



DEPARTMENT

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March 8, 2016

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, May 2015 through October 2015." (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 May 2015 through October 2015. 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 six-month survey show that elevations were stable in the Civic Center, Central City, Alamitos Bay, and Naples. The offshore area was stable except for a small area adjacent to Island Grissom, which experienced an increase of 0.09 foot (1.1 inch). The increase may have been due to increased injection in the area. In the Harbor District, Piers A and S experienced a decline of up to 0.07 foot (0.8 inch) during the six-month period. The decline is at the high end of normal limits and not expected to continue with continued mitigation measures.

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, temperature changes, and/or deep earth tectonic changes or re-pressuring operations. Surface elevations over the active Wilmington Oil Field can be expected to fluctuate under changing water flood conditions.

This matter was reviewed by Deputy City Attorney Richard F. Anthony on February 16, 2016 and by Budget Management Officer Victoria Bell on February 17, 2016.

HONORABLE MAYOR AND CITY COUNCIL
March 8, 2016
Page 2

TIMING CONSIDERATIONS

City Council action on this matter is not time critical.

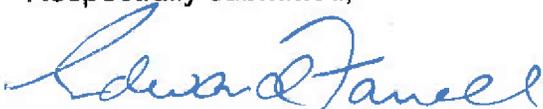
FISCAL IMPACT

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

SUGGESTED ACTION:

Approve recommendation.

Respectfully submitted,



EDWARD FARRELL
ACTING DIRECTOR OF LONG BEACH GAS AND OIL

EF:JJ

Attachment

APPROVED:



PATRICK H. WEST
CITY MANAGER

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

MAY 2015 THROUGH OCTOBER 2015

**PREPARED FOR
LONG BEACH CITY COUNCIL**

**BY THE
LONG BEACH GAS AND OIL DEPARTMENT**

CONTENTS

	<u>Page</u>
I. ELEVATION SURVEY ANALYSIS	
Elevation Change – May 2015 through October 2015	3
Elevation Change – November 2014 through October 2015.....	4
Use of Global Positioning System (GPS)	4
II. APPENDIX	
Brief History of Long Beach Subsidence	5
Survey Accuracy	6
Elevation Change Map Construction	6
III. ELEVATION CHANGE MAPS	<u>Figures</u>
May 2015 through October 2015	1
November 2014 through October 2015	2

ELEVATION SURVEY ANALYSIS

The City of Long Beach semi-annual elevation survey of the Civic Center, Central City, Harbor District, Alamitos Bay, Naples, and offshore drilling islands was conducted during November 2015. Changes in elevation that have occurred since the last two surveys, May 2015 and November 2014, 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 – May 2015 through October 2015

(Figure 1)

Elevations throughout the Alamitos Bay, Naples, Central City and the Civic Center were stable during the six-month period. The offshore islands were stable except for a small area adjacent to Island Grissom which experienced an increase of 0.09 foot (1.1 inch). The increase may have resulted from increased water injection in the area.

Piers in the eastern portion of the Harbor District were stable during the period. In the western portion of the Harbor District, Piers A and S experienced a decline of up to 0.07 foot (0.8 inch). LBGO continues to add mitigation measures for the area. The decline is not expected to continue and will be closely monitored for further remediation.

In the northern area of the Harbor District adjacent to the lease line with another operator, a small area of elevation decline of up to 0.05 foot (0.6 inch) was noted. LBGO will be closely monitoring its injection and production balance as well as the offset operator's in this area. Fluid migration patterns in the subsurface will be studied more closely to ascertain whether offset operator practices may have contributed to the observed pressure loss on the LBGO side of the field.

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 – November 2014 through October 2015

(Figure 2)

Elevations in the Alamos Bay, Naples, Civic Center, Central City and the offshore drilling islands were stable during the twelve-month period.

The Harbor District was stable during the twelve-month period with the exceptions of Piers A, J and S. Elevations on Pier J, adjacent to the Queen Mary, increased 0.06 foot (0.7 inch) and may have resulted from increased injection in the area. The eastern half of the Harbor District has stabilized compared to the previous year. Despite improvement in pressures in the subsurface as a result of considerable production shut-ins in Fault Blocks II and III, elevations on Piers A and S decreased by up to 0.10 foot (1.2 inches). LBGO has implemented additional mitigation measures and will continue to monitor the area with additional survey activities. Offset operator practices with respect to balancing production offtake and injection balance will also be critically reviewed for improvement.

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 Public Works Department's Bureau of Engineering surveyors utilize 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 1932. Oil operations accelerated subsidence and 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 not well understood. 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 and 2)

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.

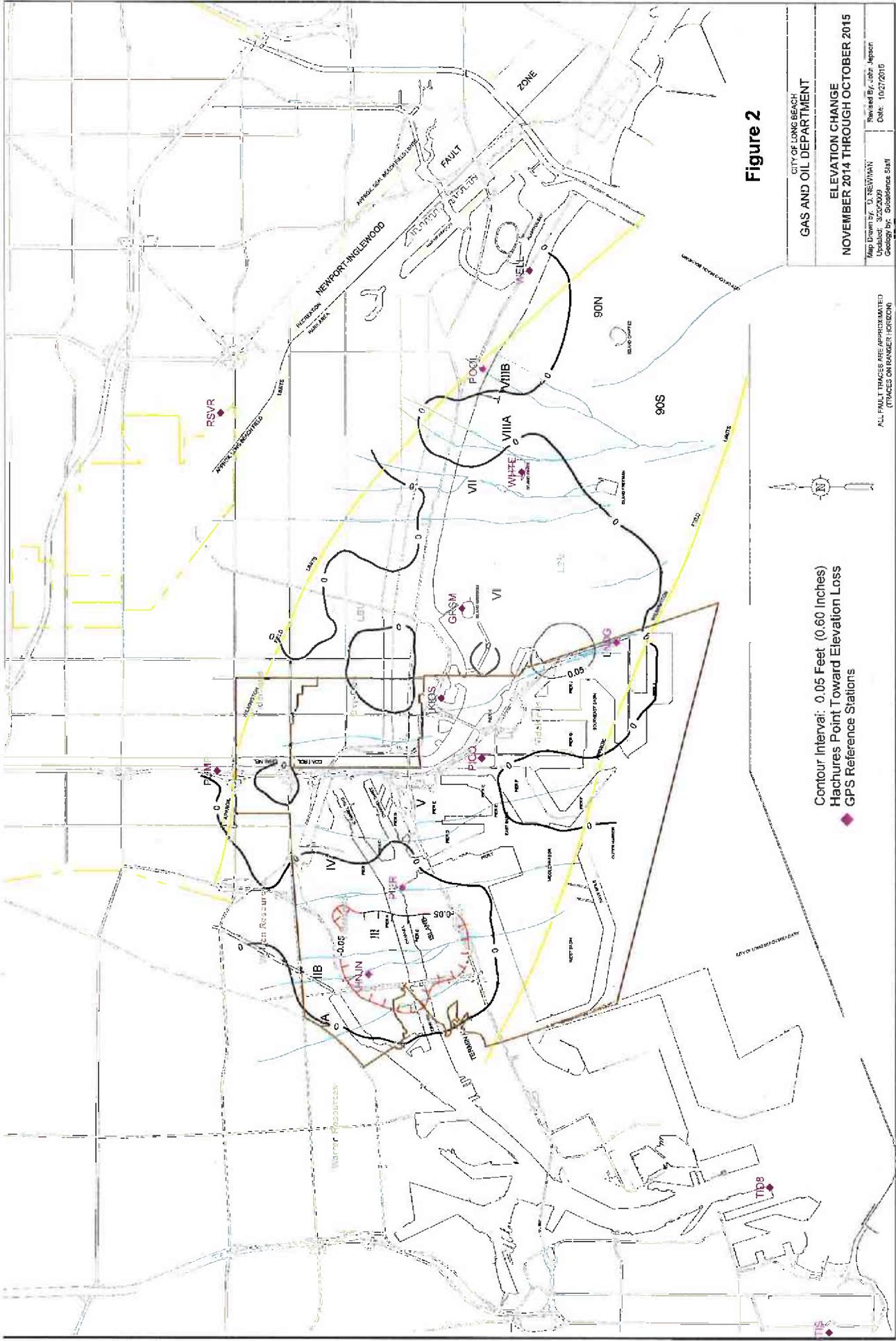


Figure 2

CITY OF LONG BEACH
 GAS AND OIL DEPARTMENT
 ELEVATION CHANGE
 NOVEMBER 2014 THROUGH OCTOBER 2015
 Map Drawn by: D. REWMAN Reviewed By: John Jepsen
 Updated: 3/20/2015 Date: 10/27/2015
 Geograph Inc. - SoCal Area Geograph Inc. - SoCal Area

Contour Interval: 0.05 Feet (0.60 Inches)
 Hachures Point Toward Elevation Loss
 ◆ GPS Reference Stations

ALL FAULT TRACES ARE APPROXIMATED
 (TRACES ON RANNEY-HORSON)