CITY OF
LONG BEACH

Long Beach Energy Resources
2400 East Spring Street, Long Beach, CA 90806
(562) 570-2000

C-7

March 22, 2022

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 2020 through November 2021." (Citywide)

DISCUSSION

The City of Long Beach (City), through the Energy Resources Department (Energy Resources), supervises oil production and subsidence control operations in the Wilmington Oil Field. Energy Resources 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 2020 through November 2021. The Energy Resources 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, Naples, the offshore islands, and the City north of Wilmington Oil Field. During the first six-month period, the Alamitos Beach shoreline experienced a rise in elevation of up to 0.06 foot (0.7 inch), a trend that reversed during the second half of the year, possibly due to temporary changes in fluid injection volume. The decline is not expected to continue. The central portion of the Harbor District experienced an annual rise in elevation of as much as 0.08 foot (1 inch). The northwest corner of the Harbor District experienced an annual decline in elevation of as much as 0.07 foot (0.8 inch). The elevation changes are minor, and fluid injection and production will be closely monitored and adjusted to mitigate future changes. Finally, elevation changes of up 0.1 foot (1.2 inches) were observed outside of the Wilmington Oil Field operated areas, specifically near the Recreation Park District, Marine Stadium and the Colorado Lagoon. The changes are considered minor and are possibly due to normal tectonic movement along the active Palos Verdes and Newport-Inglewood fault zones.

The Energy Resources survey uses a series of benchmarks to determine elevation changes. Studies by Energy Resource's engineers and geologists show 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, dewatering activities, and/or re-pressuring operations in the oil field. Surface elevations over the active Wilmington Oil Field can be expected to fluctuate under changing waterflood conditions.

This matter was reviewed by Deputy City Attorney Richard F. Anthony on February 22, 2022 and by Revenue Management Officer Geraldine Alejo on March 3, 2022.

TIMING CONSIDERATIONS

City Council action on this matter is not time critical.

FISCAL IMPACT

This recommendation has no staffing impact beyond the budgeted scope of duties and is consistent with existing City Council priorities. There is no fiscal or local job impact associated with this recommendation.

SUGGESTED ACTION:

Approve recommendation.

Respectfully submitted,

ROBERT M. DOWELL
DIRECTOR OF ENERGY RESOURCES

ATTACHMENT: ELEVATION CHANGES REPORT

APPROVED:

THOMAS B. MODICA
CITY MANAGER

ELEVATION CHANGES
IN THE
CITY OF LONG BEACH

NOVEMBER 2020 THROUGH NOVEMBER 2021

PREPARED

FOR

LONG BEACH CITY COUNCIL

BY THE

ENERGY RESOURCES DEPARTMENT

CONTENTS

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 2021 and November 2021. Annual and semi-annual changes in elevation that have occurred since the last three surveys, November 2020, May 2021 and November 2021, are discussed in this report. The results in this report reflect elevation changes both within and beyond the influence of oil field operations, as some changes are due to natural geologic factors.

Elevation Change – November 2020 through May 2021 (Figure 1)

Elevations in Naples, Central City, Civic Center, the offshore islands, and the City of Long Beach north of Wilmington Oil Field were stable during this six-month period.

The Piers in the Harbor District were also stable during this period, with minor elevation changes observed in small areas of both Piers A and T. The elevations of the northeast portion of Pier T and the southeast corner of Pier A rose by as much as 0.07 foot (0.8 inch). Pier A West declined by as much as 0.06 foot (0.7 inch). The elevation changes are considered minor and are within normal limits for field operations.

The Alamitos Beach shoreline experienced a rise in elevation of up to 0.06 foot (0.7 inch). The elevation increase did not continue into the second half of the year.

Minor elevation changes were observed outside of Wilmington Oil Field operated areas within the Palos Verdes and Newport-Inglewood fault zones. Elevation decreases of as much as 0.08 foot (1 inch) were observed in several areas including: the Marine Stadium marina, the shoreline adjacent to the Los Cerritos Channel, and PCH, west of Anaheim Bay. A rise of up to 0.06 foot (0.7 inch) was observed near Recreation Park district, and the Port of Los Angeles. The elevation changes are considered minor and are possibly due to normal tectonic movement along the active Palos Verdes and Newport-Inglewood fault zones.

Elevation Change – May 2021 through November 2021 **(Figure 2)**

Elevations throughout the Alamitos Bay, Naples, Central City, Civic Center, the offshore islands, and the City of Long Beach north of Wilmington Oil Field were stable during this six-month period.

The Piers in the Harbor District were also stable during this period, with minor elevation changes observed at Piers A, S and T. The eastern half of Pier S experienced an elevation increase of as much as 0.09 foot (1.1 inches). The elevation changes are minor, and fluid injection and production will be closely monitored and adjusted to mitigate future changes. A minor decline of up to 0.06 foot (0.7 inch) was observed on the northern edges of Pier A and Pier A West, and the southern portion of Pier T.

The Alamitos Beach shoreline experienced a decline in elevation of up to 0.08 foot (1 inch) during the six-month period. The elevation change is minor and likely due to temporary changes in fluid injection volume. The decline is not expected to continue.

Elevation changes observed along the Palos Verdes and Newport-Inglewood fault zones in the first six-month period continued into the second half of the year. A decline in elevation up to 0.05 foot (0.6 inch) was observed near the Colorado Lagoon, adjacent to the Newport-Inglewood fault zone. The Recreation Park District experienced a rise in elevation of 0.1 foot (1.2 inches). A decline in elevation of as much as 0.05 foot (0.6 inch) was observed on the western corner of Terminal Island, adjacent to the Palos Verdes fault zone. The elevation changes are considered minor and are possibly due to normal tectonic movement along the active Palos Verdes and Newport-Inglewood fault zones.

Elevation Change – November 2020 through November 2021 **(Figure 3)**

Elevations throughout the Alamitos Bay, Naples, Central City, Civic Center, the offshore islands, and the City of Long Beach north of Wilmington Oil Field were stable during the twelve-month period.

Piers A, D, E and T in the central part of the Harbor District experienced an annual rise of up to 0.08 foot (1 inch). An annual elevation decline of up to 0.07 foot (0.8 inch) was observed in the northwest portion of the Harbor District in Pier A and Pier A West. An elevation decline of 0.06 foot (0.7 inch) was also observed on the shoreline northwest of Island Grissom. The elevation changes are minor, and fluid injection and production will be closely monitored and adjusted to mitigate future changes.

Annual elevation changes were observed outside of Wilmington Oil Field operated areas adjacent to the Palos Verdes and Newport-Inglewood fault zones. A rise of as much as 0.08 foot (1 inch) was observed near the Recreation Park District. A decline of 0.06 foot (0.7 inch) was observed in the Port of Los Angeles adjacent to the Palos Verdes fault zone. The elevation changes are minor and are possibly due to normal tectonic movement along the active Palos Verdes and Newport-Inglewood fault zones.

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 14 permanent reference GPS base stations, communication equipment, computer server, monitoring software and five mobile GPS receivers. The Long Beach Energy Resources surveyors and contract 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 include: 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

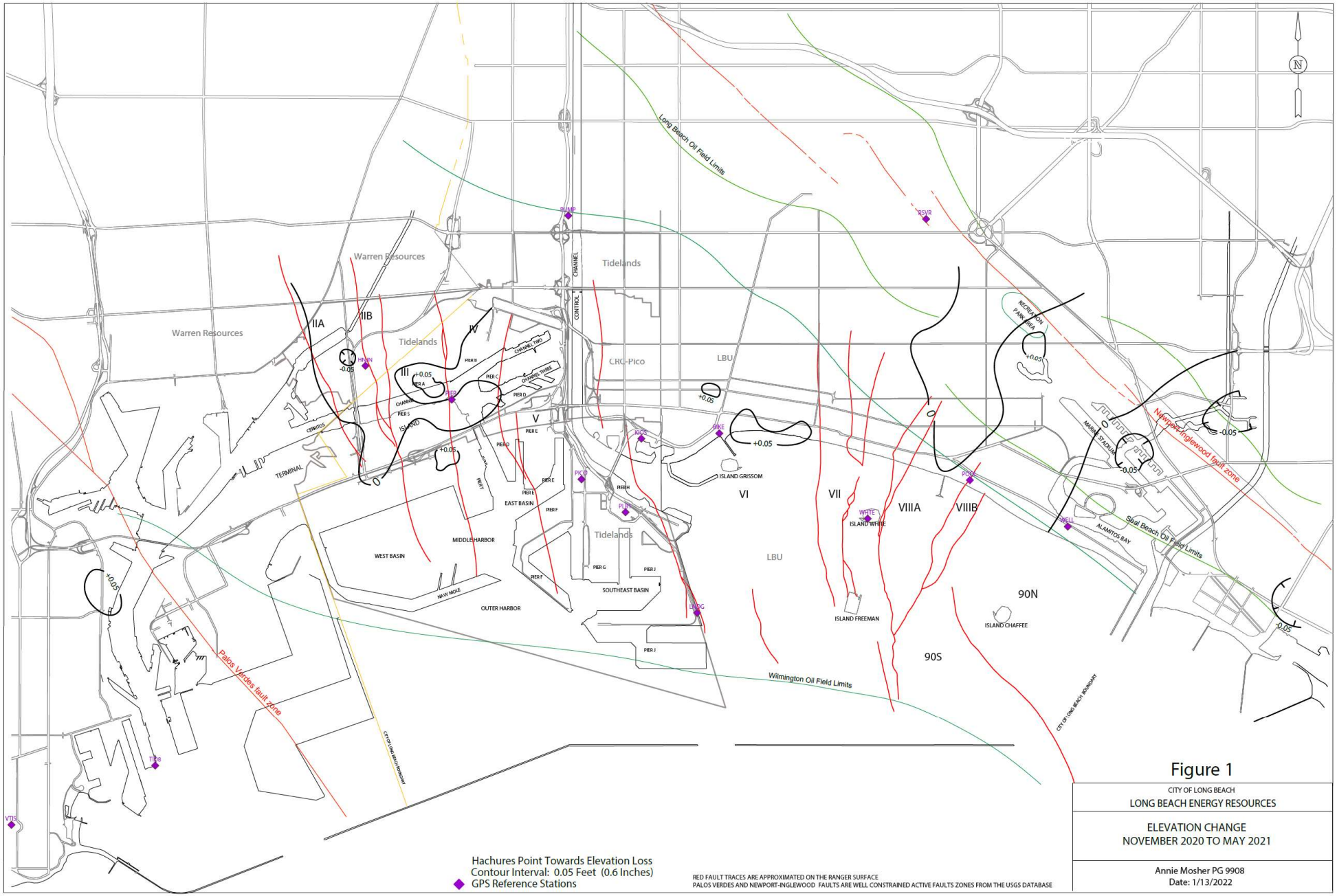
The May 2002 Elevation Leveling Campaign marked the conversion from spirit, first and second order rod leveling, to GPS surveying of bench mark elevations.

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 (0.6 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.



Hachures Point Towards Elevation Loss
Contour Interval: 0.05 Feet (0.6 Inches)
GPS Reference Stations

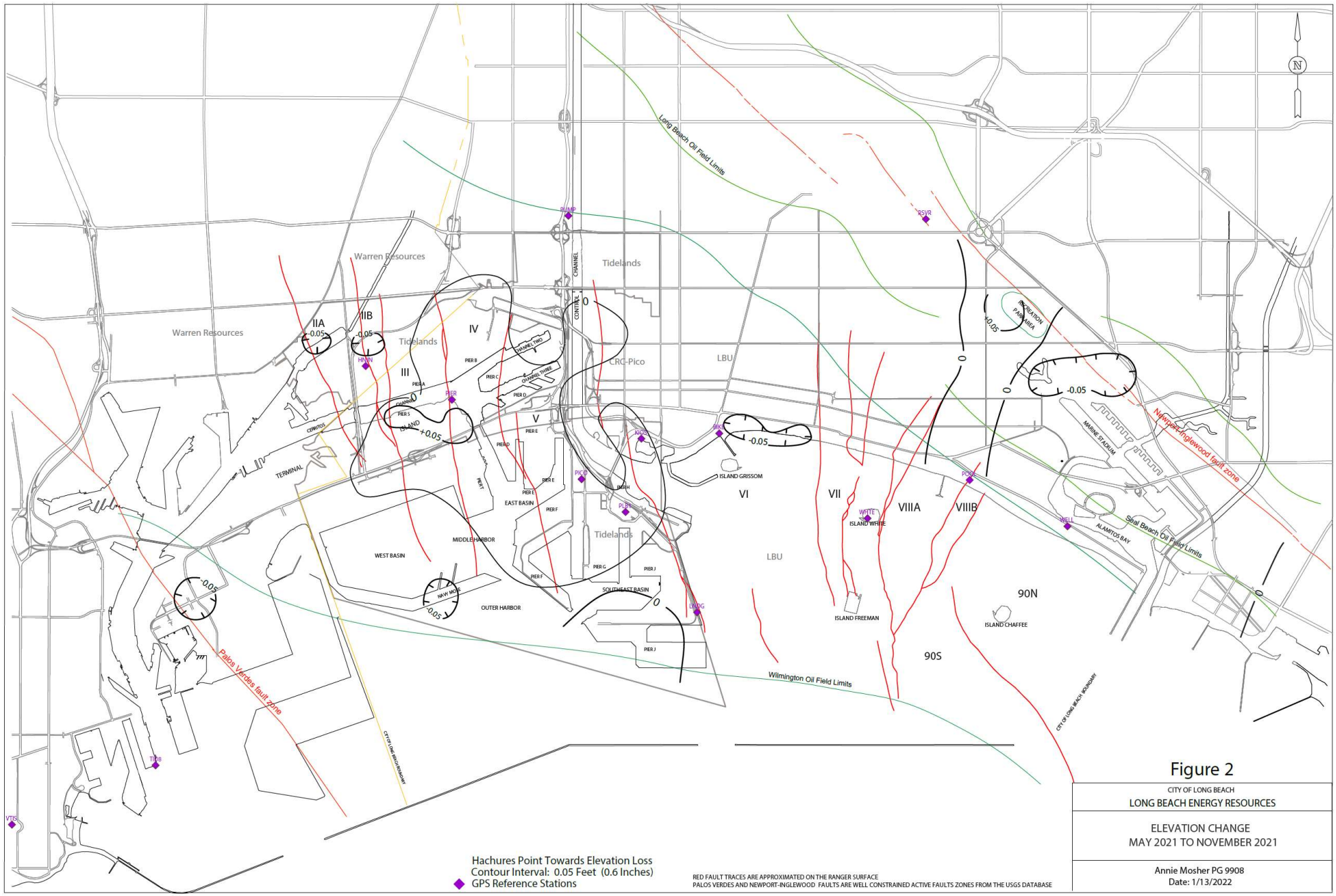
RED FAULT TRACES ARE APPROXIMATED ON THE RANGER SURFACE
PALOS VERDES AND NEWPORT-INGLEWOOD FAULTS ARE WELL CONSTRAINED ACTIVE FAULTS ZONES FROM THE USGS DATABASE

Figure 1

CITY OF LONG BEACH
LONG BEACH ENERGY RESOURCES

ELEVATION CHANGE
NOVEMBER 2020 TO MAY 2021

Annie Mosher PG 9908
Date: 1/13/2022



Hachures Point Towards Elevation Loss
Contour Interval: 0.05 Feet (0.6 Inches)
GPS Reference Stations

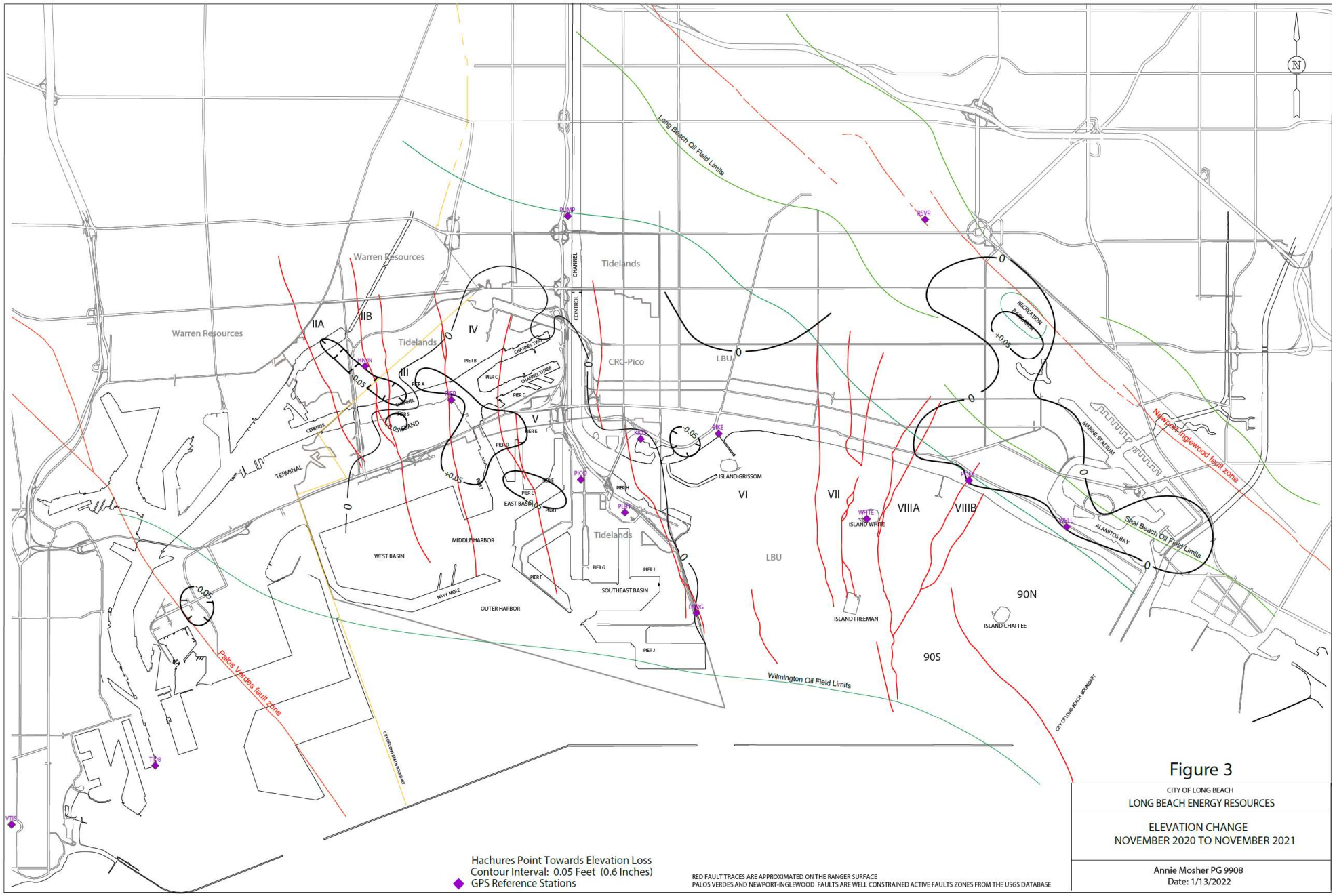
RED FAULT TRACES ARE APPROXIMATED ON THE RANGER SURFACE
PALOS VERDES AND NEWPORT-INGLEWOOD FAULTS ARE WELL CONSTRAINED ACTIVE FAULTS ZONES FROM THE USGS DATABASE

Figure 2

CITY OF LONG BEACH
LONG BEACH ENERGY RESOURCES

ELEVATION CHANGE
MAY 2021 TO NOVEMBER 2021

Annie Mosher PG 9908
Date: 1/13/2022



Hachures Point Towards Elevation Loss
Contour Interval: 0.05 Feet (0.6 Inches)
GPS Reference Stations

RED FAULT TRACES ARE APPROXIMATED ON THE RANGER SURFACE
PALOS VERDES AND NEWPORT-INGLEWOOD FAULTS ARE WELL CONSTRAINED ACTIVE FAULTS ZONES FROM THE USGS DATABASE

Figure 3

CITY OF LONG BEACH
LONG BEACH ENERGY RESOURCES

ELEVATION CHANGE
NOVEMBER 2020 TO NOVEMBER 2021

Annie Mosher PG 9908
Date: 1/13/2022