



March 8, 2011

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 2010 through October 2010." (Citywide)

DISCUSSION

The City of Long Beach (City), 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 2010 through October 2010. The LBGO survey includes the following areas: Civic Center, Central City, Alamitos Bay, Naples, Harbor District, and an offshore area encompassing the four offshore oil islands.

The results of the six-month survey show that elevations were stable in the Civic Center, Central City, Alamitos Bay, Naples, and the Harbor District. A portion of the offshore area surrounding Island Grissom experienced an elevation gain of up to 0.096 feet (1.2 inches). LBGO is mitigating the elevation change in this area by decreasing water injection requirements.

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 in a rebounded area can be expected to fluctuate under changing water flood conditions.

This item was reviewed by Deputy City Attorney Richard F. Anthony and by Budget Management Officer Victoria Bell on February 14, 2011.

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TIMING CONSIDERATIONS

City Council action on this matter is not time critical.

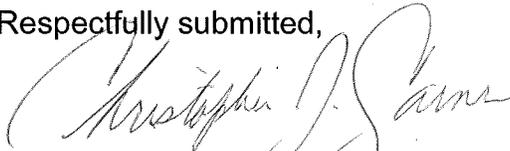
FISCAL IMPACT

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

SUGGESTED ACTION:

Approve recommendation.

Respectfully submitted,



CHRISTOPHER J. GARNER
DIRECTOR OF LONG BEACH GAS AND OIL

CJG:JDJ:lld
03-08-11 Elevation Report

Attachment

APPROVED:



PATRICK H. WEST
CITY MANAGER

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

MAY 2010 THROUGH OCTOBER 2010

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 survey of the Civic Center, Central City, Harbor District, Alamitos Bay, Naples, and offshore areas was conducted during November 2010. Changes in elevation that have occurred since the last two surveys, May 2010 and November 2009, are discussed in this report. The results in this report reflect elevation changes both within and beyond the scope of oilfield operations. Some changes are due to natural geologic factors.

Elevation Change – May 2010 through October 2010 (Figure 1)

Elevations throughout the Civic Center, Alamitos Bay, and Naples area were stable during the six-month period. A portion of the offshore area surrounding Island Grissom experienced an elevation gain of up to 0.096 feet (1.2 inches). LBGO is mitigating the elevation change in this area by decreasing water injection requirements.

The Harbor District remained stable with the exception of Pier S. Pier S experienced an elevation increase of up to 0.063 feet (0.76 inches). The elevation increase was the result of increased water injection requirements by LBGO during the last six months.

Elevations in the City of Long Beach beyond the boundaries of the Wilmington Oil Field were stable. Minor elevation changes in geologically active areas outside the Wilmington Oil Field indicate that this six-month period was an “up” period semi-regionally.

Elevation Change – November 2009 through October 2010 (Figure 2)

Elevations in the Central City and offshore areas near Island Grissom experienced an elevation increase of up to 0.14 feet (1.6 inches) during the 12-month period. LBGO is mitigating the elevation increase by lowering water injection requirements. Elevations throughout the Central City, Alamitos Bay, and Naples areas remained stable during the 12-month period.

The Harbor District was stable during the 12-month period with one exception. Piers A, S, and T experienced an elevation loss of up to 0.073 feet (0.88 inches). The elevation loss is within the range of recent elevation changes in the area. There is no reason for concern as LBGO is mitigating the elevation changes by increasing and realigning water injection.

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 twelve (12) 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 feet (-0.43 inches) 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 (Figure 6). 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.

In the 1990s, a large Harbor redevelopment project on Pier A destroyed several bench marks that overlaid the now curtailed steamflood project. Elevation losses in the area were suspected, and the destruction of these bench marks made it difficult to monitor any changes. In 1998, after the bench marks were replaced, additional well bore investigations determined that subsurface compaction of the deep shale intervals was occurring above the steam flooded zones due to high temperatures. The Fault Block II

Tar Zone Steamflood was terminated in 1999, and cold-water injection was initiated. The forced cooling of the deep formations has remedied the subsidence problem.

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, mobile instrument geometries, a coincident spirit leveling and GPS bench mark elevation survey, City surveyors estimate the accuracy of GPS elevations to be 8 to 10 millimeters (0.025 feet or 0.30 inches). Areas are considered to be stable where elevation change is less than 0.025 feet (0.30 inches).

Studies by the City's subsidence control engineers, geologists, and consultants show that the bench marks may at times rise and fall somewhat rhythmically 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 feet (0.60 inches) on an Elevation Change Map gained an elevation of one-twentieth of a foot or six-tenths of an inch during that period. The small hachures along contour lines point towards a loss in elevation.

Bench Mark Location Map (Figure 3)

This map shows the location of bench marks used for the Bench Mark and Net Injection Graphs.

Bench Mark and Net Injection Graphs, Harbor District (Figures 4 – 7)

The bench marks are normalized to mean sea level. Bench marks are plotted each time they are surveyed and are shown on a graph with a history of net injection for that same area and time. The net injection is the amount of water injected into the reservoirs that underlie that particular bench mark minus the gross fluid produced from the reservoirs in barrels per day. The graphs cover 20 years of net injection and bench mark monitoring.

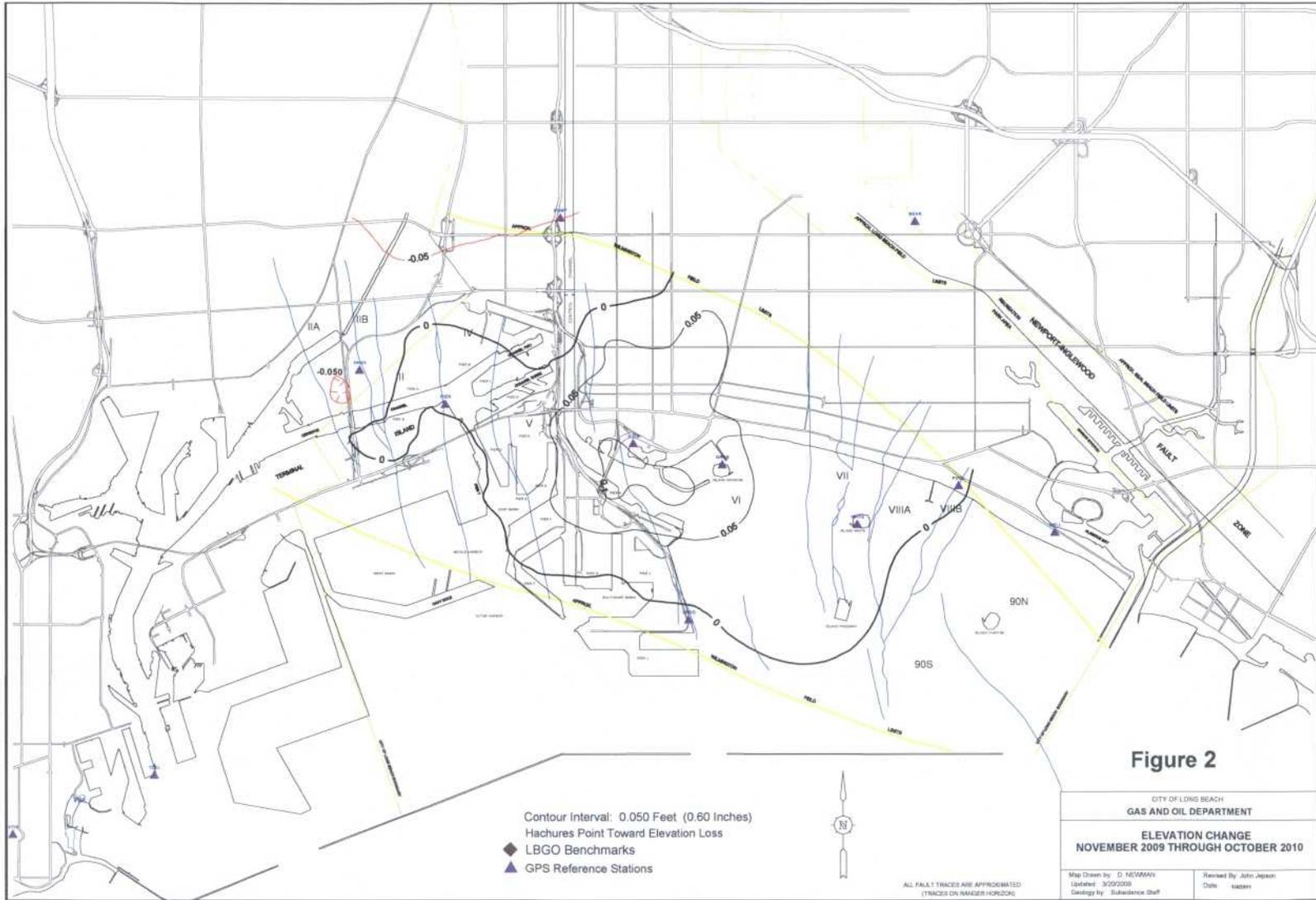
In general, these graphs show a good correlation between the net injection and elevation change. For example, an increase in net injection is usually followed by an increase in elevation. There tends to be a lag time of months and sometimes years between the net injection change and the subsequent elevation change. The elevation plots of bench marks on Figures 4 through 7 in the Harbor District illustrate surface elevation fluctuations that can be expected to occur under the dynamic reservoir conditions experienced in extremely mature waterflooding operations.

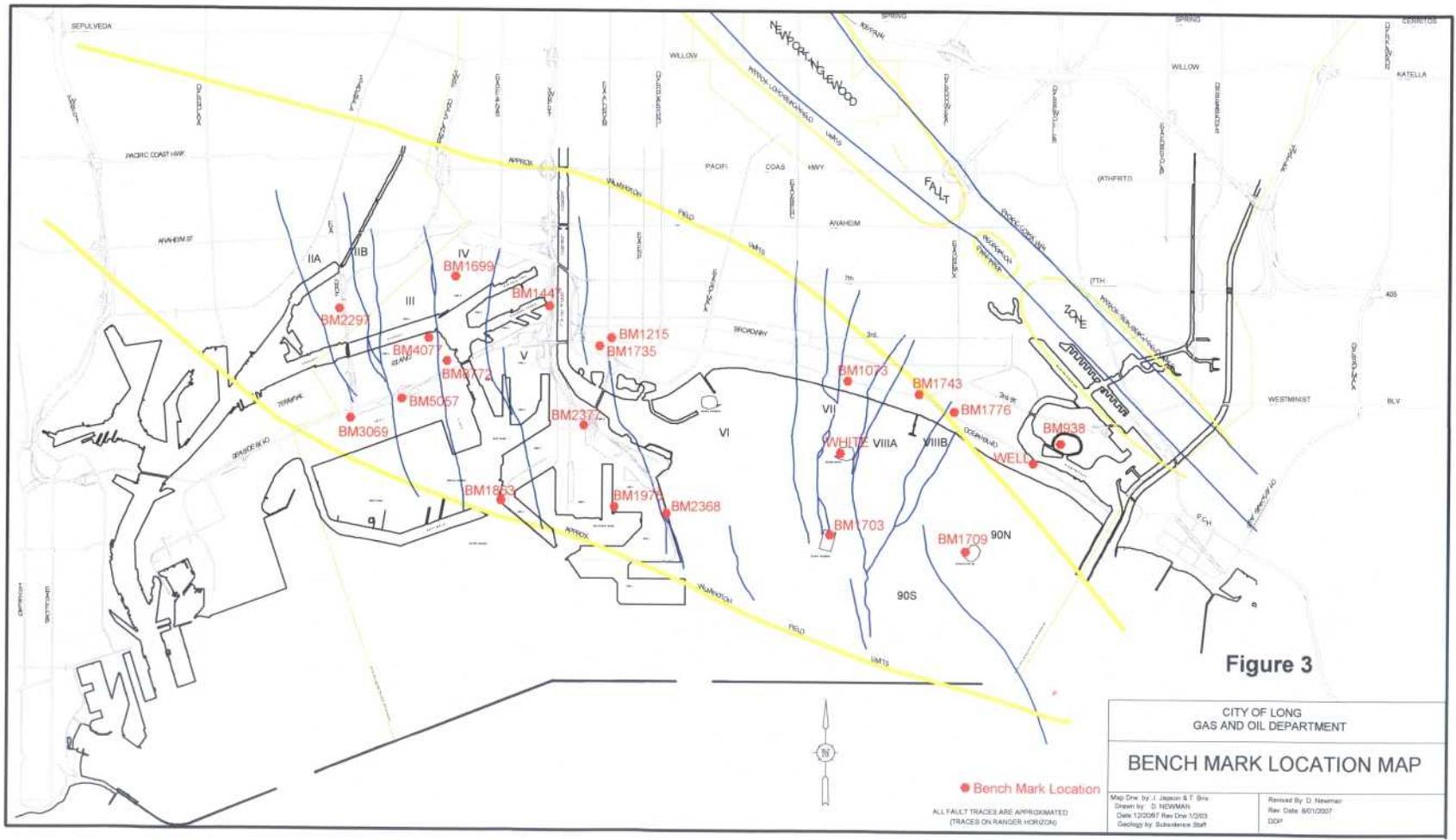
Bench Mark and Net Injection Graphs, Ocean Boulevard and the Offshore Drilling Islands (Figures 8 – 13)

The last 20 years of elevation changes and accompanying net injection histories are shown on Figures 8 through 13 for bench marks located along Ocean Boulevard and on the offshore drilling islands. The elevation changes at Ocean Boulevard near Magnolia Avenue are shown by the graph of Bench Mark 1735 and Bench Mark 1215 on Figure 8. Permanent GPS Station WELL on Figure 12 shows surface elevation changes on the Alamitos Bay Peninsula. Bench Mark 938 monitors elevation on Naples Island.



Figure 1





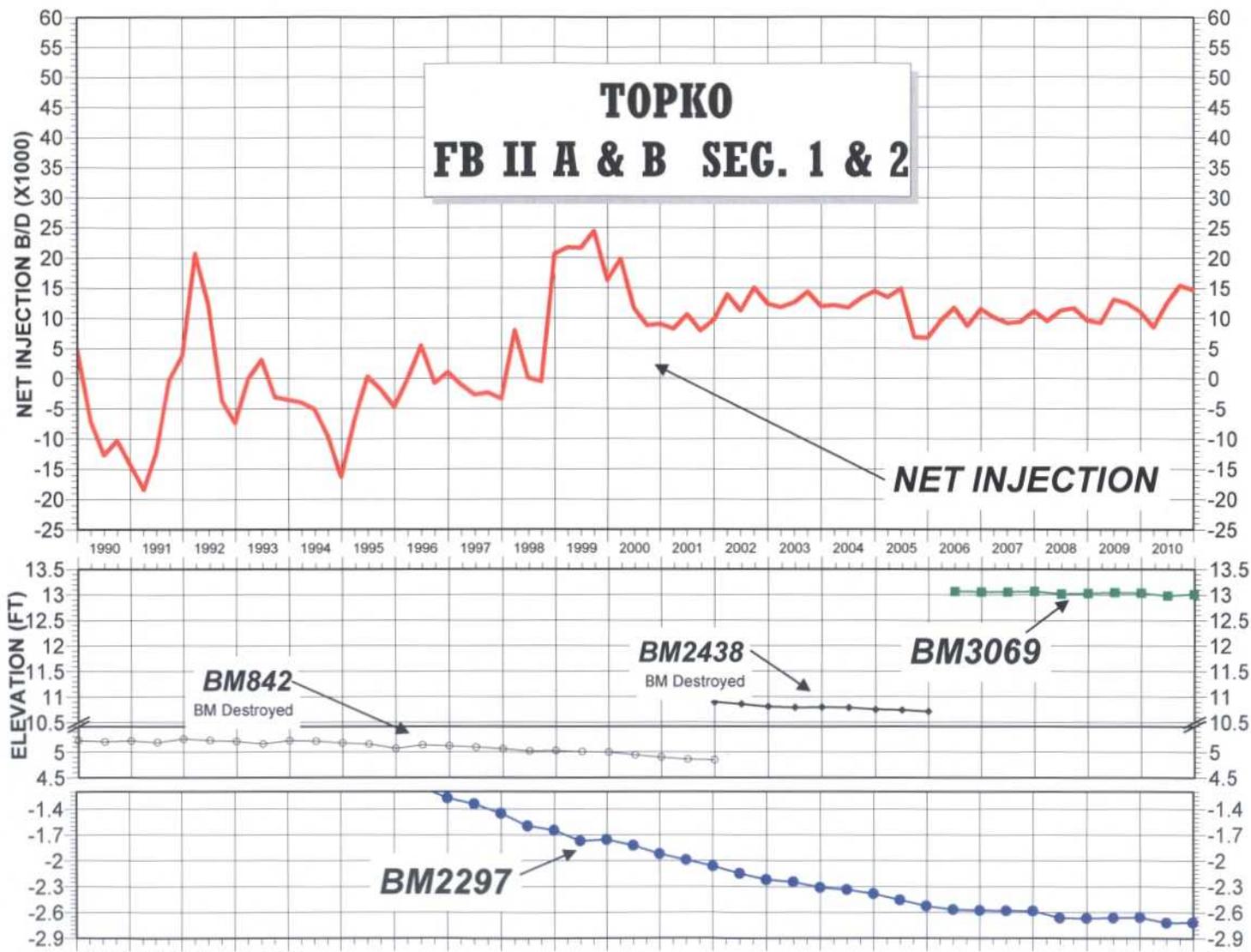
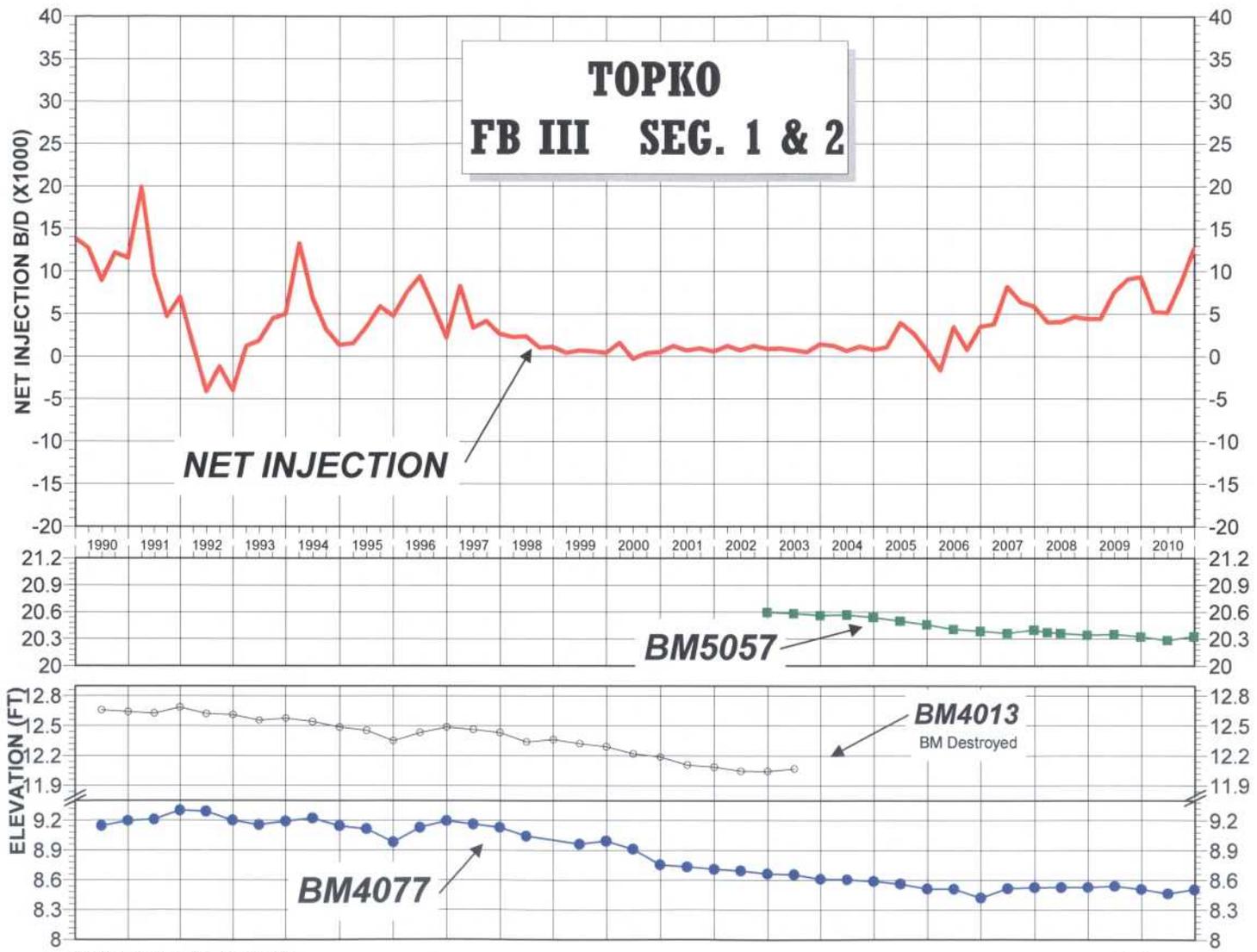


Figure 4



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Figure 5

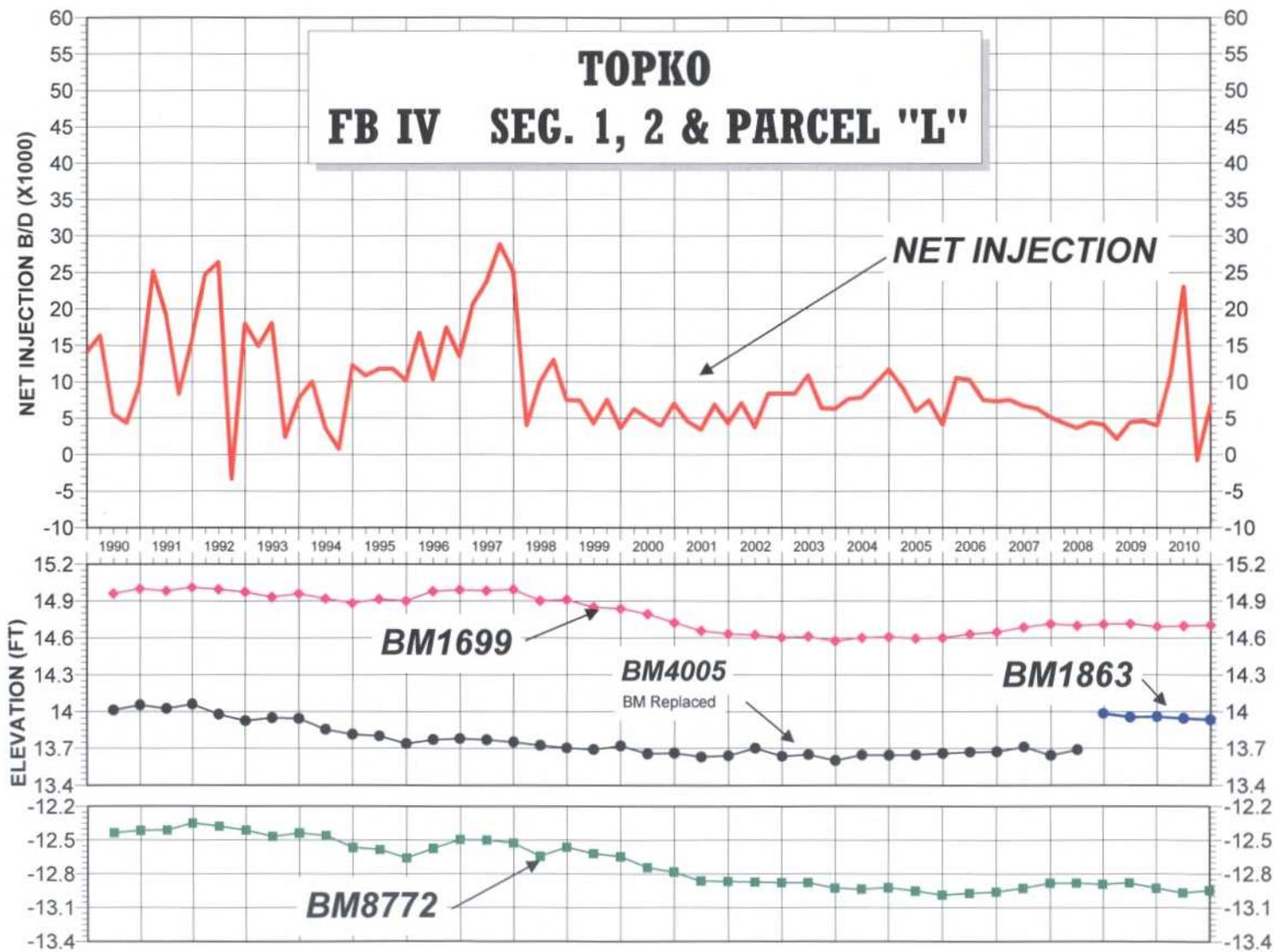
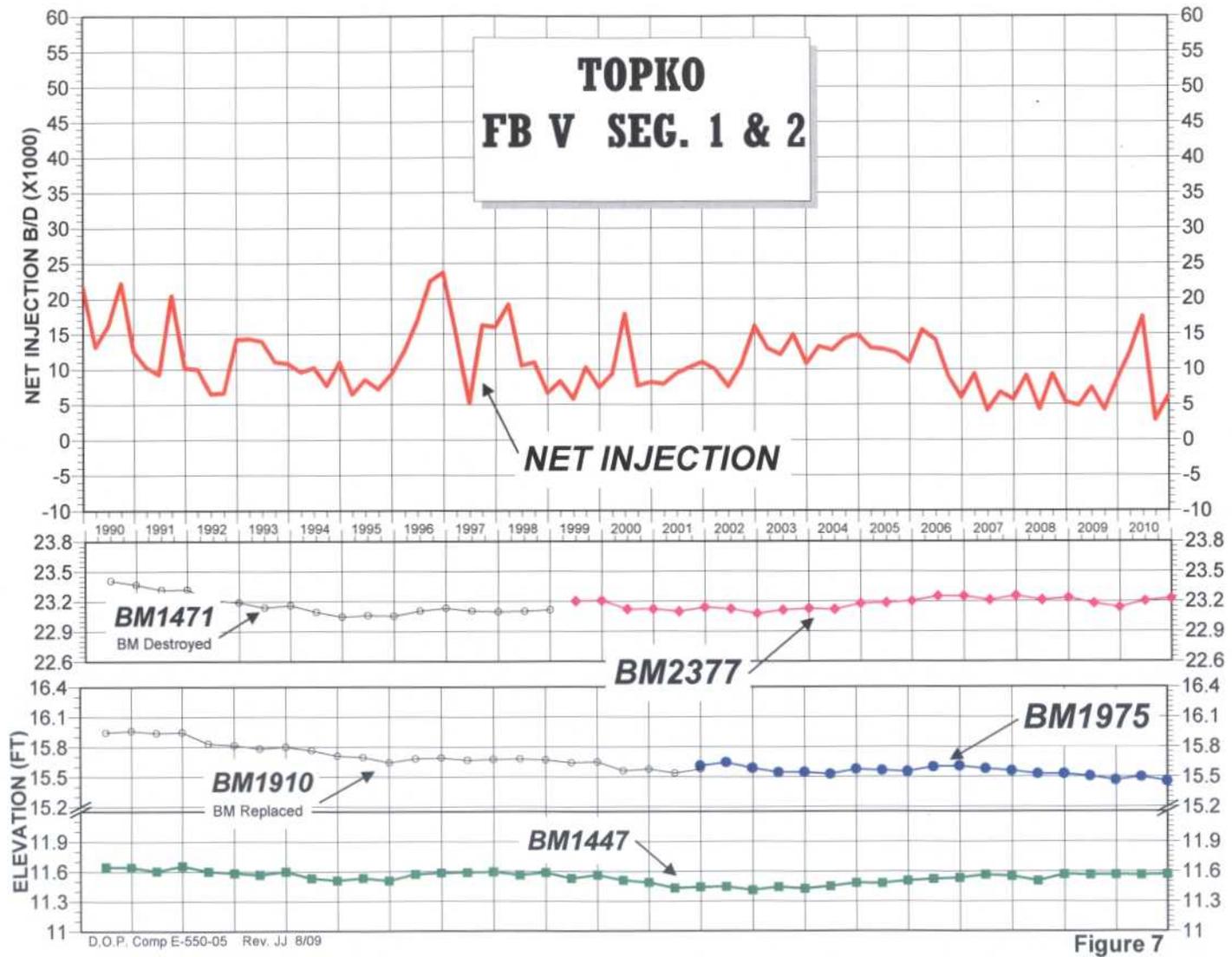


Figure 6



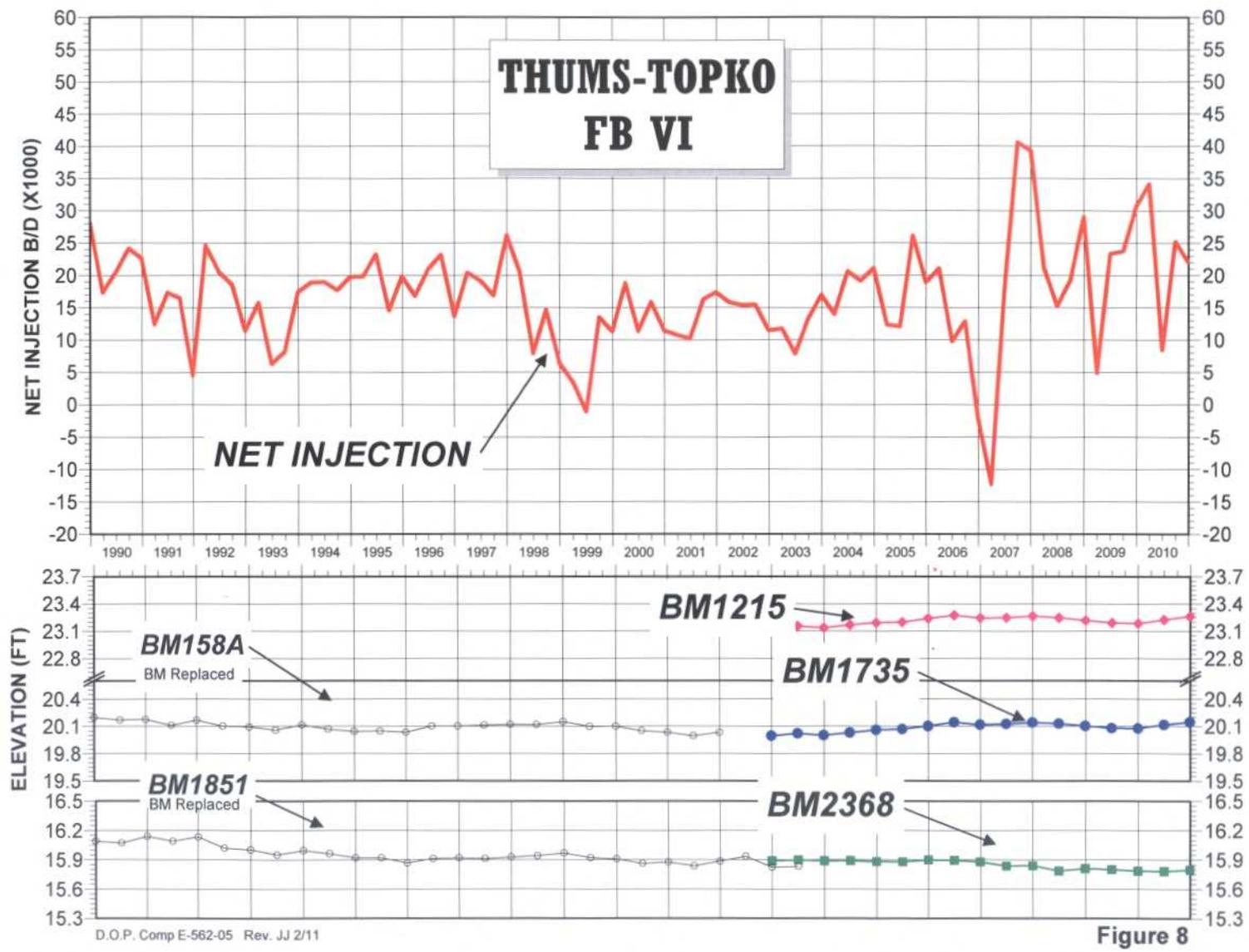


Figure 8

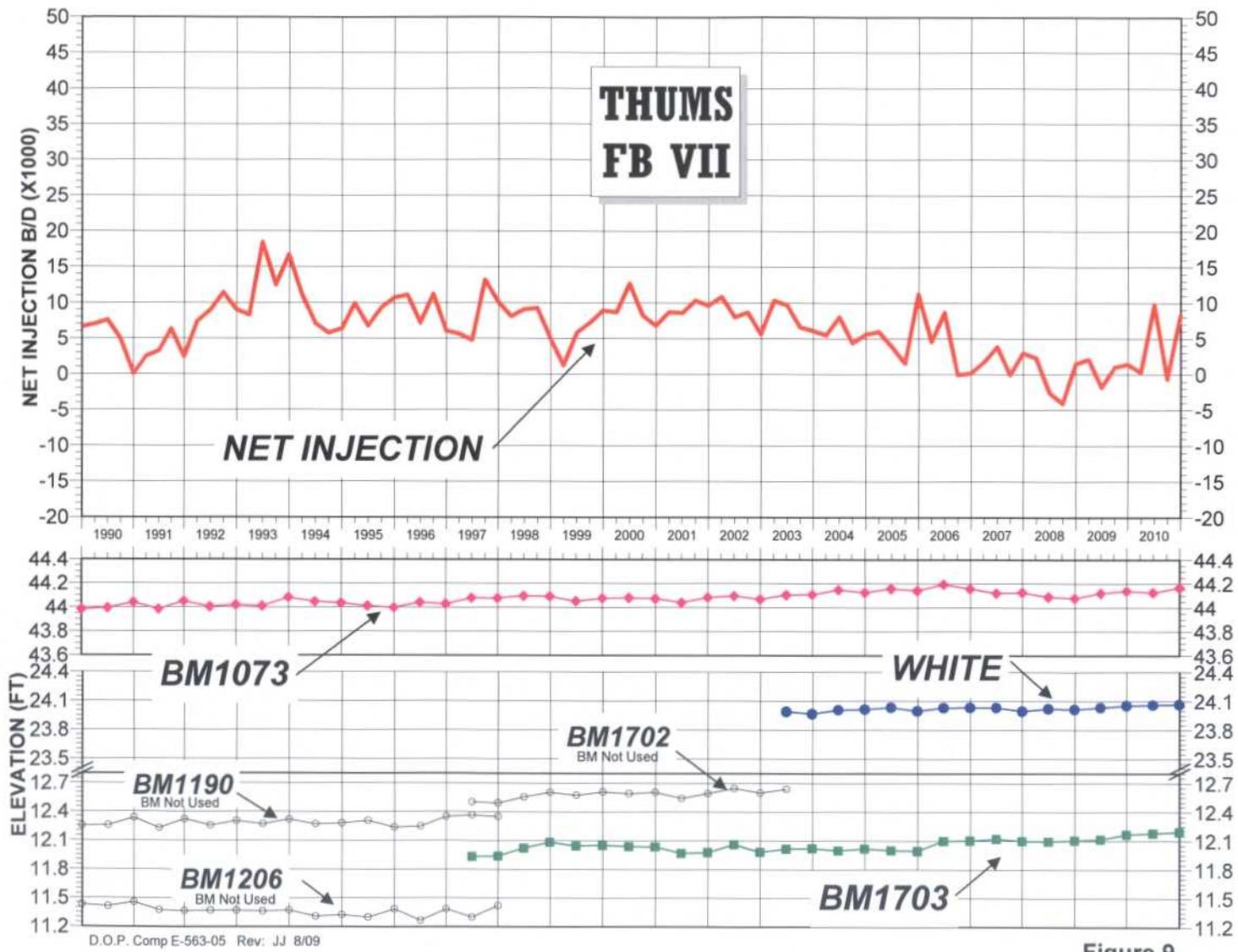


Figure 9

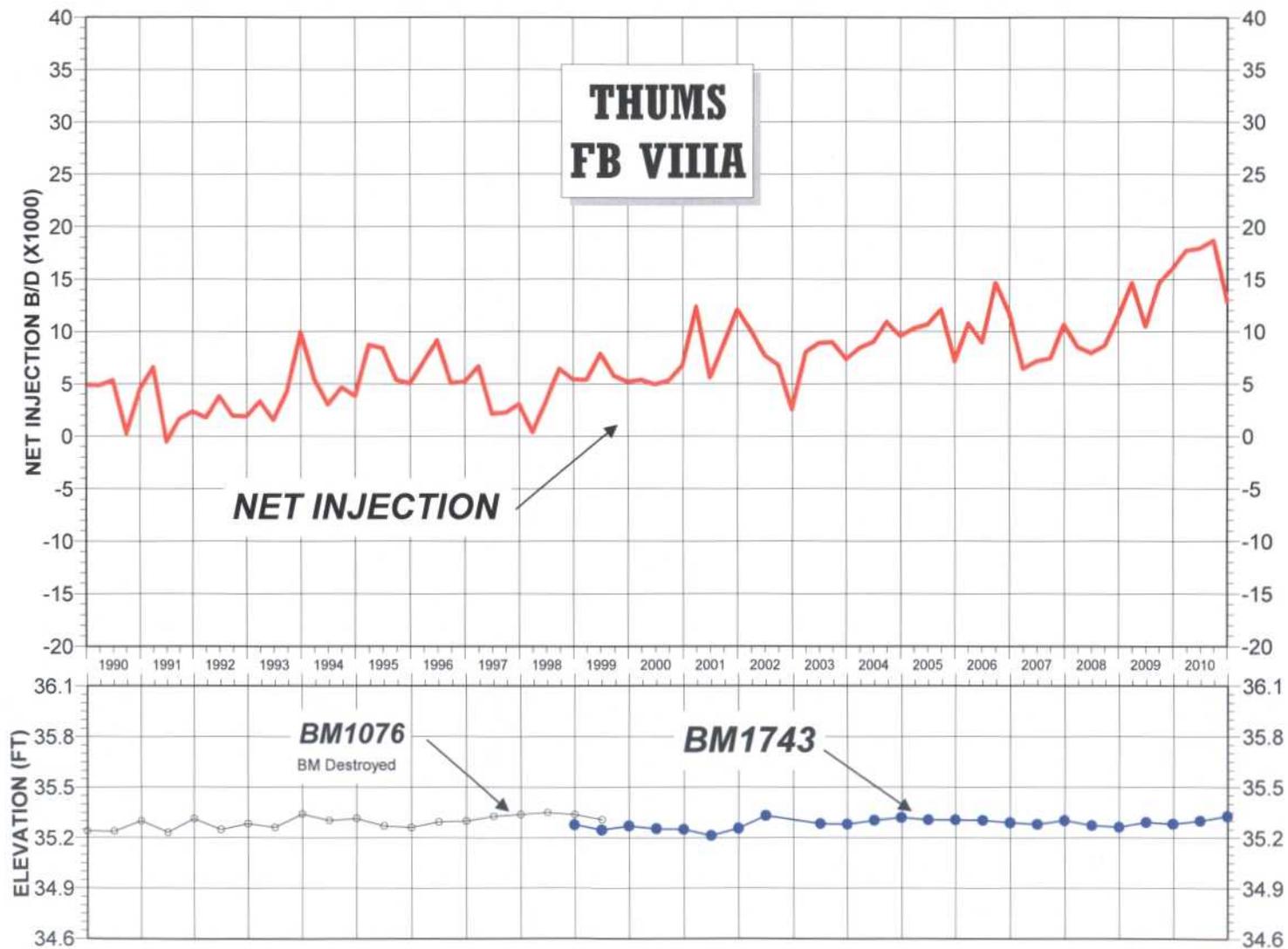


Figure 10

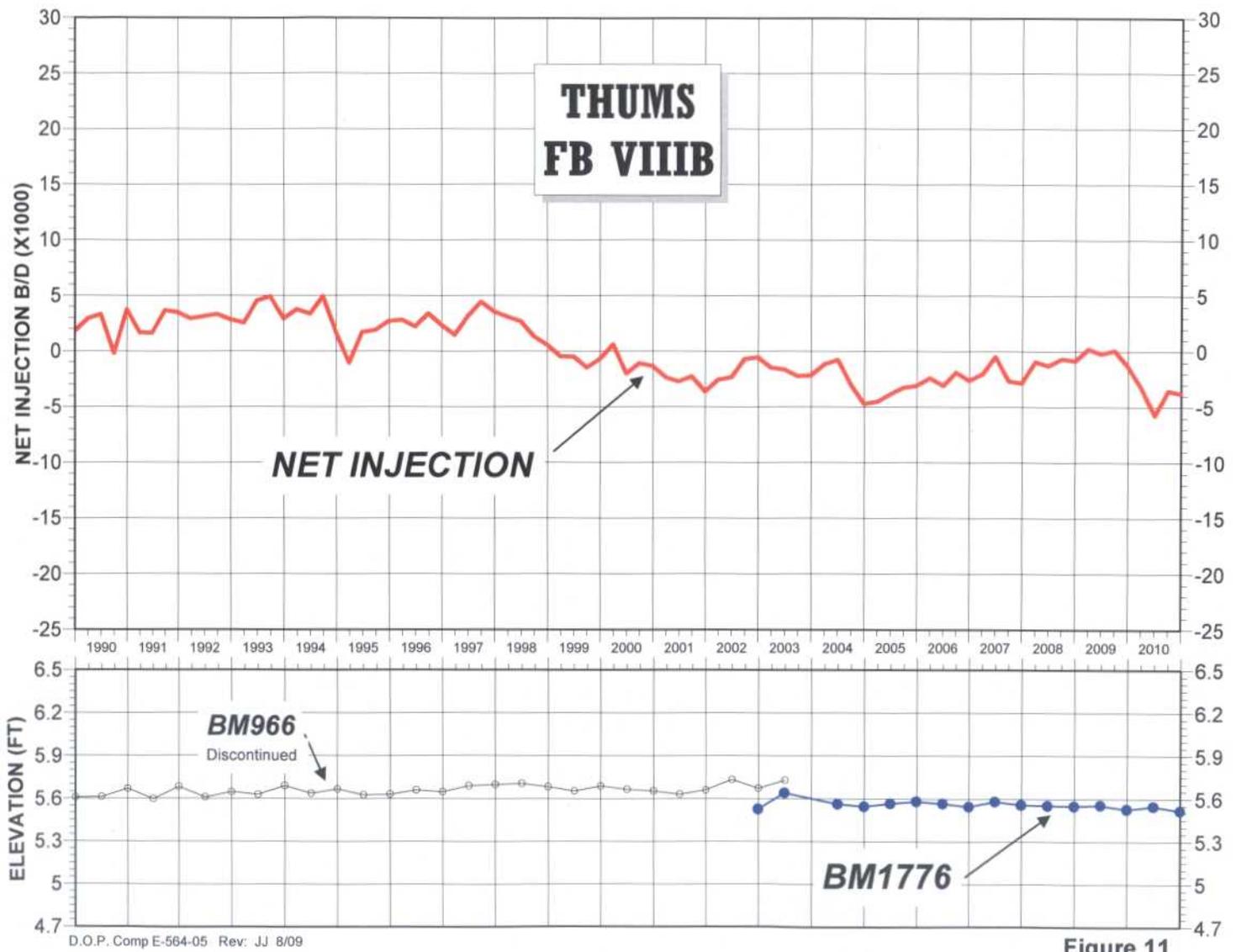
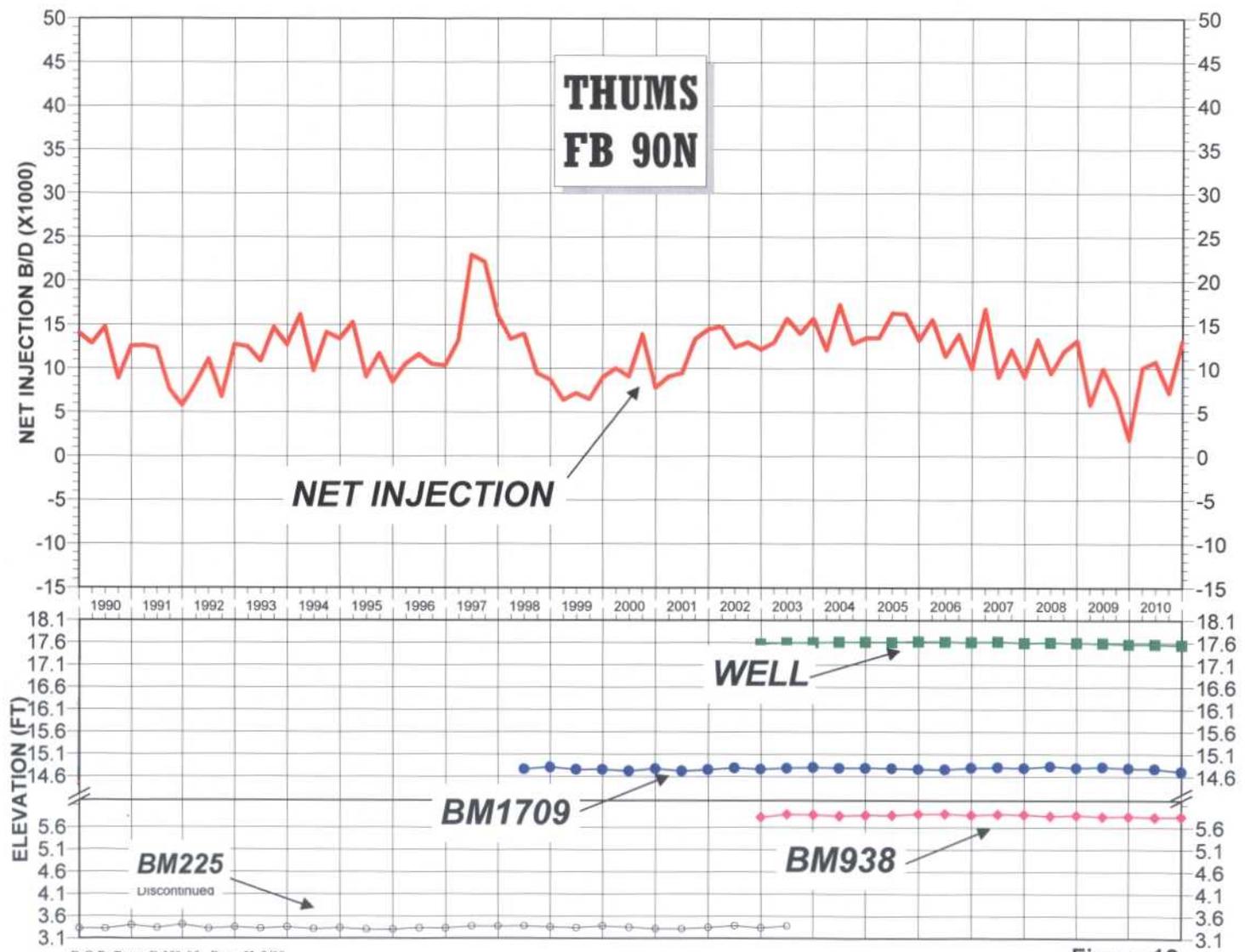


Figure 11



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Figure 12

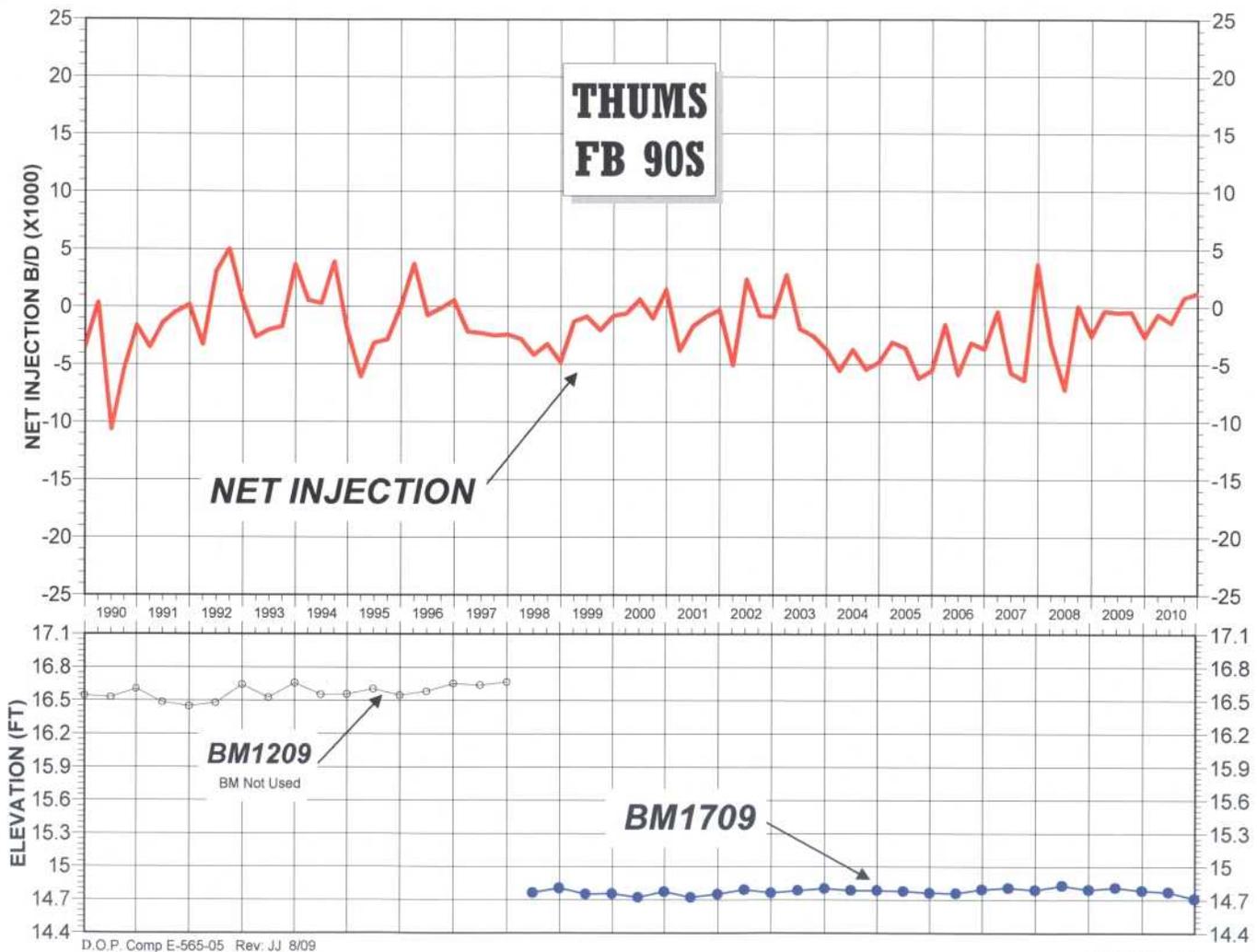


Figure 13