

APPENDIX B

Vertical Hydraulic Gradients Drinking Water Protection Study Fairchild Air Force Base, Washington

1.0 ALLUVIUM AND WANAPUM BASALT – BASEWIDE SWGE

Vertical hydraulic gradients were calculated for well pairs screened in the alluvium and the Wanapum Basalt. Vertical hydraulic gradients were calculated for well pairs meeting the following criteria:

- If the wells had a measurement during the last Basewide SWGE in 2012 (only data from this SWGE was used), and
- If the wells assigned in the last SWGE were in the Alluvium or the “Basalt A,” and
- If the well pairs were within approximately 30 ft of another, and
- If the wells had the necessary well construction details (available ground surface, top of casing, and screened interval information).

There is no general guidance to determine an acceptable distance in either space or time. Generally, the distances should be selected to be minimized but this is not always practical. Acceptable temporal changes can be assessed by analyzing continuously monitored wells screened within both units and comparing the change in the selected timeframe to the total range. Similarly, an acceptable spatial distance can be determined by analyzing the local horizontal hydraulic gradients, and selecting a spatial distance that would minimize any chance of significant variation due to horizontal hydraulic gradients alone. Given all the measurements were collected as part of a synoptic event, the temporal component of hydraulic head changes was assumed to be insignificant. A distance of 30 ft was selected based on visual inspection and testing different tolerances (e.g., 10 ft through 100 ft).

2.0 ALLUVIUM AND WANAPUM BASALT – ERPIMS DATABASE

From the ERPIMS database, additional vertical gradients were calculated for well pairs screened in the alluvium and the Wanapum Basalt for the following criteria:

- If the wells had a measurement within 50 days of another, and
- If the well pairs were within 50 ft of another, and,
- If the wells had the necessary well construction details (available ground surface, top of casing, and screened interval information)

As discussed above, there is no general guidance to determine an acceptable distance in either space or time. Given this search included wells that were not necessarily part of the SWGE, a larger tolerance—both temporally and spatially—was required to achieve a sufficient number of well pairs. A tolerance of 50 days and 50 ft was found to be acceptable based upon a visual analysis. Given the larger tolerance, these well pairs have a larger influence from horizontal and temporal changes, but the results are consistent with the well pairs from the SWGE such that there is no reason to exclude any given well pair.

The 2020 Well Inventory was used to assign formations to the wells in the ERPIMS database. Wells that were included in multiple units (e.g., the unconsolidated material and in Basalt A) were excluded. There are differences in naming of wells between the 2020 Basewide Well Inventory and in the ERPIMS database, and database joins were completed as-is; no significant effort was put forth to clean up the inconsistencies in the well names between the two databases (ERPIMS and the 2020 Basewide Well Inventory); this remains a data gap.



The 2020 Basewide Well Inventory table was used as the primary source for the screened formation of the well. This may cause some errors. For example, MW-340 and MW-468 are listed in the Unconsolidated and in Basalt A, respectively. The screen information is as follows:

- MW-340: 18-28 ft below ground surface (bgs); 2406-2416.8 ft above mean sea level (amsl); well log indicates weathered basalt at 8 ft bgs.
- MW-468: 16.5-26.5 ft bgs, 2410.36-2420.36 amsl (no log available).

MW-340 therefore has an incorrect screened formation in the 2020 Basewide Well Inventory, and this well (MW-340) was removed from this analysis.

This effort revealed a total of 19 well pairs. All of the well pairs had multiple measurements over time, providing insight into the changing vertical gradients with time. There is a range of 2 to 12 measurements in time depending on the well pair, and a total of 125 measurements of which 86 indicated upward flow. All of the well pairs are within SS039. Of the 19 well pairs, 5 had a change in upward versus downward groundwater flow direction over time, but most were consistent in direction and in magnitude. In general, the upgradient portion of SS039 has generally upward groundwater flow, while northeast of AFFF Release Area 3 there is generally downward groundwater flow.

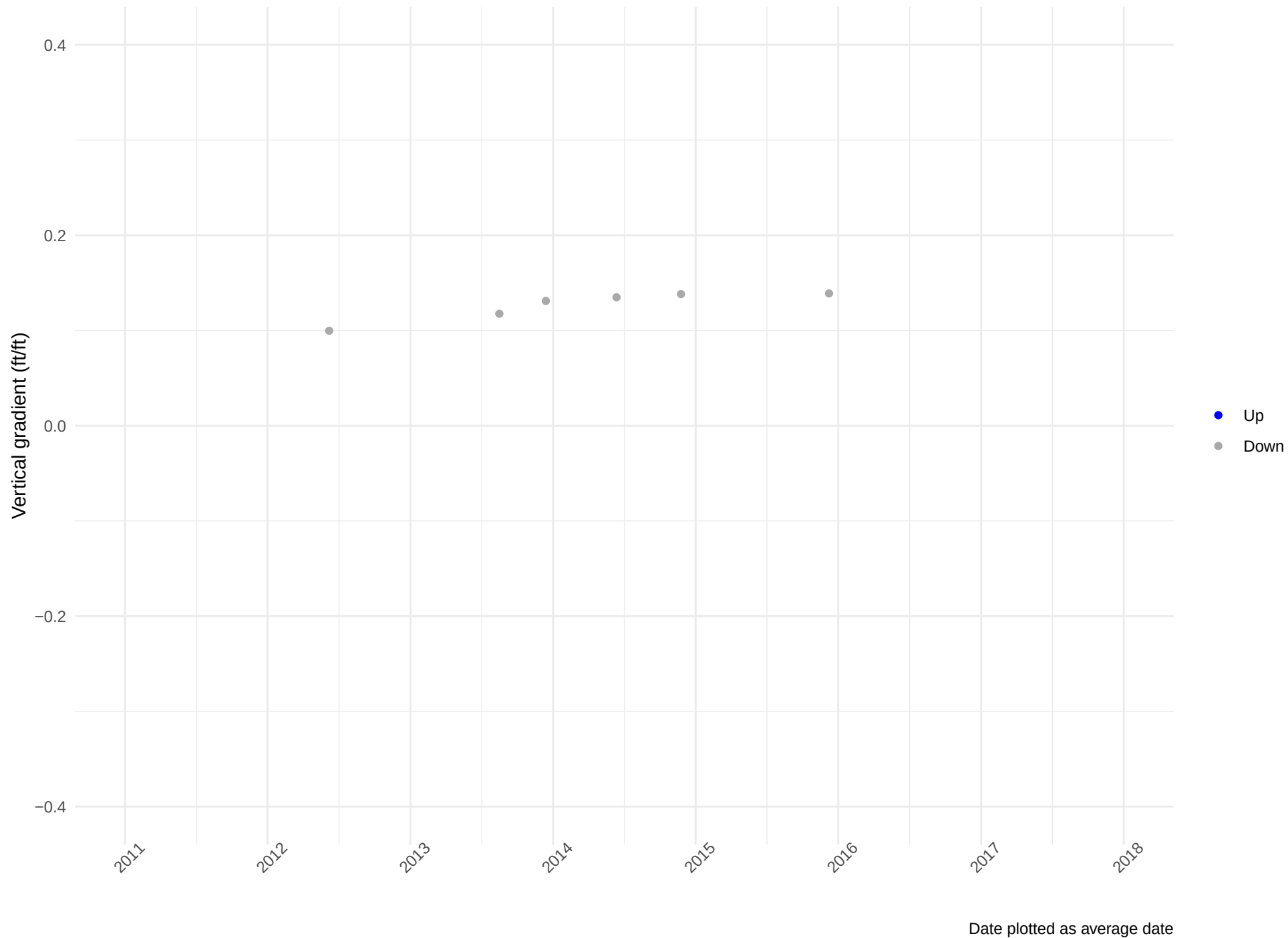
Vertical hydraulic gradient measurements are highly sensitive to slight errors in water level measurement. The sensitivity to errors in measurements are enhanced when the elevations are similar.

An analysis of groundwater elevations from the ERPIMS database revealed a total of 19 well pairs (all within SS039) with multiple (2-12) measurements over time. Of the total of 125 measurements, 86 indicated upward flow. Five well pairs had a change in upward versus downward groundwater flow direction over time, but most were consistent in direction and in magnitude. In general, the upgradient portion of SS039 has generally upward groundwater flow, while northeast of AFFF Release Area 3 there is generally downward groundwater flow.

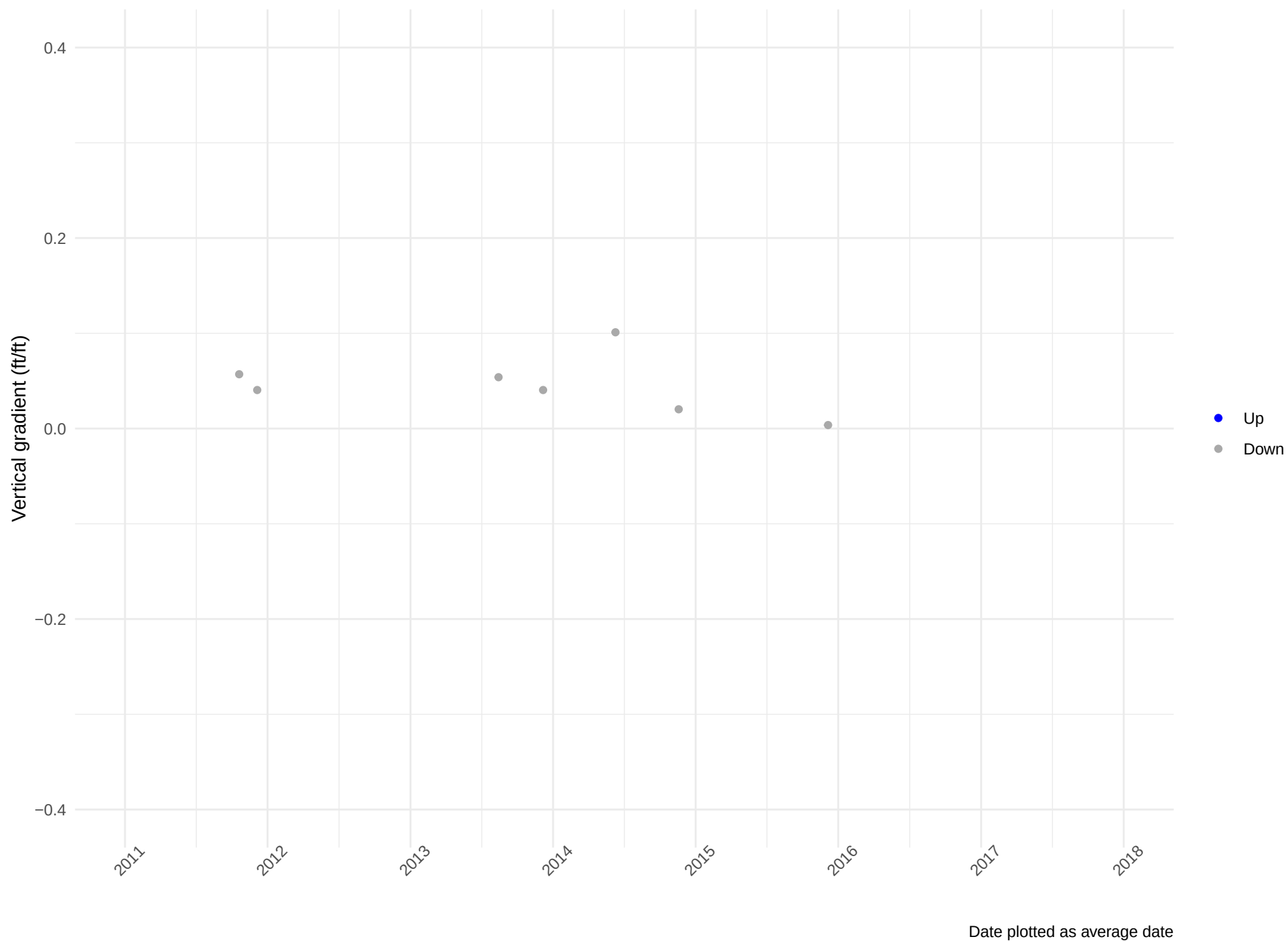
3.0 WANAPUM BASALT AND GRANDE RONDE BASALT

Few wells are screened within the deeper Grande Ronde Basalt. Consequently, adequate assessment of vertical hydraulic gradients are limited because this analysis requires two co-located wells, groundwater measurements collected within a short period of time between the two wells, and accurate and available construction details available (e.g., screen intervals, measuring point elevation, etc.).

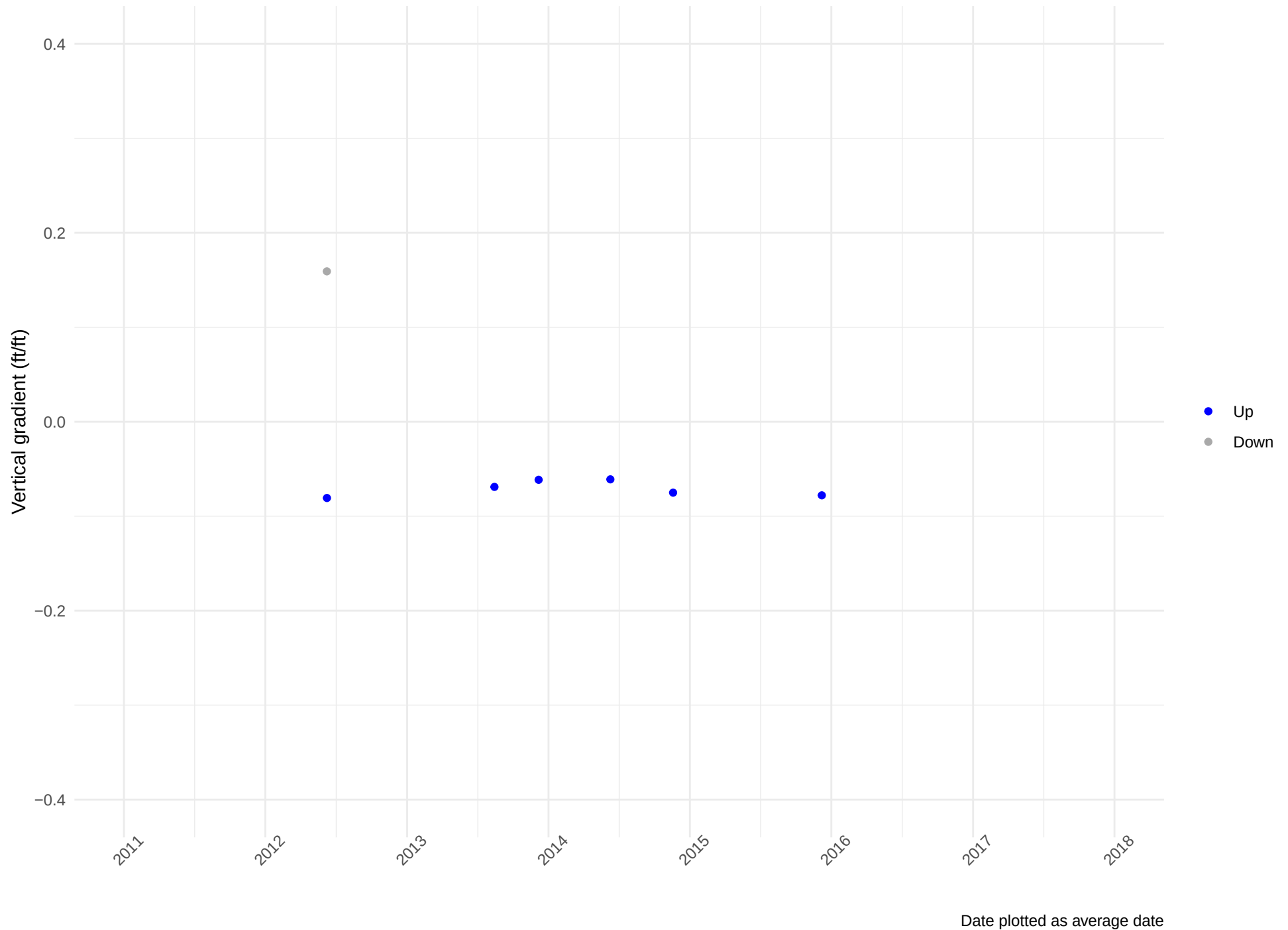
MW-301 & MW-418



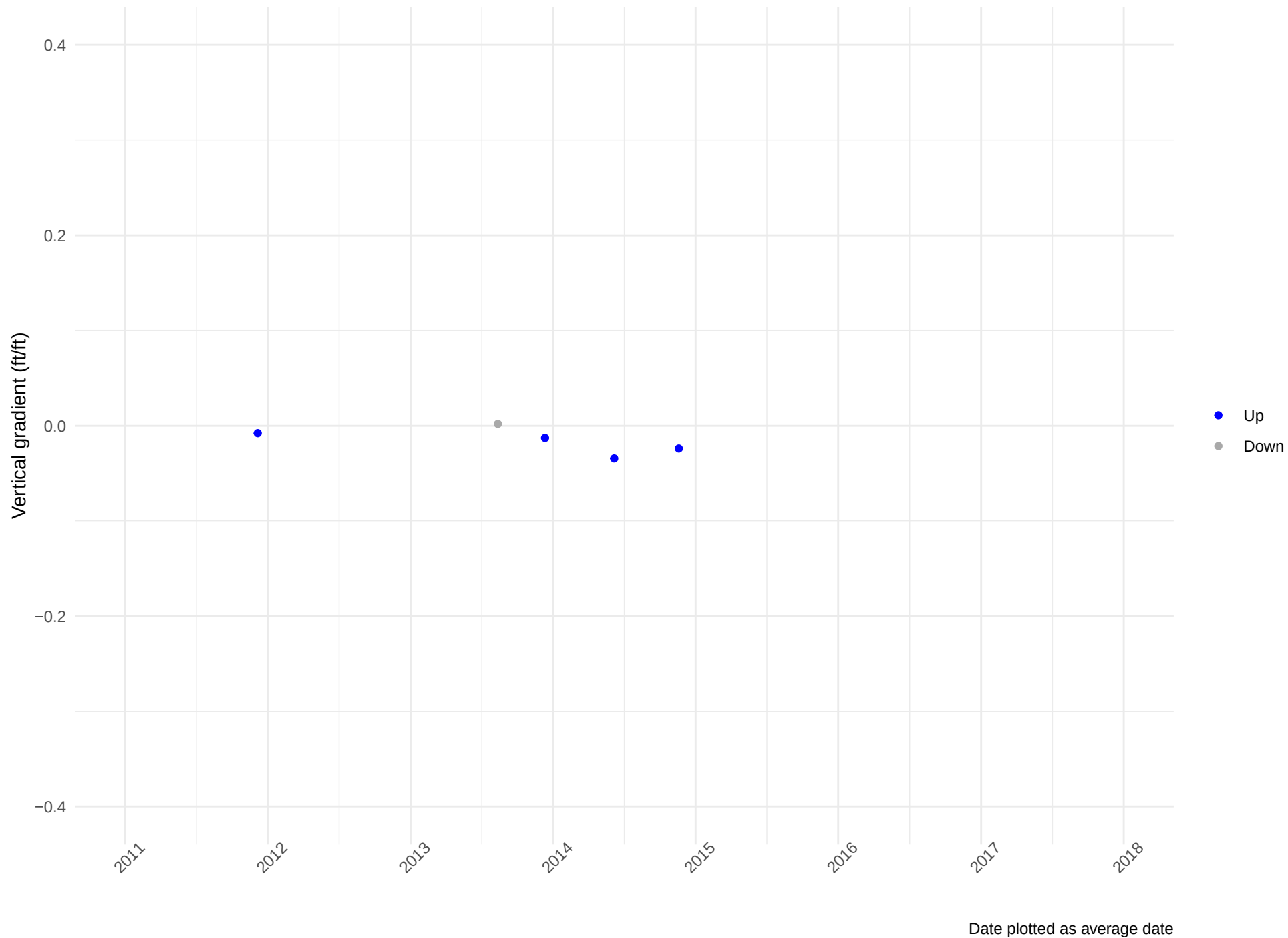
MW-343 & MW-384



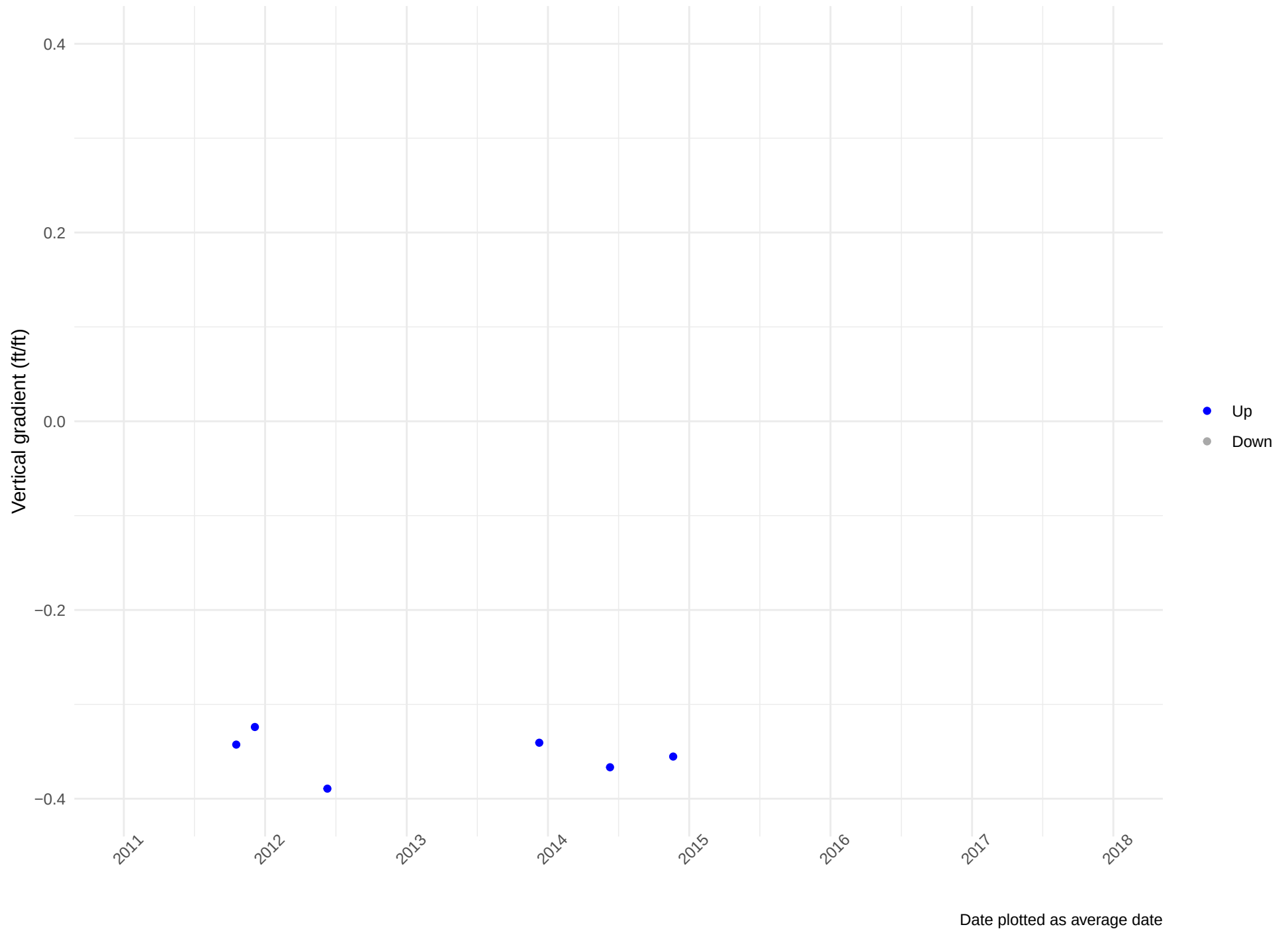
MW-344 & MW-333



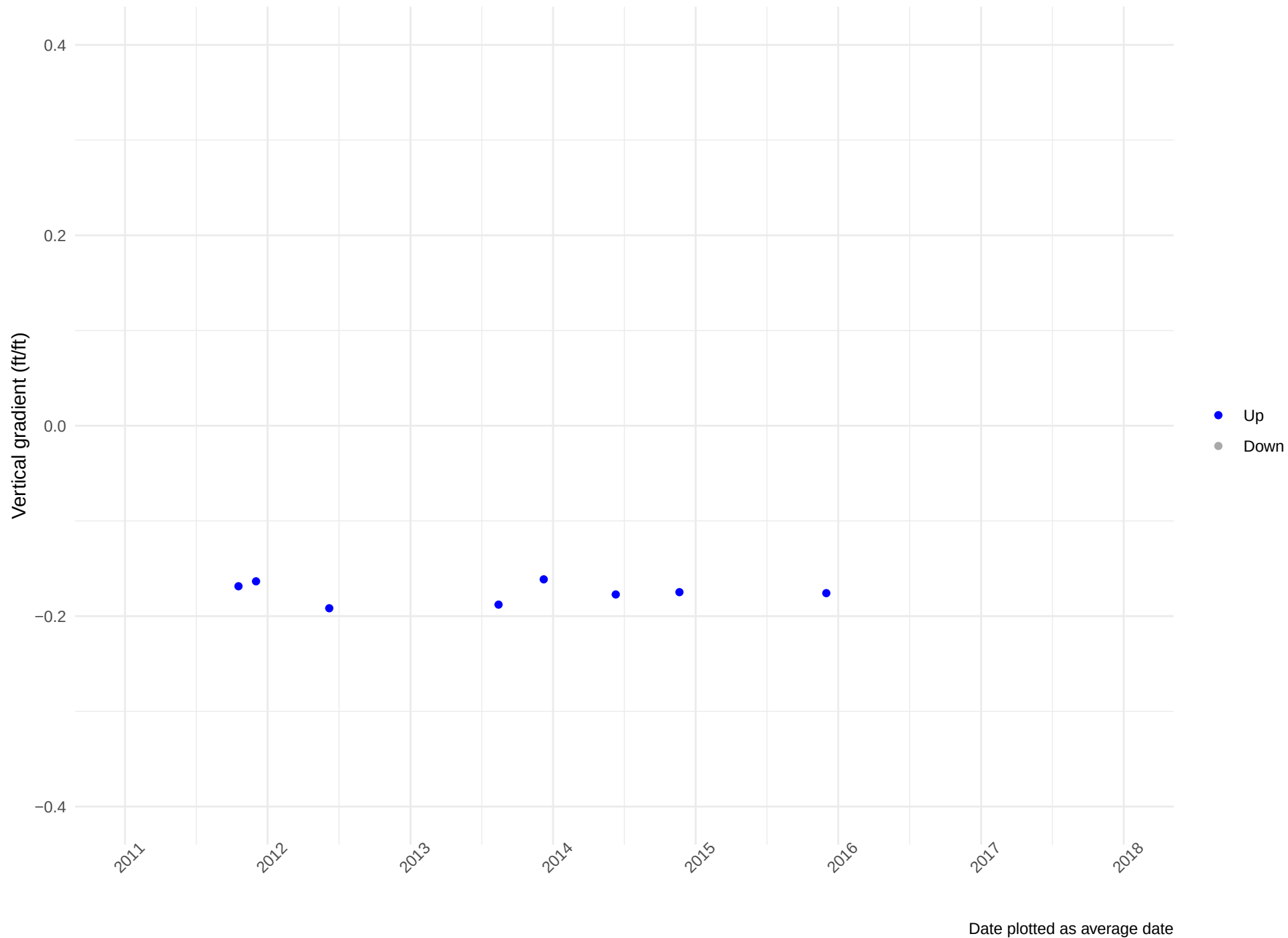
MW-352 & MW-336



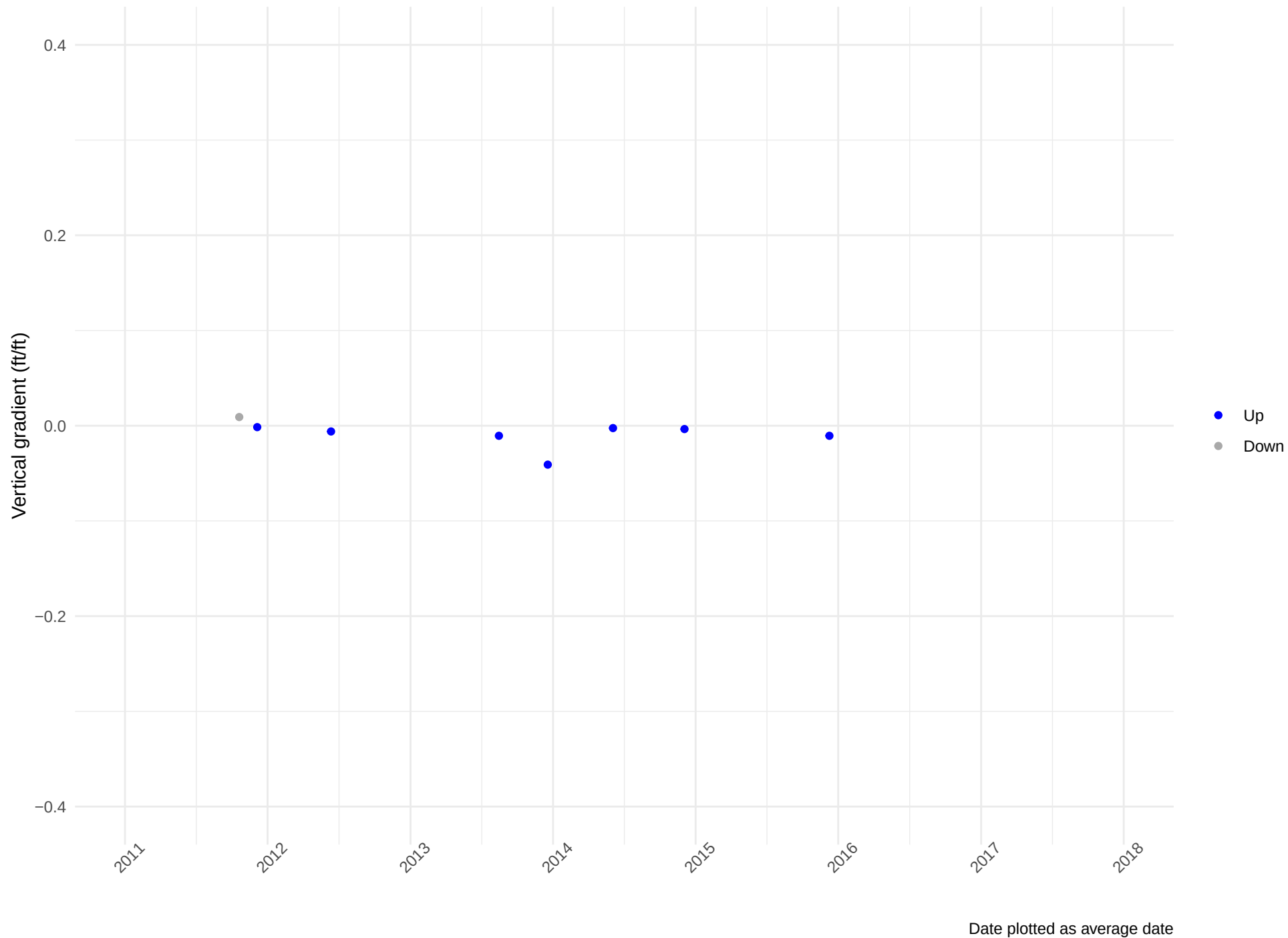
MW-379 & MW-380



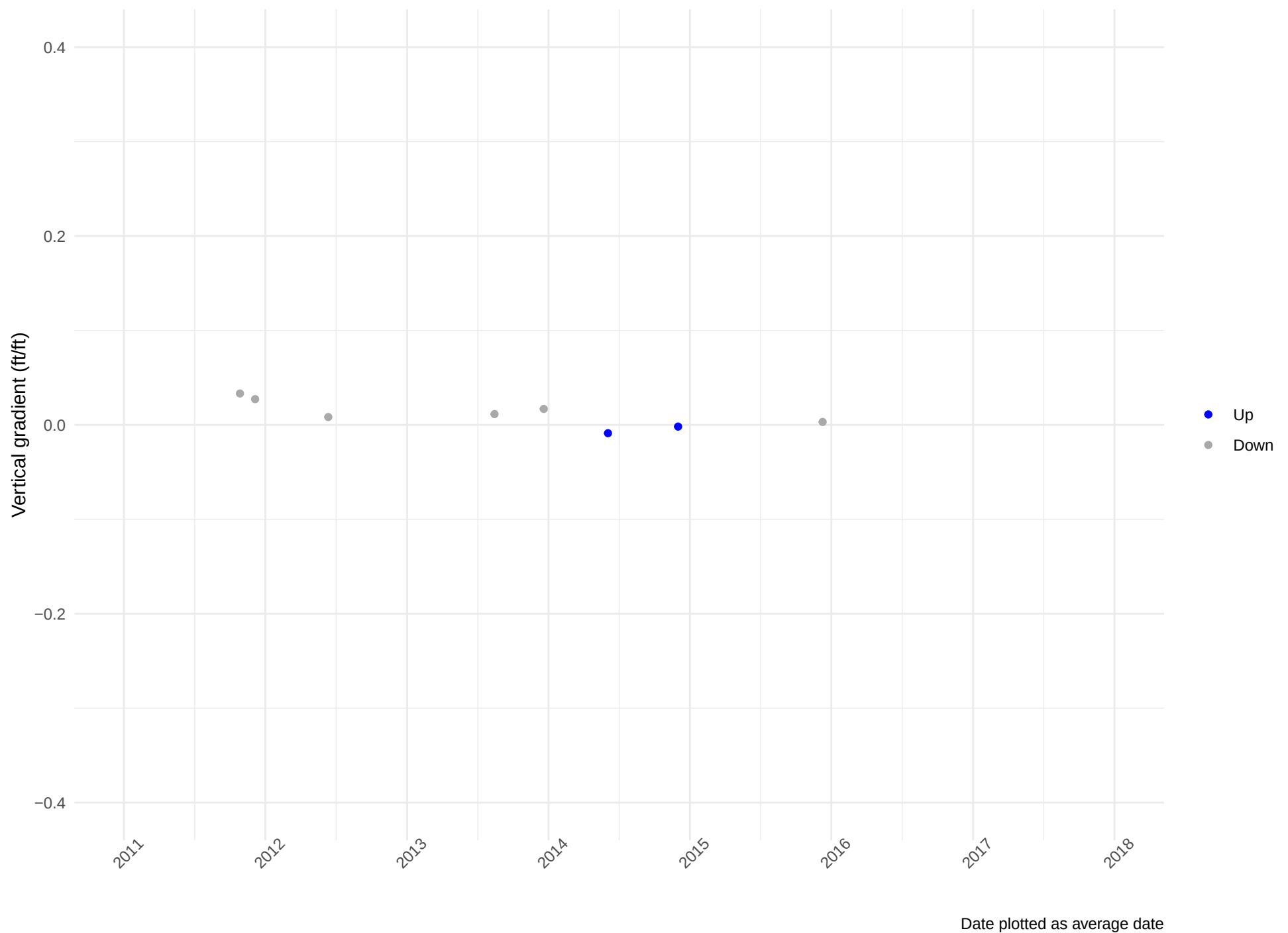
MW-381 & MW-382



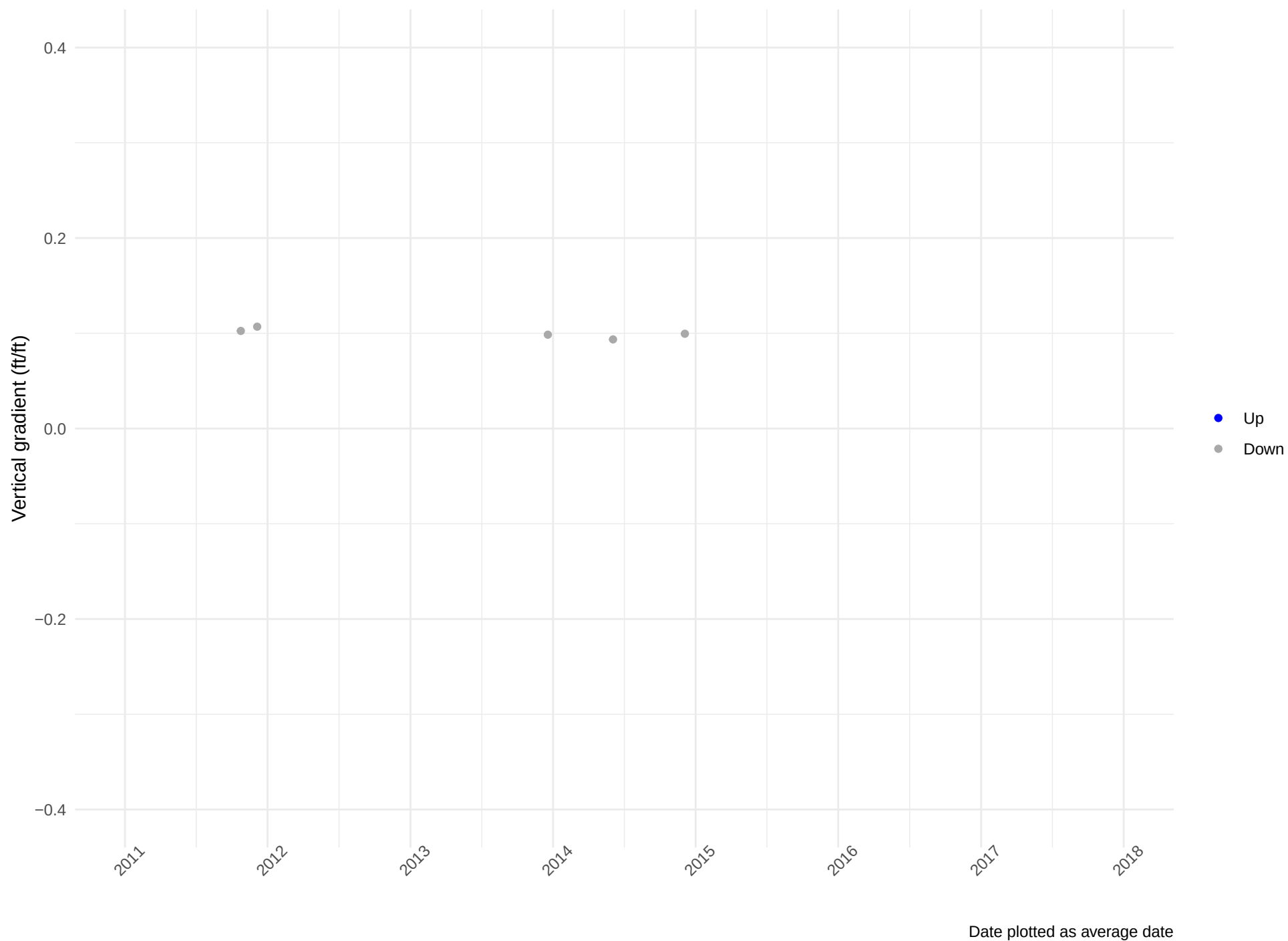
MW-386 & MW-387



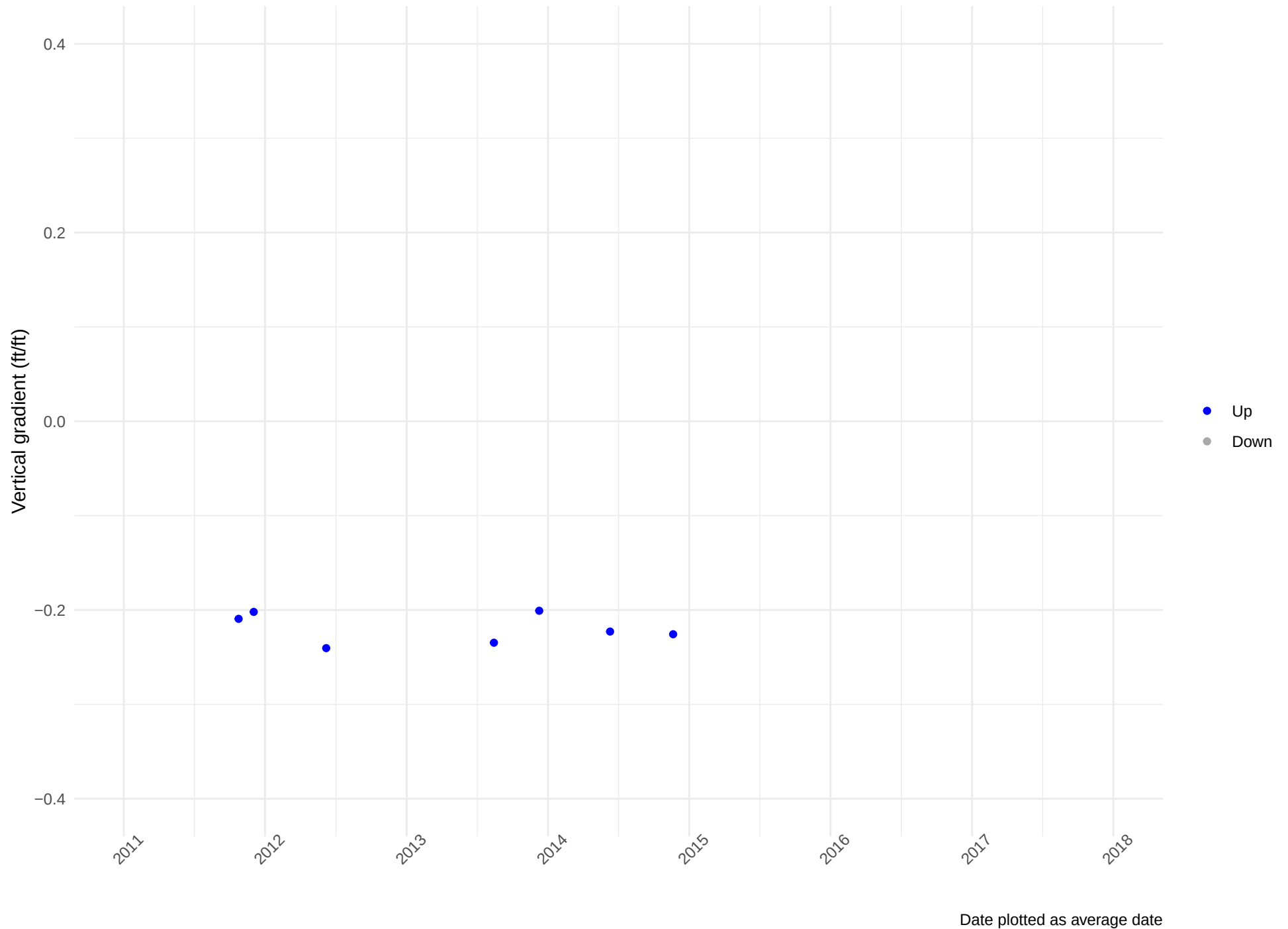
MW-389 & MW-390



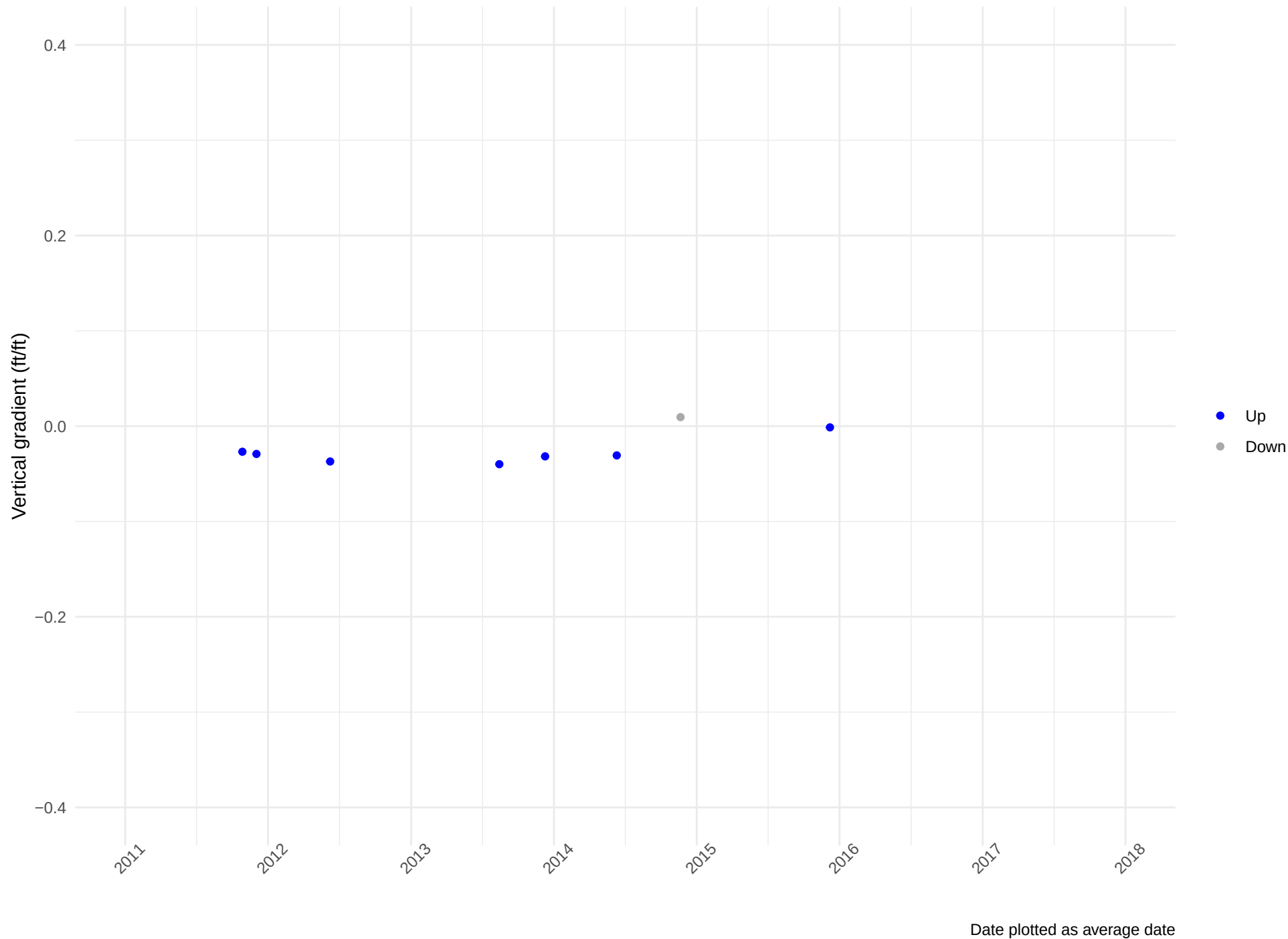
MW-391 & MW-392



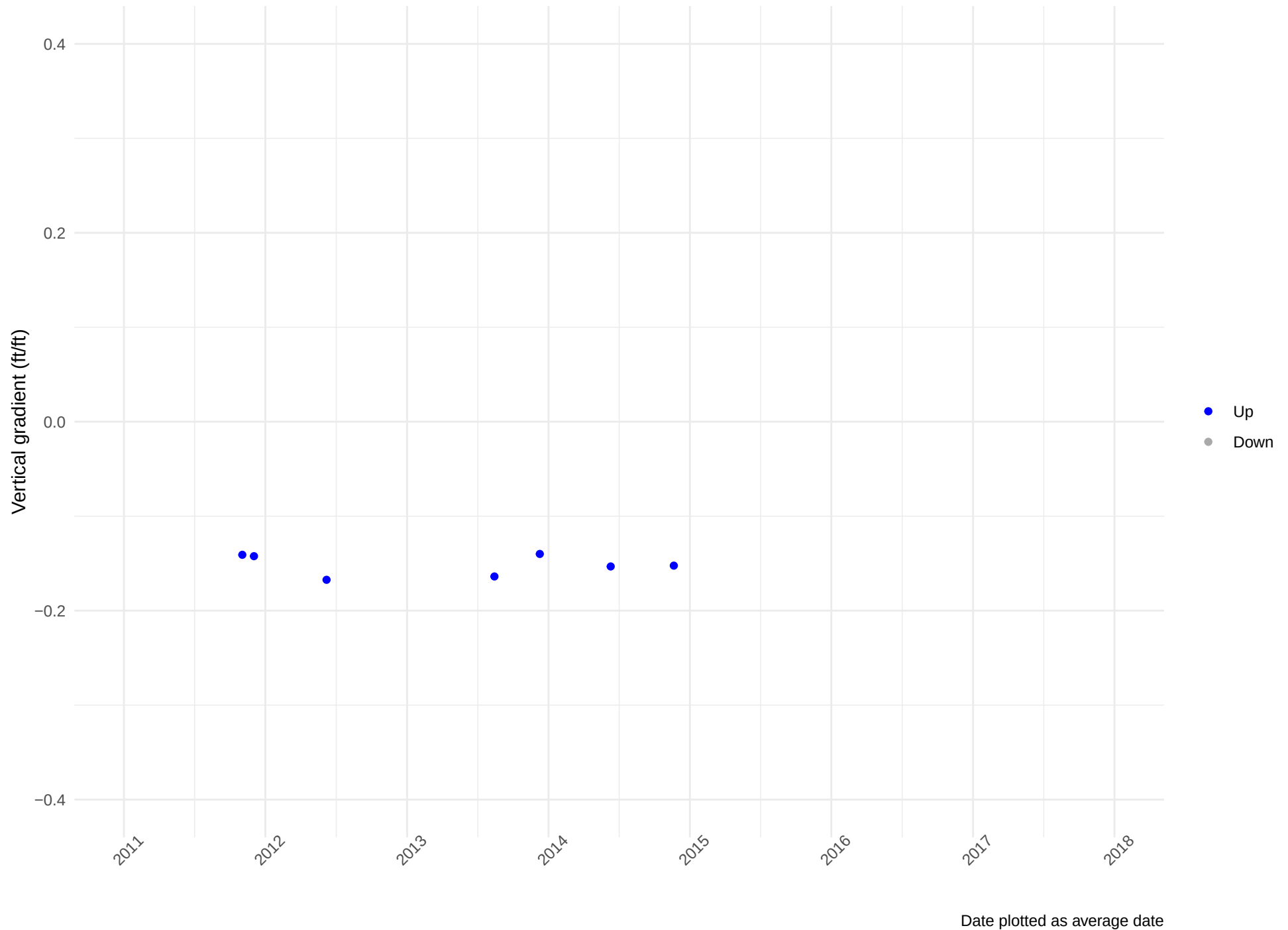
MW-393 & MW-394



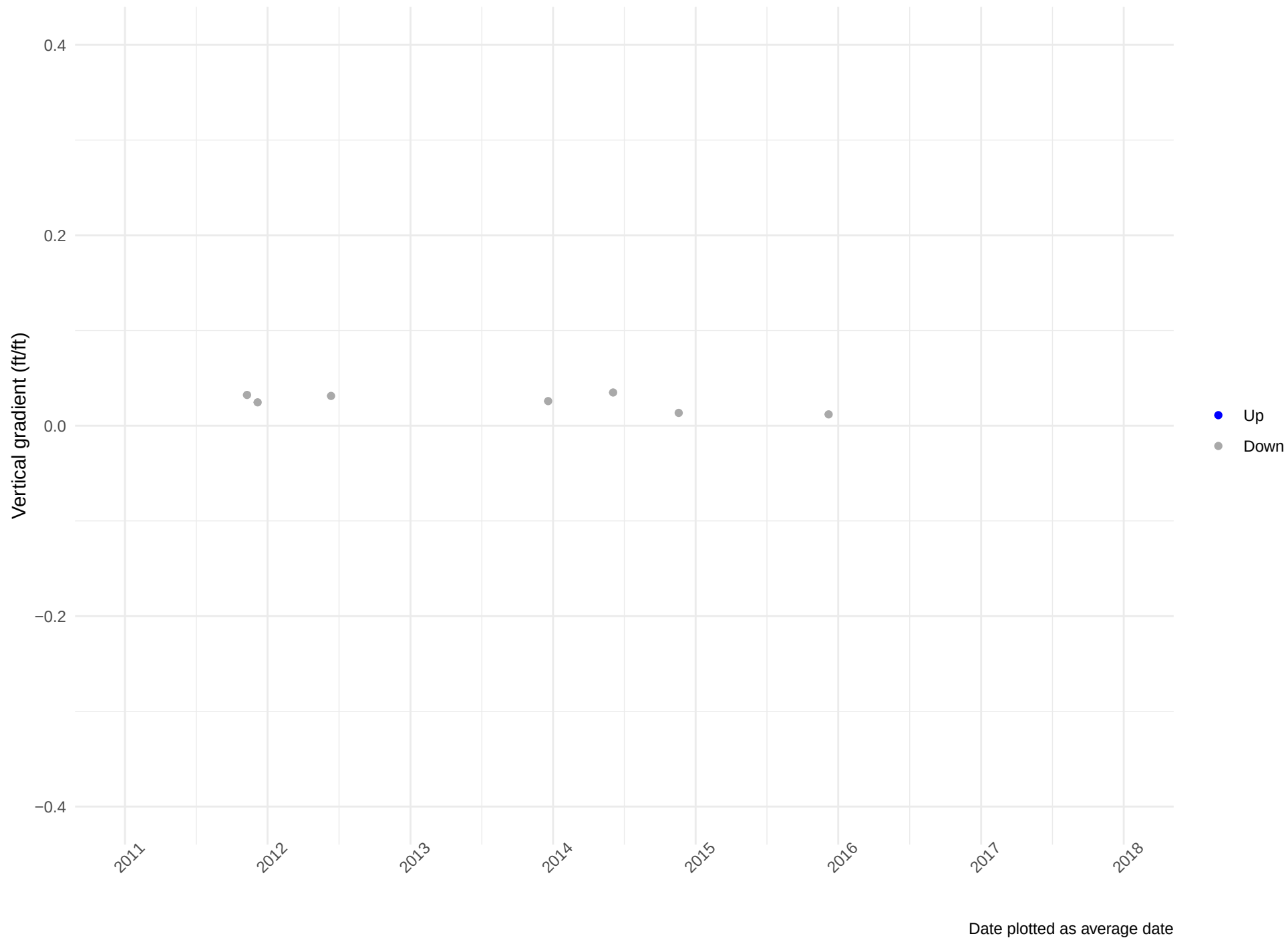
MW-398 & MW-399



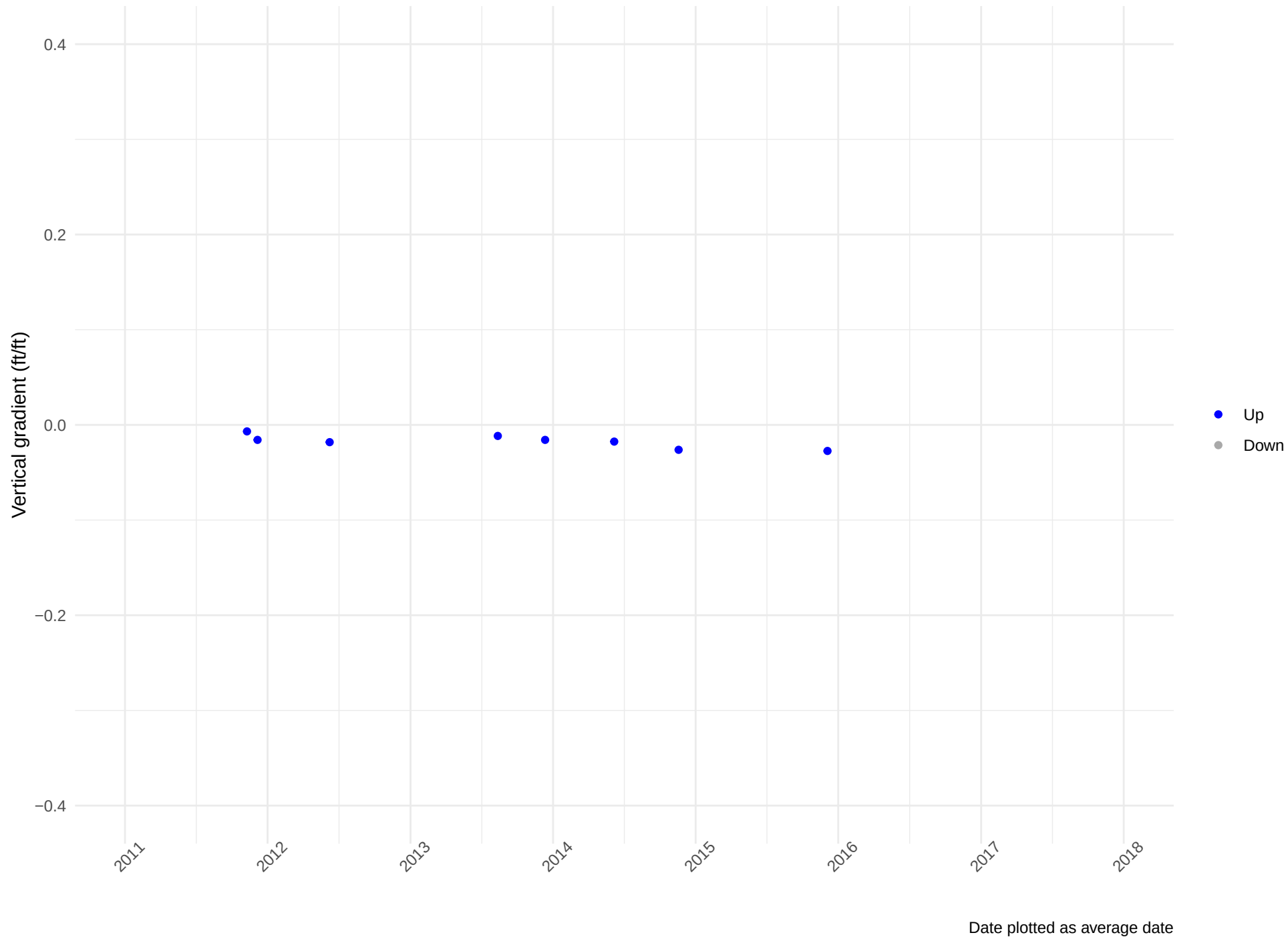
MW-400 & MW-401



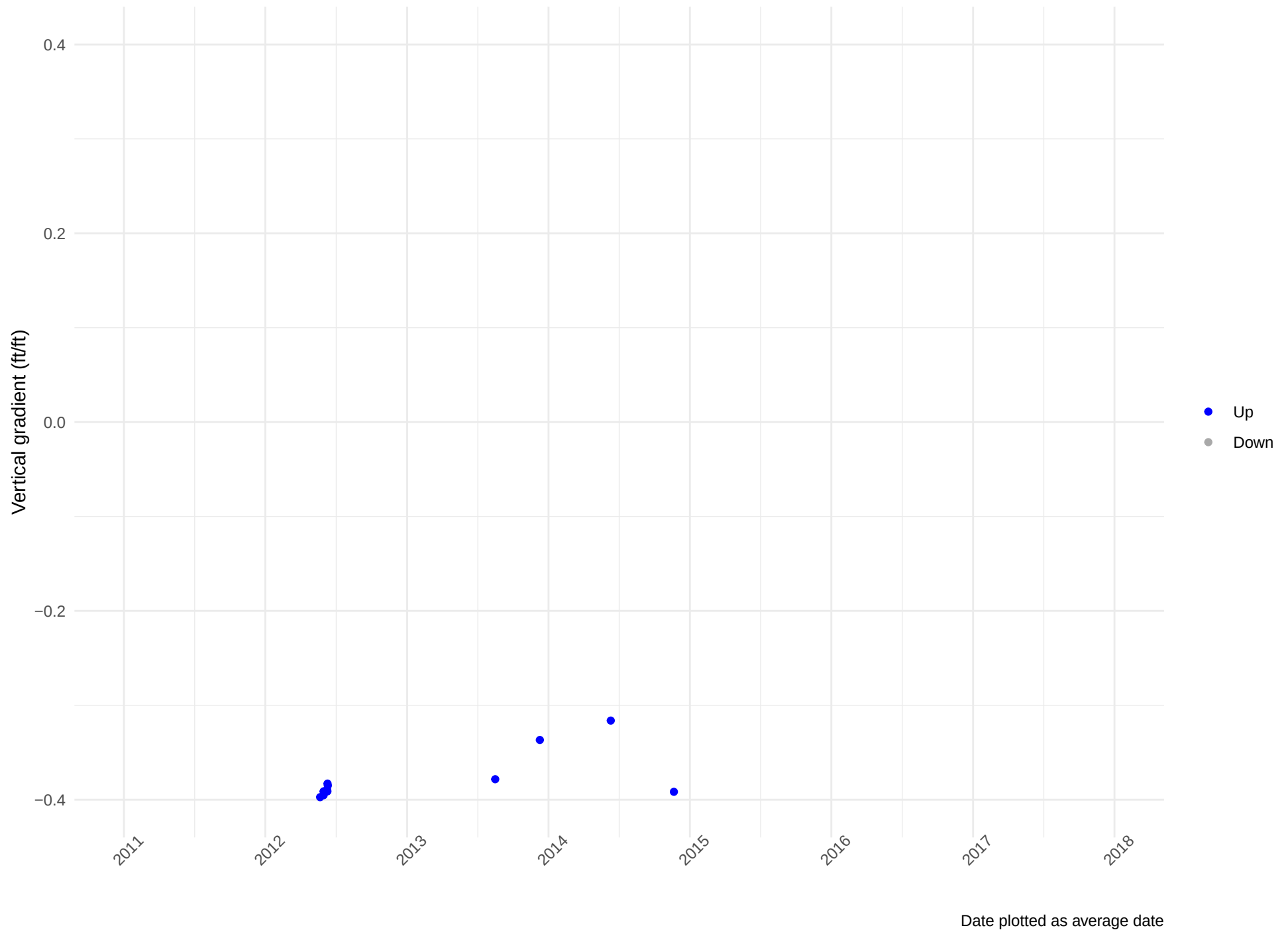
MW-407 & MW-408



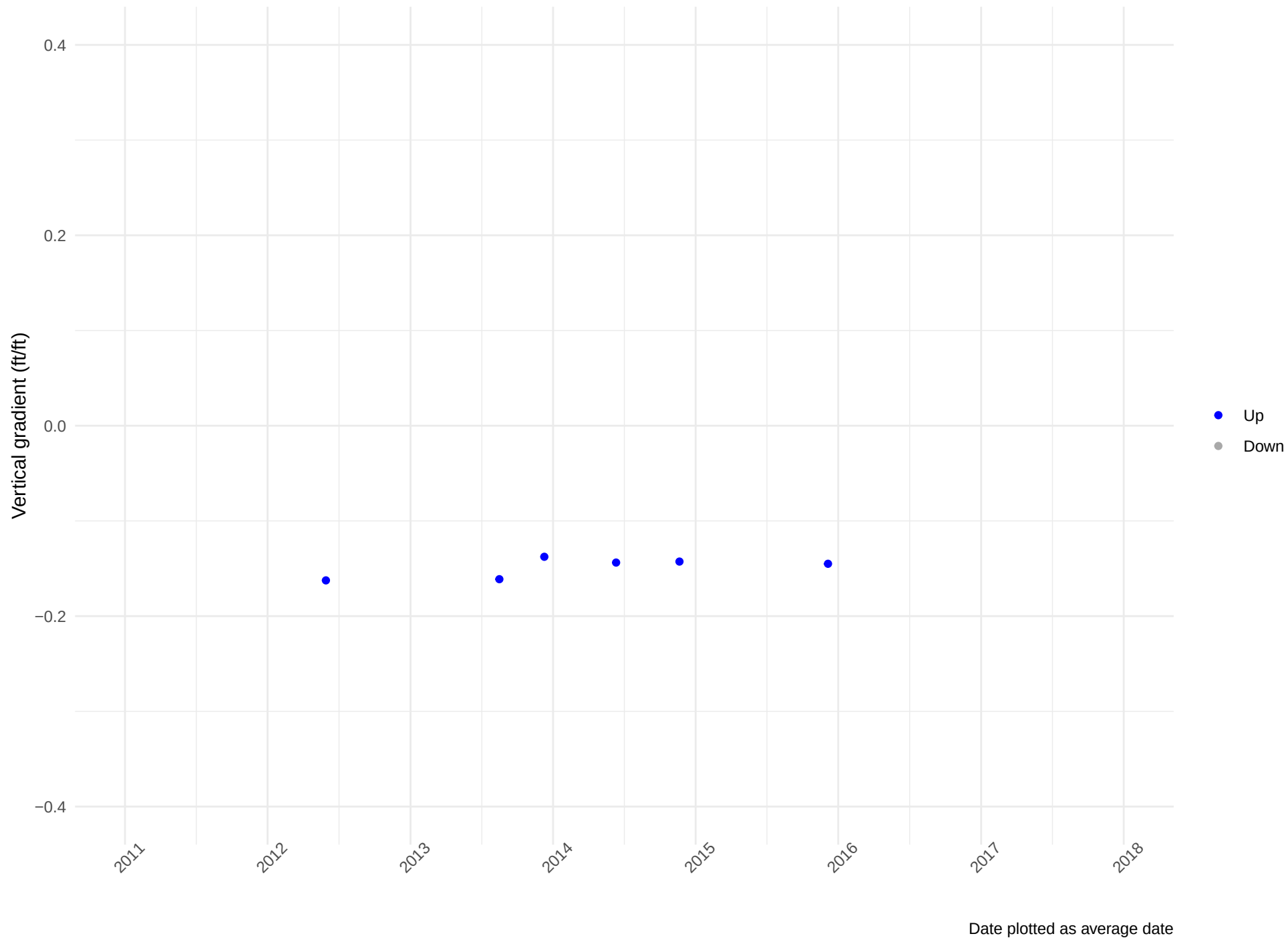
MW-410 & MW-411



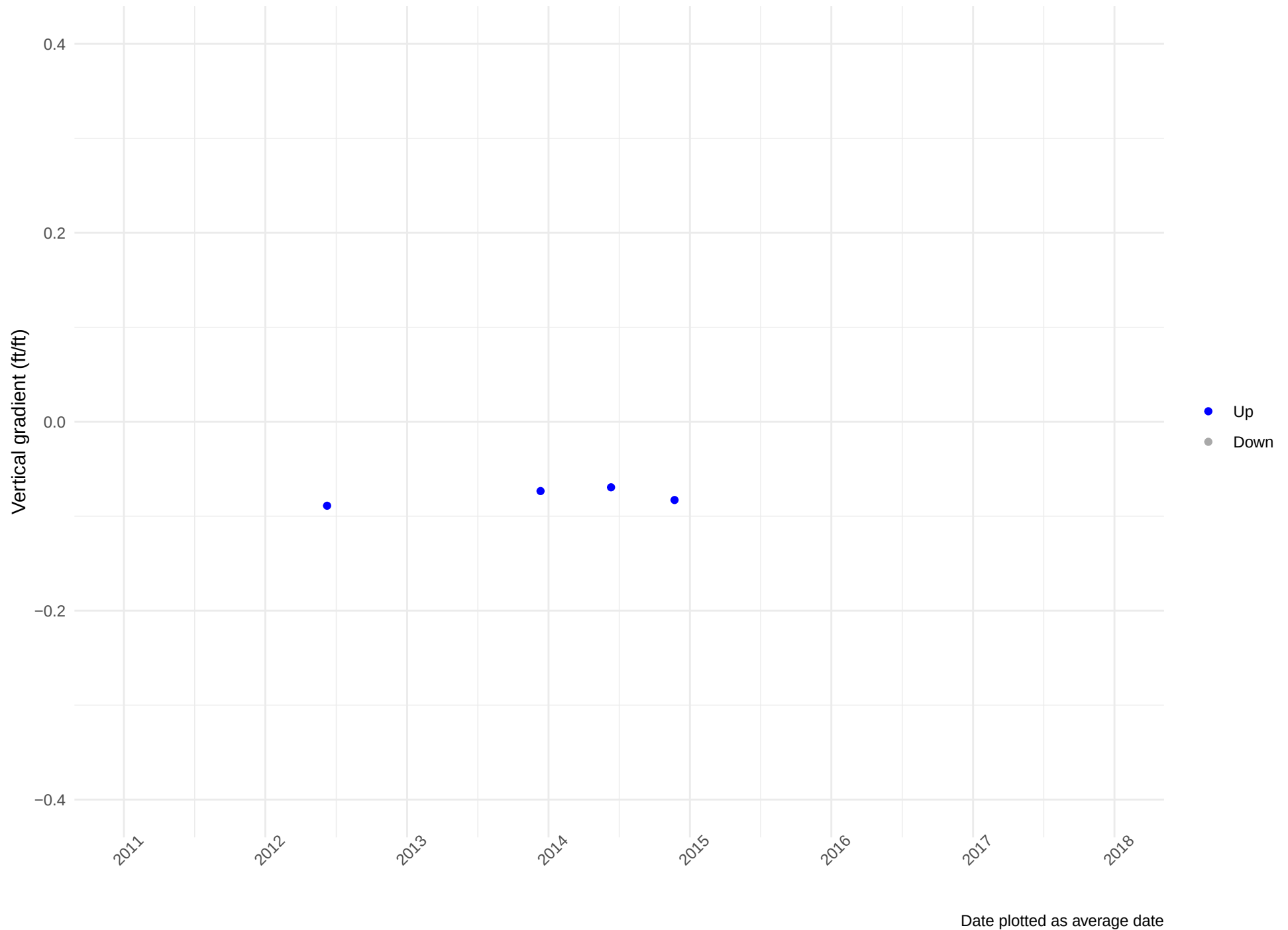
MW-419 & MW-420



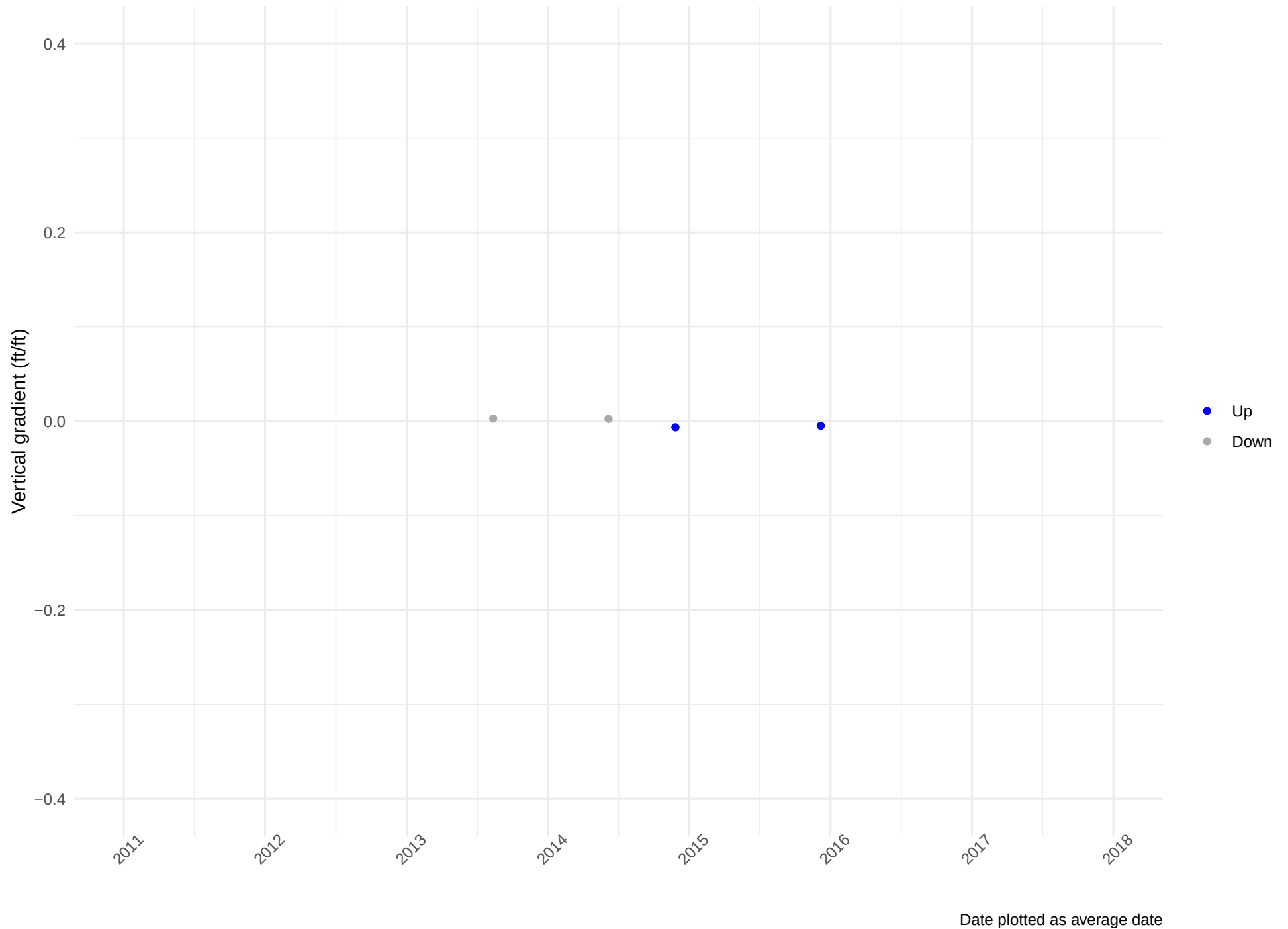
MW-428 & MW-429



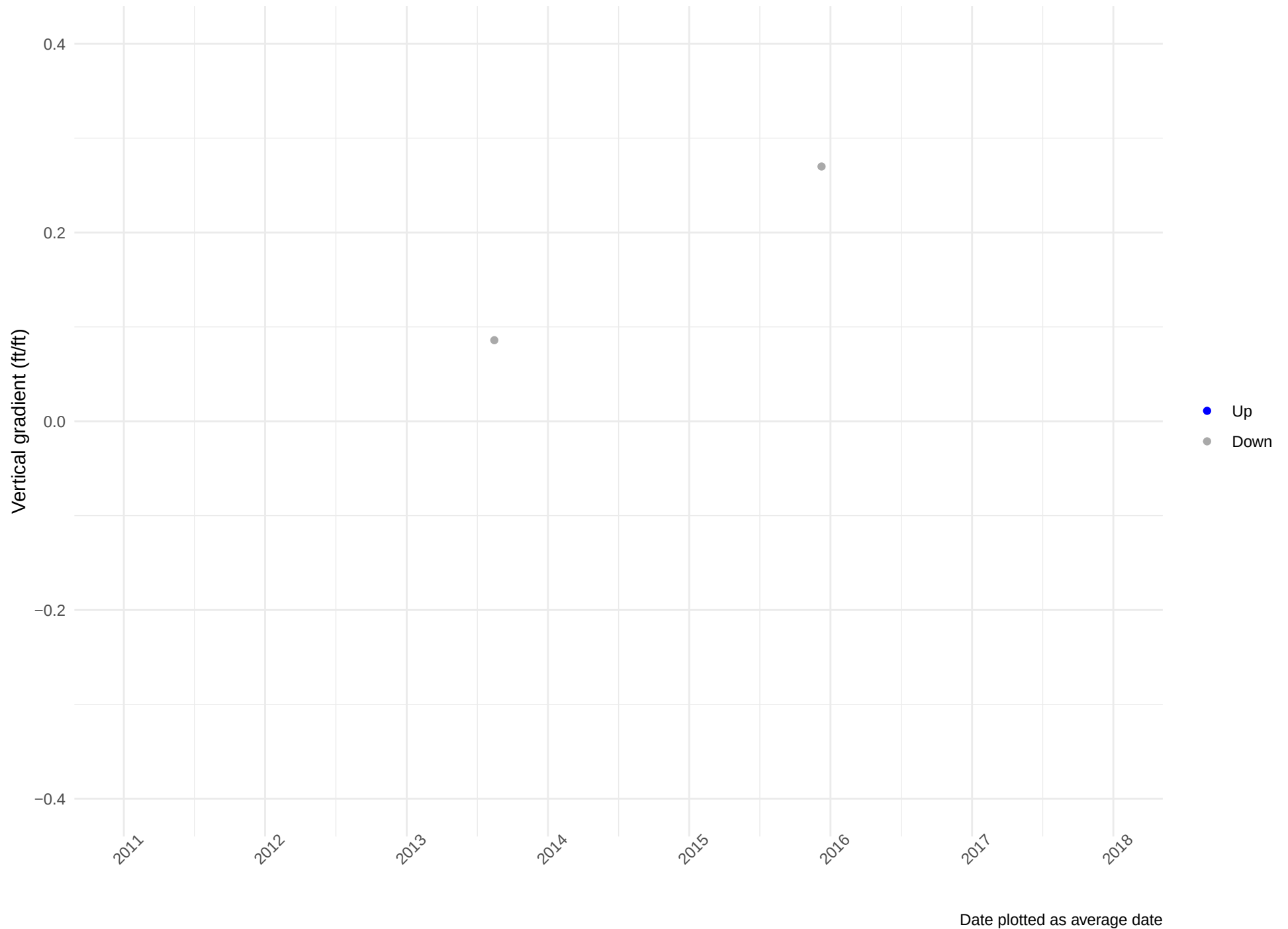
MW-437 & MW-438



MW-455 & MW-338



MW-460 & MW-299



MW-468 & MW-340

