation changes, but should not be accepted without consideration of the above factors. Annual survey data tend to average these fluctuations and depict a more dependable picture of the relative movements of bench marks.

## **Elevation Change Map Construction**

**(Figures 1, 2 and 3)**

All data are presented as contour lines showing the average change in surface elevation during a particular time period. For example, any point along a line reading 0.05 foot (0.60 inch) on an Elevation Change Map gained an elevation of one-twentieth of a foot or six-tenth of an inch during that period. The small hachures along contour lines point towards a loss in elevation.



Figure 1

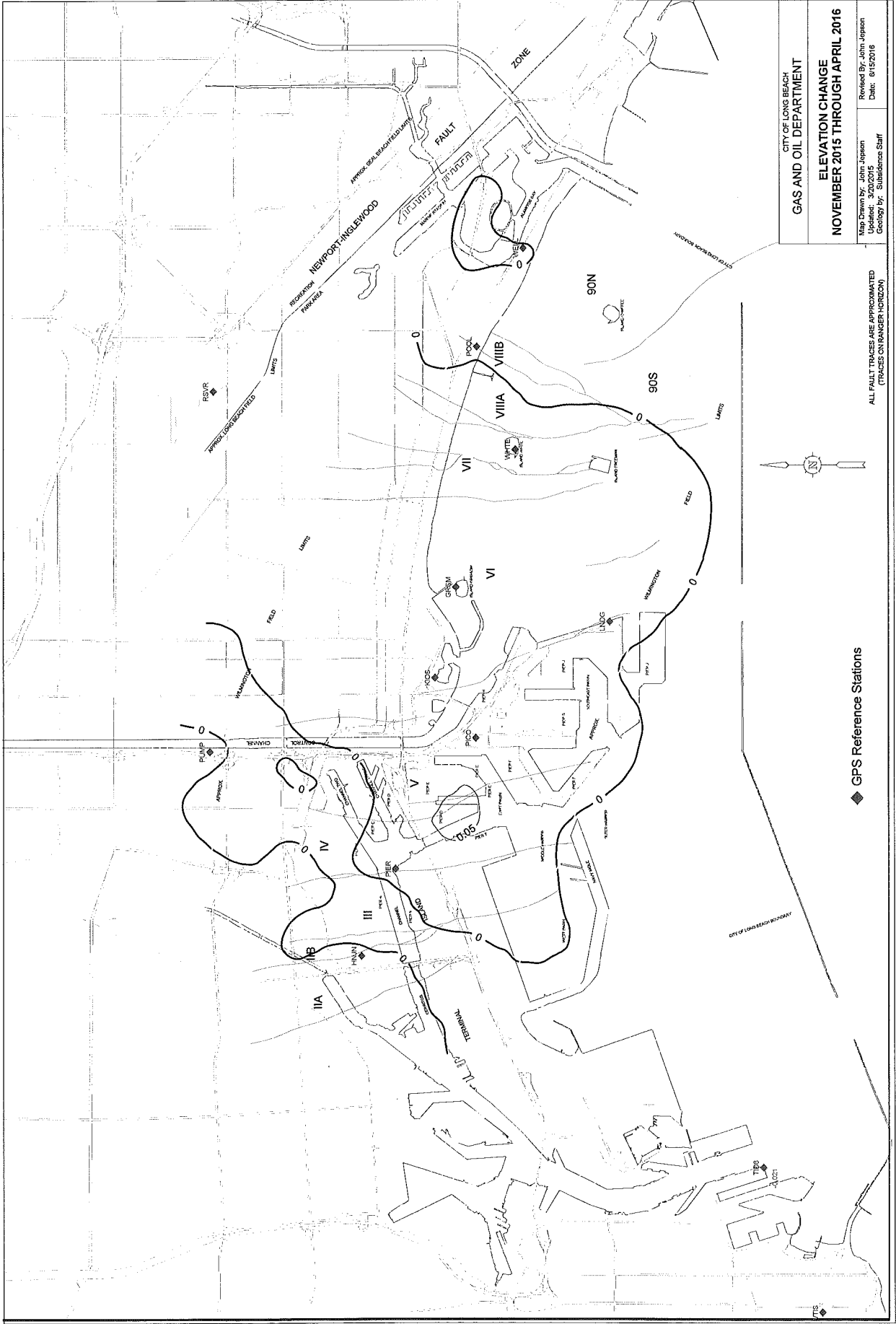


Figure 2

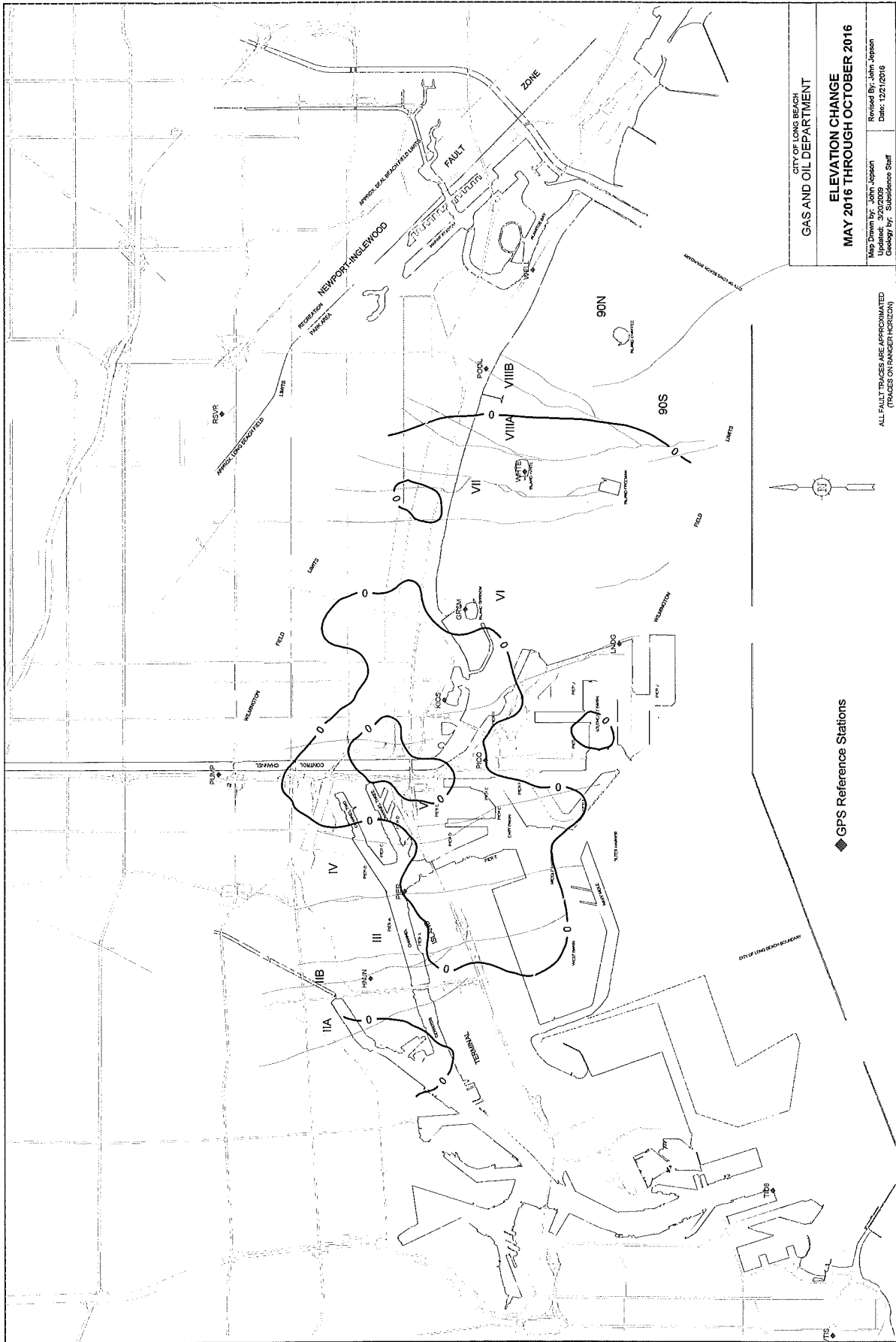


Figure 3

