CITY OF
LONG BEACH

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

March 21, 2023

C-10

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 2021 through November 2022." (Citywide)

DISCUSSION

The City of Long Beach (City), through the Energy Resources Department (ER), supervises oil production and subsidence control operations in the Wilmington Oil Field. ER conducts surface elevation surveys every six months to monitor surface elevation changes in the oil fields and adjacent city areas. This report focuses on surface elevation changes that have occurred from November 2021 through November 2022. The ER 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 surface elevations were stable in the Civic Center, Central City, Alamitos Bay, Naples, and the offshore islands. During the first six-month period rises were observed in the Harbor District and Shoreline Village area of up to 0.067 foot (0.80 inch) and 0.055 foot (0.66 inch), respectively. These surface elevation changes are considered minor and are likely due to changes in injection volumes within the Wilmington Oil Field. Surface elevation rises of up to 0.069 foot (0.83 inch) were observed in the Port of Los Angeles and near Recreation Park. These changes are considered minor and are possibly due to normal tectonic movement along the active Palos Verdes and Newport-Inglewood fault zones.

The rising trend observed in the Harbor District during the first six-month period reversed in the second six-month period, resulting in a surface elevation loss of as much as 0.074 foot (0.88 inch). This surface elevation loss was expected due to controlled changes in fluid injection volumes. Additional surface elevation changes of up 0.061 foot (0.73 inch) were observed outside of the Wilmington Oil Field operated areas, specifically near Recreation Park, the southwest corner of Pier J and north of 7th Street. An annual surface elevation loss of as much as 0.093 foot (1.1 inches) was observed in the Harbor District and along the shoreline of Alamitos Beach. All semi-annual and annual surface elevation changes are considered minor and are being closely monitored.

The ER survey uses a series of benchmarks to determine surface elevation changes. Studies by ER'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 surface 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 27, 2023 and by Revenue Management Officer Geraldine Alejo on March 6, 2023.

TIMING CONSIDERATIONS

City Council action on this matter is not time critical.

FISCAL IMPACT

This recommendation has no staffing impact beyond the normal 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

APPROVED:

THOMAS B. MODICA
CITY MANAGER

ATTACHMENT: ELEVATION CHANGES REPORT

ELEVATION CHANGES
IN THE
CITY OF LONG BEACH

NOVEMBER 2021 THROUGH NOVEMBER 2022

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 2022 and November 2022. Annual and semi-annual changes in elevation that have occurred since the last three surveys, November 2021, May 2022 and November 2022, 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. All semi-annual and annual elevation changes described in this report are considered minor and are being closely monitored.

Elevation Change – November 2021 through May 2022 (Figure 1)

Elevations in the Civic Center, Central City, Alamitos Bay, Naples, the offshore islands, the shoreline, 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 survey period, with a minor elevation increase of as much as 0.067 foot (0.80 inch) observed in small areas of both Piers A and S, directly onshore from the Cerritos Channel. Minor elevation rises of as much as 0.061 foot (0.73 inch) were also observed near the Navy Mole in the southern portion of Pier T and in Shoreline Village adjacent to the Rainbow Harbor. The elevation changes observed in the first six-month period are considered minor; however, fluid injection volumes were closely monitored in the Harbor District to mitigate further elevation gains into the second six-month survey period.

Minor elevation rises of up to 0.069 foot (0.83 inch) were observed outside of Wilmington Oil Field operated areas within the Port of Los Angeles and near Recreation Park. These changes are considered minor and are possibly due to normal tectonic movement along the Palos Verdes and Newport-Inglewood Fault zones.

Elevation Change – May 2022 through November 2022 **(Figure 2)**

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

The rising trend observed in the Harbor District during the first six-month period reversed in the second six-month survey period, resulting in an elevation loss of as much as 0.074 foot (0.88 inch). This minor elevation loss was expected due to controlled changes in fluid injection volume. Additionally, an elevation loss of 0.055 foot (0.66 inch) was observed on the southwest corner of Pier J. The elevation changes are minor, and fluid injection and production rateswill be closely monitored and adjusted to mitigate future changes.

Minor elevation rises of up to 0.053 foot (0.64 inch) were observed north of 7th Street and and north of Wilmington Oil Field. An elevation loss of as much as 0.061 foot (0.73 inch) was observed east of Recreation Park, adjacent to the Newport-Inglewood Fault. These elevation changes are minor and are not considered to be related to oilfield operations.

Elevation Change – November 2021 through November 2022 **(Figure 3)**

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

Minor annual elevation changes were observed in the Harbor District. Elevation losses of as much as 0.093 foot (1.1 inches) were observed on Piers A and S, directly onshore from the Cerritos Channel. This was a continuation of the minor elevation losses recorded in the first six-month elevation survey period. A decline in elevation of as much as 0.056 foot (0.67 inch) was observed on Piers T and D, directly south of the Long Beach International Gateway Bridge. These elevation changes are considered minor and are being closely monitored.

The Alamitos Beach shoreline and Shoreline Village experienced minor annual elevation changes. A rise of as much as 0.060 foot (0.72 inch) was observed in Shoreline Village, directly onshore from Rainbow Harbor. An elevation loss of as much as 0.068 foot (0.82 inch) extended from the eastern portion of Shoreline Village to the Alamitos Beach shoreline. The elevation change is minor and likely due to temporary changes in fluid injection volume. The decline is being closely monitored and is not expected to continue.

Use of Global Positioning System (GPS)

This report is based solely upon computer processed data utilizing the City of Long Beach Real Time Network (CLBRTN). The CLBRTN 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 (loss 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

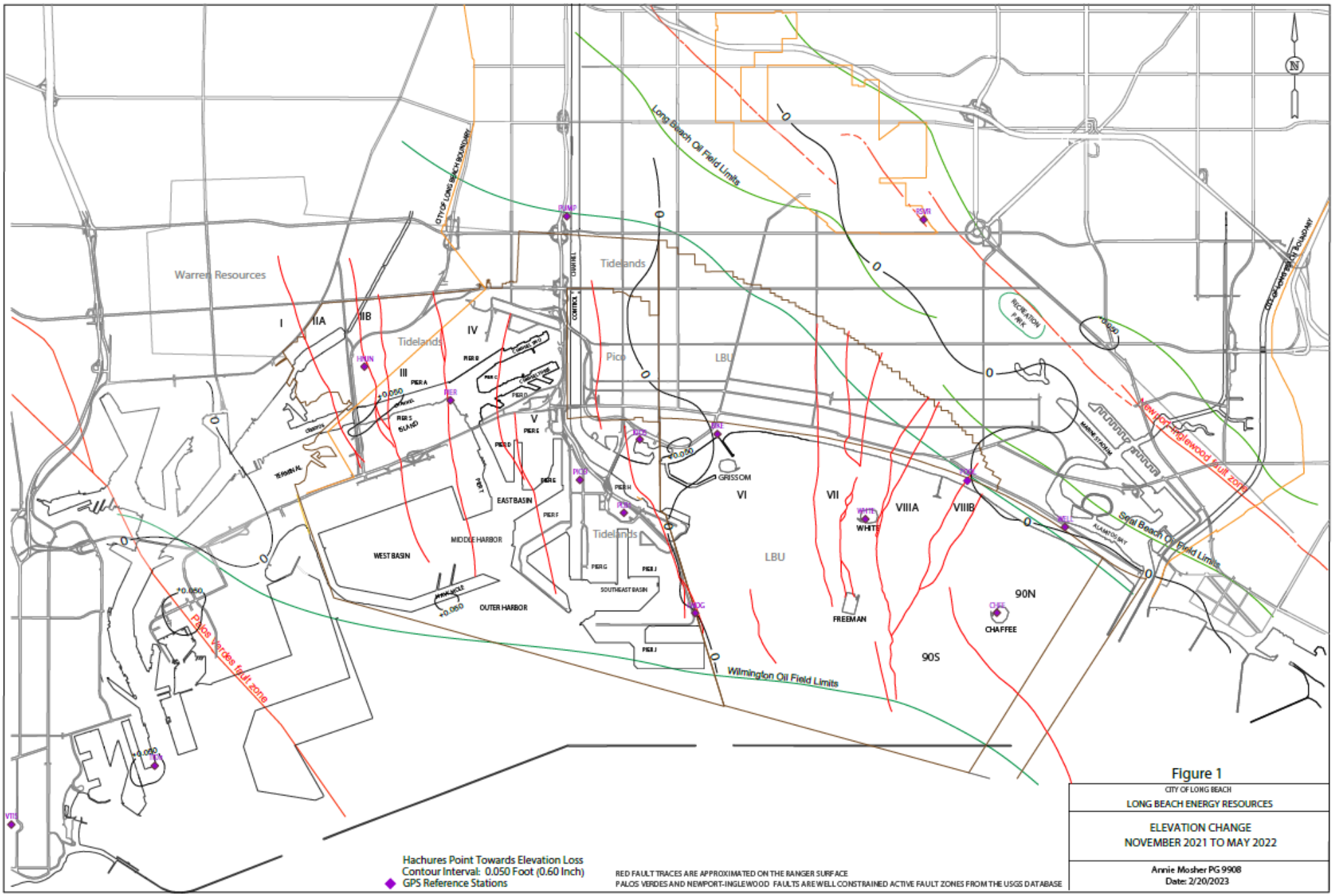
The May 2002 Elevation Leveling Campaign marked the conversion from spirit, first and second order rod leveling, to GPS surveying of bench mark elevations.

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 waterflood 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 0.050 foot (0.60 inch) on an Elevation Change Map is presumed to have 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: 0.050 Foot (0.60 Inch)
GPS Reference Stations

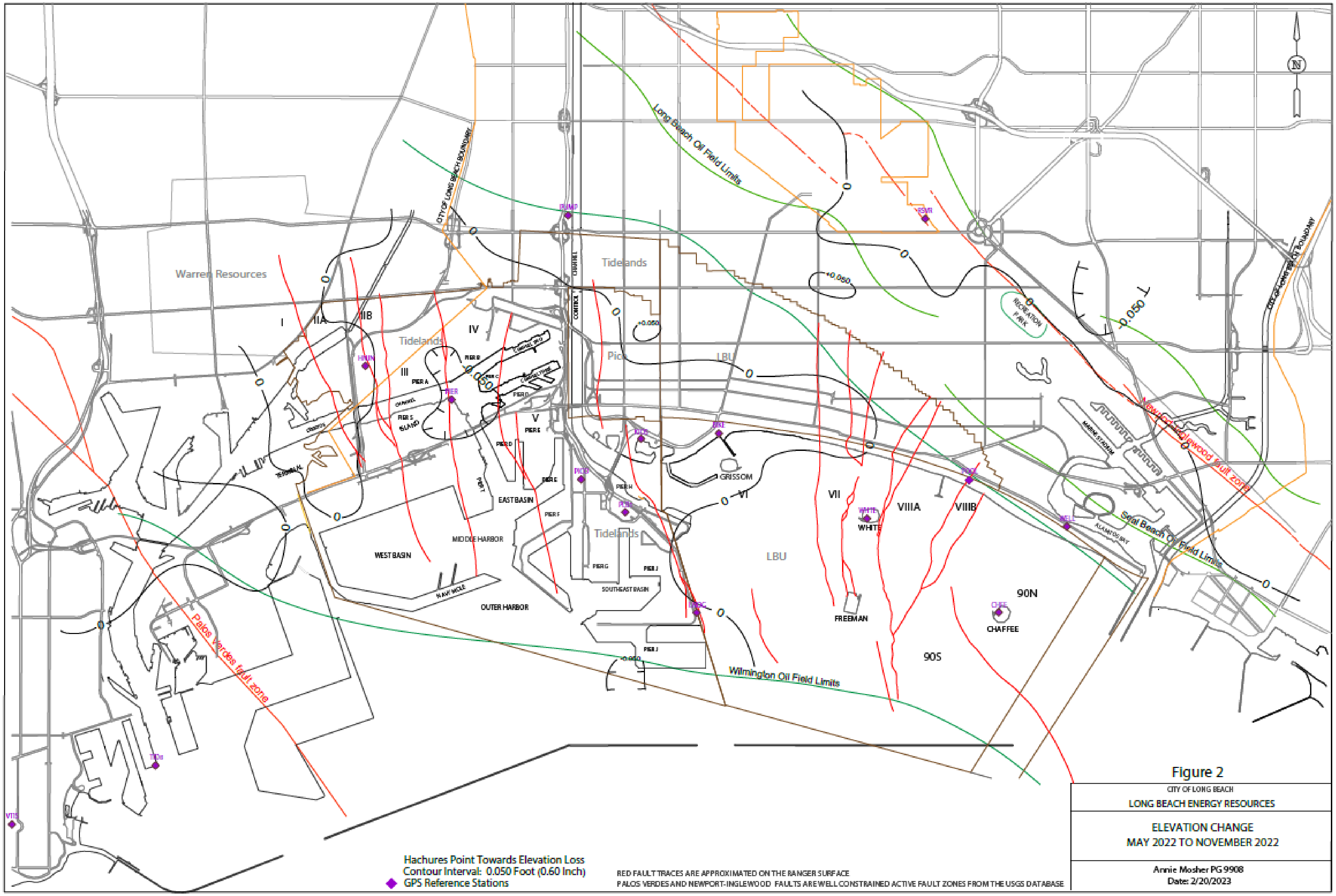
RED FAULT TRACES ARE APPROXIMATED ON THE RANGER SURFACE
PALOS VERDES AND NEWPORT-INGLEWOOD FAULTS ARE WELL CONSTRAINED ACTIVE FAULT ZONES FROM THE USGS DATABASE

Figure 1

CITY OF LONG BEACH
LONG BEACH ENERGY RESOURCES

ELEVATION CHANGE
NOVEMBER 2021 TO MAY 2022

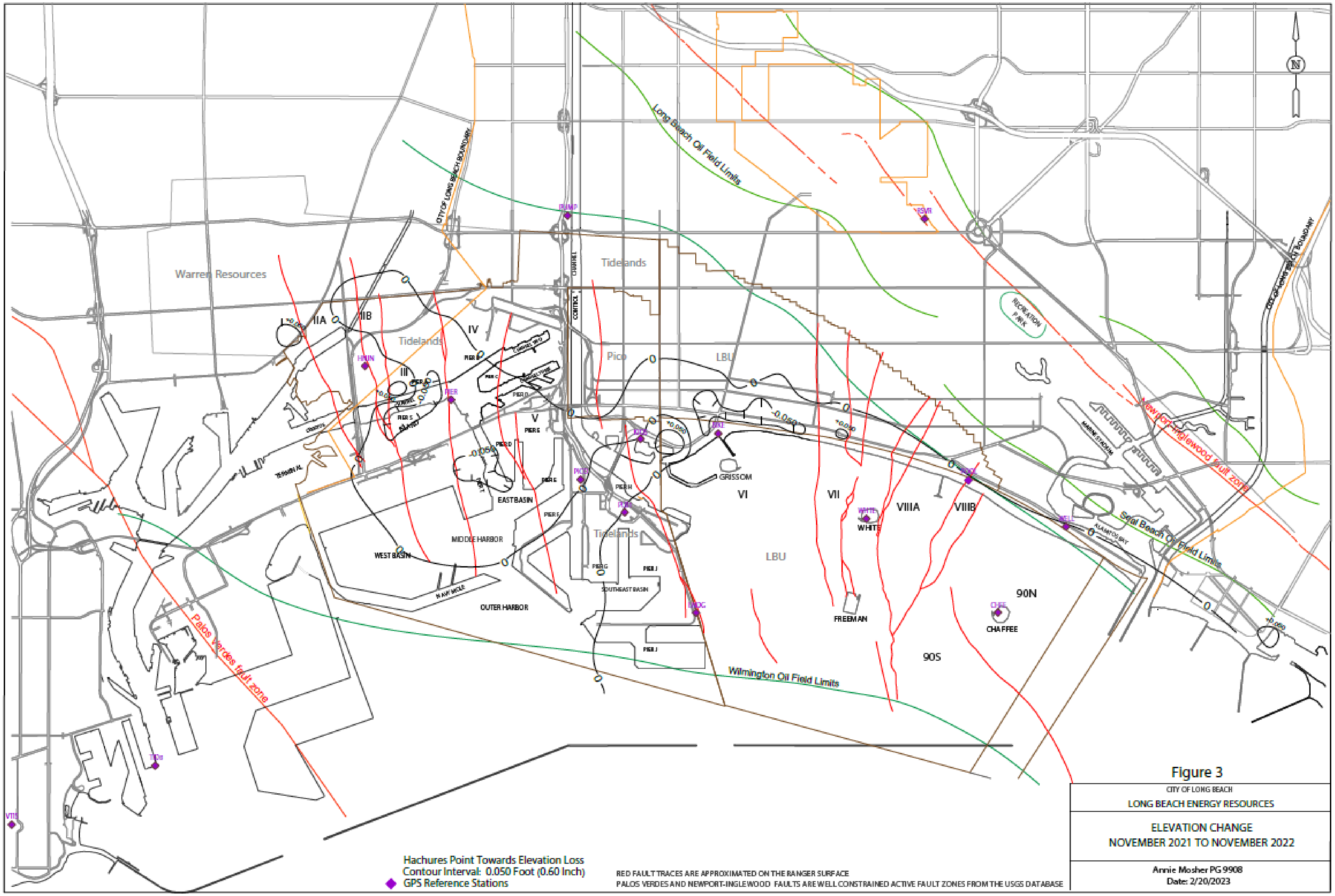
Annie Mosher PG 9908
Date: 2/20/2023


Warren Resources
Tidelands
Tidelands
Tidelands
Pico
LBU
LBU
Long Beach Oil Field Limits
Wilmington Oil Field Limits
Seal Beach Oil Field Limits
Palos Verdes fault zone
Newport-Inglewood fault zone
CITY OF LONG BEACH BOUNDARY
CITY OF LONG BEACH BOUNDARY
I
IIA
IIB
III
IV
V
VI
VII
VIIIA
VIIIB
90N
90S
WEST BASIN
MIDDLE HARBOR
EAST BASIN
OUTER HARBOR
SOUTHEAST BASIN
NAVY MOLE
PIER A
PIER B
PIER C
PIER D
PIER E
PIER F
PIER G
PIER H
PIER J
PIER S
PIER T
TERMINAL ISLAND
CONTROL CHANNEL
GRISSOM
WHITE
FREEMAN
CHAFFEE
RECREATION PARK
MARINE STADIUM
ALAMITOS BAY
+0.050
+0.050
+0.050
-0.050
-0.050
0
N

Hachures Point Towards Elevation Loss
Contour Interval: 0.050 Foot (0.60 Inch)
◆ GPS Reference Stations

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

Figure 2
CITY OF LONG BEACH
LONG BEACH ENERGY RESOURCES
ELEVATION CHANGE
MAY 2022 TO NOVEMBER 2022
Annie Mosher PG 9908
Date: 2/20/2023



Hachures Point Towards Elevation Loss
Contour Interval: 0.050 Foot (0.60 Inch)
◆ GPS Reference Stations

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Figure 3

CITY OF LONG BEACH
LONG BEACH ENERGY RESOURCES

ELEVATION CHANGE
NOVEMBER 2021 TO NOVEMBER 2022

Annie Mosher PG 9908
Date: 2/20/2023