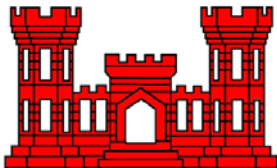


Appendix C

Part 1

Hydraulics and Hydrology



**U.S. Army Corps of Engineers
Memphis District**

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APPENDIX C

HYDRAULICS & HYDROLOGY

INTRODUCTION

Authorized project improvements proposed under Memphis District General Design Memorandum 101 St. Johns Bayou and New Madrid Floodway Missouri Phase II (GDM 101) will tend to maintain lower water surface elevations than currently exist during certain months of the year in the sump areas of St. Johns Bayou and the New Madrid Floodway. A hydraulic analysis was performed by the Memphis District Hydraulics Branch for existing and authorized project conditions in St. Johns Bayou and for existing, authorized, alternative 3.1, alternative 3.2, and alternative 4 project conditions in the New Madrid Floodway. The results of the analysis provide descriptive statistics required for the SEIS and are reported in this appendix.

BACKGROUND

Descriptive information of St. Johns Bayou and the New Madrid Floodway is provided below.

St. Johns Bayou

The St. Johns Bayou drainage basin is approximately 450 square miles in area and extends from Commerce and Benton, Missouri to New Madrid, Missouri (Plate 1). The basin has maximum dimensions of approximately 40 miles from north to south and approximately 25 miles from east to west. Under existing conditions the basin is separated from its natural outlet at the Mississippi River by levees. These levees form a sump and protect the southern portion of the basin interior from Mississippi River floodwaters (Plate 2). A gravity outlet consisting of six 10 ft x 10 ft box culverts extends through the Birds Point-New Madrid Setback Levee, permitting the basin to drain freely when the Mississippi River elevation is lower than the interior elevation. The existing sump ditch bottom is approximately 258 NGVD. Closure of the gates protects the interior from high Mississippi River stages. The existing gravity gate system was completed in 1953.

Runoff from intra-basin precipitation cannot drain by gravity during periods when the Mississippi River stage exceeds the interior water level. Under authorized project conditions a 1000 cfs pump station will be installed to permit removal of interior floodwater when the gravity outlets are closed against a high Mississippi River stage. The normal start and stop pump elevations will be 279 and 277 NGVD, respectively. During the waterfowl season the start and stop pump elevations will be 286 and 285 NGVD, respectively.

Operation of the project pump station from February through May will tend to maintain lower water surface elevations than currently exist in the sump area of St. Johns Bayou. During summer and fall

there will be little difference between existing and project conditions, since most drainage will still be gravity-flow through the existing gates. During December and January project water levels are expected to be higher due to intentional flooding of the sump area to promote waterfowl habitat.

To evaluate possible environmental impacts due to the lowered water levels expected in some months, an analysis was required. The approach taken was to perform a continuous simulation of interior water surface elevations for the period 1943-2009. The starting date of the simulation was 1 October, 1942.

New Madrid Floodway

The Birds Point-New Madrid Floodway was authorized by the Flood Control Act approved 15 May 1928. The Floodway is designed to convey part of the Mississippi River flow during extreme floods, thereby reducing stages at Cairo, Illinois. It has been operated twice, during the flood of 1937 and the flood of 2011. The Floodway extends from Birds Point to New Madrid and lies between the Birds Point-New Madrid Setback Levee and the Mississippi River Mainline Levee (Plate 1).

The Floodway drainage basin created by the surrounding levees has an area of approximately 183 square miles (Plate 1). The Floodway has a maximum length of about 30 miles from northeast to southwest and a maximum width of approximately 10 miles from northwest to southeast.

Unlike St. Johns Bayou, the New Madrid Floodway under existing conditions is subject to flooding from the Mississippi River. Levees completely surround and protect the Floodway, except at the Floodway outlet at New Madrid. The 1500 ft wide opening at New Madrid serves as an outlet during Floodway operation. Since operation of the Floodway is a rare event, the normal function of the opening is to provide a drainage outlet for the Floodway basin. Mud Ditch is the stream emerging from the Floodway outlet, with a bottom elevation of 261.23 NAVD. However, during high Mississippi River stages at New Madrid, the opening admits floodwaters from the river into the interior of the Floodway. Note that elevations in this document are related to NAVD in the New Madrid Floodway and to NGVD in St. Johns Bayou to properly correlate to the topographic data generated for the respective basins.

Under authorized project conditions the 1500 ft opening will be closed, forming a sump. A gravity outlet with an invert elevation of 261.23 NAVD and a 1500 cfs pump station will be installed to permit operation comparable to that proposed for St. Johns Bayou. The normal start and stop pump elevations will be 278.23 and 275.23 NAVD, respectively. During the 1 December to 31 January waterfowl season, the start and stop pump elevations will be 285.63 and 284.63 NAVD, respectively. The Floodway project results in a more significant change in interior stage-durations than for St. Johns Bayou, because the Floodway at New Madrid will be converted from an existing condition without backwater protection to a project condition of protection provided by levees and pumps. A continuous simulation was performed for the Floodway for the period 1943-2009, comparable to the analysis performed for St. Johns Bayou.

Three additional alternative projects were also analyzed for the New Madrid Floodway and are referred to as alternative 3.1, alternative 3.2, and alternative 4. These alternative projects differ from the authorized project with respect to higher normal start and stop pump elevations and changes in gate closing elevations to increase fish access availability into and out of the Floodway during fish spawning and rearing season. The alternative 3.1 project analysis presented in this appendix is based on start pump, stop pump, and gate closing elevations as follows:

- (1) For the period from 15 November through 28 February, start pump, stop pump, and gate closing elevations are 289.5, 288.5, and 288.0 NAVD88, respectively.
- (2) For the period from 1 March through 15 April, start pump, stop pump, and gate closing elevations are 288.0, 287.0, and 286.0 NAVD88, respectively.
- (3) For the period from 16 April through 30 May, start pump, stop pump, and gate closing elevations are 284.0, 282.0, and 284.0 NAVD88, respectively.
- (4) For the period from 1 June through 14 November, start pump, stop pump, and gate closing elevations are 280, 278.5, and 278.5 NAVD88, respectively.

The alternative 3.2 project analysis presented in this appendix is based on start pump, stop pump, and gate closing elevations as follows:

- (1) For the period from 15 November through 28 February, start pump, stop pump, and gate closing elevations are 289.5, 288.5, and 288.0 NAVD88, respectively.
- (2) For the period from 1 March through 15 April, start pump, stop pump, and gate closing elevations are 286.0, 285.0, and 284.0 NAVD88, respectively.
- (3) For the period from 16 April through 30 May, start pump, stop pump, and gate closing elevations are 282.0, 280.0, and 282.0 NAVD88, respectively.
- (4) For the period from 1 June through 14 November, start pump, stop pump, and gate closing elevations are 280, 278.5, and 278.5 NAVD88, respectively.

The alternative 4 project analysis presented in this appendix is based on start pump, stop pump, and gate closing elevations that do not change throughout the year and are 289.5, 288.5, and 288.0 NAVD88, respectively.

The St. Johns Bayou basin and the Floodway basin have a common outlet to the Mississippi River downstream of the proposed pump stations. The authorized pump stations for St. Johns Bayou and the New Madrid Floodway are about 0.2 miles apart (Plate 1). Mud Ditch joins St. Johns Bayou immediately downstream of the authorized pump stations. From the mouth of Mud Ditch to the Mississippi River, the final reach of St. Johns Bayou is approximately 0.5 miles long. The New Madrid gage is located approximately 0.3 miles downstream of the mouth of St. Johns Bayou.

METHOD

The descriptive statistics reported herein are based on a continuous simulation of the respective basins for the period 1943-2009. Neither St. Johns Bayou nor the Floodway have gage records

suitable for this analysis. Therefore, synthetic elevations were generated for the basins, which were compared to observed elevations on the Mississippi River at New Madrid.

Data

Basic data available for the study included Mississippi River elevations, rainfall, topography, and land cover. Mississippi River stage data at New Madrid was used for the period-of-record. Period-of-record rainfall data were available for the nearby towns of New Madrid, Missouri, Cairo, Illinois, and Sikeston, Missouri. Original study elevation-area curves based on conventional topographic mapping were available, as well as LIDAR-based curves prepared specifically for this analysis.

Wetland elevation in the sump areas of St. Johns Bayou and the New Madrid Floodway was computed based on continuous duration of flooding in the growing season. The *Analysis of Sump Daily Elevations* section describes wetland elevation calculations and the 14 day duration elevation used in the current legal wetland definition.

Determination of Daily Sump Elevations

St. Johns Bayou and the New Madrid Floodway were studied separately. For both basins it was necessary to develop a continuous synthetic record of daily sump elevations for 1943-2009. During the original development of GDM 101, hydrologic and hydraulic models were developed which served as the basis for design. These same models were the basis of the daily elevations used for existing and project conditions in the current analysis.

Synthetic daily inflows to the sump were calculated using the computer program HUXRAIN. The program uses the Antecedent Precipitation Index (API) method to estimate runoff from rainfall (see Appendix C Part 2). The rainfall data recorded at New Madrid, Cairo, and Sikeston were prorated by Thiessen polygons to estimate intra-basin rainfall depths. A pump-simulation computer program used the HUXRAIN synthetic daily inflows, the Mississippi River elevation, and information describing operation of the gravity outlet and pump station to calculate daily elevations at the sump.

St. Johns Bayou - For the existing conditions simulation, it was assumed that the gravity gates at the outlet structure would be operated to minimize interior stages throughout the period-of-record. Under project conditions waterfowl habitat will be maintained in December and January. During December and January, the simulation modeled flashboards with a crest elevation of 284.0 NGVD, which tended to maintain a minimum pool for waterfowl.

New Madrid Floodway - Under existing conditions there is no provision to control water surface elevation in the sump area. The daily elevation is either the elevation of the Mississippi River at New Madrid or the elevation associated with Mud Ditch discharge, whichever is higher.

Under project conditions the determination of daily sump elevation was made comparable to that for St. Johns Bayou. During December and January, the simulation modeled flashboards with a crest elevation of 283.0 NAVD, which tended to maintain a minimum pool for waterfowl.

Analysis of Daily Sump Elevations

Three types of hydrologic evaluation were performed for the analysis--wetland elevation, waterfowl habitat elevation, and fish habitat acreage.

1. Wetland Elevation - One criterion in the determination of nonagricultural wetlands is the degree of continuous inundation during the growing season. The growing season used in the analysis is 20 March to 11 November (237 days). According to current U. S. Army Corps of Engineers wetland policy, nonagricultural areas that are continuously inundated or saturated less than 14 days of the growing season are defined as non-wetlands. Those nonagricultural areas that are continuously inundated or saturated at least 14 days during the growing season may be wetlands, depending on the soil type and vegetation present. For each year in the simulation period, the highest 14 day duration elevations during the growing season were determined in the sump area. The median value of these annual maxima was taken as the effective 14 day duration elevation.

The computer program WETSORT was used to perform the statistical analyses for determination of wetland elevations due to continuous inundation. For each year of the period-of-record, WETSORT identified the span of consecutive days within the growing season having the highest minimum elevation and reported that minimum elevation. For example, the procedure used to determine the 14 day duration for existing conditions in St. Johns Bayou sump was as follows: The growing season in the project area was defined as 20 March to 11 November. For the period-of-record 1943-2009 (67 years), WETSORT identified for each year of the growing season the span of 14 consecutive days in St. Johns Bayou sump having the highest minimum elevation and reported that minimum elevation. WETSORT ranked each of the reported elevations in descending order. The median elevation determined from this group of 67 elevations was 287.1. This process was repeated for authorized project conditions in the St. Johns Bayou sump and for existing, authorized, alternative 3.1, alternative 3.2, and alternative 4 project conditions in the New Madrid Floodway.

The daily water surface elevations input to WETSORT were based on the combined effects of Mississippi River stages, local runoff events, and project operations, such as gate closure and pumping, if applicable. The daily water surface elevations do not account for wetland areas such as isolated shallow depressions that hold water under existing and project conditions for extended periods of time after inundation occurs.

2. Waterfowl Habitat Elevation - Evaluation of waterfowl habitat was performed by others for St. Johns Bayou existing and authorized project conditions and for the New Madrid Floodway existing, authorized, alternative 3.1, alternative 3.2, and alternative 4 project conditions. These evaluations were based on estimates of the habitat acreage available during the applicable season. Habitat acreage is dependent on the sump elevation-area relationship and elevation hydrograph. The

daily sump elevations prepared for this study were used as input to WETSORT for three waterfowl periods: November, December-January, and February-March. For this analysis, a span of three consecutive days for each waterfowl period for each year of the period-of-record was used. For each group of 67 elevations determined for each of the waterfowl periods that occurred during the period-of-record for existing and authorized project conditions in the St. Johns Bayou sump and for existing, authorized, alternative 3.1, alternative 3.2, and alternative 4 project conditions in the New Madrid Floodway, a frequency analysis was performed. The frequency analysis determined the elevations with a 99, 50, 20, 10, 4, 2, and 1 percent chance of annual exceedence, presented as the 1.01, 2, 5, 10, 25, 50, and 100 year return periods, respectively.

3. Fish Habitat Acreage - Evaluation of fish habitat was performed by others for St. Johns Bayou existing and authorized project conditions and for the New Madrid Floodway existing, authorized, alternative 3.1, alternative 3.2, and alternative 4 project conditions. These evaluations were based on estimates of the habitat acreage available during the 01 March-31 March early season, the 01 April-15 May mid-season, and the 16 May-30 June late season. Habitat acreage is dependent on the sump elevation-area relationship and elevation hydrograph. The daily sump elevations prepared for this study were used as input to a computer program to obtain estimates of habitat acreage. Habitat was also considered to be affected by the 2-yr and 5-yr frequency elevations, shown in Table 1. Note that the 2-yr frequency elevation has a 50 percent chance of annual exceedence, and the 5-yr frequency elevation has a 20 percent chance of annual exceedence.

Table 1 2-Yr and 5-Yr Frequency Sump Elevations

Project Area	Condition	2-yr Freq. Elev, ft	5-yr Freq. Elev, ft
St. Johns Bayou	Existing	291.0	294.1
	Authorized Project	290.4	292.6
New Madrid Floodway	Existing	292.1	296.6
	Authorized Project	285.7	286.5
	Alternative 3.1	287.6	288.7
	Alternative 3.2	287.2	288.3
	Alternative 4	288.5	289.6

Fish spawning and rearing habitat acreage was estimated using the computer program EnviroFish. Data required by the program consisted of the minimum number of days needed to compute available spawning habitat and maximum and minimum water depths, as shown in Table 2. Note that agricultural and fallow land were the only land use categories that were evaluated as spawning

habitat; all other land uses were evaluated as rearing habitat, which does not require a duration value. The beginning and ending years of the simulation period (1943-2009), the beginning and ending dates of the season, the HEC-DSSVue pathname of daily elevations, and the HEC-DSSVue pathname of daily water surface acreages were also required. The sump area was divided into land use categories for fish habitat. Although the EnviroFish program does not use food-source data, the land use categories serve to describe the surfaces available for spawning and rearing.

**Table 2 EnviroFish Input Data
by Land Use Category**

Item	Agri. Land	Developed Land	Fallow Land	Forested Land	Herbaceous Land	Open Water Bodies	Pasture Land	Scrub/ Shrub Land
	acres	Acres	acres	acres	acres	acres	acres	acres
Season	Early	01Mar -31Mar	01Mar -31Mar	01Mar -31Mar	01Mar -31Mar	01Mar -31Mar	01Mar -31Mar	01Mar -31Mar
	Mid	01Apr -15May	01Apr -15May	01Apr -15May	01Apr -15May	01Apr -15May	01Apr -15May	01Apr -15May
	Late	16May -30Jun	16May -30Jun	16May -30Jun	16May -30Jun	16May -30Jun	16May -30Jun	16May -30Jun
Duration, days	8	NA	8	NA	NA	NA	NA	NA
Max Water Depth, ft	99	99	99	99	99	99	99	99
Min Water Depth, ft	1.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0

ANALYSIS RESULTS

St. Johns Bayou - St. Johns Bayou water surface elevations are affected by existing and authorized project conditions. Project elevations may be higher during December and January due to intentional flooding of the interior; late winter and spring elevations are lowered for agricultural requirements; summer and fall elevations are only slightly lower than existing conditions. The results of the St. Johns Bayou sump analysis are presented graphically in Plates 3-72. Plates 3-70 present yearly plots (1942-2009) of existing and authorized project conditions for interior pool water surface elevations. Plate 71 presents a 365-day plot of interior pool elevation maxima, means, medians, and minima for the simulation period under existing conditions. Plate 72 presents a 365-day plot of interior pool elevation maxima, means, medians, and minima for the simulation period under authorized project conditions.

Wetland Elevation - It is estimated that for authorized project conditions the 14 day limiting nonagricultural wetland elevation will decrease 4.4 ft (Table 3).

**Table 3 Wetland Elevation 1943-2009
St. Johns Bayou Sump**

Evaluation Type:	Existing Conditions No Pump Elev, ft NGVD	Authorized Project Conditions 1000 cfs Pump Elev, ft NGVD
Wetland Elevation (20Mar-11 Nov)		
14 day duration	287.1	282.7

Waterfowl Habitat Elevation - Table 4 presents the waterfowl elevations for existing and authorized project conditions in the sump area of St. Johns Bayou. Authorized project elevations are a maximum of 2.6 feet lower than corresponding existing elevations during November for the 5 year return period. During the December-January waterfowl period, authorized project elevations are higher than existing elevations for the 1.01, 2, 5, and 10 year return periods, with a maximum difference of 24.2 feet for the 1.01 year return period; authorized project elevations are lower than existing elevations for the 25, 50, and 100 year return periods. Authorized project elevations are a maximum 2.9 feet lower than existing elevations during February-March for the 100 year return period.

**Table 4 Waterfowl Elevation 1943-2009
St. Johns Bayou Sump**

Return Period Years	November	November	Dec-Jan	Dec-Jan	Feb-Mar	Feb-Mar
	Existing Conditions No Pump	Authorized Project Conditions 1000 cfs Pump	Existing Conditions No Pump	Authorized Project Conditions 1000 cfs Pump	Existing Conditions No Pump	Authorized Project Conditions 1000 cfs Pump
	Elev, ft NGVD	Elev, ft NGVD	Elev, ft NGVD	Elev, ft NGVD	Elev, ft NGVD	Elev, ft NGVD
1.01	258.0	258.0	260.8	285.0	269.3	267.4
2	272.6	270.8	284.6	288.5	287.9	286.6
5	279.9	277.3	288.2	290.3	291.4	289.7
10	282.8	280.8	290.2	291.2	293.4	291.3
25	284.9	284.1	292.3	292.2	295.5	293.2
50	285.6	284.7	293.8	292.8	297.0	294.4
100	286.4	285.4	295.1	293.3	298.3	295.4

Fish Habitat Acreage - The summary habitat acreage values for the entire simulation period in the sump area of St. Johns Bayou are presented in Table 5 for current land use and in Table 6 for future land use. Indicated existing fish habitat acreages were greatest on agricultural land and forested land. Lesser acreages were obtained for developed land, fallow land, herbaceous land, open water bodies, and pasture land. The scrub/shrub land acreage was zero. Fish habitat acreages will be reduced under project conditions. The reduction is typically on the order of forty percent.

Data shown in the tables for the three time periods are not additive, e.g. the three period results should not be added to obtain a total yearly acreage for a given land use.

**Table 5 Fish Habitat Acreage
Current Land Use
St. Johns Bayou**

Item	Agri. Land acres	Developed Land acres	Fallow Land acres	Forested Land acres	Herbaceous Land Acres	Open Water Bodies Acres	Pasture Land acres	Scrub/ Shrub Land acres
01Mar-31Mar								
Existing	1054.6	59.5	39.9	1085.8	46.2	119.4	2.9	0.0
Authorized Project	588.0	32.7	25.7	726.1	30.1	91.4	1.0	0.0
01Apr-15May								
Existing	1043.7	67.5	40.2	1156.3	49.4	120.5	3.9	0.0
Authorized Project	563.7	35.3	24.0	739.5	30.9	90.6	1.2	0.0
16May-30Jun								
Existing	369.5	27.2	12.4	518.2	21.7	64.6	1.5	0.0
Authorized Project	139.2	13.8	5.3	278.5	11.2	44.1	0.5	0.0

**Table 6 Fish Habitat Acreage
Future Land Use
St. Johns Bayou**

Item	Agri. Land acres	Developed Land acres	Fallow Land acres	Forested Land acres	Herbaceous Land Acres	Open Water Bodies acres	Pasture Land acres	Scrub/ Shrub Land acres
01Mar-31Mar								
Existing	904.8	59.5	39.9	1263.3	96.9	144.8	2.9	0.0
Authorized Project	493.5	32.7	25.7	836.2	61.5	107.1	1.0	0.0
01Apr-15May								
Existing	892.5	67.5	40.2	1357.4	106.9	149.2	3.9	0.0
Authorized Project	474.7	35.3	24.0	855.8	64.2	107.2	1.2	0.0
16May-30Jun								
Existing	322.7	27.2	12.4	598.6	44.7	76.1	1.5	0.0
Authorized Project	119.6	13.8	5.3	318.1	22.5	49.7	0.5	0.0

New Madrid Floodway - New Madrid Floodway water surface elevations are affected by existing, authorized, alternative 3.1, alternative 3.2, and alternative 4 project conditions. The results of the New Madrid Floodway analysis are presented graphically in Plates 73-145. Plates 73-140 present yearly plots (1942-2009) of existing, authorized project, and alternative project conditions for interior pool water surface elevations. Plate 141 presents a 365-day plot of interior pool elevation maxima, means, medians, and minima for the simulation period under existing conditions. Plate 142, Plate 143, Plate 144, and Plate 145 present 365-day plots of interior pool elevation maxima, means, medians, and minima for the simulation period for the authorized project, alternative 3.1, alternative 3.2, and alternative 4, respectively.

Wetland Elevation - The wetland elevation for alternative 3.1 is 0.5 ft higher than alternative 3.2 and 7.6 ft higher than the authorized project (Table 7). The wetland elevation for alternative 4 is 0.6 ft lower than existing conditions.

**Table 7 Wetland Elevation 1943-2009
New Madrid Floodway Sump**

Evaluation Type:	Existing Conditions Open & No Pump	Authorized Project Conditions Closure & 1500 cfs Pump	Alt. 3.1 Project Conditions Closure & 1500 cfs Pump	Alt. 3.2 Project Conditions Closure & 1500 cfs Pump	Alt. 4 Project Conditions Closure & 1500 cfs Pump
	Elev, Ft NAVD	Elev, Ft NAVD	Elev, Ft NAVD	Elev, Ft NAVD	Elev, Ft NAVD
Wetland Profile (20Mar-11 Nov)					
14 day duration	287.7	276.0	283.6	283.1	287.1

Waterfowl Habitat Elevation - Waterfowl elevations for existing and authorized project conditions in the sump area of the New Madrid Floodway are presented in Table 8. Authorized project elevations are a maximum of 2.6 feet lower than corresponding existing elevations during November for the 5 year return period. During the December-January waterfowl period, authorized project elevations are higher than existing elevations for the 1.01, 2, 5, and 10 year return periods, with a maximum difference of 21.1 feet for the 1.01 year return period; authorized project elevations are lower than existing elevations for the 25, 50, and 100 year return periods. Authorized project elevations are a maximum 2.9 feet lower than existing elevations during February-March for the 100 year return period.

**Table 8 Waterfowl Elevation 1943-2009
New Madrid Floodway Sump**

Return Period Years	November	November	Dec-Jan	Dec-Jan	Feb-Mar	Feb-Mar
	Existing Conditions Open & No Pump	Authorized Project Conditions Closure & 1500 cfs Pump	Existing Conditions Open & No Pump	Authorized Project Conditions Closure & 1500 cfs Pump	Existing Conditions Open & No Pump	Authorized Project Conditions Closure & 1500 cfs Pump
	Elev, ft NAVD	Elev, ft NAVD	Elev, ft NAVD	Elev, ft NAVD	Elev, ft NAVD	Elev, ft NAVD
1.01	262.8	262.4	262.9	284.0	275.3	267.2
2	272.1	270.5	282.1	285.5	288.5	281.0
5	276.9	275.5	289.0	286.2	293.4	282.8
10	279.3	278.5	292.9	286.5	296.0	283.9
25	282.0	280.5	297.1	286.9	298.4	285.0
50	283.8	281.2	299.5	287.1	299.9	285.8
100	285.4	281.7	301.9	287.3	301.4	286.4

Table 9 presents the waterfowl elevations for alternative 3.1 and alternative 3.2. To the nearest 0.1 feet, no difference is indicated between the alternative 3.1 and alternative 3.2 November and December-January waterfowl periods. During the February-March waterfowl period, alternative 3.1 elevations are a maximum 0.5 feet higher than alternative 3.2 elevations for the 5 year return period.

**Table 9 Waterfowl Elevation 1943-2009
New Madrid Floodway Sump**

Return Period Years	November	November	Dec-Jan	Dec-Jan	Feb-Mar	Feb-Mar
	Alt. 3.1 Project Conditions Closure & 1500 cfs Pump	Alt. 3.2 Project Conditions Closure & 1500 cfs Pump	Alt. 3.1 Project Conditions Closure & 1500 cfs Pump	Alt. 3.2 Project Conditions Closure & 1500 cfs Pump	Alt. 3.1 Project Conditions Closure & 1500 cfs Pump	Alt. 3.2 Project Conditions Closure & 1500 cfs Pump
	Elev, ft NAVD	Elev, ft NAVD	Elev, ft NAVD	Elev, ft NAVD	Elev, ft NAVD	Elev, ft NAVD
1.01	262.4	262.4	284.0	284.0	275.3	275.3
2	271.5	271.5	286.2	286.2	286.1	285.7
5	276.9	276.9	287.4	287.4	288.5	288.0
10	279.3	279.3	288.0	288.0	289.3	289.0
25	282.0	282.0	288.5	288.5	289.9	289.6
50	283.1	283.1	288.9	288.9	290.3	290.0
100	283.9	283.9	289.3	289.3	290.7	290.4

Table 10 presents the waterfowl elevations for alternative 4. To the nearest 0.1 feet, alternative 4 elevations are a maximum 0.1 feet higher than alternatives 3.1 and alternative 3.2 during the November waterfowl period. No difference is indicated between alternative 3.1, alternative 3.2, and alternative 4 for the December-January waterfowl period. During the February-March waterfowl period, alternative 4 elevations are a maximum 1.1 feet higher than alternative 3.1 elevations for the 50 year and 100 year return periods.

**Table 10 Waterfowl Elevation 1943-2009
New Madrid Floodway Sump**

Return Period Years	November	Dec-Jan	Feb-Mar
	Alt. 4 Project Conditions Closure & 1500 cfs Pump	Alt. 4 Project Conditions Closure & 1500 cfs Pump	Alt. 4 Project Conditions Closure & 1500 cfs Pump
	Elev, ft NAVD	Elev, ft NAVD	Elev, ft NAVD
1.01	262.4	284.0	275.3
2	271.6	286.2	286.5
5	277.0	287.4	289.1
10	279.4	288.0	290.3
25	282.0	288.5	290.9
50	283.1	288.9	291.4
100	284.0	289.3	291.8

Fish Habitat Acreage - The summary habitat acreage values for the entire simulation period in the sump area of the New Madrid Floodway are presented in Table 11 for current land use and in Table 12 for future land use. Indicated existing fish habitat acres were greatest on agricultural land and forested land. Lesser acreages were obtained for developed land, fallow land, herbaceous land, open water bodies, pasture land, and scrub/shrub land. The program indicates that fish habitat acreages will be reduced under project conditions. Program output indicates alternative 3.1 will typically maintain about ten times the habitat acreage as the authorized project and that alternative 3.2 will typically maintain six to seven times the habitat acreage as the authorized project.

As stated above, the three period results should not be summed to obtain a total yearly acreage for a given land use.

**Table 11 Fish Habitat Acreage
Current Land Use
New Madrid Floodway**

Item	Agri. Land acres	Developed Land acres	Fallow Land acres	Forested Land acres	Herbaceous Land acres	Open Water Bodies Acres	Pasture Land acres	Scrub/ Shrub Land acres
01Mar-31Mar								
Existing	3124.6	105.3	21.2	1462.4	285.2	137.1	2.6	0.3
Authorized Project	34.0	0.5	2.4	81.9	13.0	17.3	0.0	0.0
Alternative 3.1	802.4	18.3	9.4	881.3	274.7	94.1	0.4	0.1
Alternative 3.2	450.2	9.2	5.2	567.5	272.3	83.4	0.3	0.0
Alternative 4	1209.9	25.9	11.4	1062.3	275.8	100.5	0.4	0.2
01Apr-15May								
Existing	3009.8	108.2	22.9	1523.3	277.1	145.7	2.5	0.4
Authorized Project	21.0	0.2	2.4	73.2	13.3	16.8	0.0	0.0
Alternative 3.1	374.9	10.0	5.7	586.4	254.5	74.6	0.3	0.1
Alternative 3.2	154.3	3.6	3.9	342.8	195.1	58.5	0.2	0.0
Alternative 4	1286.0	29.2	11.7	1136.5	265.8	101.5	0.4	0.2
16May-30Jun								
Existing	927.9	49.1	10.1	679.6	142.8	74.1	1.1	0.2
Authorized Project	13.8	0.1	1.6	52.4	5.6	11.4	0.0	0.0
Alternative 3.1	29.9	0.6	2.0	123.7	69.1	24.8	0.1	0.0
Alternative 3.2	17.4	0.3	2.0	105.0	38.7	21.0	0.0	0.0
Alternative 4	447.5	12.4	5.0	534.0	138.3	52.8	0.2	0.1

**Table 12 Fish Habitat Acreage
Future Land Use
New Madrid Floodway**

Item	Agri. Land acres	Developed Land acres	Fallow Land acres	Forested Land acres	Herbaceous Land acres	Open Water Bodies Acres	Pasture Land acres	Scrub/ Shrub Land acres
01Mar-31Mar								
Existing	2906.4	105.3	21.2	1677.7	344.6	166.7	2.6	0.3
Authorized Project	11.7	0.5	2.4	112.2	15.6	18.5	0.0	0.0
Alternative 3.1	606.2	18.3	9.4	1074.4	327.8	120.7	0.4	0.1
Alternative 3.2	262.5	9.2	5.2	751.8	322.8	108.7	0.3	0.0
Alternative 4	1005.7	25.9	11.4	1260.6	330.3	127.8	0.4	0.2
01Apr-15May								
Existing	2801.8	108.2	22.9	1734.8	335.0	174.7	2.5	0.4
Authorized Project	1.5	0.2	2.4	102.8	15.6	18.0	0.0	0.0
Alternative 3.1	227.0	10.0	5.7	757.8	301.0	97.9	0.3	0.1
Alternative 3.2	67.7	3.6	3.9	467.4	228.3	75.0	0.2	0.0
Alternative 4	1087.3	29.2	11.7	1333.0	319.5	128.4	0.4	0.2
16May-30Jun								
Existing	839.1	49.1	10.1	787.5	170.9	88.2	1.1	0.2
Authorized Project	1.0	0.1	1.6	72.4	6.7	11.9	0.0	0.0
Alternative 3.1	1.1	0.6	2.0	178.8	81.2	30.8	0.1	0.0
Alternative 3.2	0.0	0.3	2.0	139.4	44.9	24.1	0.0	0.0
Alternative 4	359.3	12.4	5.0	638.7	165.5	66.5	0.2	0.1

Operation of the New Madrid Floodway

As a result of closure of the New Madrid Floodway under authorized and alternative project conditions, impacts to the flowlines for each condition were evaluated due to operation of the New Madrid Floodway. A description of each of the operation plans is included in Appendix K, Birds Point-New Madrid Floodway Operation.

Extensive model tests of the Mississippi River Levee system have been made to compare the current system response with that resulting from closing the existing gap at the lower end of the Floodway. Model test results are included in a report entitled “Transmittal of the Mississippi Basin Model Letter Report 89-1, Birds Point-New Madrid Floodway Reconnaissance Study,” dated July 27, 1990. The report reflected steady-state Project Design Flood (PDF) tests and PDF hydrograph tests, considering the 1986 Plan of Operation of the New Madrid Floodway.

The results from the steady-state PDF tests comparing current conditions with and without the 1500-foot levee closure indicate very little difference in stages at Mississippi River gage locations. The only measured increases in stages with the closure were at Hickman, Kentucky and H.W. 173, which were 0.1 feet and 0.3 feet higher, respectively. A 0.1 feet decrease in stage was measured at the New Madrid gage for the test with the closure. The maximum increase in water surface elevation at stations along the riverside of the frontline levee was 0.5 feet at levee mile 81.

The results from the steady-state PDF tests show increases along the Birds Point-New Madrid Setback Levee due to closure of the 1500-foot gap. The increase in water surface elevation along the setback levee by closing the gap is presented in Table 13.

Table 13 Water Surface Elevation along Setback Levee

Levee Mile	Distance	Existing	Project	Difference
	ft	Elev, ft NGVD	Elev, ft NGVD	
0	0	327.1	327.1	0.0
1	5215	326.9	326.9	0.0
2	10513	326.6	326.6	0.0
3	15801	325.7	325.9	0.2
4	21099	325.4	325.6	0.2
5	26309	325.0	325.2	0.2
6	31637	324.4	324.7	0.3
7	36929	322.4	322.7	0.3
8	42251	321.2	321.7	0.5
9	47563	320.3	320.9	0.6
10	52705	320.1	320.9	0.8
11	58017	319.1	320.2	1.1
12	63321	319.0	320.0	1.0
13	68621	318.8	319.9	1.1
14	73927	318.7	319.8	1.1
15	79119	318.6	319.8	1.2
16	84410	318.5	319.8	1.3
16.7	87984	318.2	319.5	1.3
17	89516	318.1	319.4	1.3
18	94634	318.0	319.3	1.3
19	99921	318.0	319.2	1.2
20	105123	317.9	319.1	1.2
20.3	106712	317.8	319.0	1.2
21	110421	317.8	319.0	1.2
22	115713	317.7	318.9	1.2
23	121012	317.6	318.8	1.2
24	126288	317.6	318.7	1.1
24.2	127327	317.3	318.4	1.1
25.5	134137	316.0	317.5	1.5
26	136789	315.9	317.4	1.5
27	142093	315.1	316.4	1.3
28	147504	315.1	316.4	1.3
29	152778	314.5	315.9	1.4
30	157984	314.0	315.4	1.4
31	163271	313.0	314.3	1.3
32	168666	312.0	313.2	1.2
33	174006	309.7	311.6	1.9
34	179300	308.8	311.6	2.8
35	181970	307.9	311.6	3.7
36	186117	307.7	307.7	0.0

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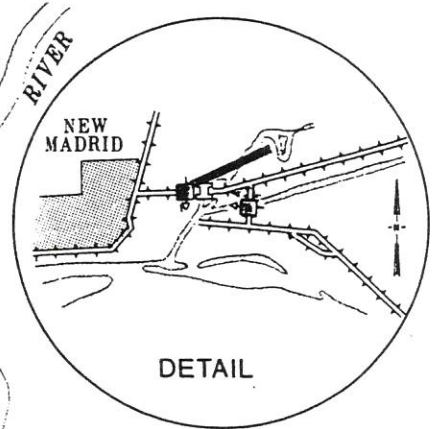
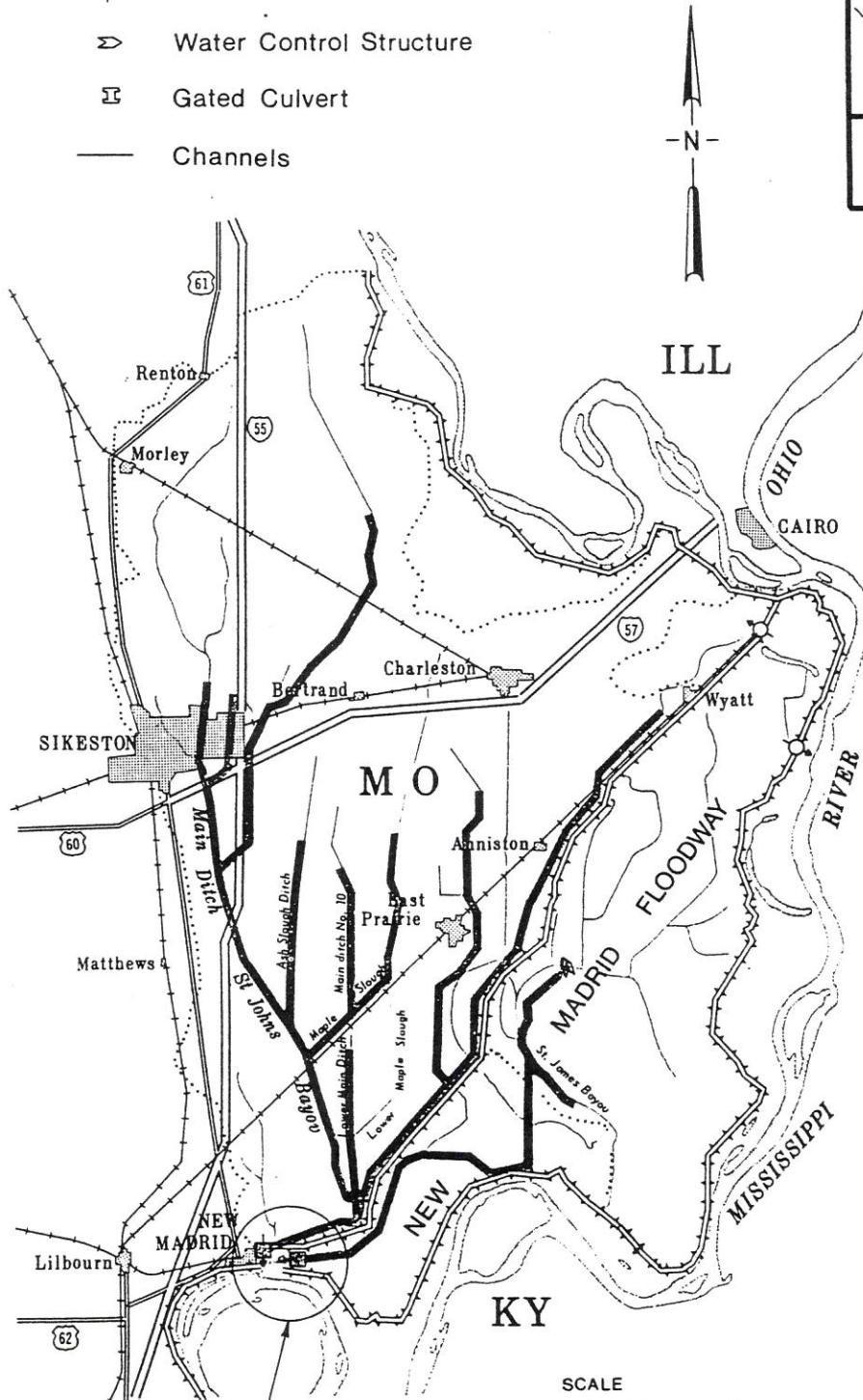
Analysis of Potential Modification to the Plan of Operation for the Birds Point-New Madrid Floodway. U.S. Army Corps of Engineers Memphis District. 1985.

LEGEND

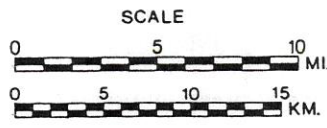
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- Watershed Divide
- Channel Plug
- Pumping Station
- Outlet Structure
- Water Control Structure
- Gated Culvert
- Channels
- Recommended
- Under Construction
- Completed



VICINITY MAP
SCALE IN MILES
0 20 40



SEE DETAIL

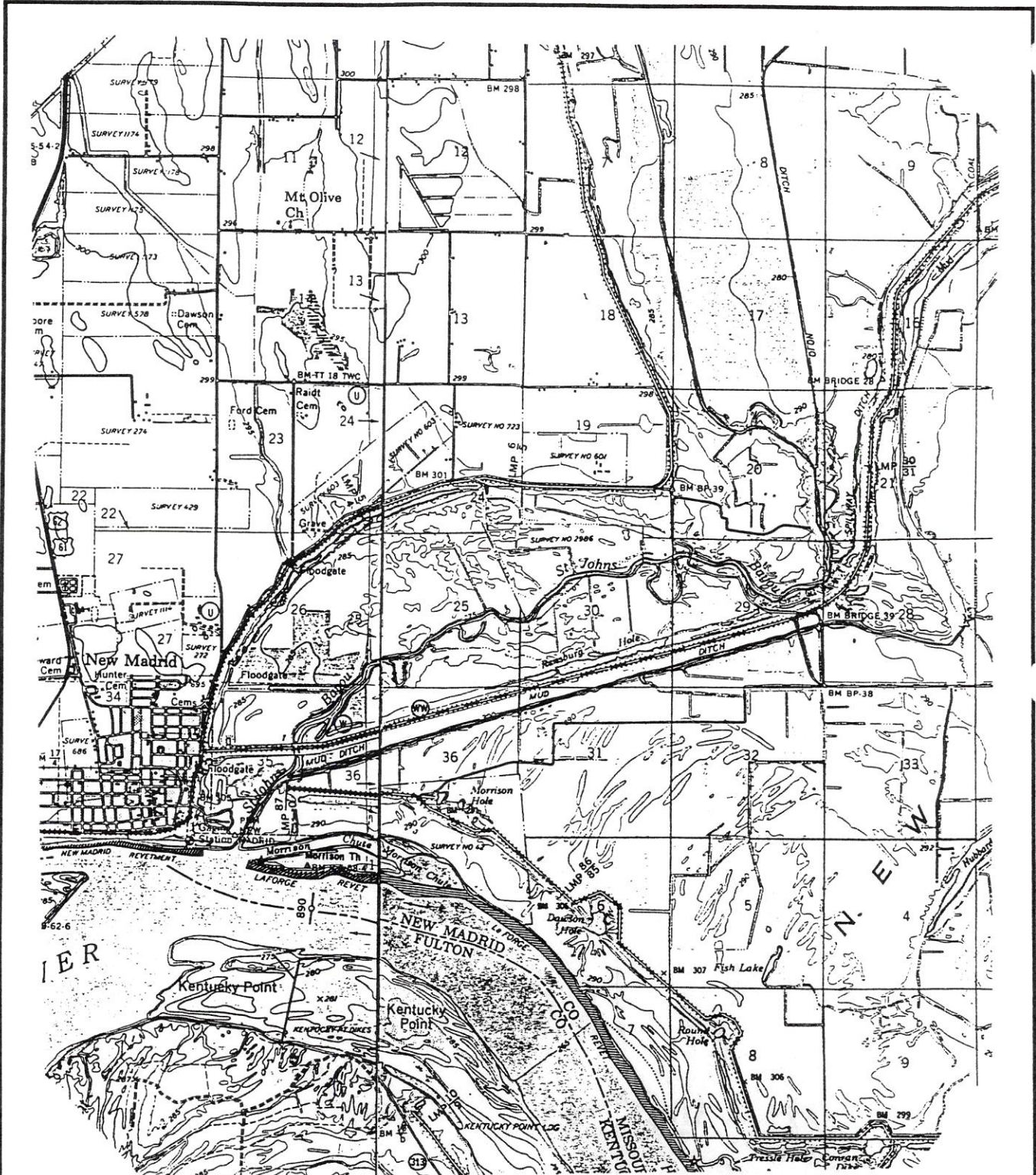


MISSISSIPPI RIVER COMMISSION
ST JOHNS BAYOU AND
NEW MADRID FLOODWAY MO.

OFFICE OF THE DISTRICT ENGINEER
MEMPHIS, TENN.

30 SEPTEMBER 1985

PLATE 1

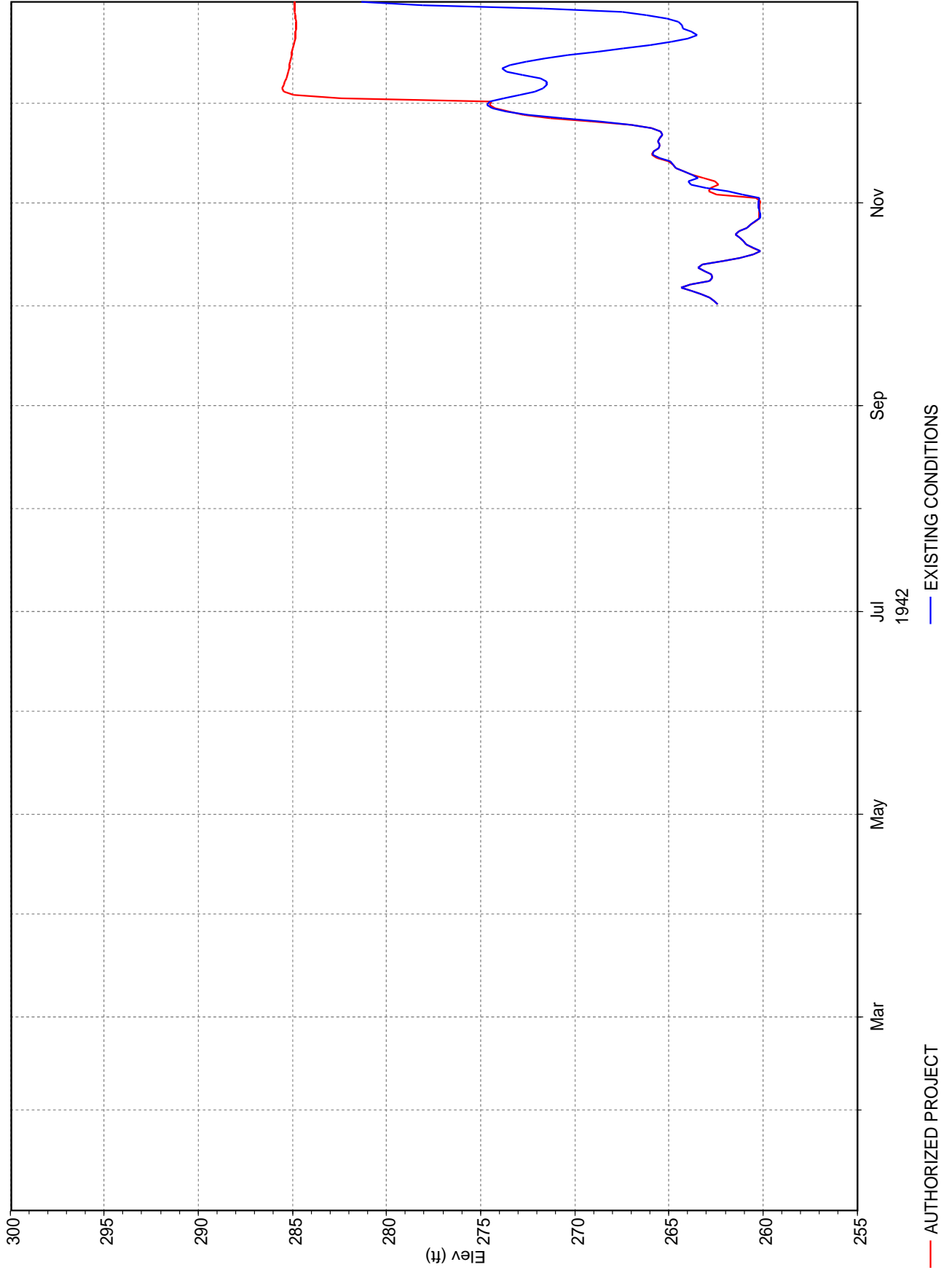


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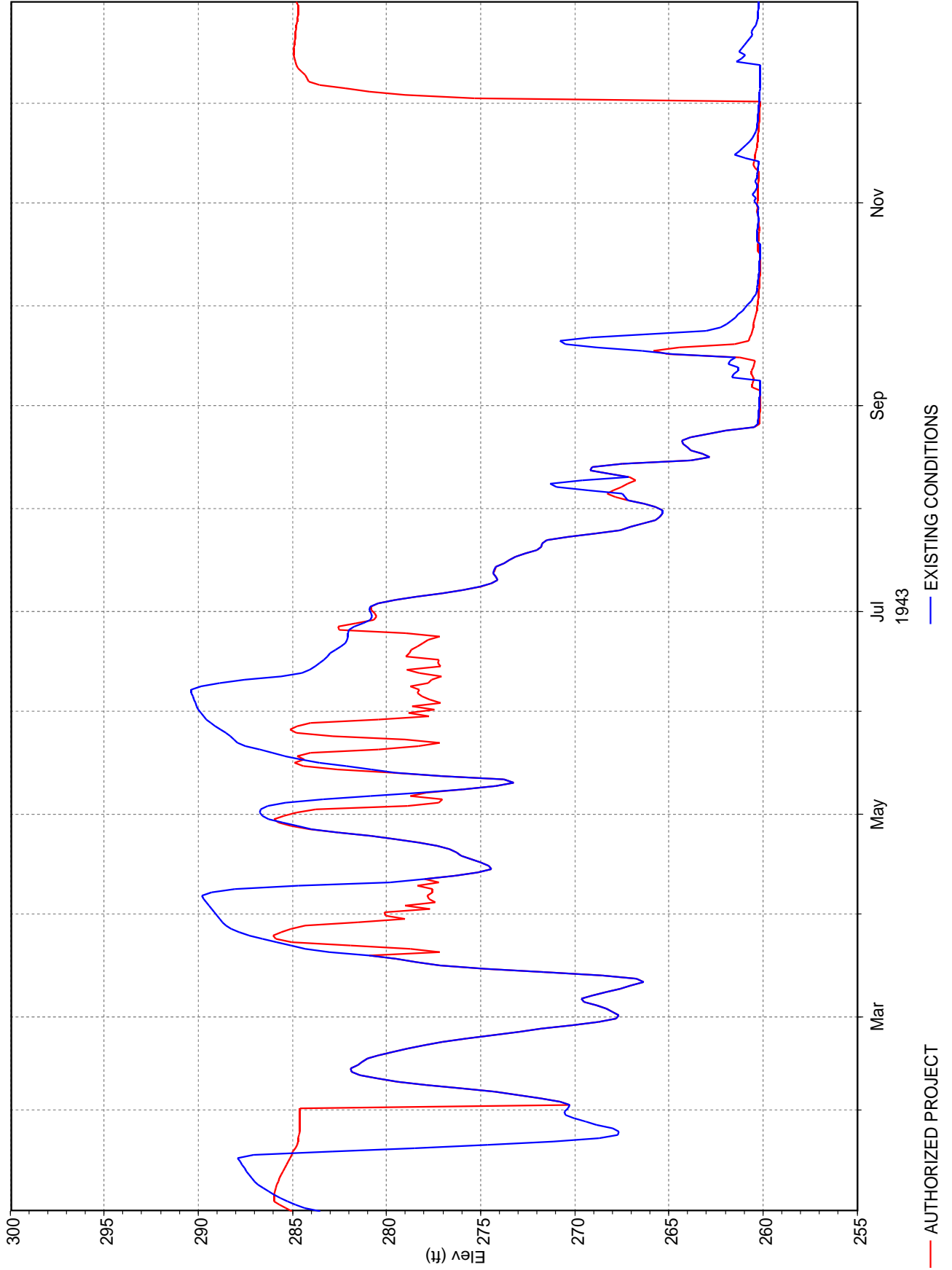
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PLATE 2

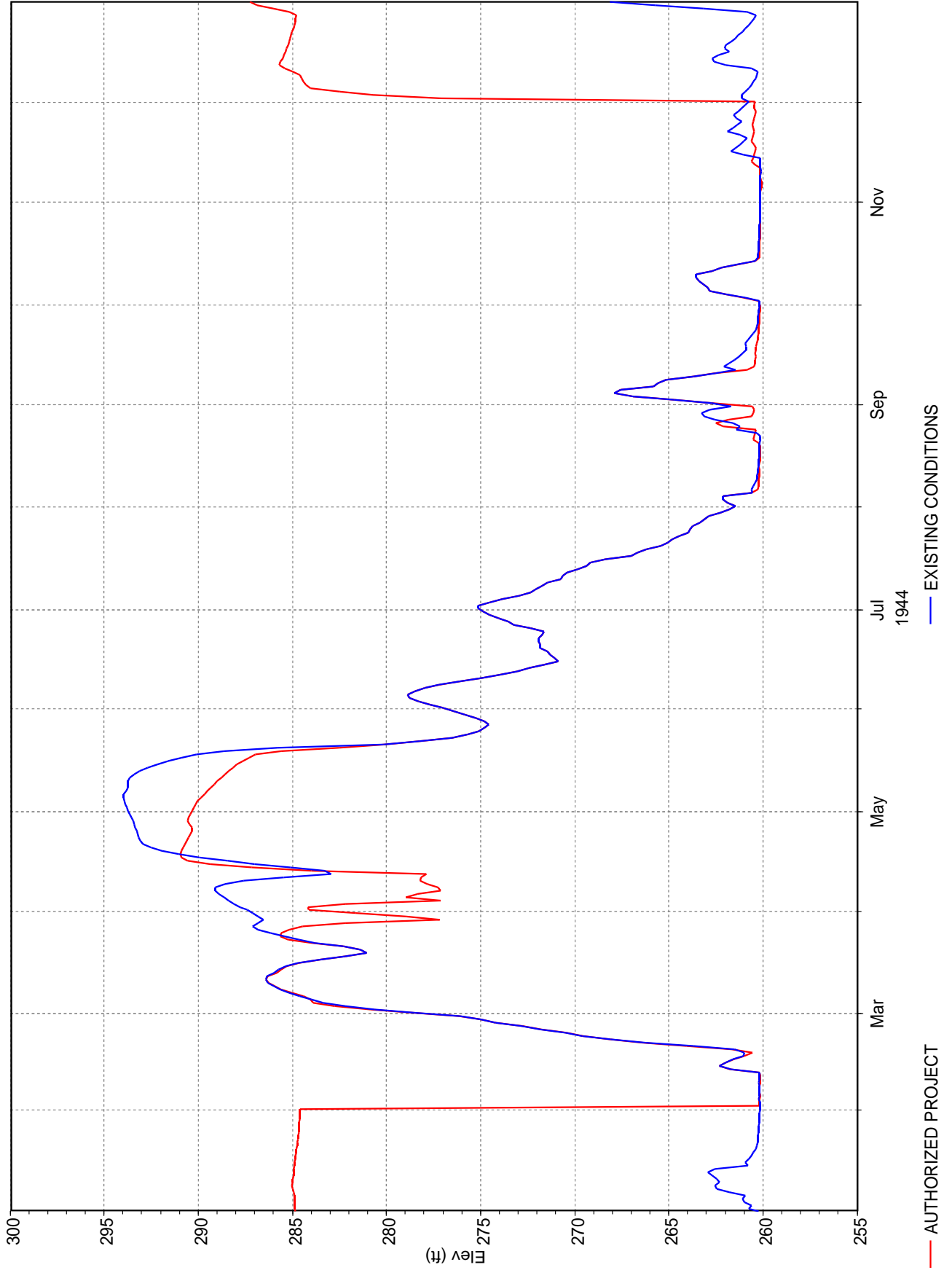
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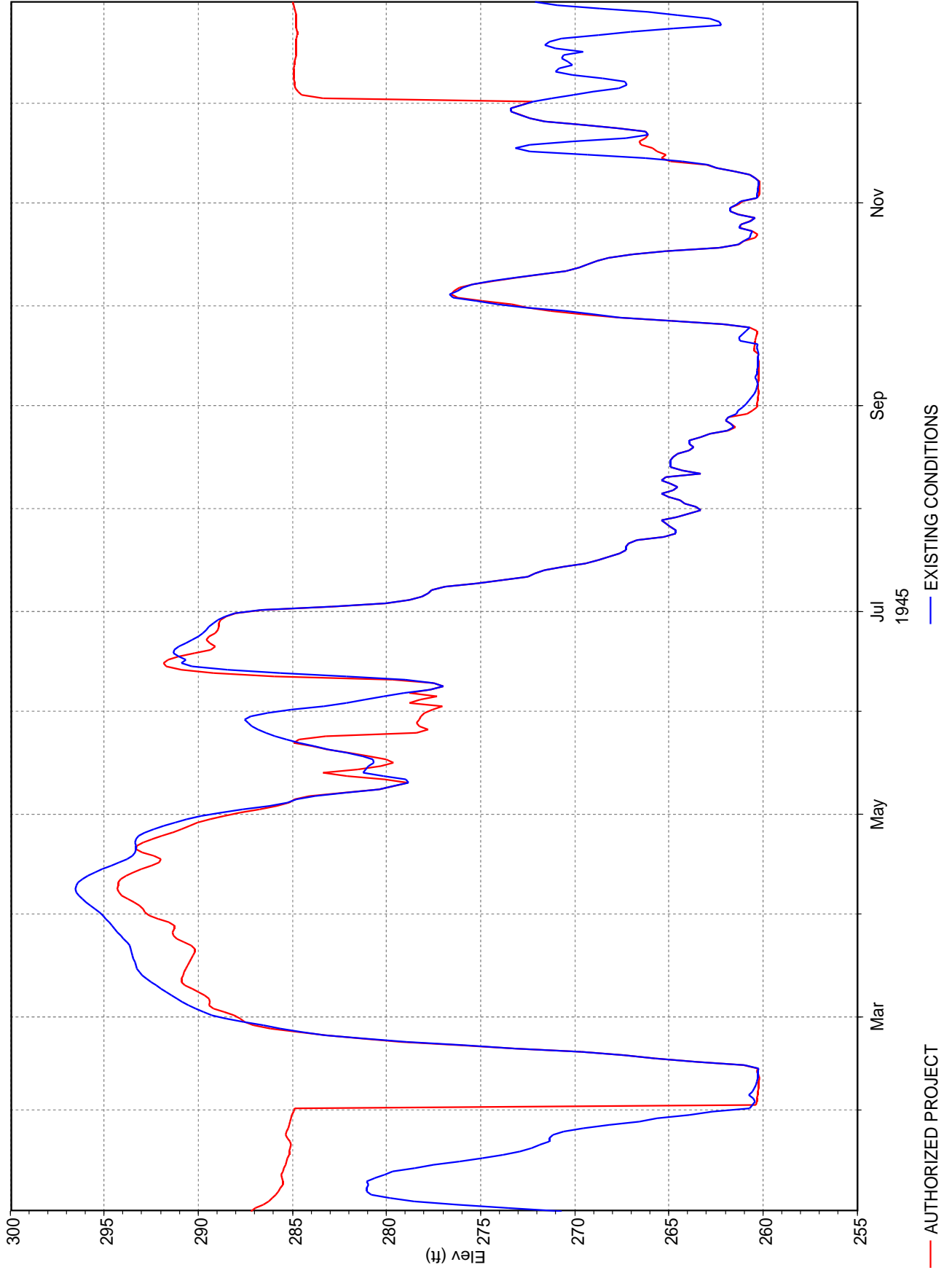
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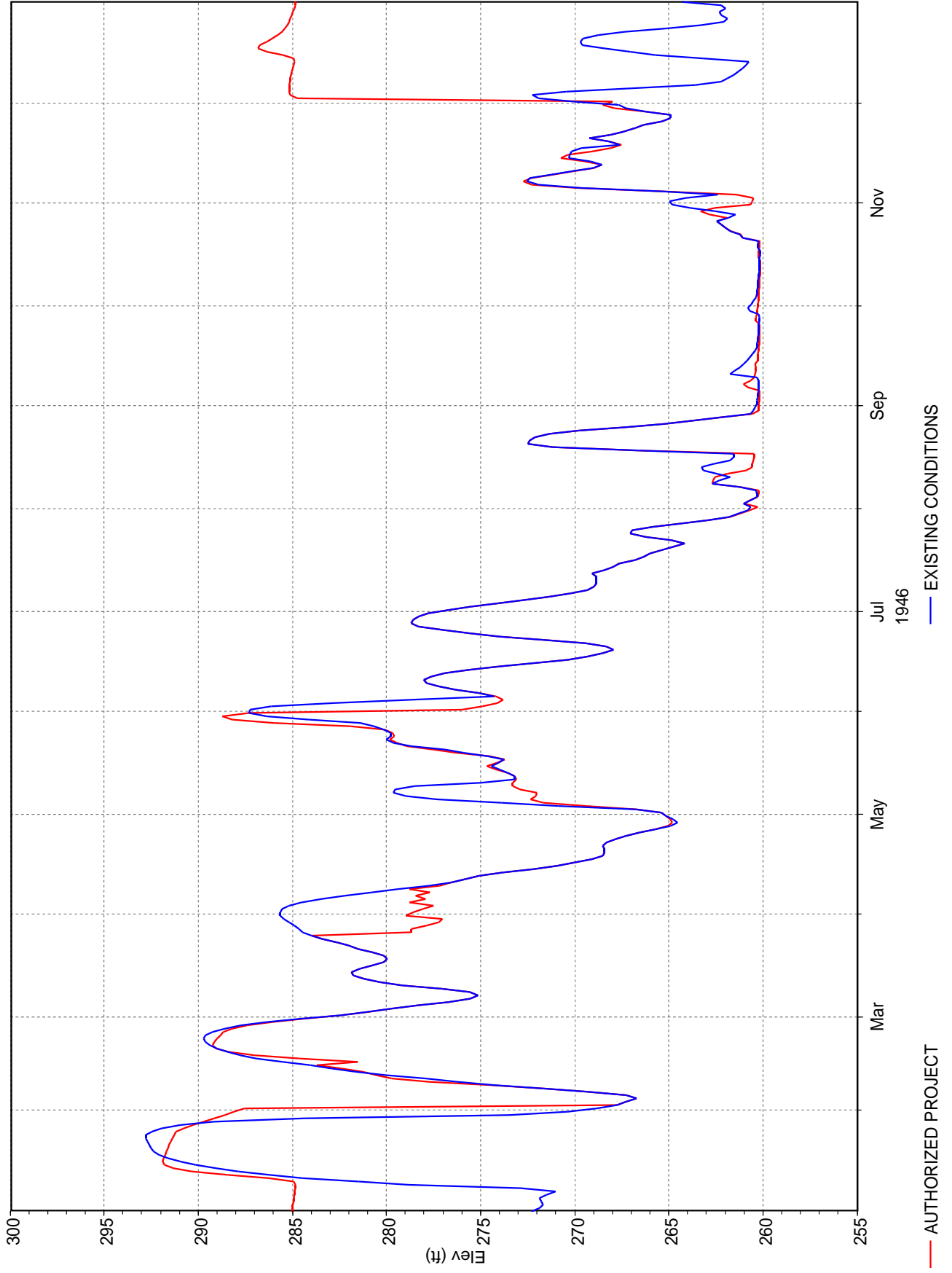
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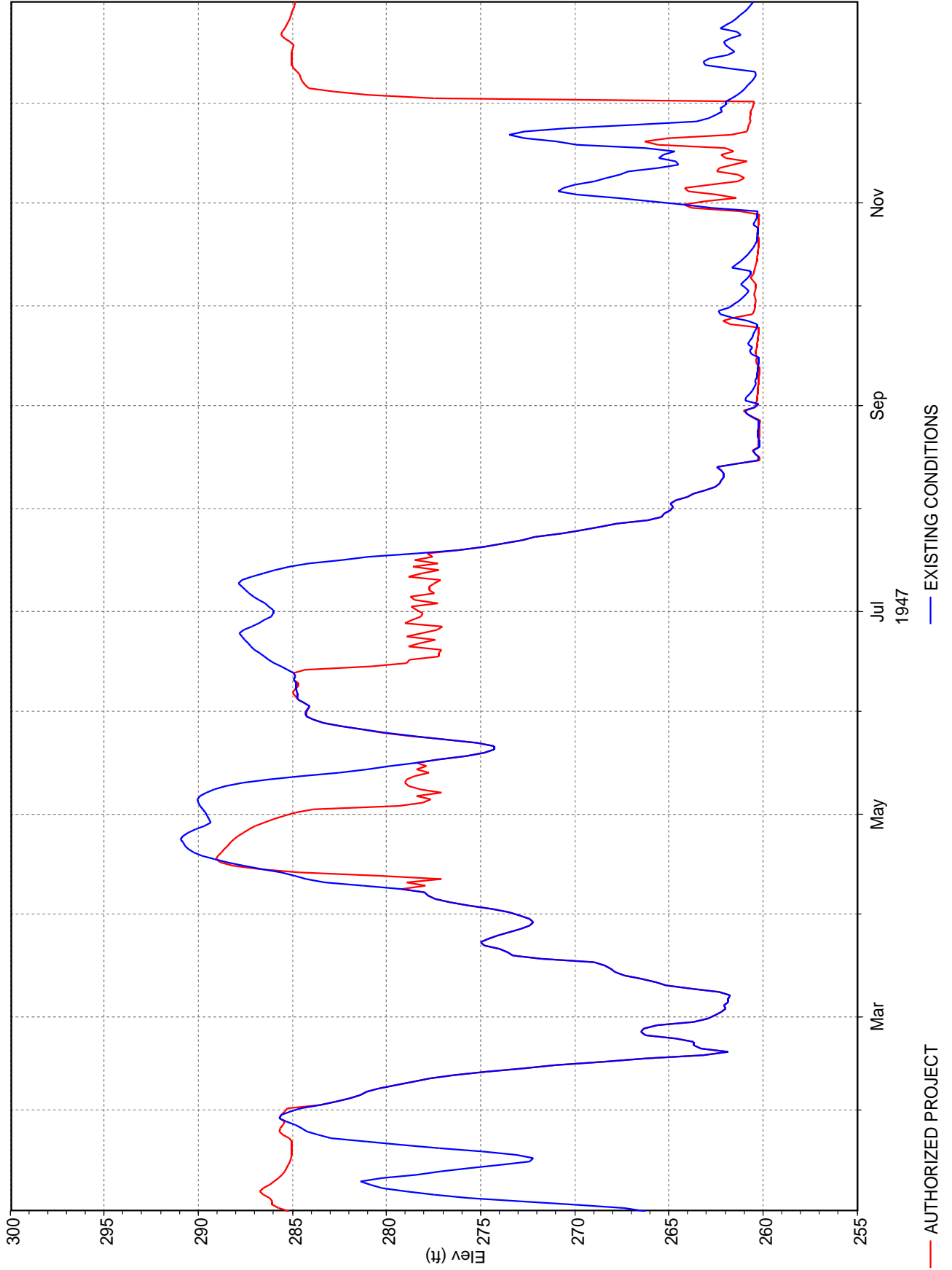
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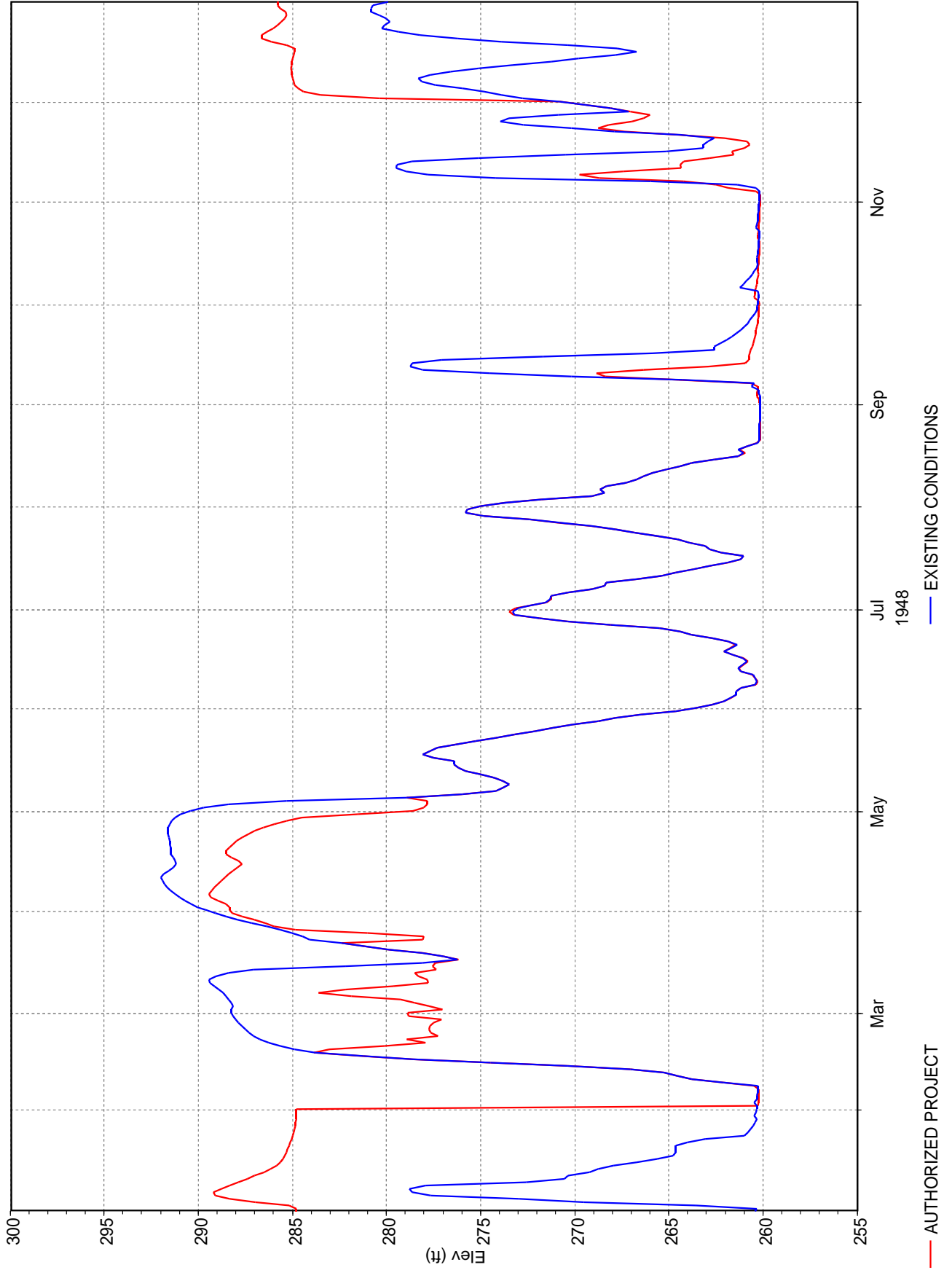
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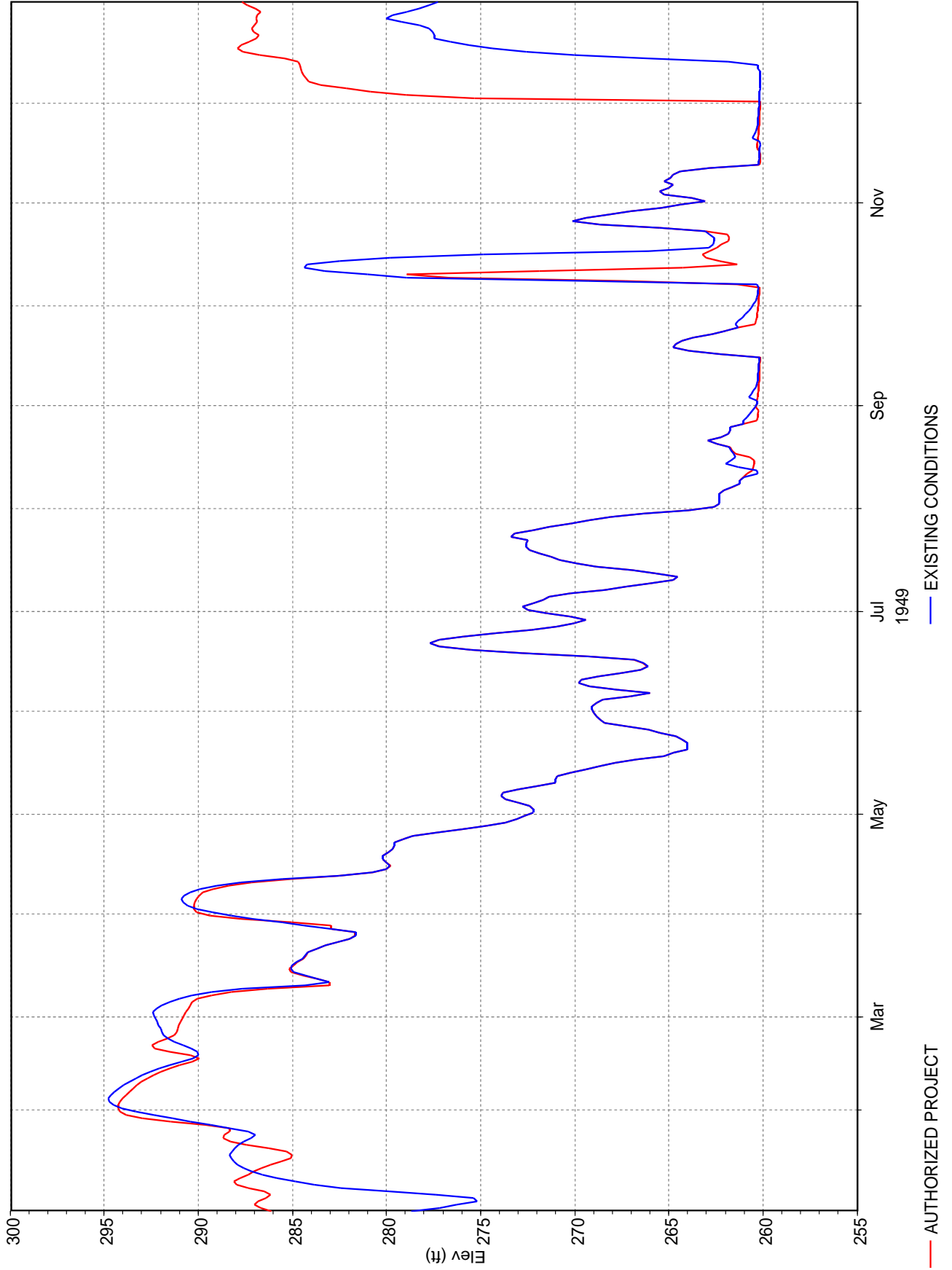
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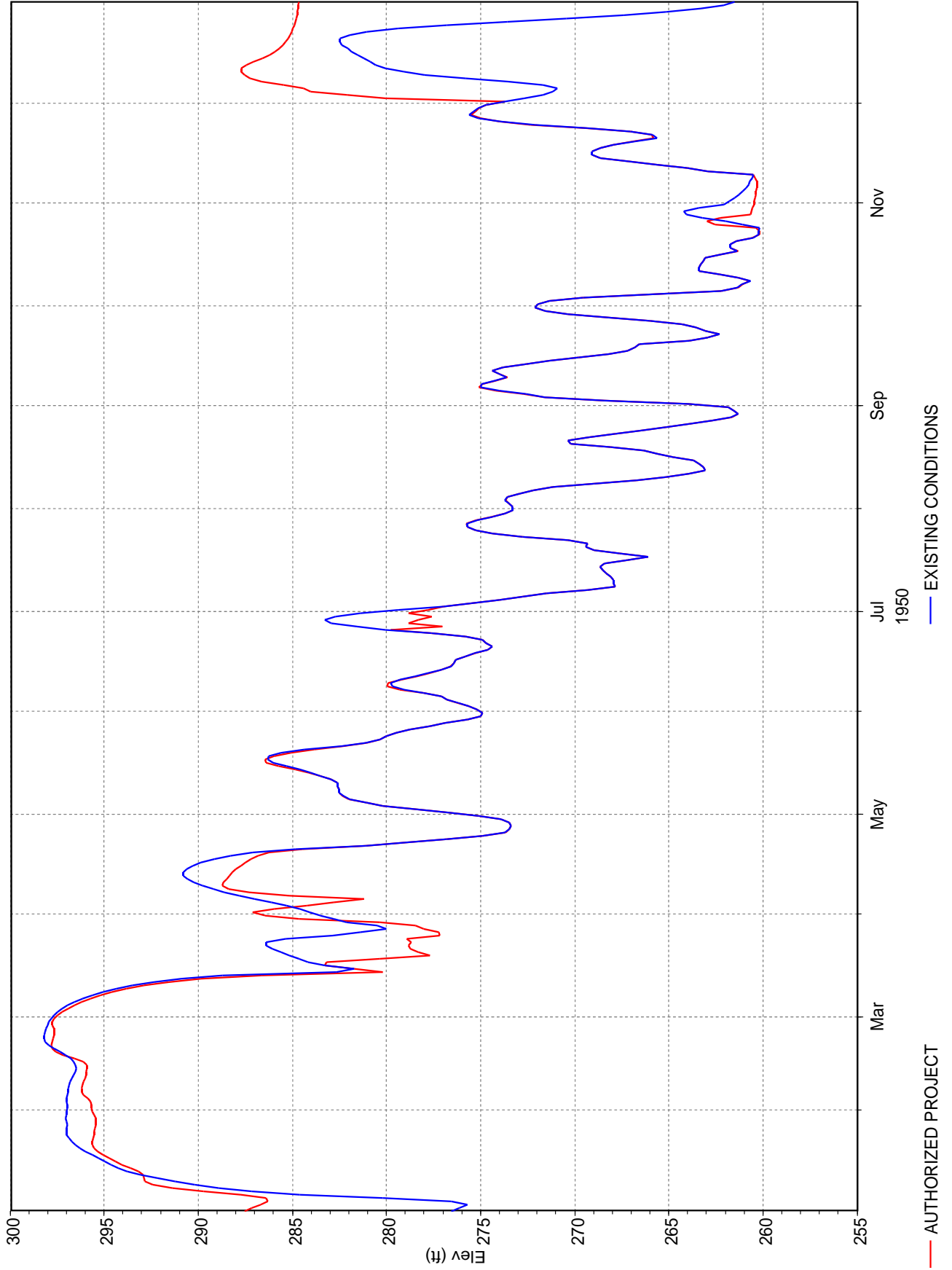
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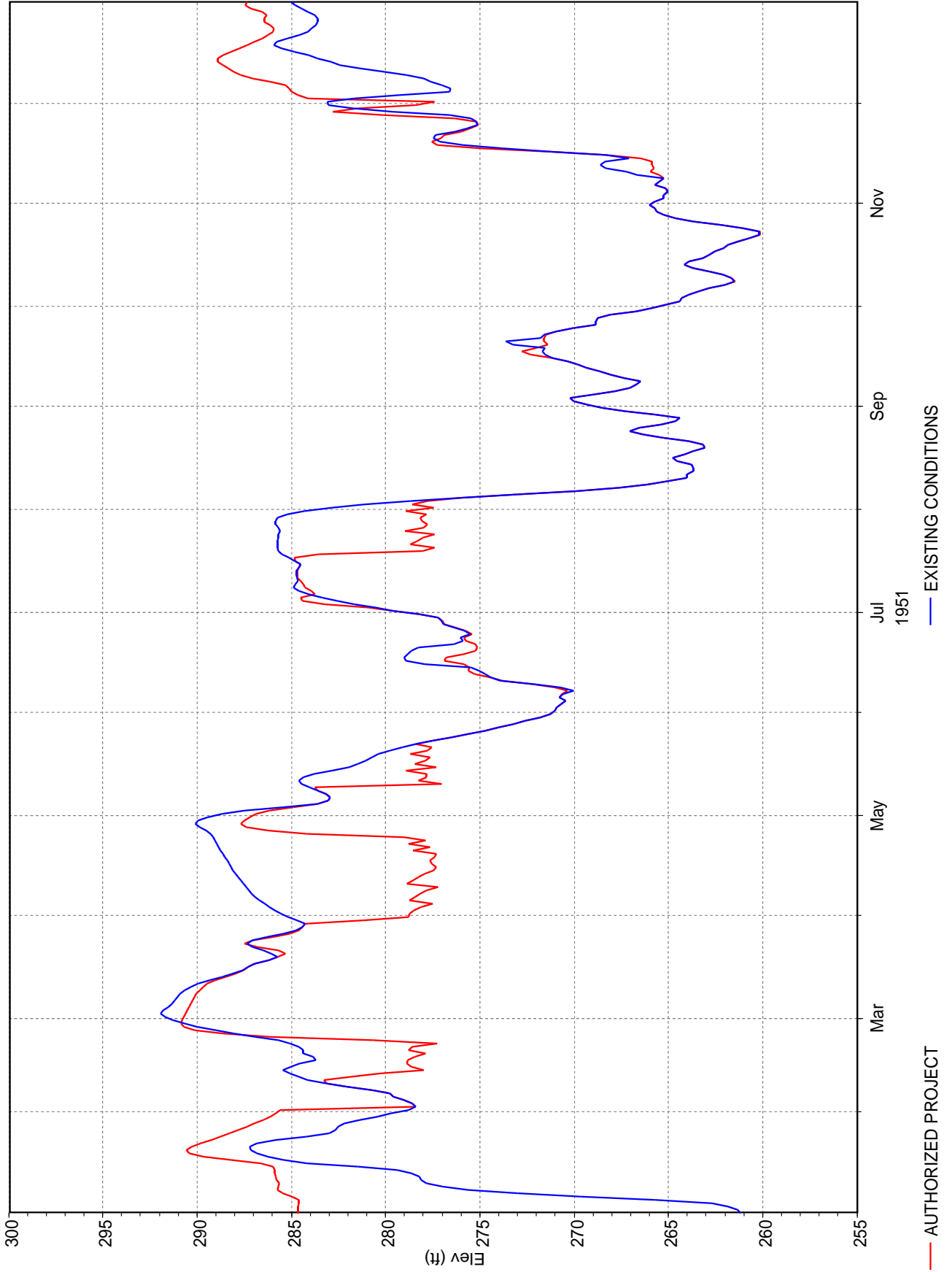
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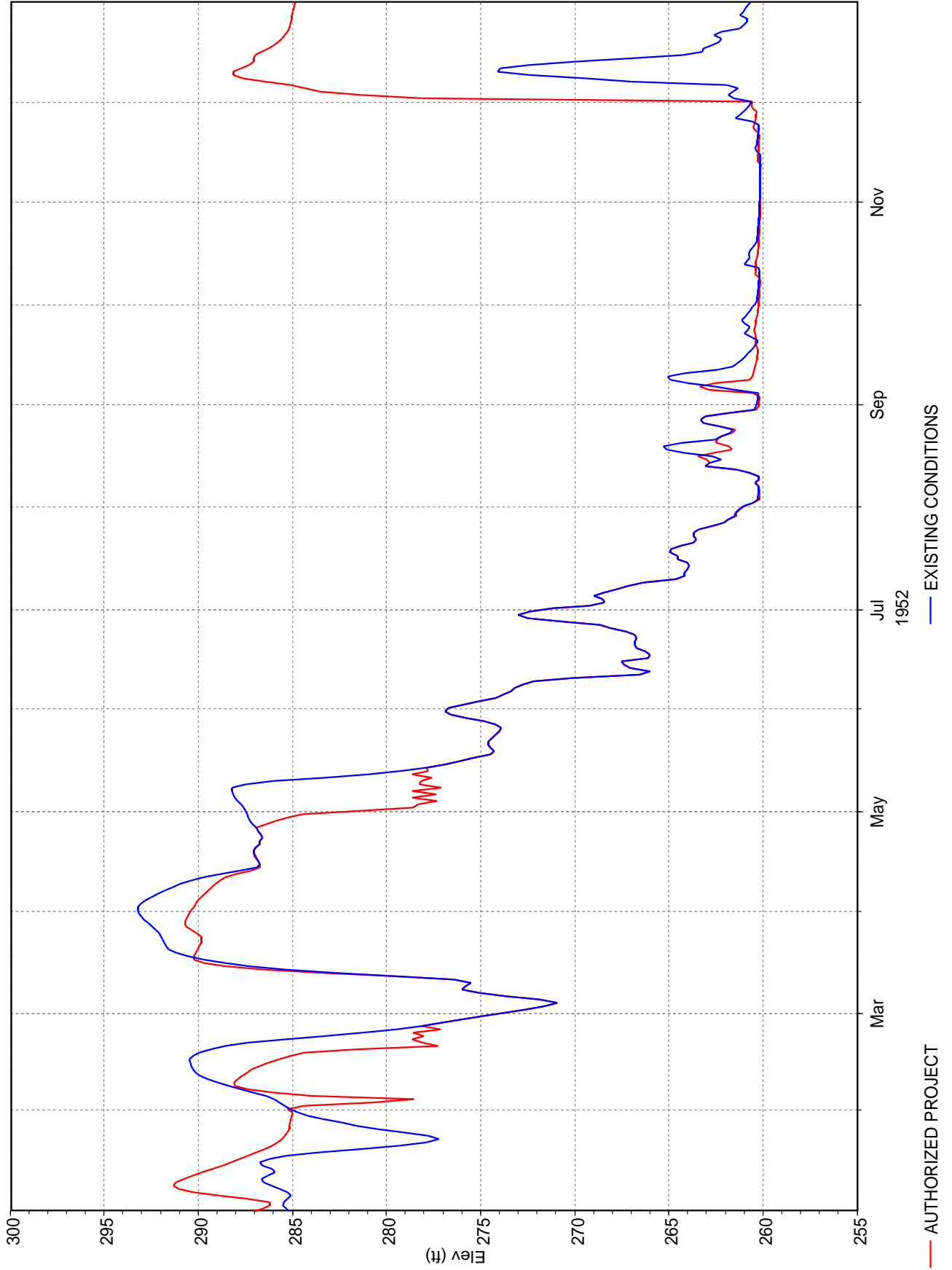
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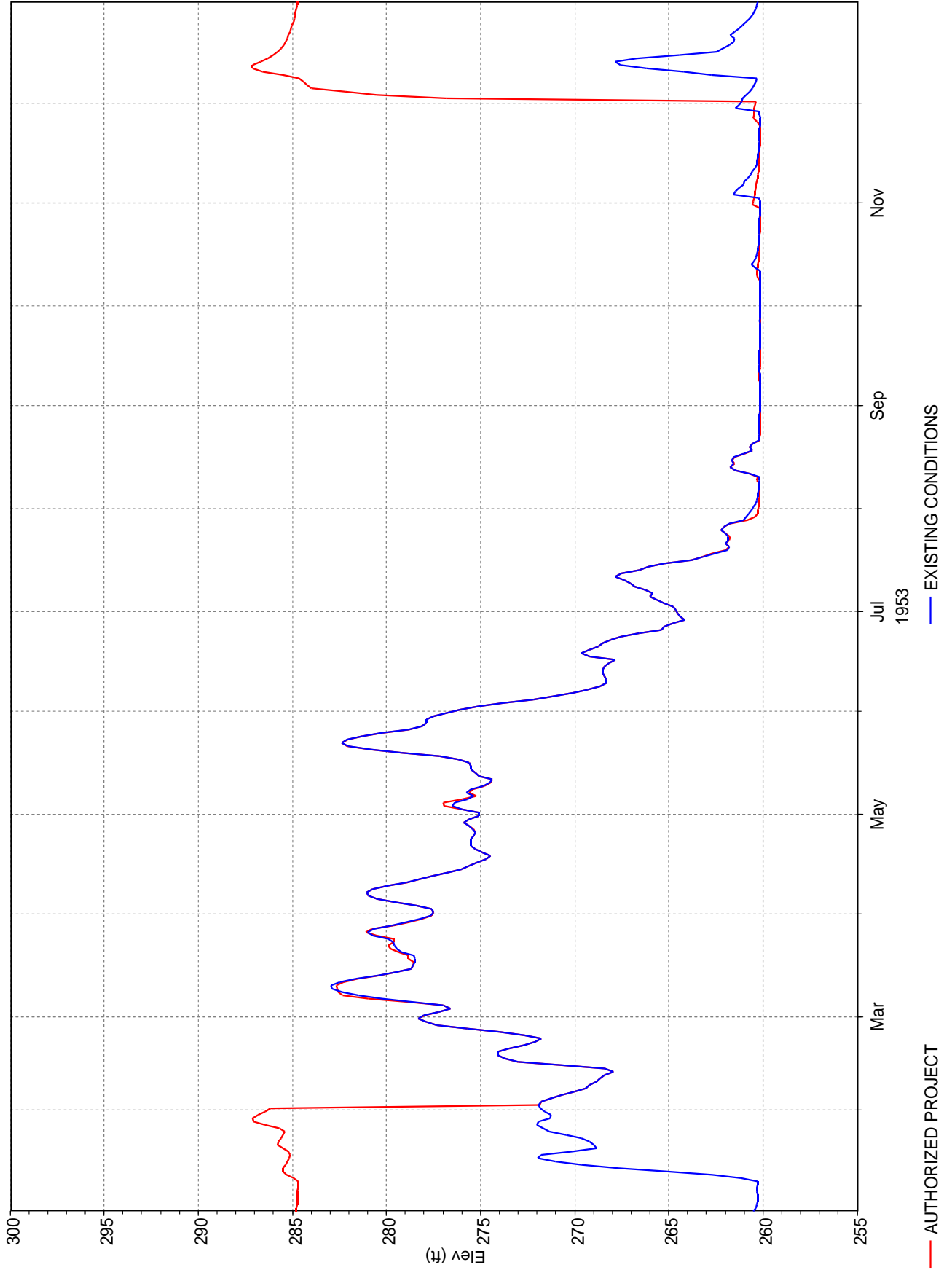
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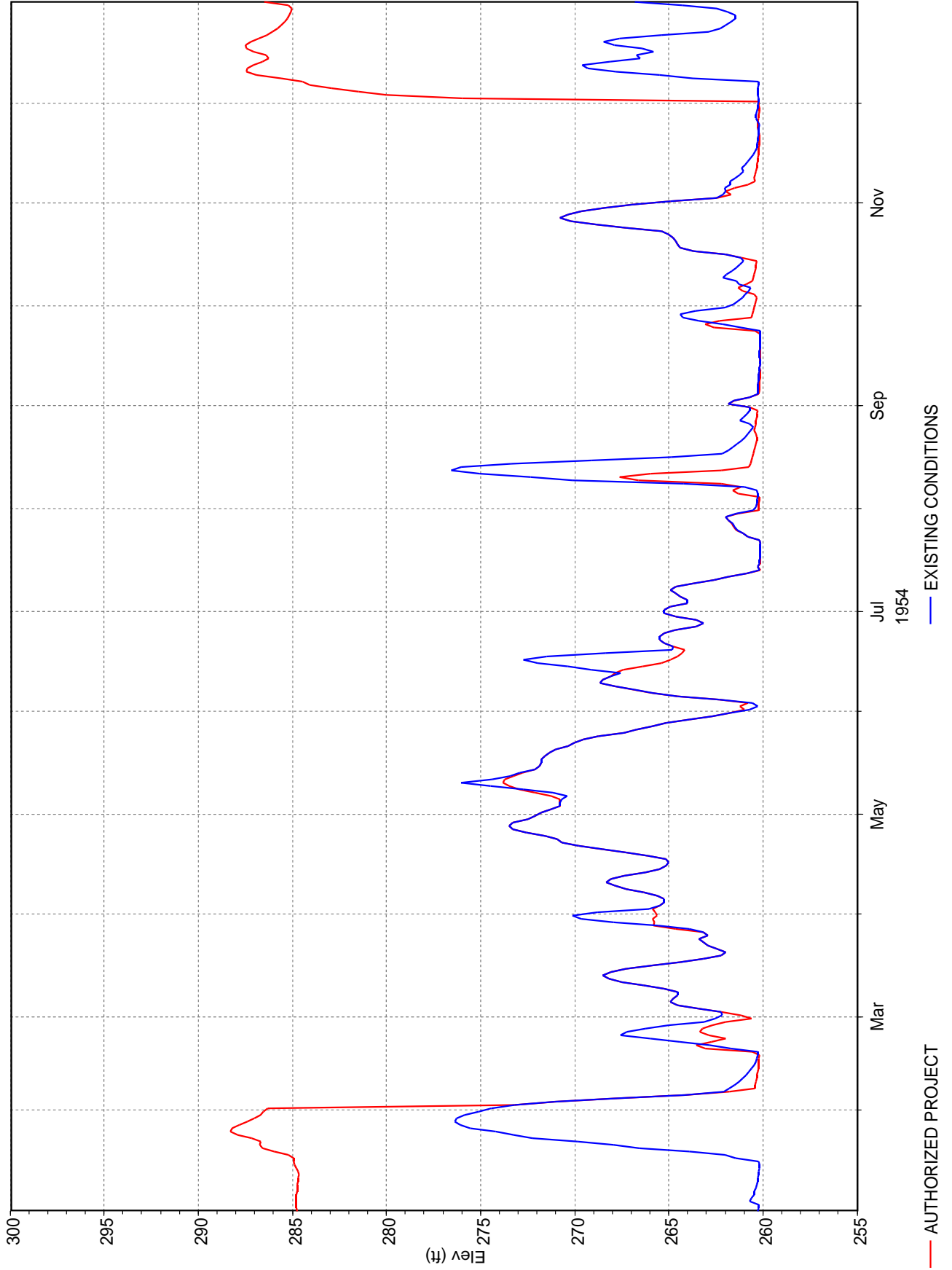
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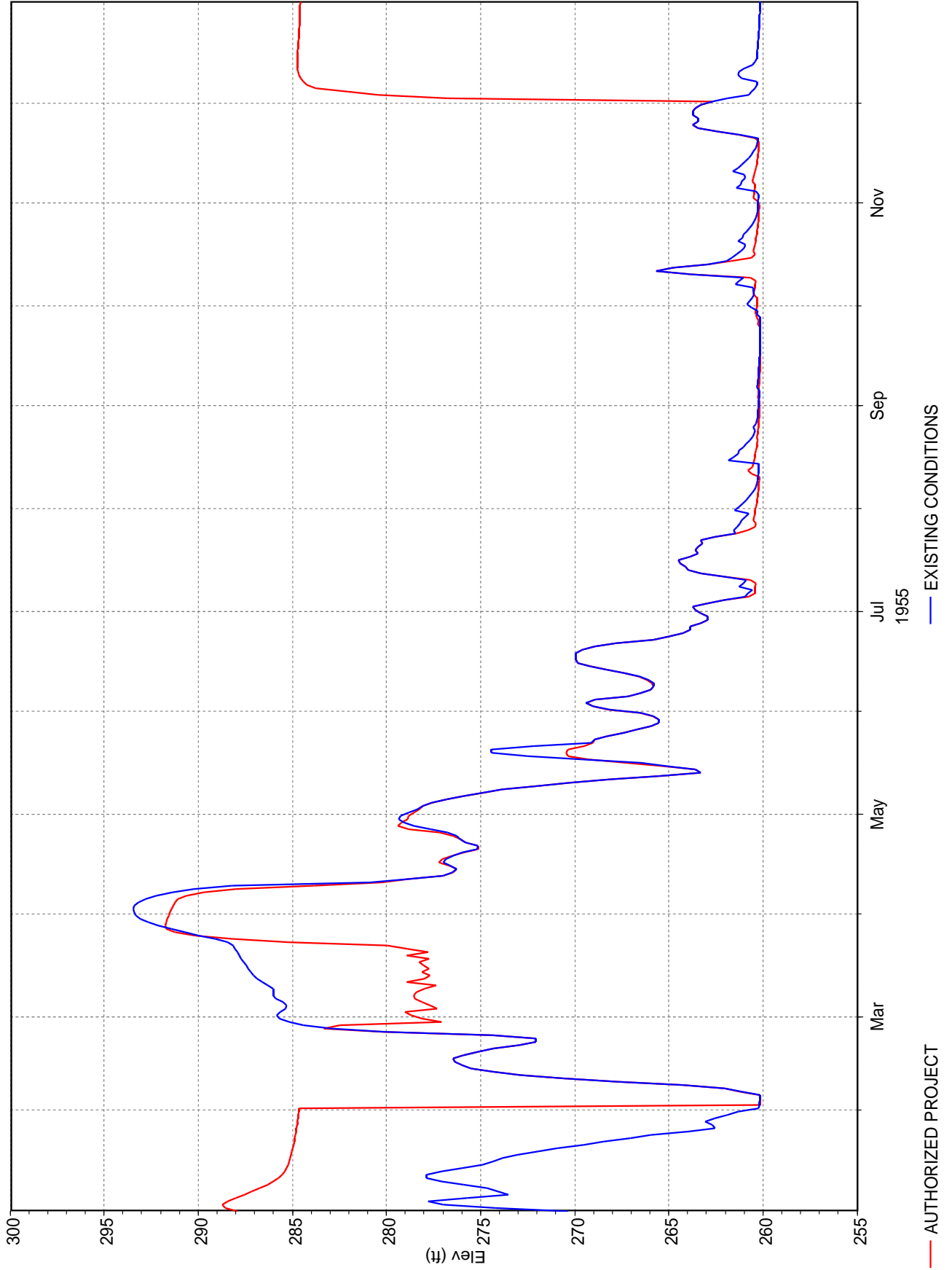
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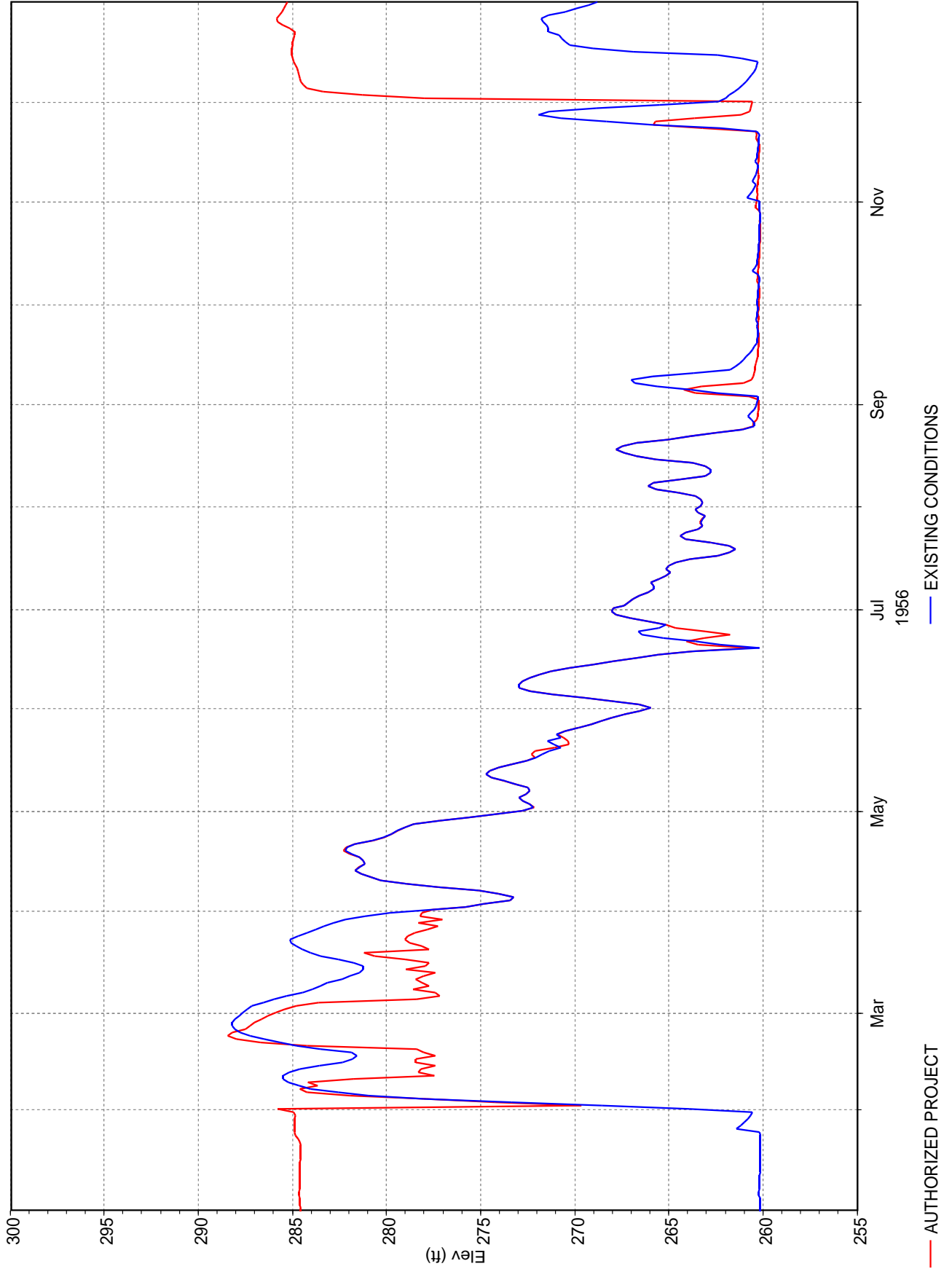
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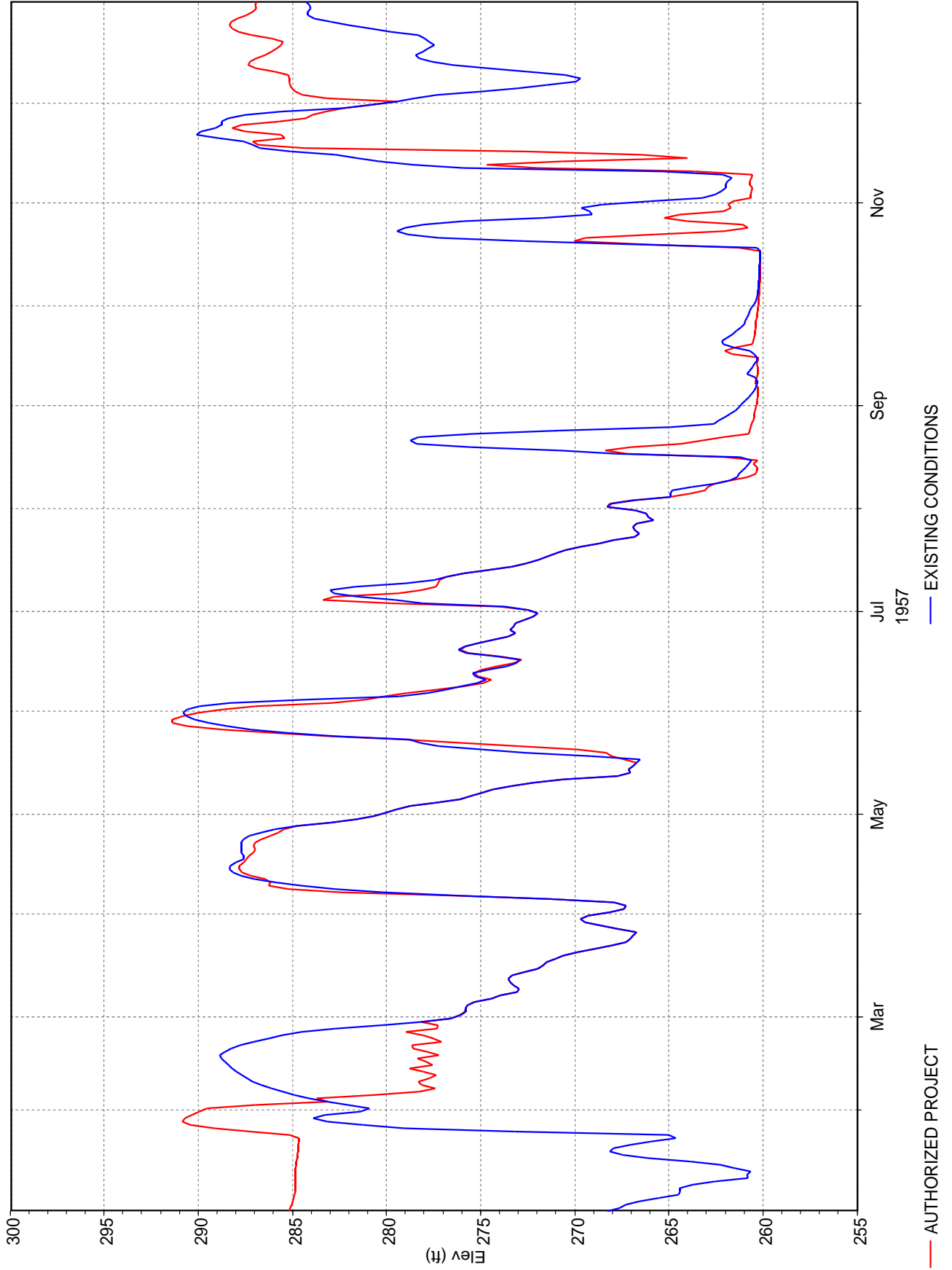
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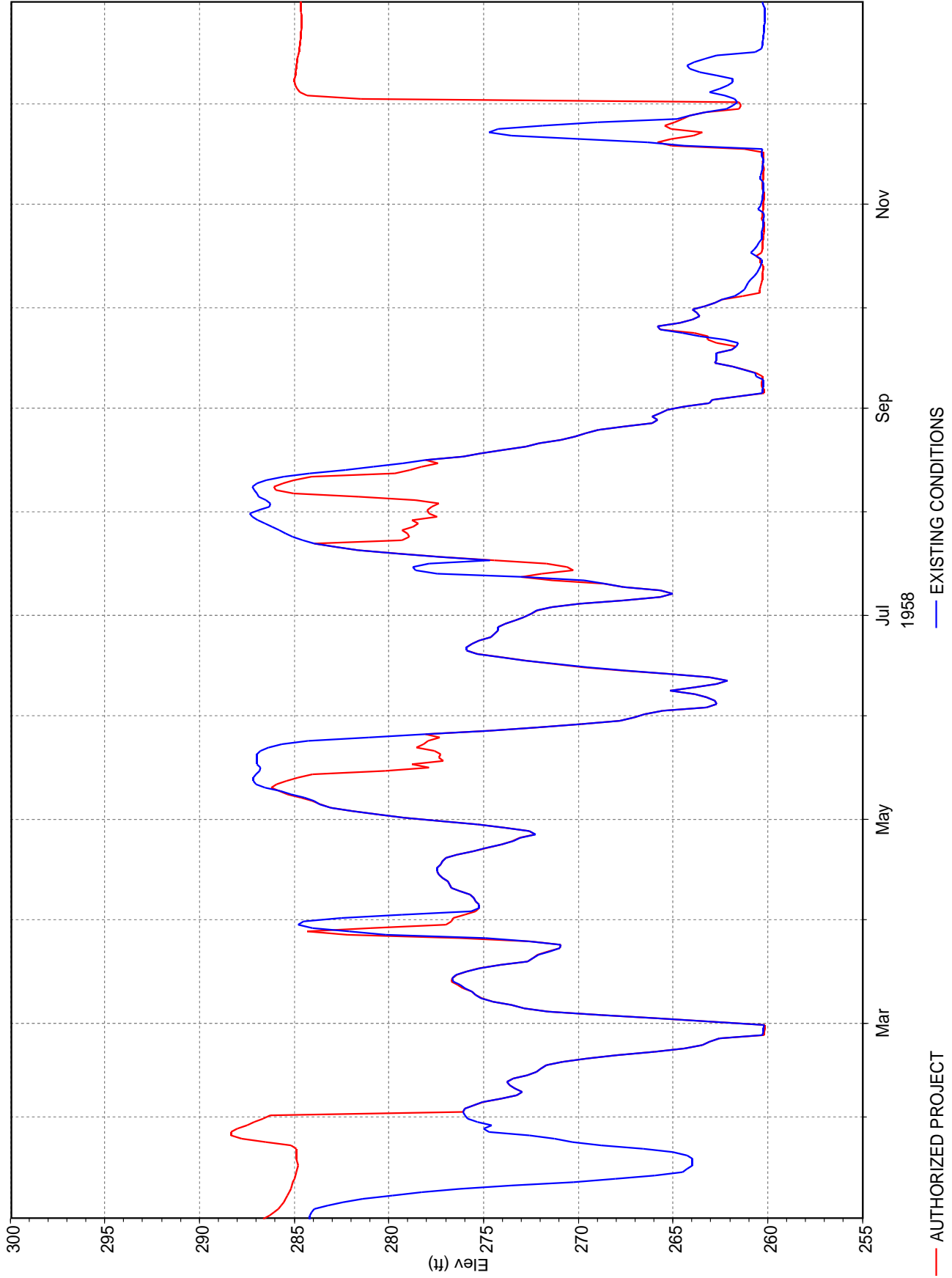
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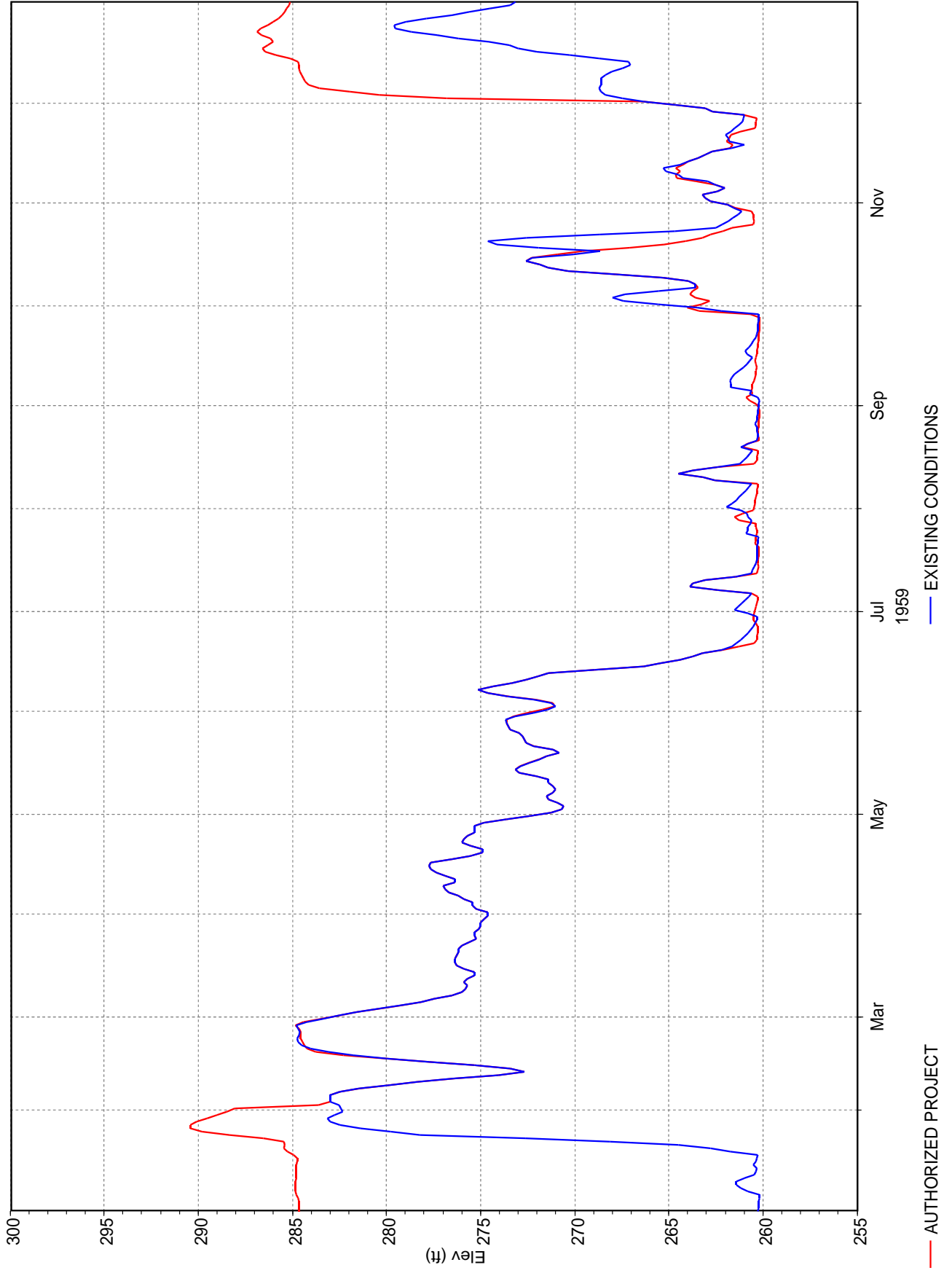
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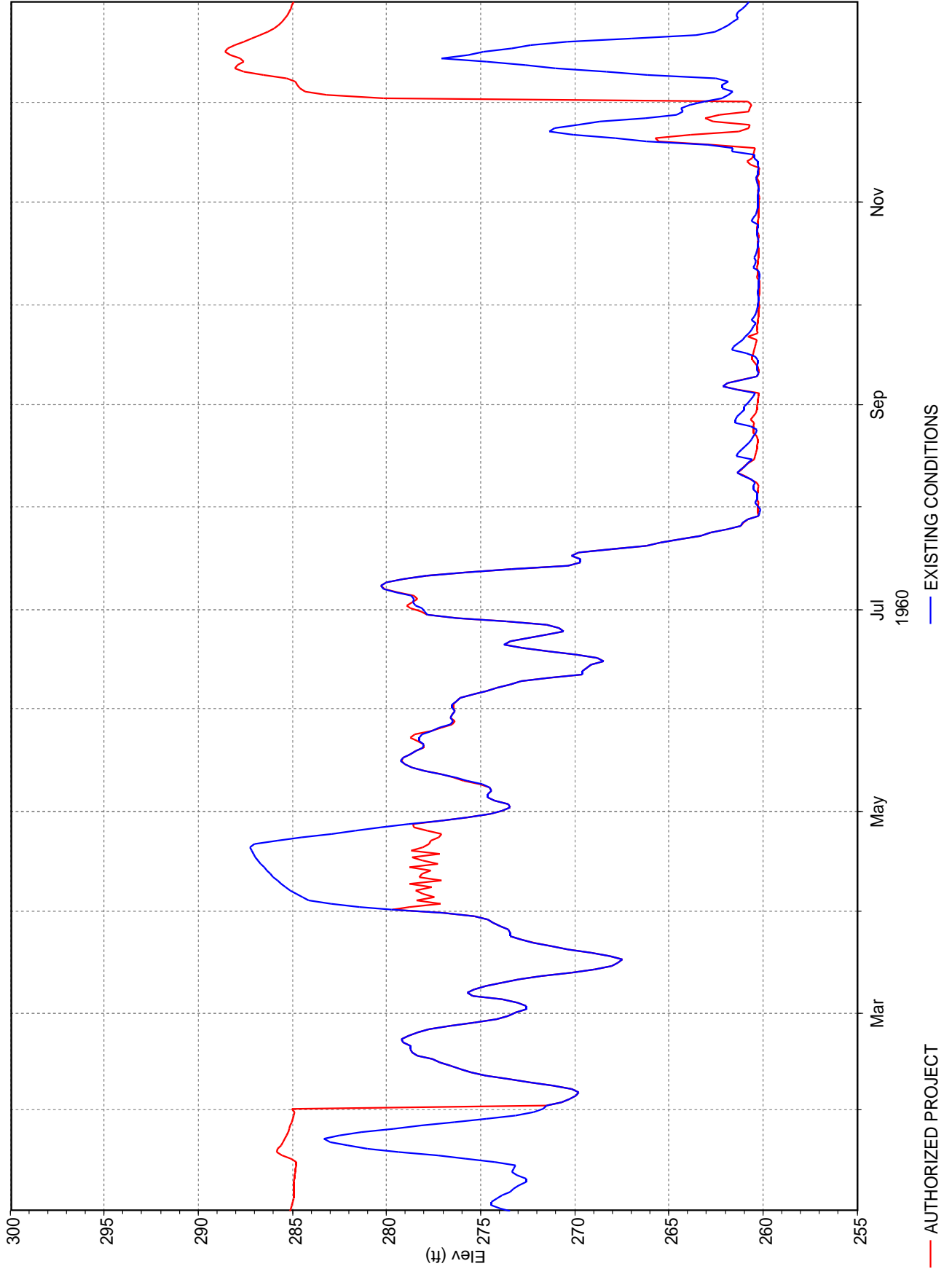
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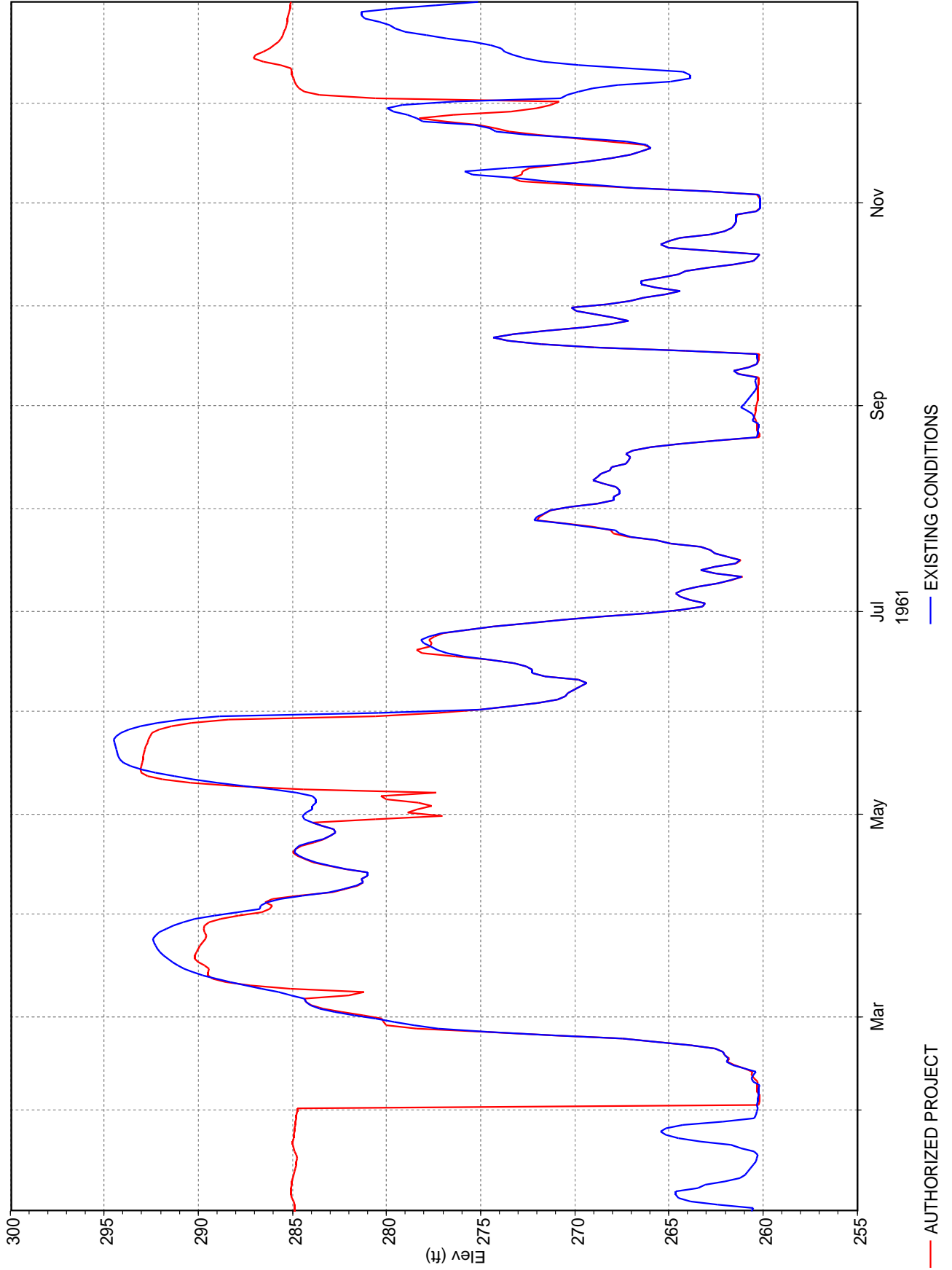
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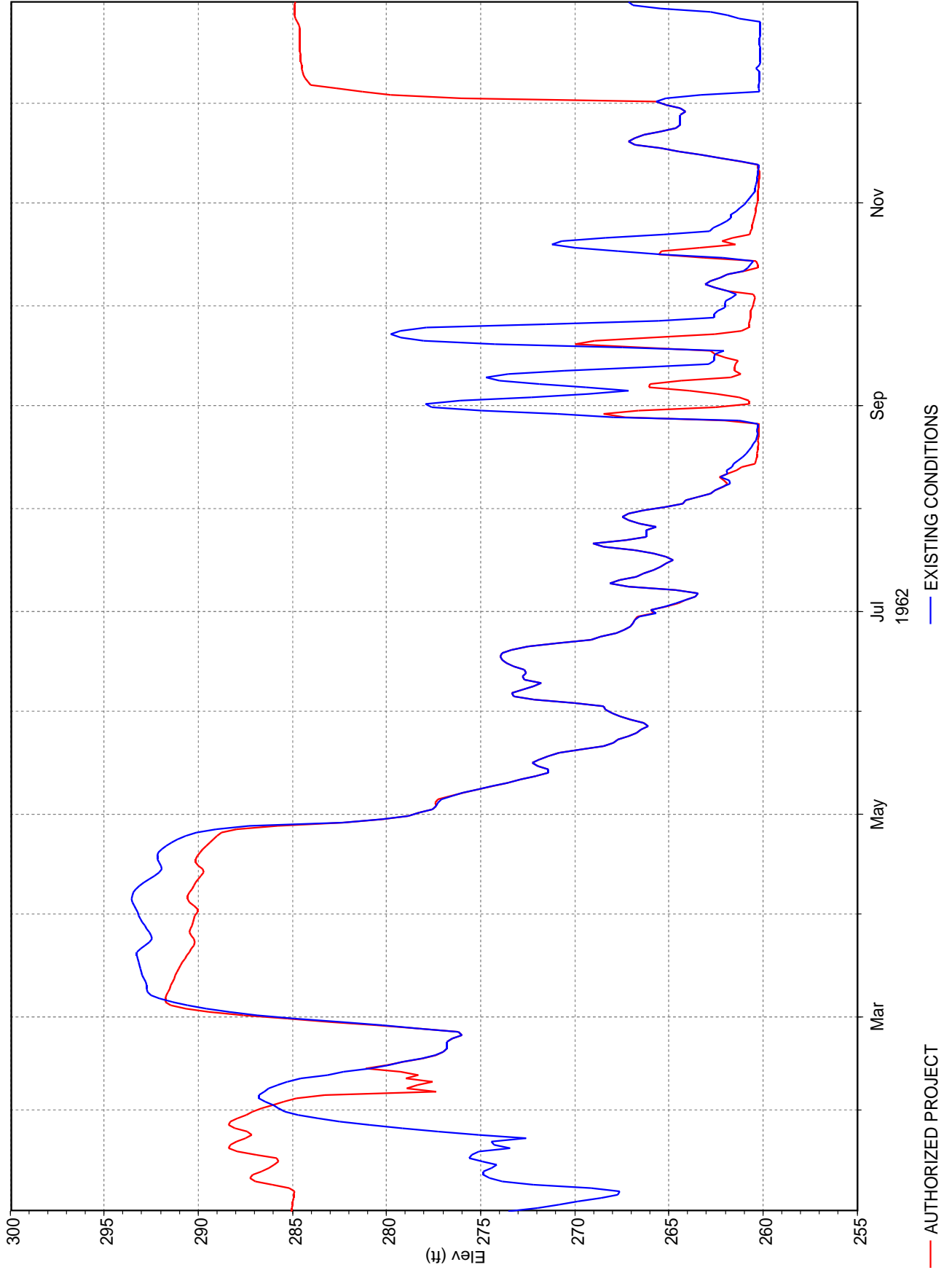
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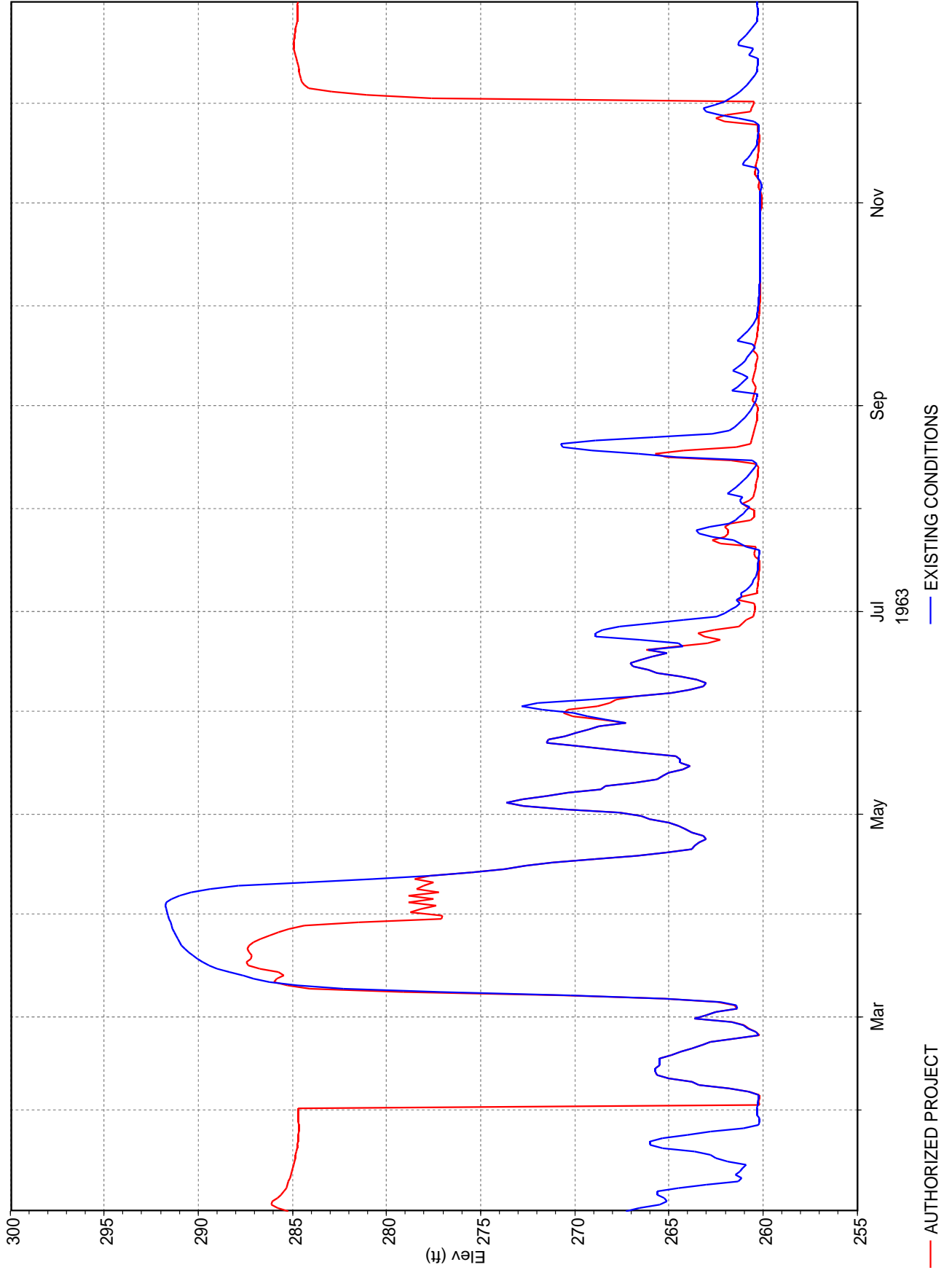
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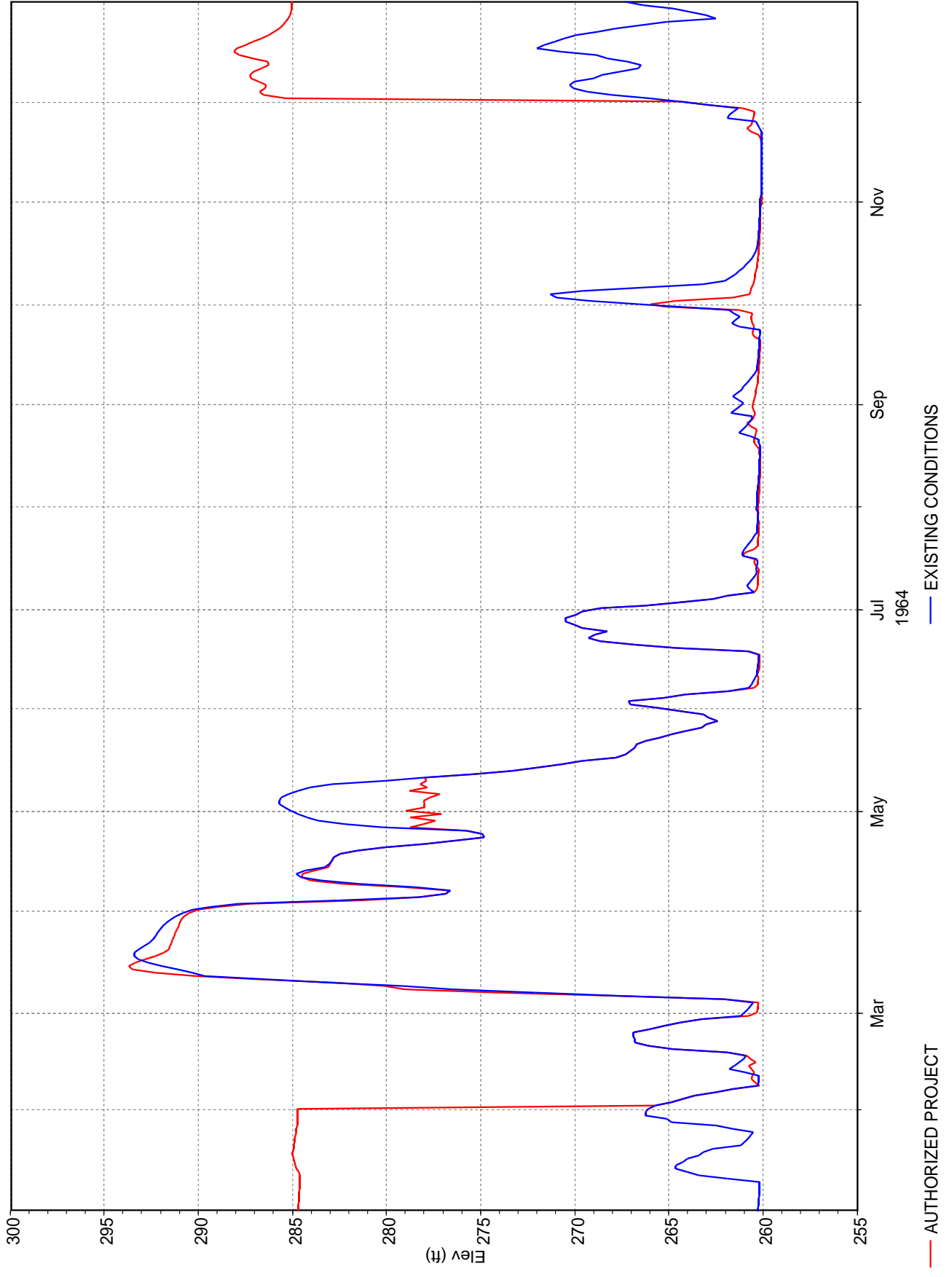
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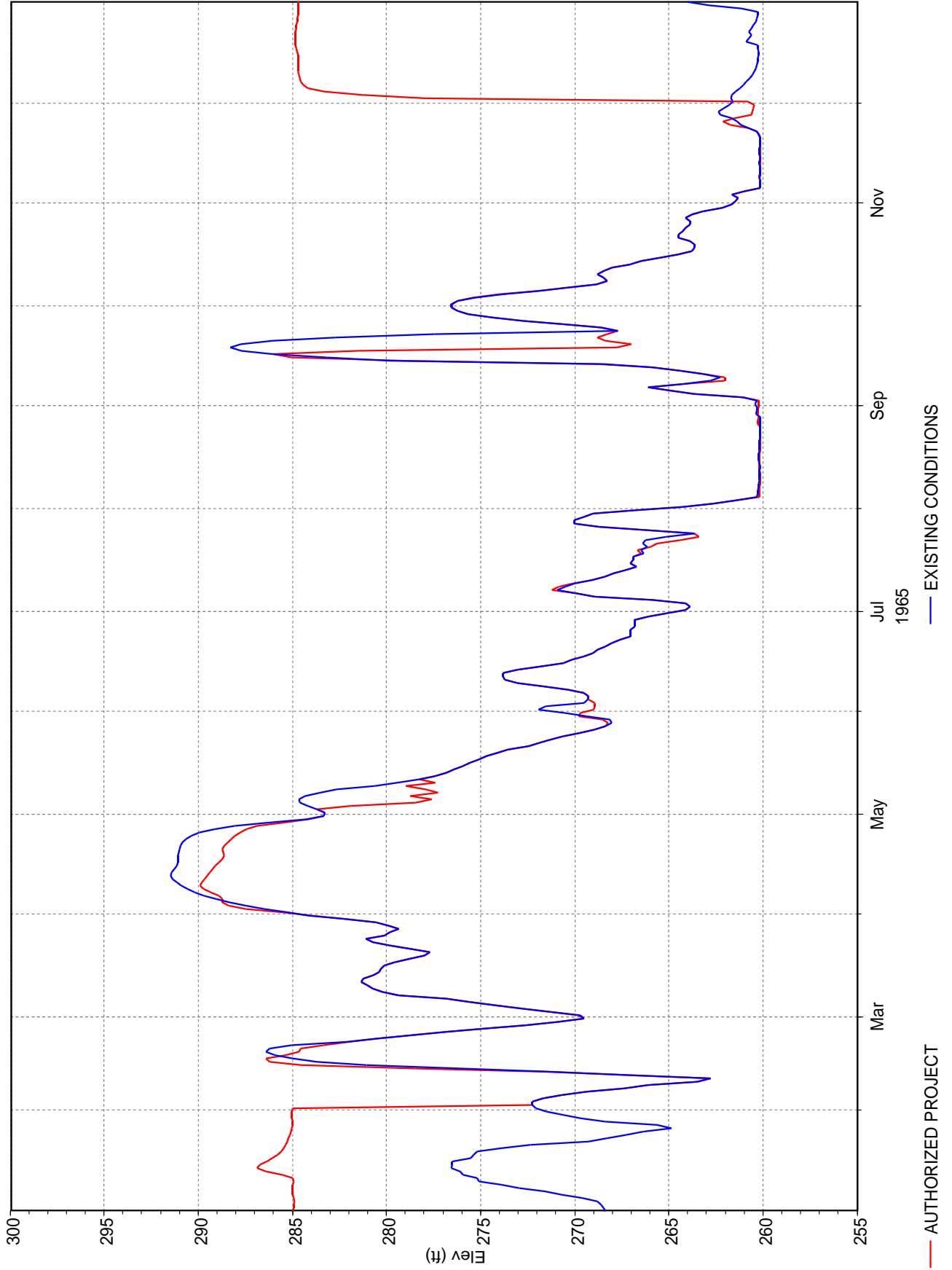
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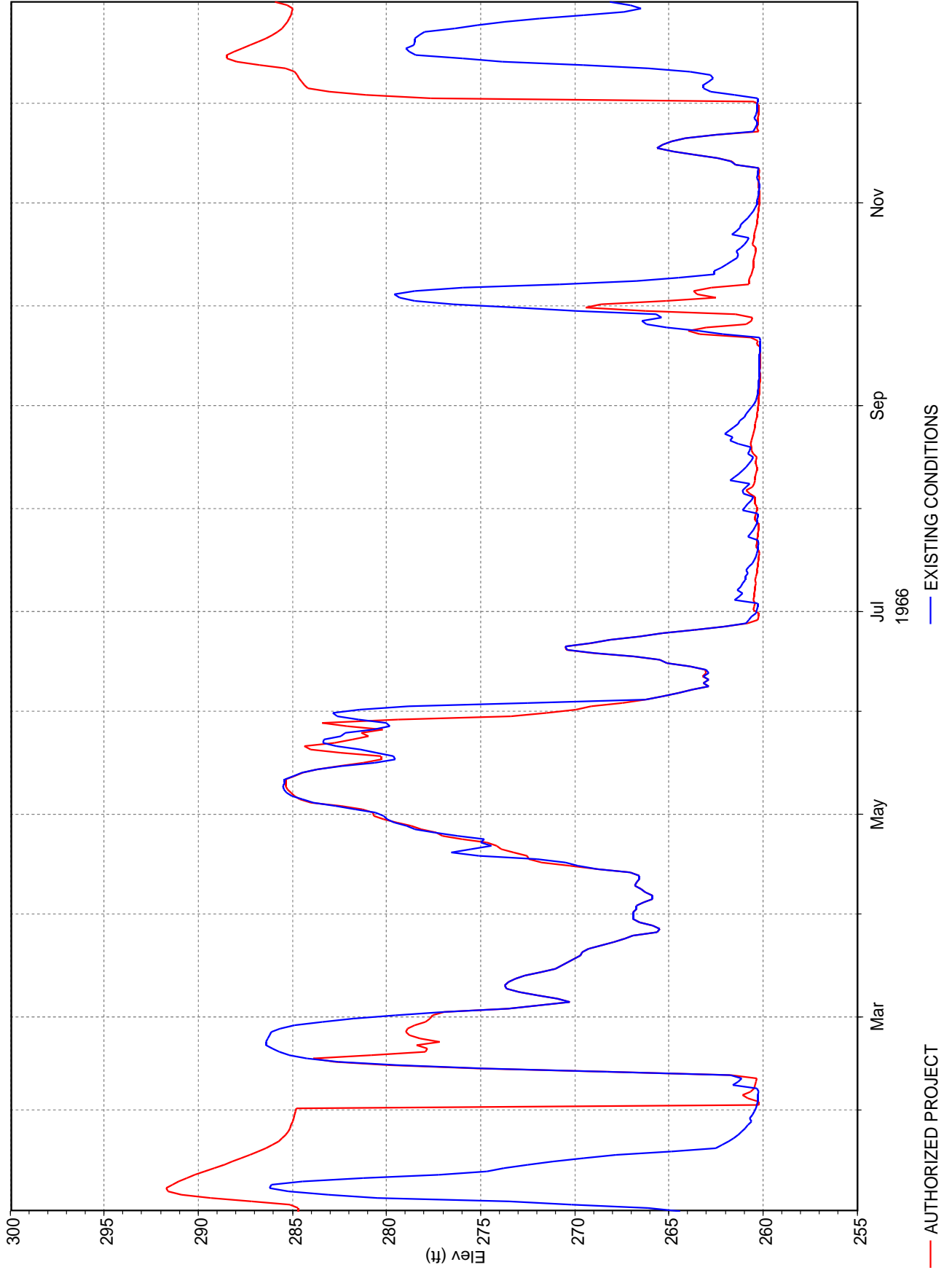
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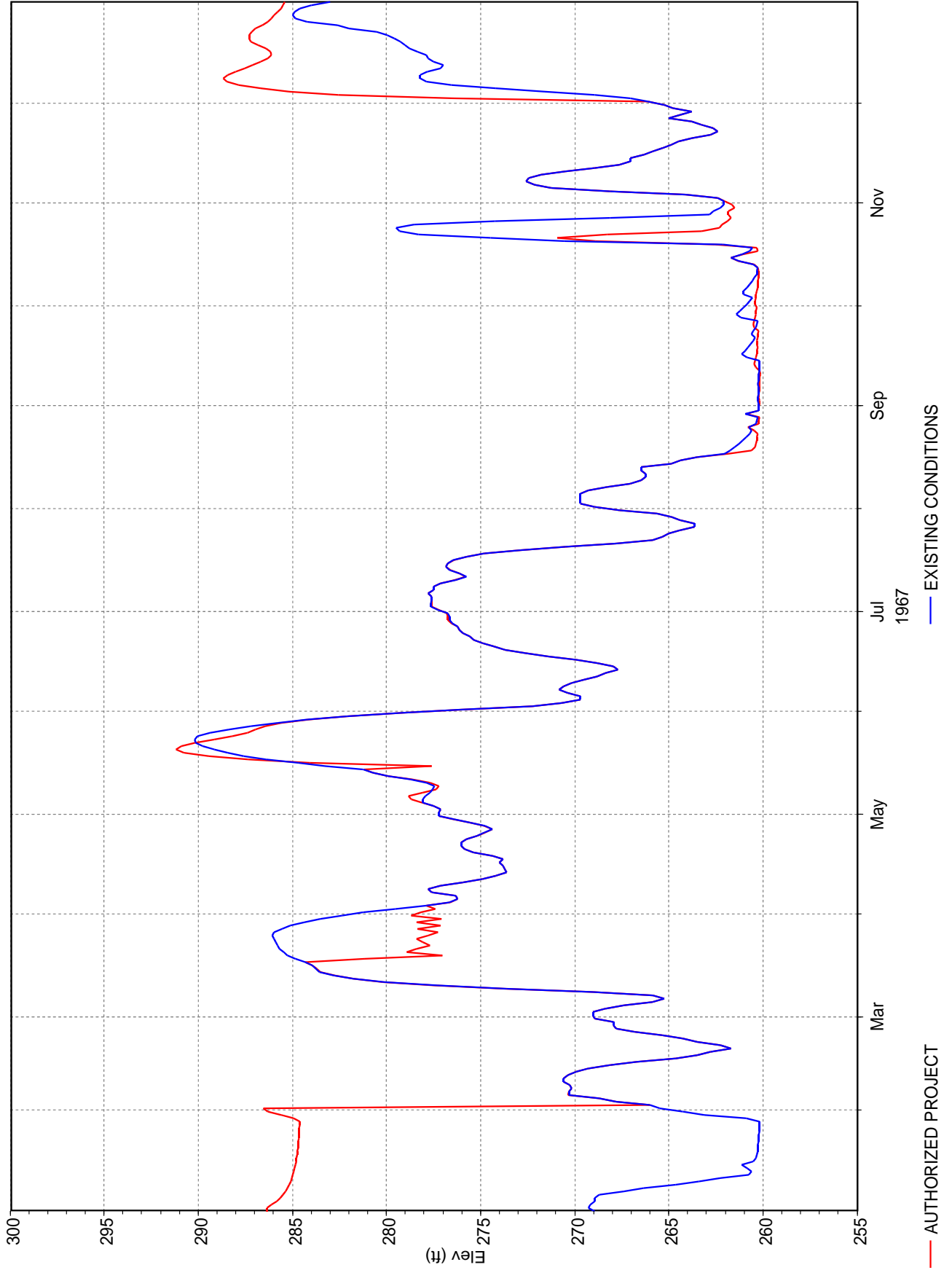
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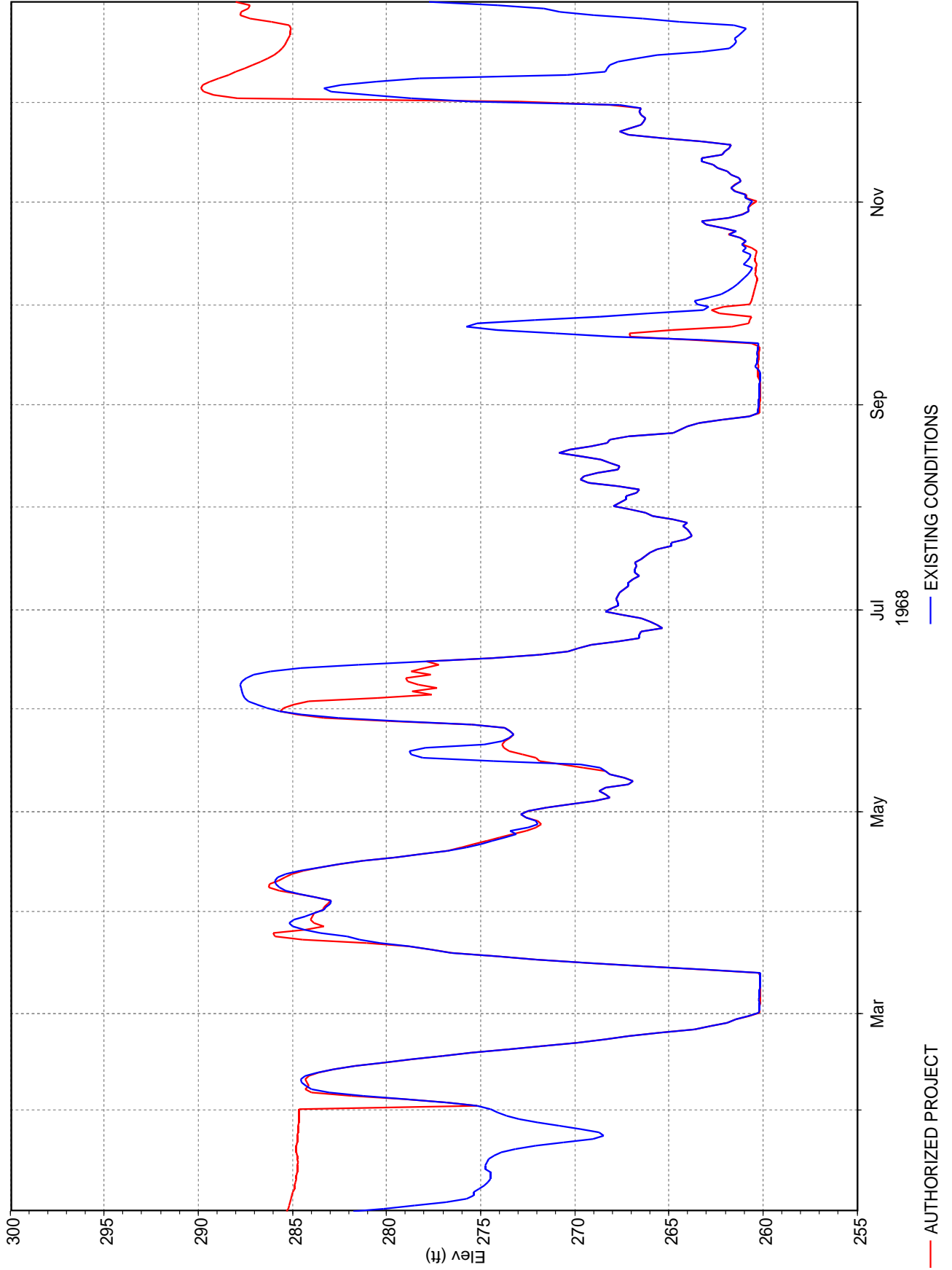
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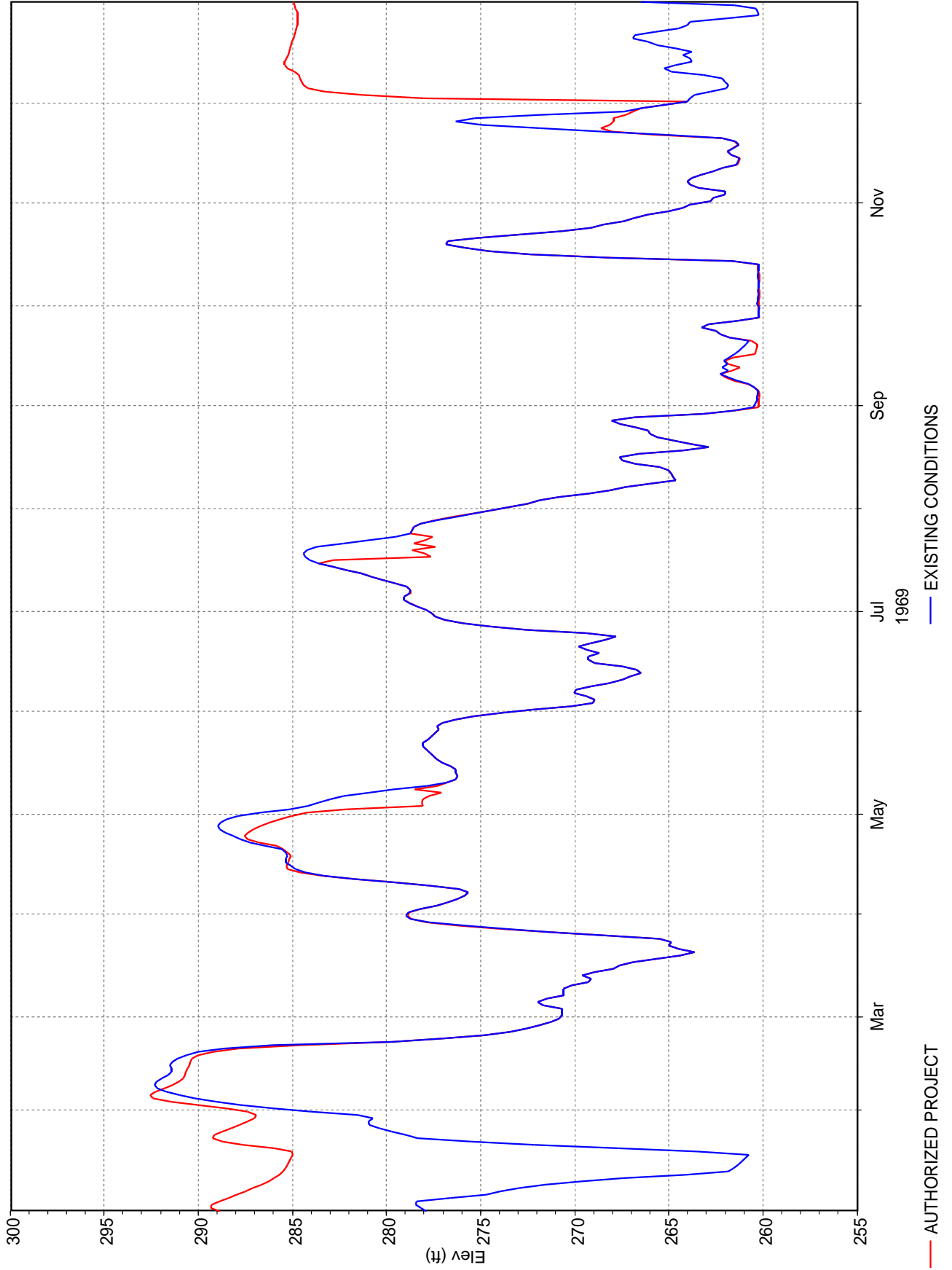
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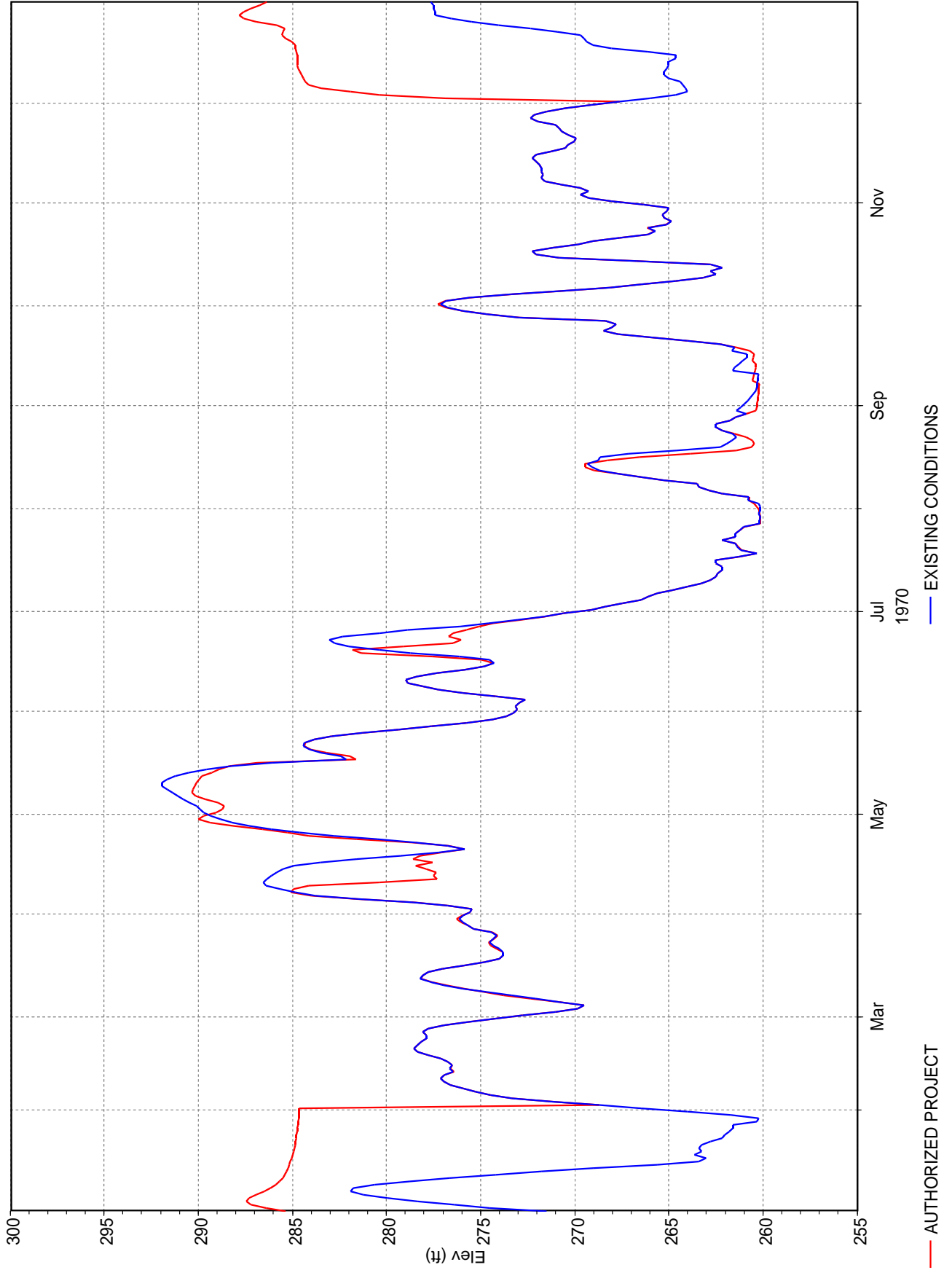
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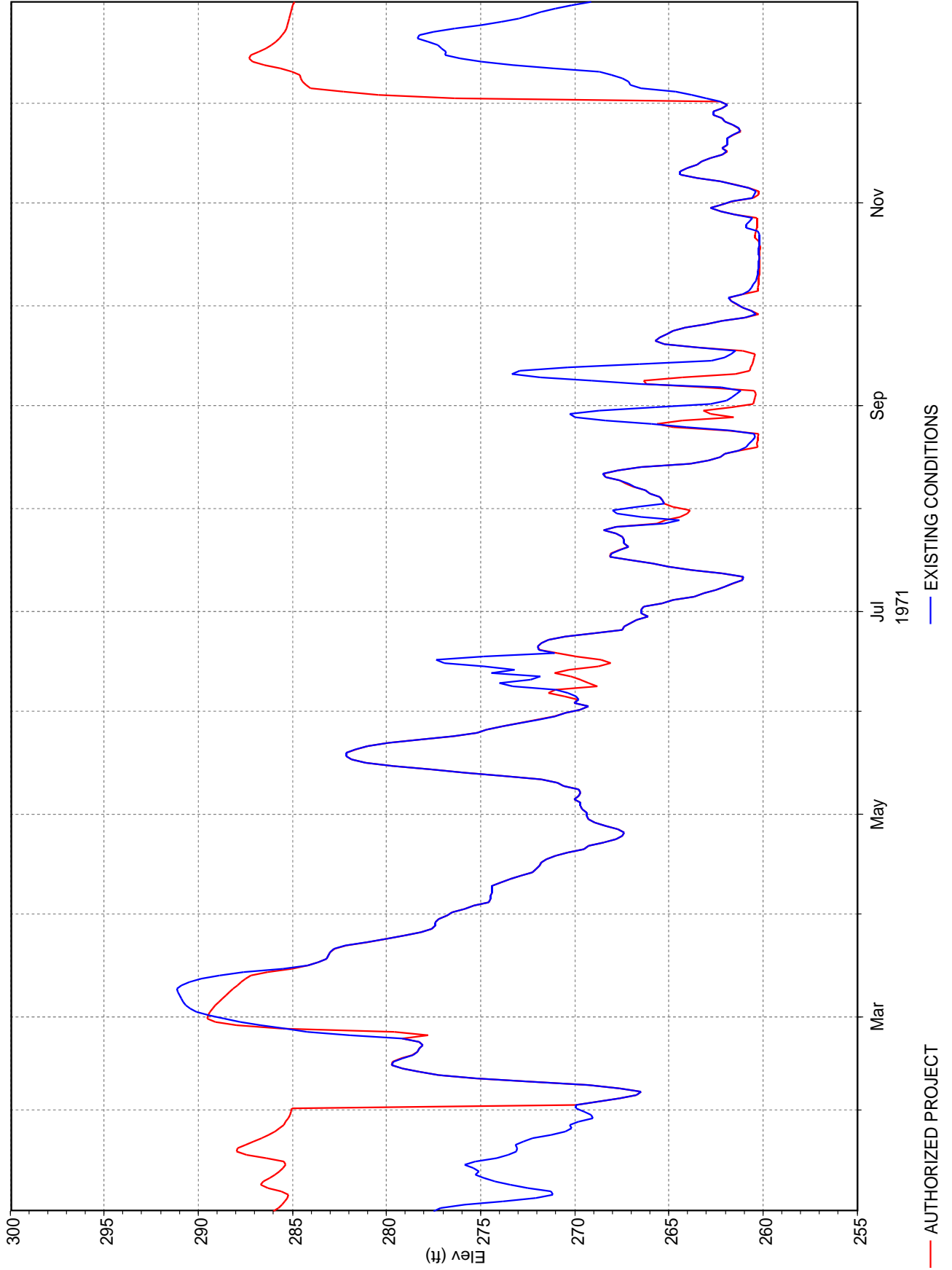
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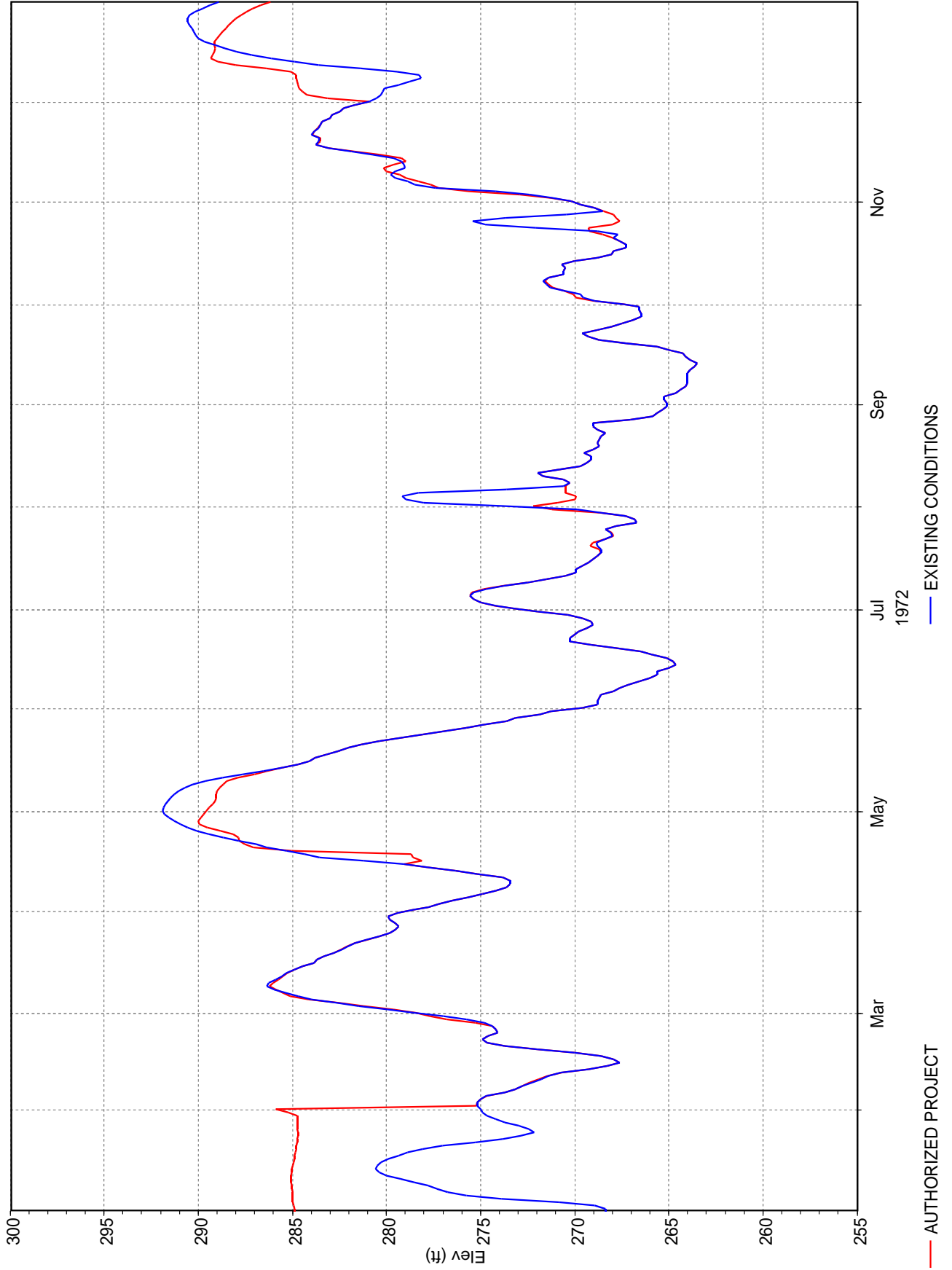
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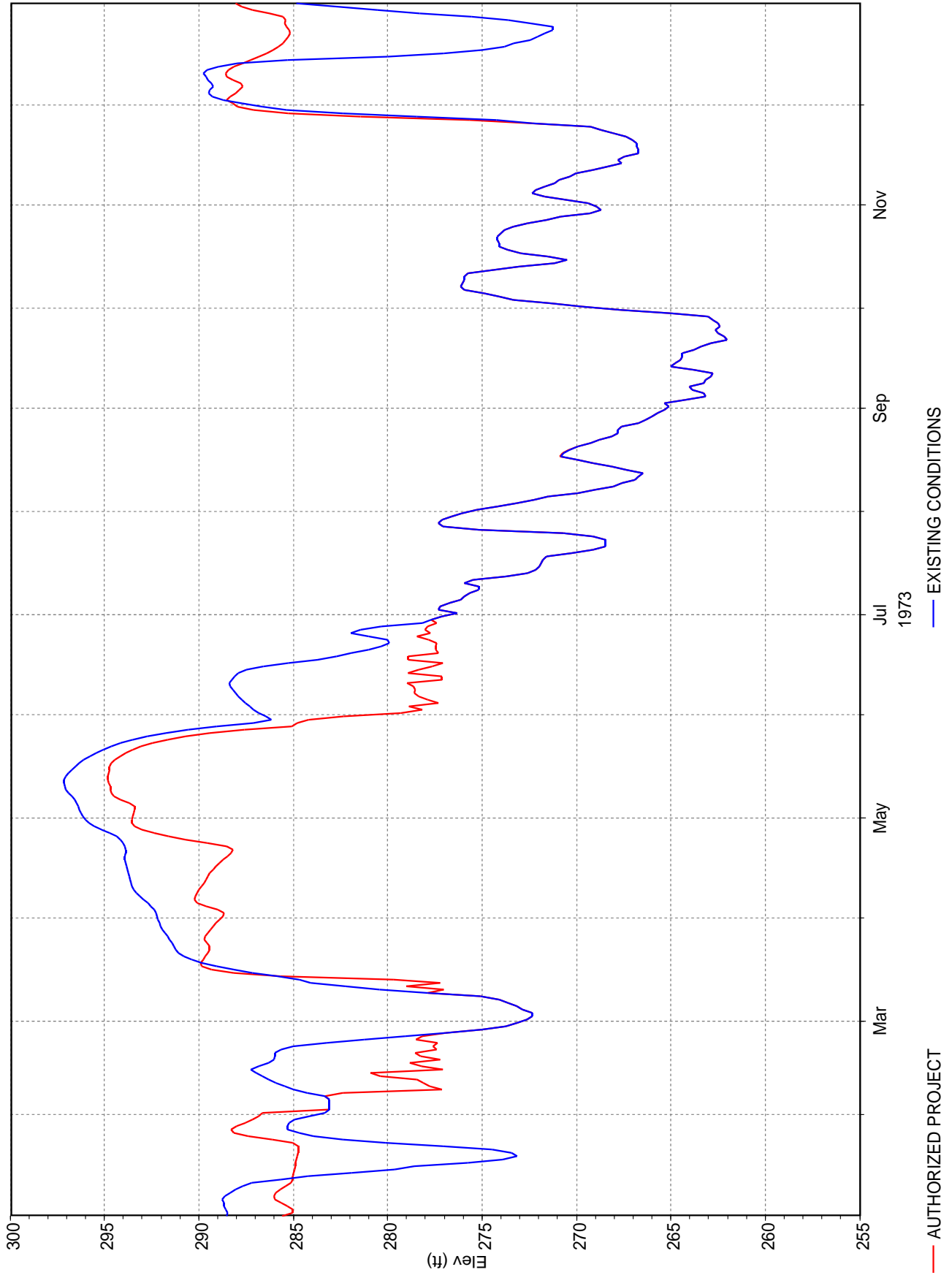
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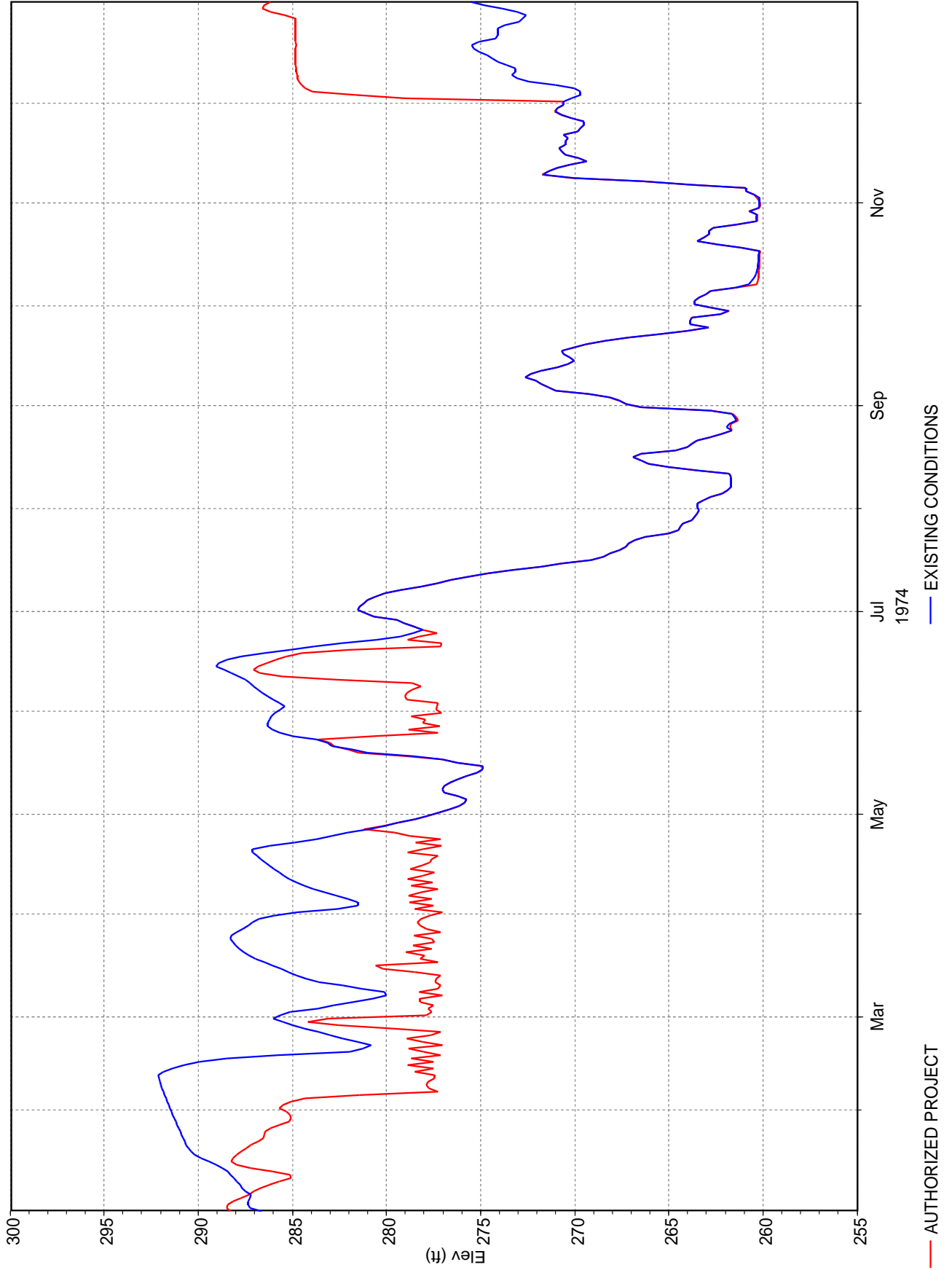
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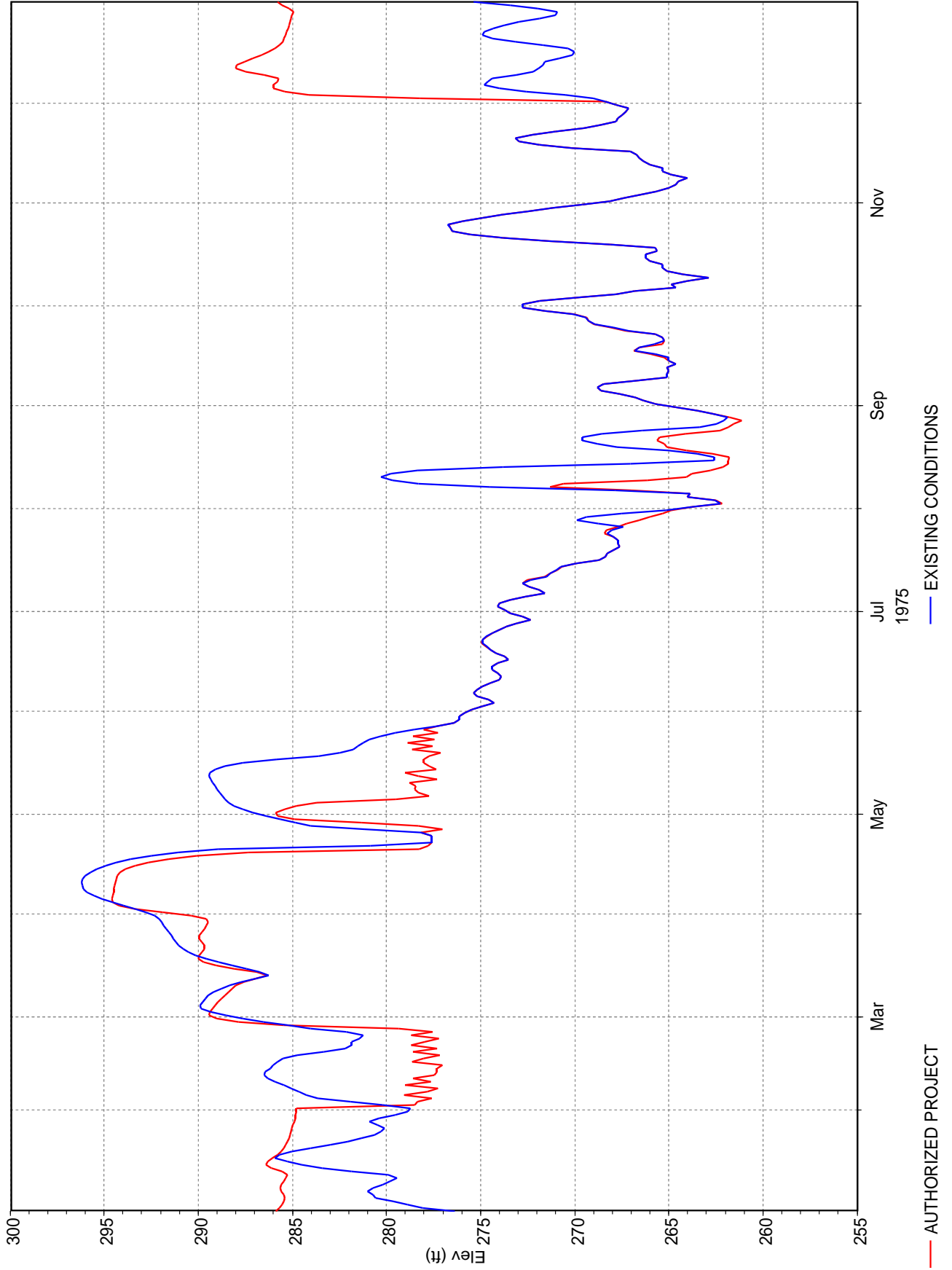
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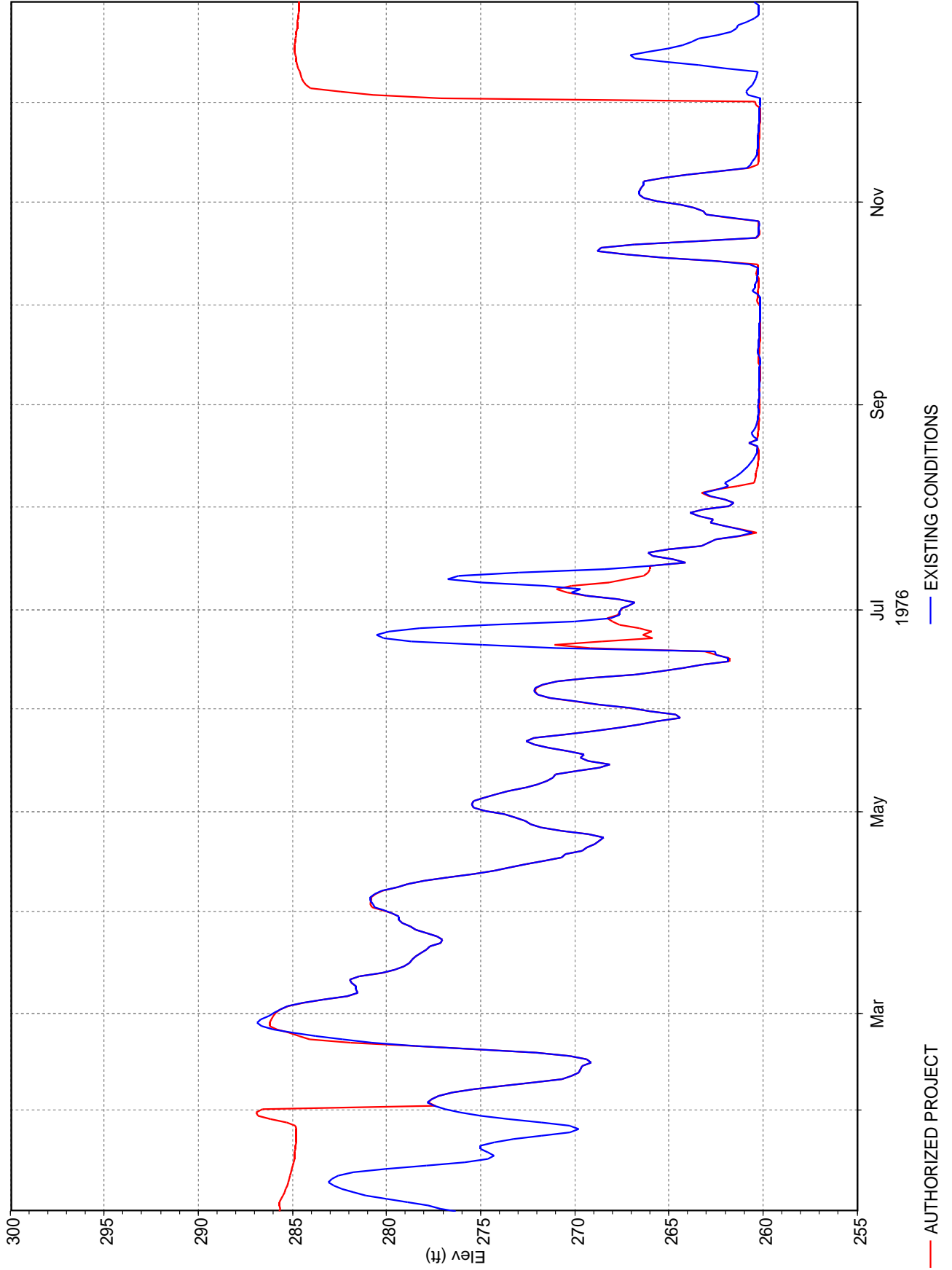
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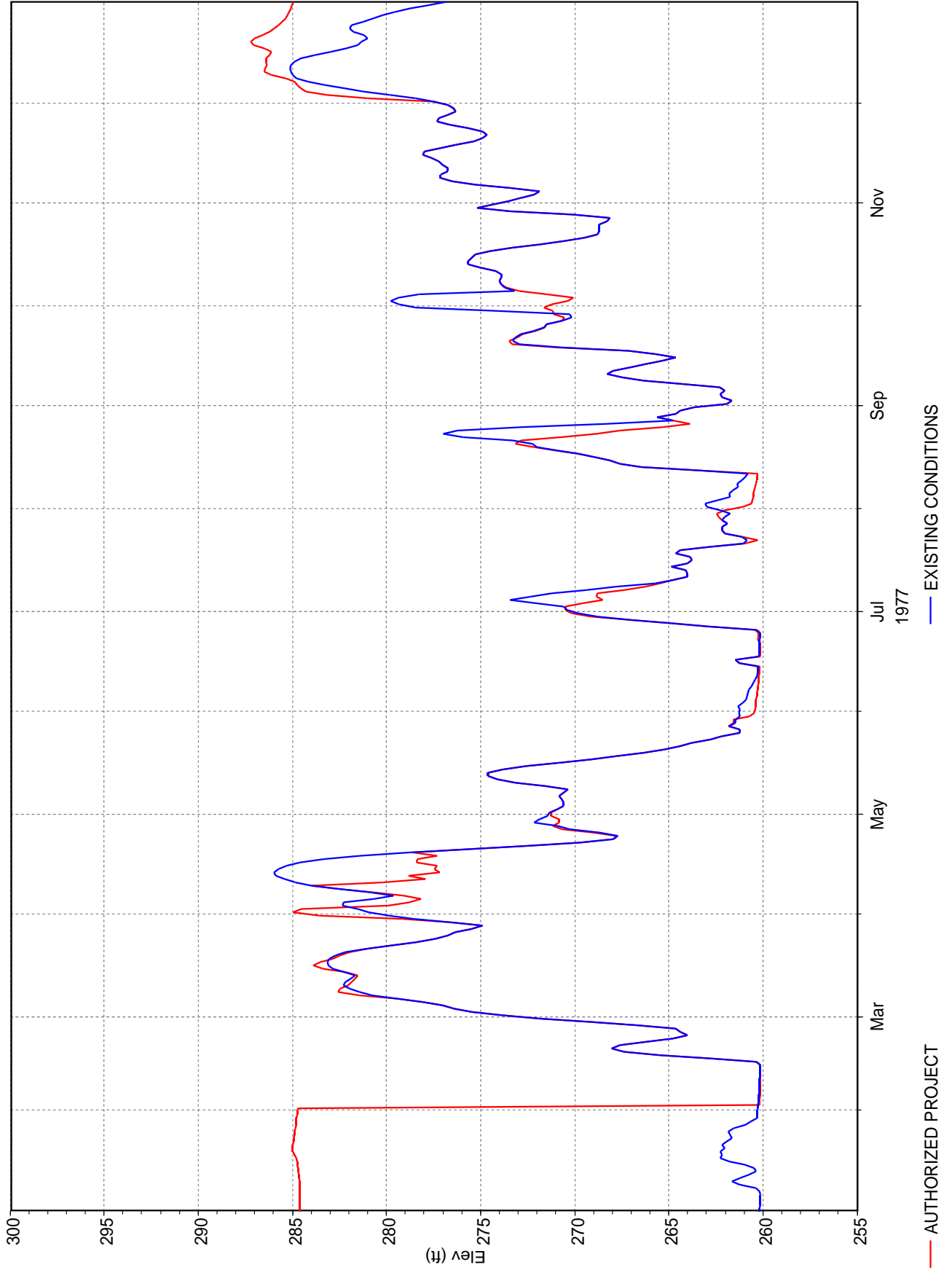
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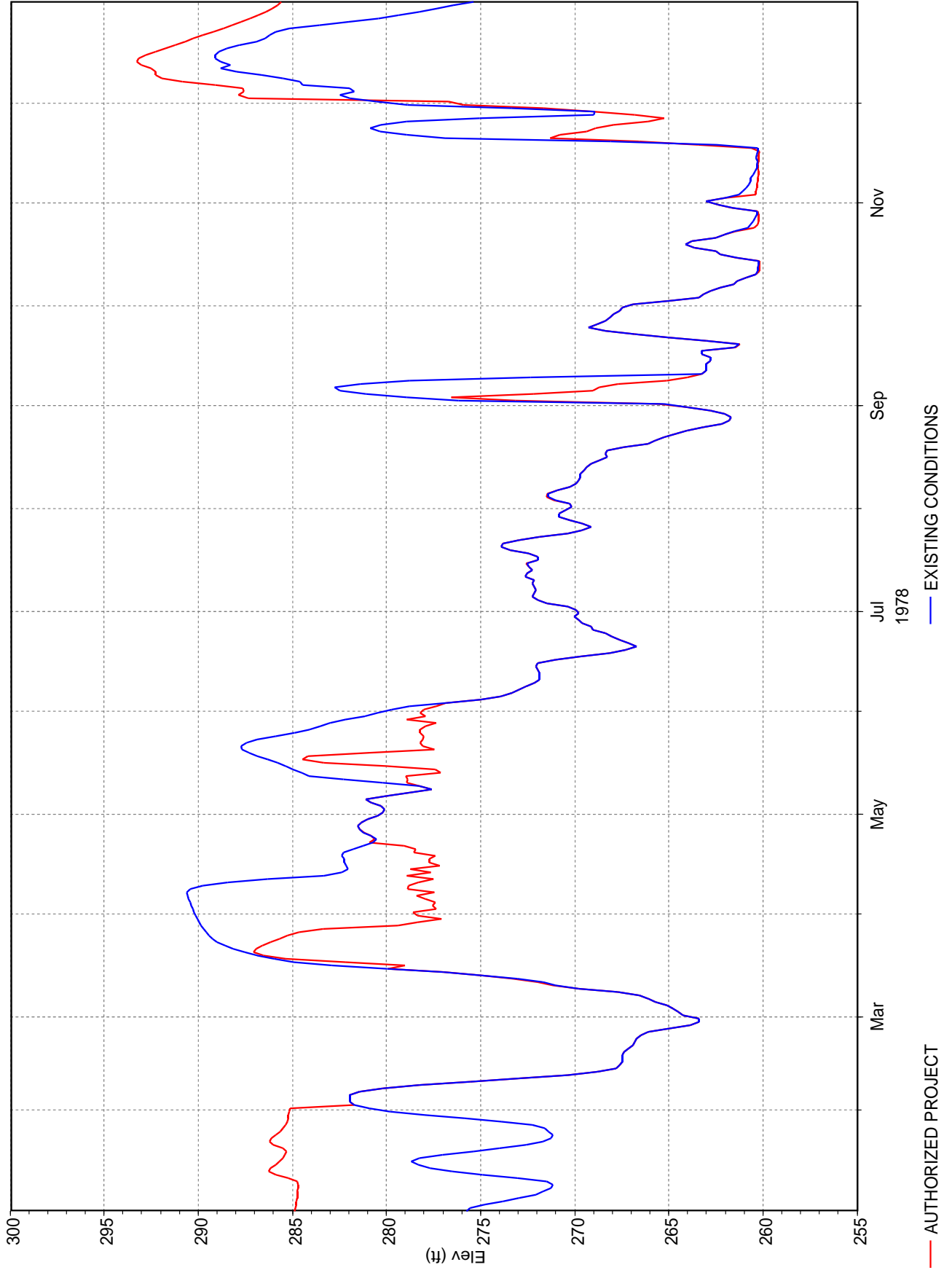
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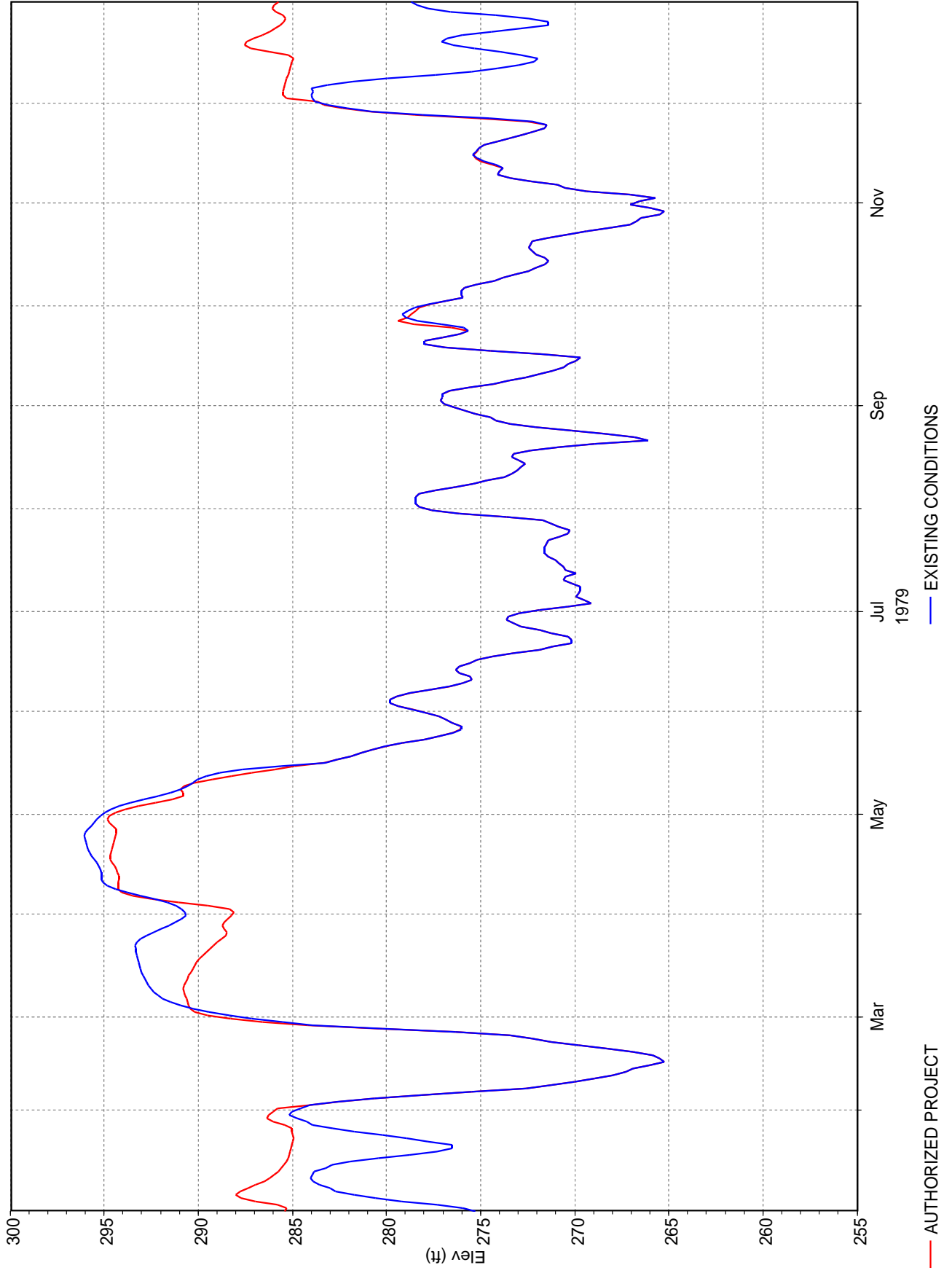
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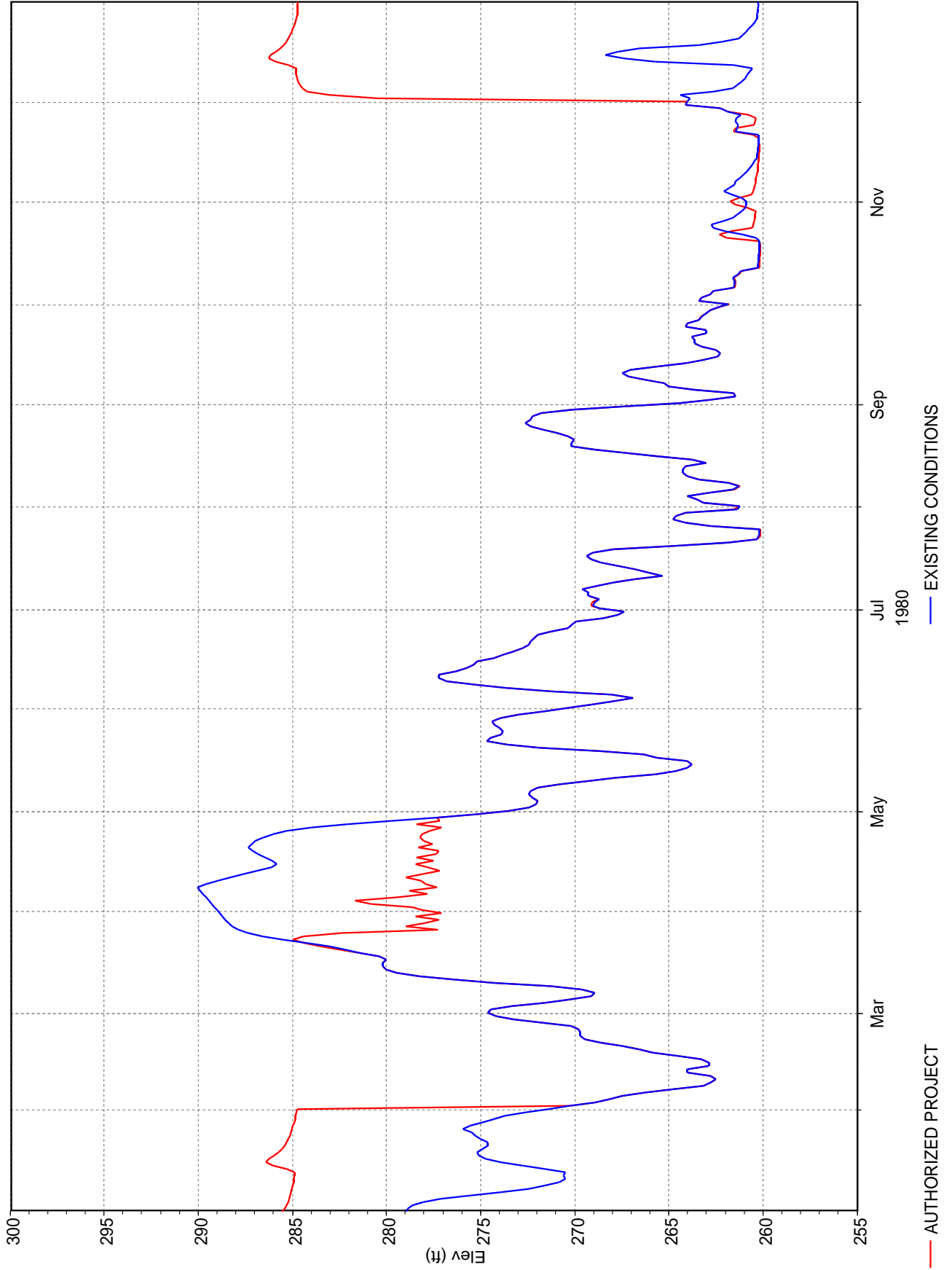
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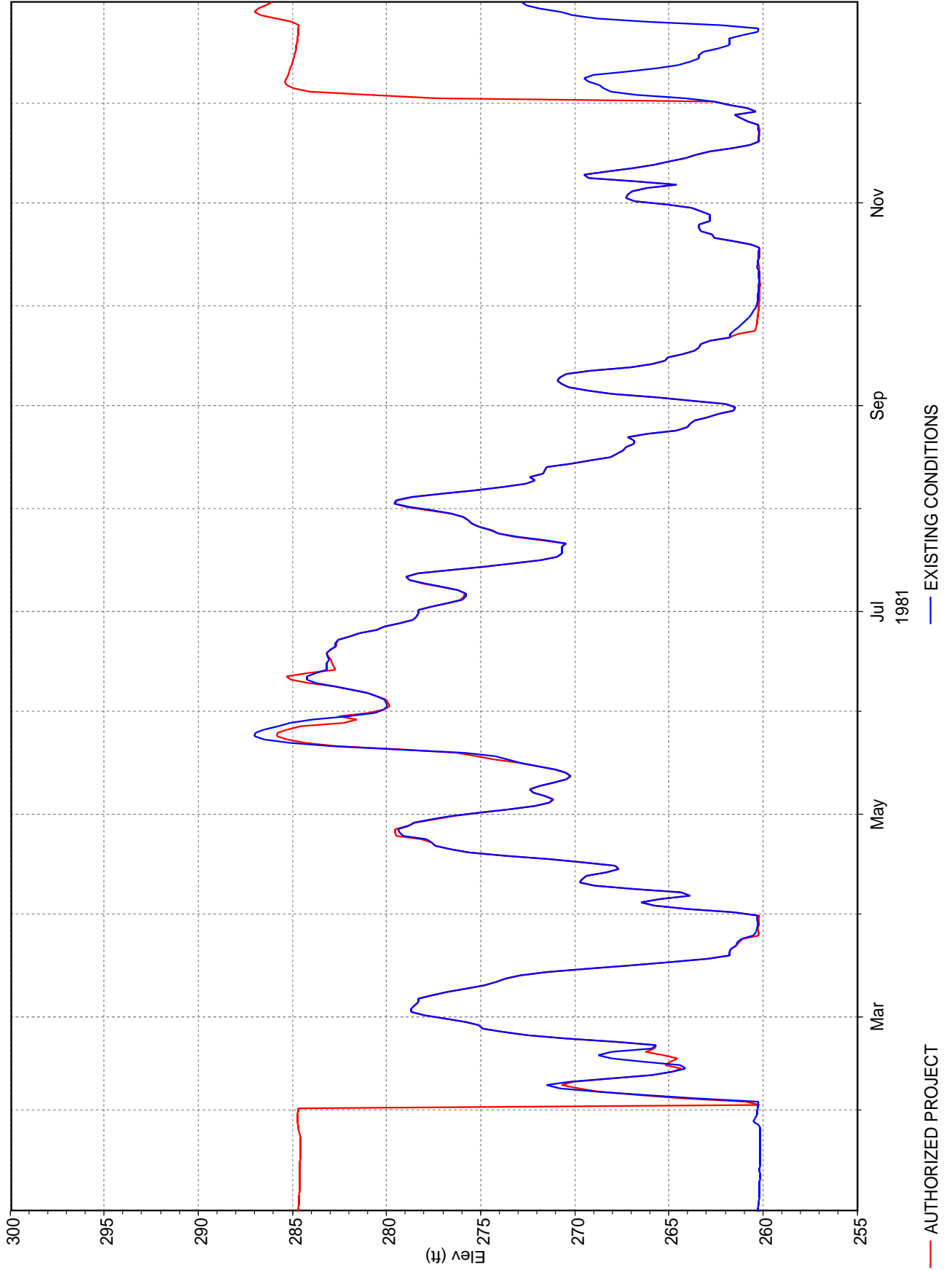
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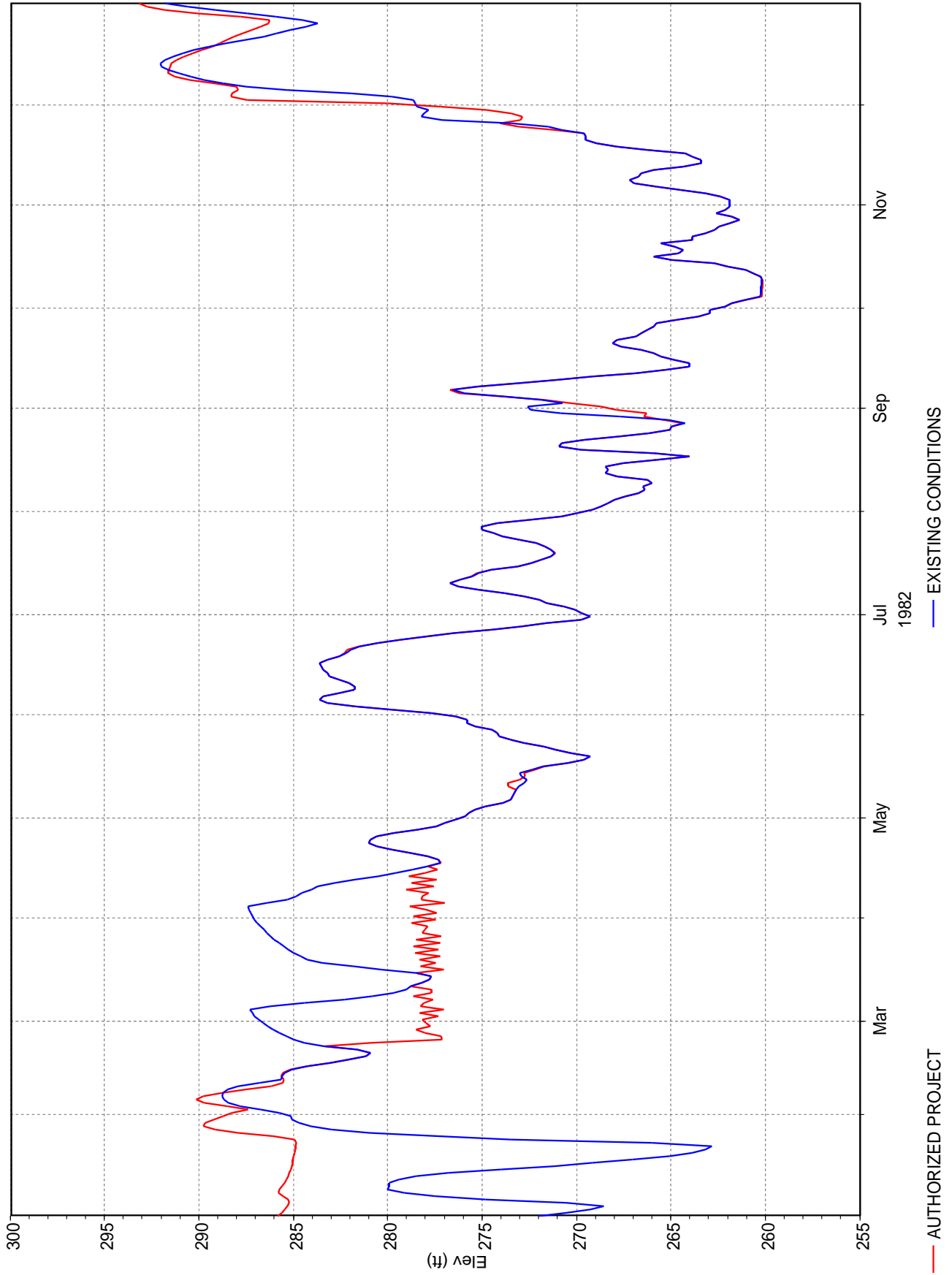
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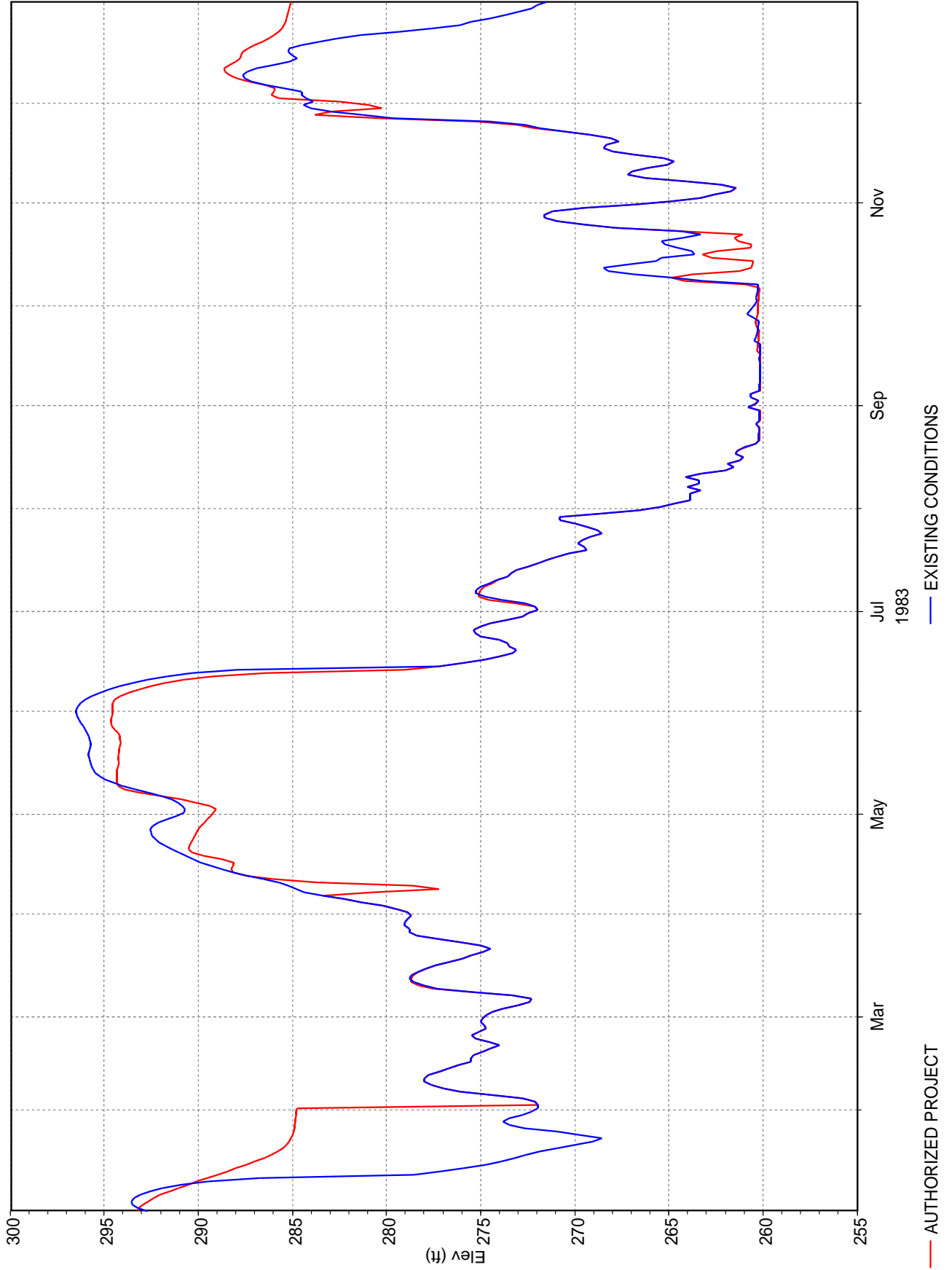
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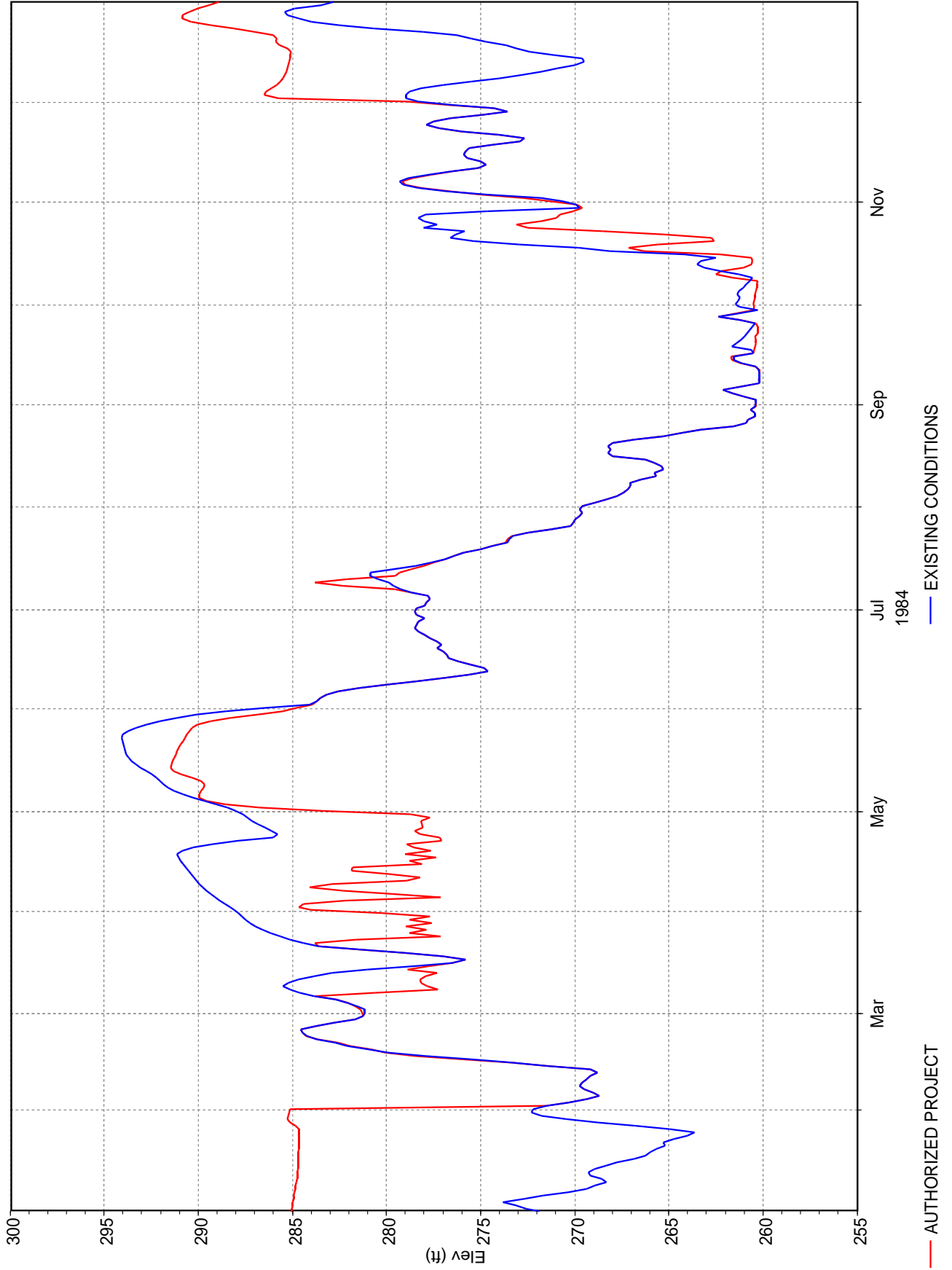
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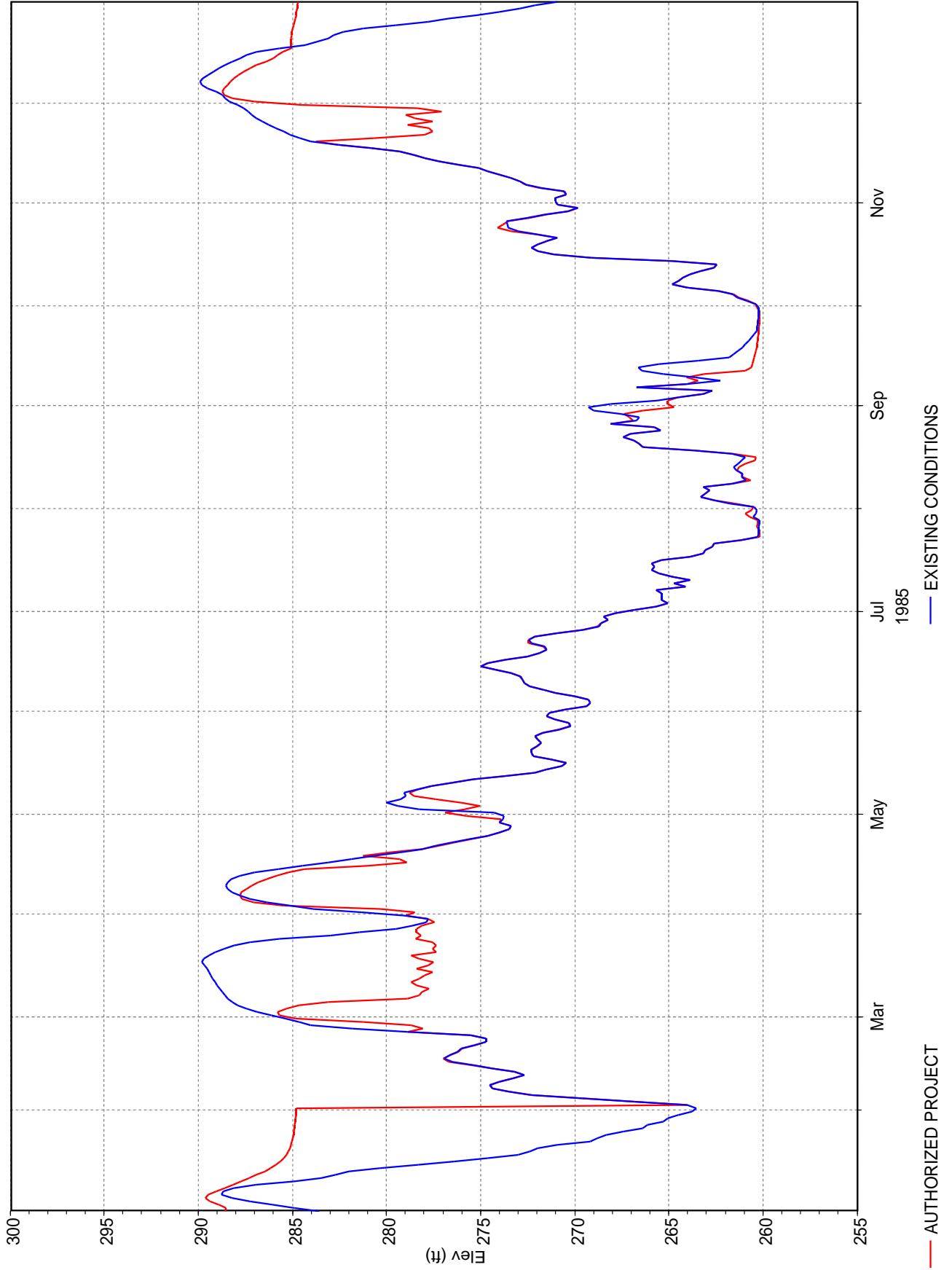
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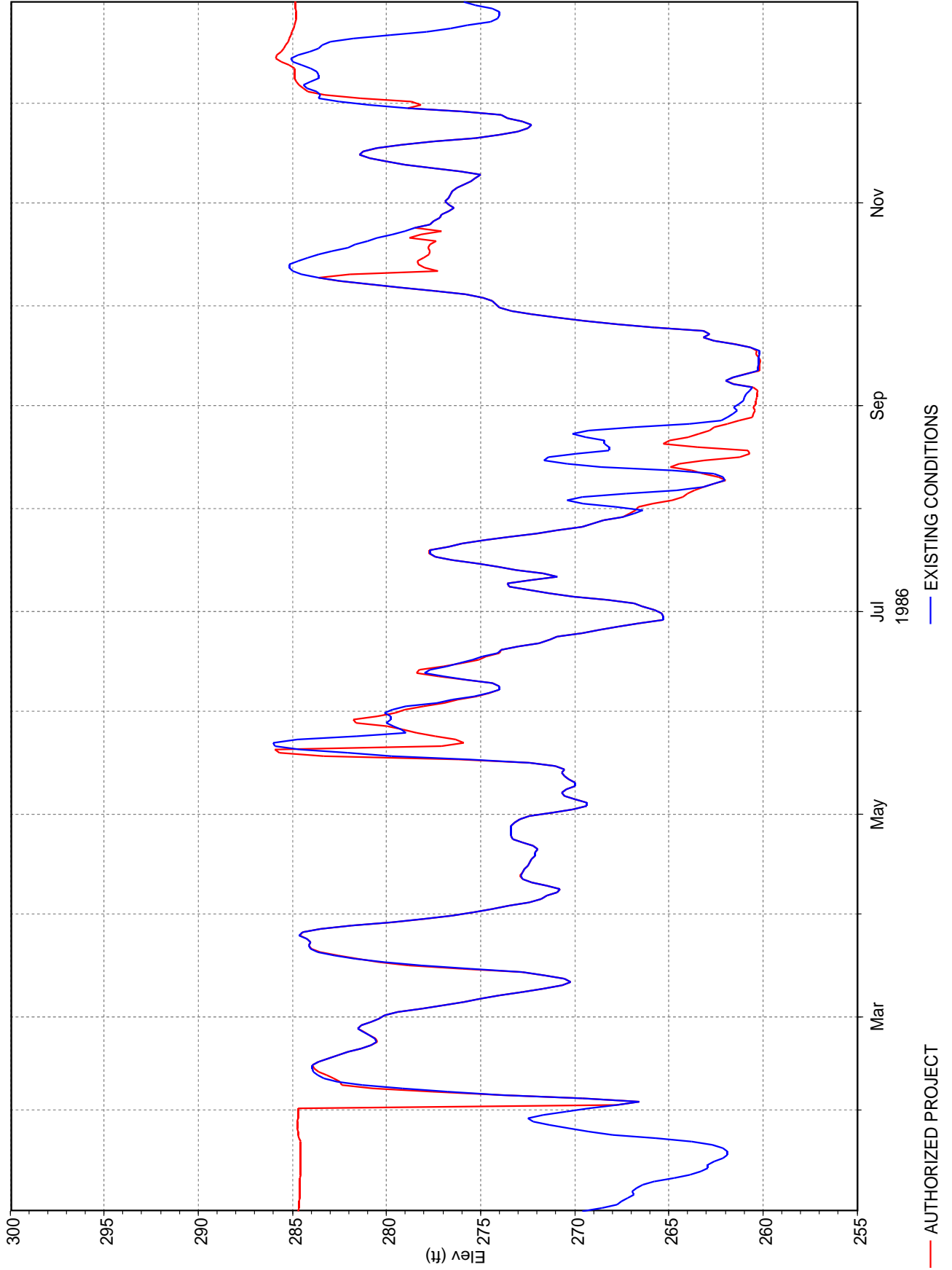
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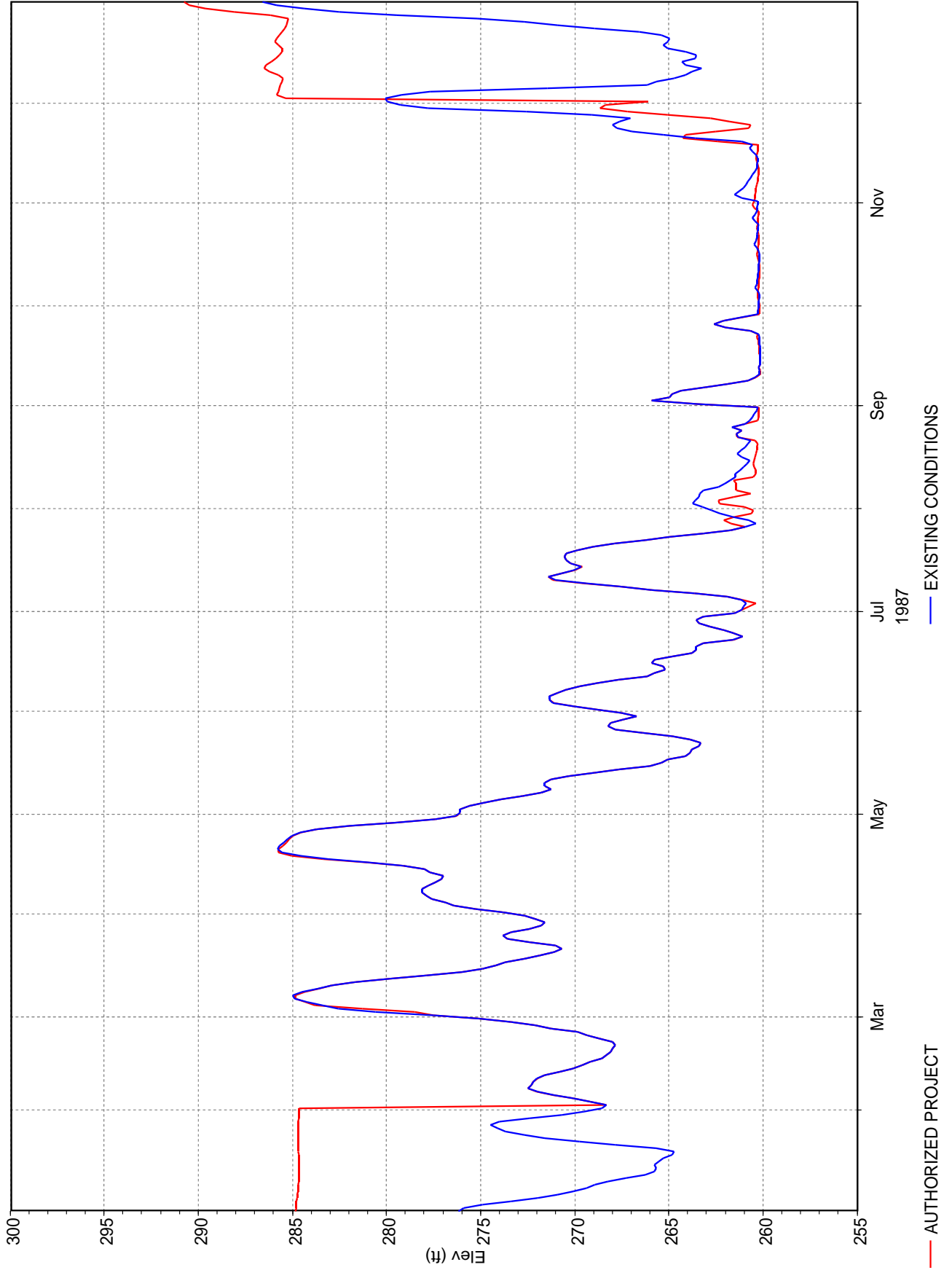
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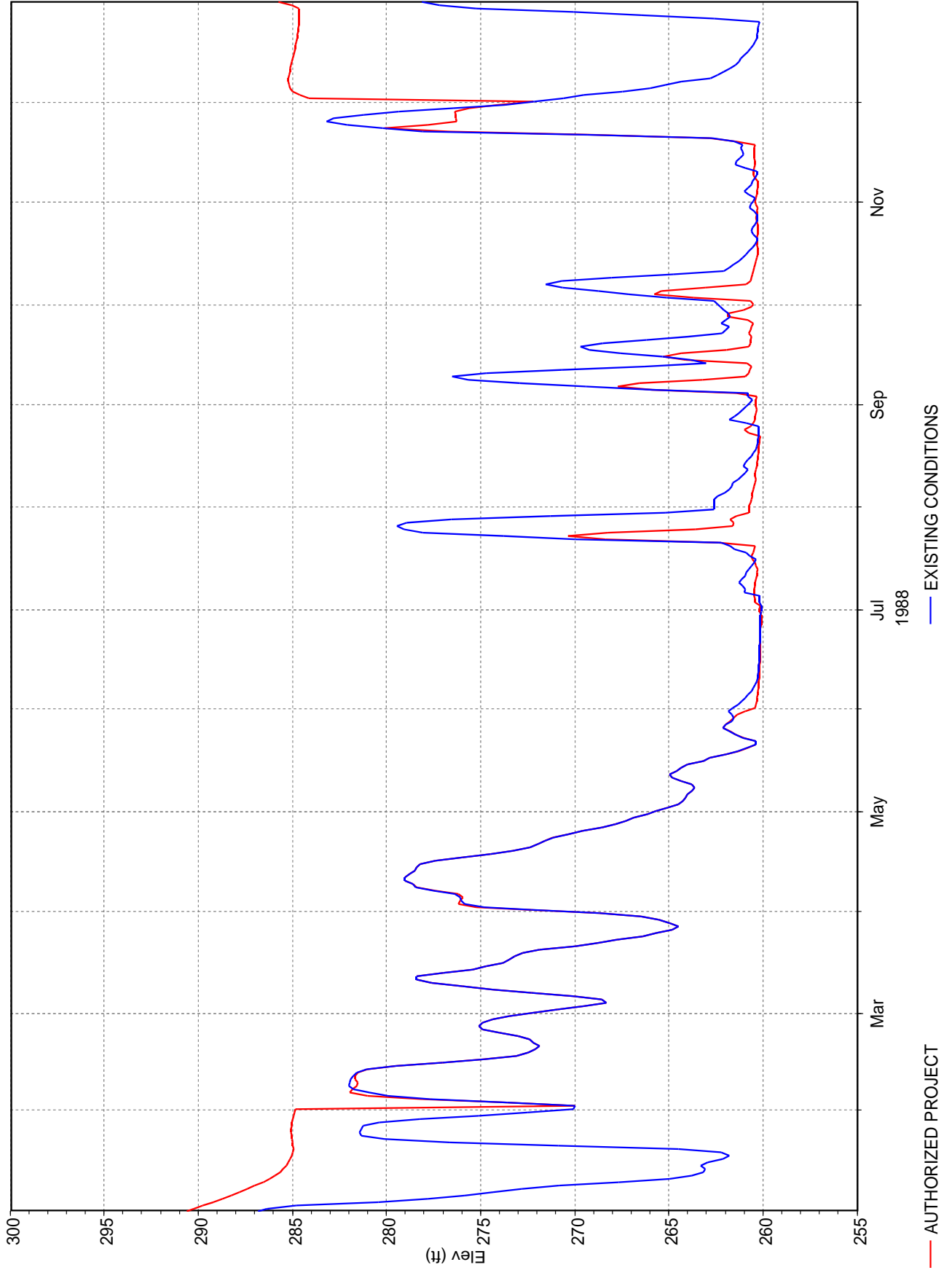
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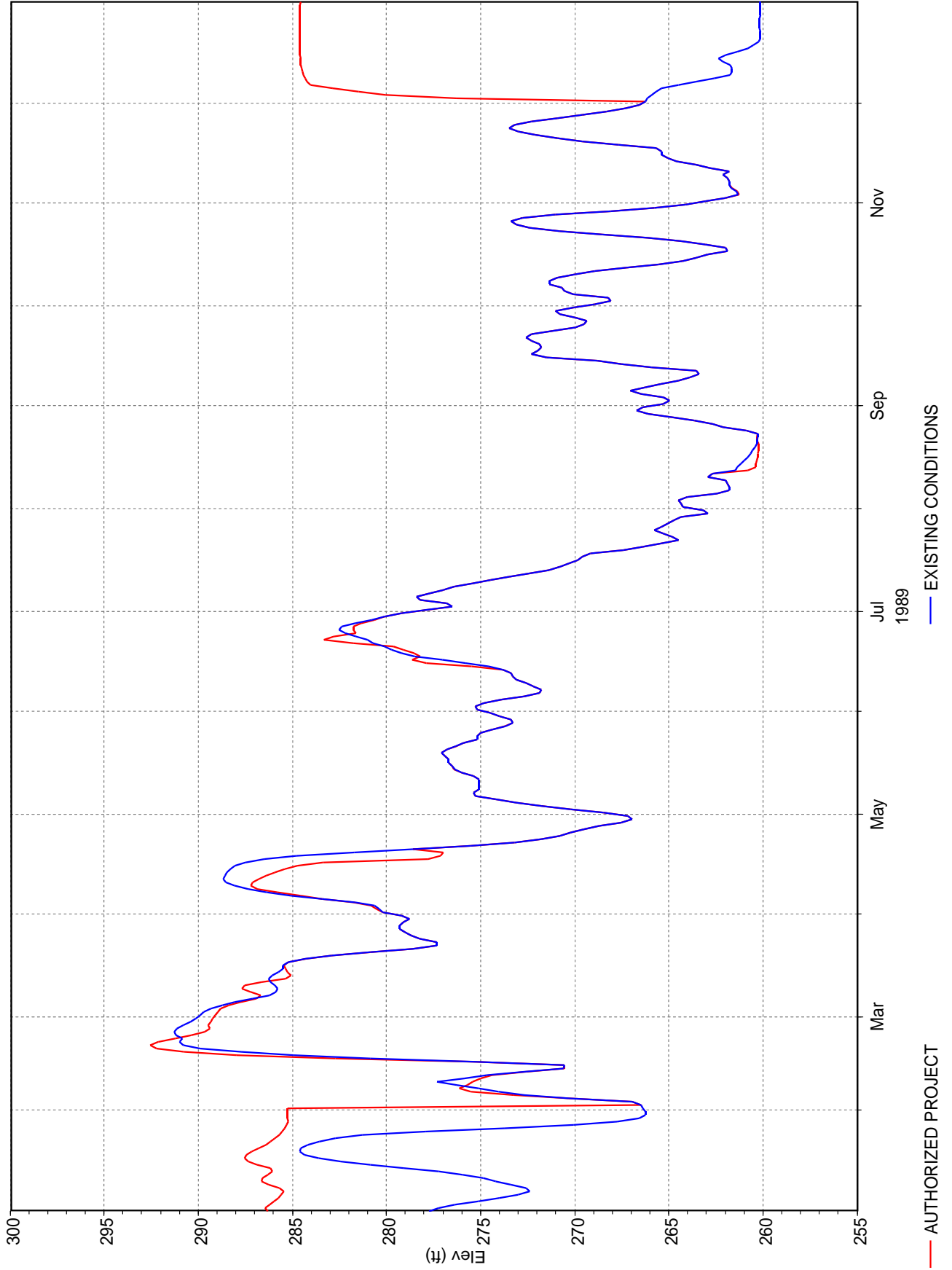
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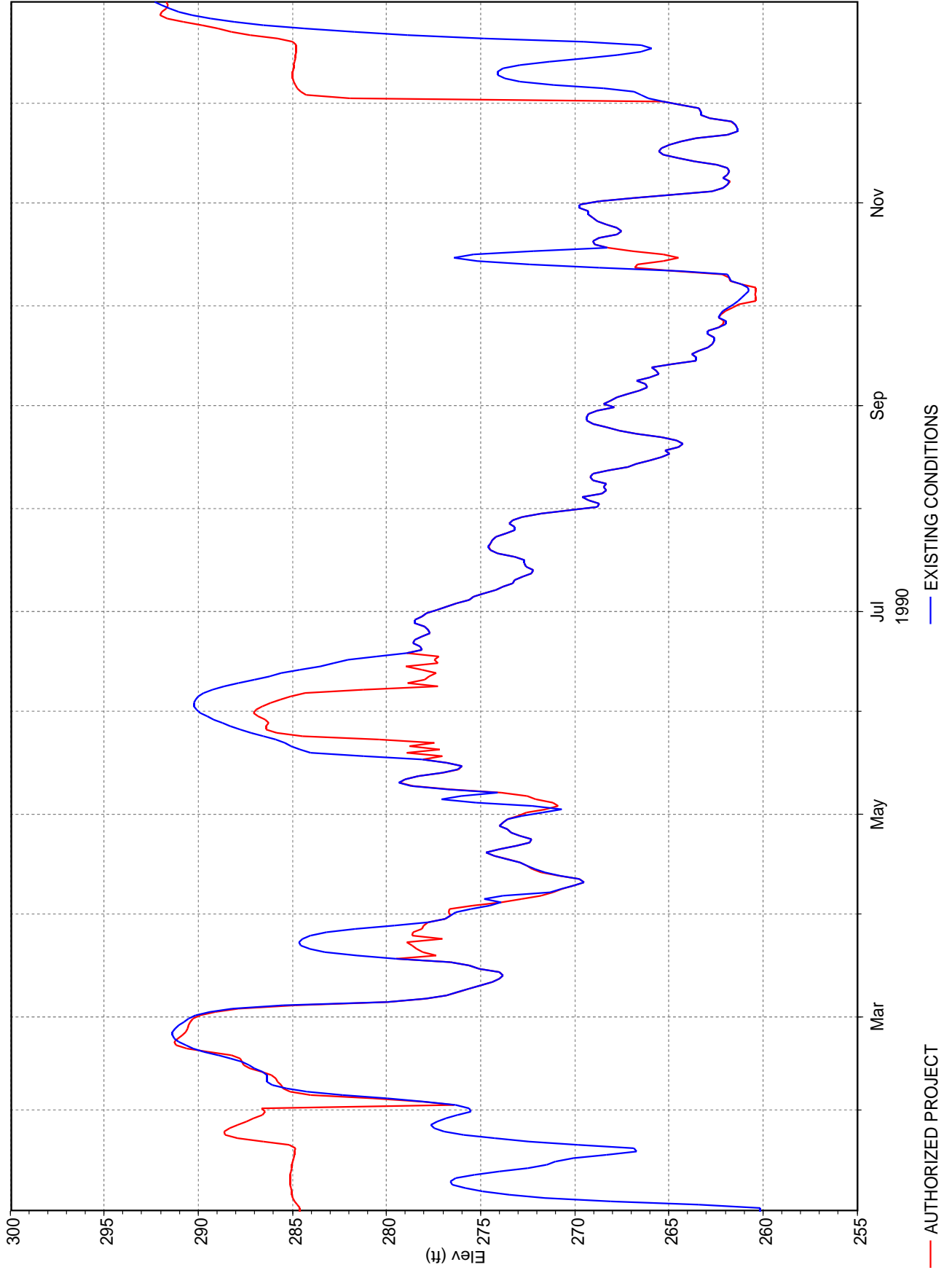


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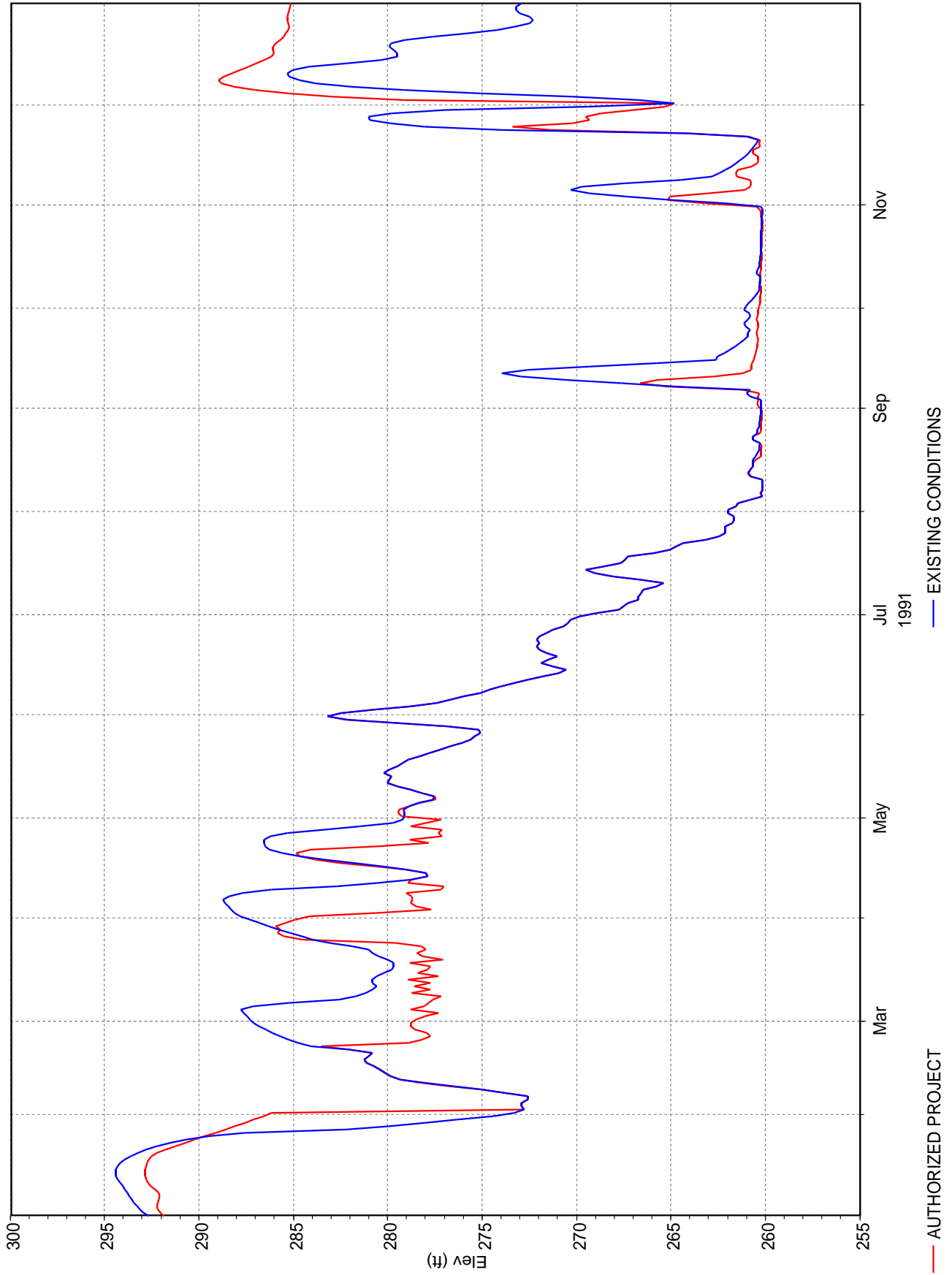


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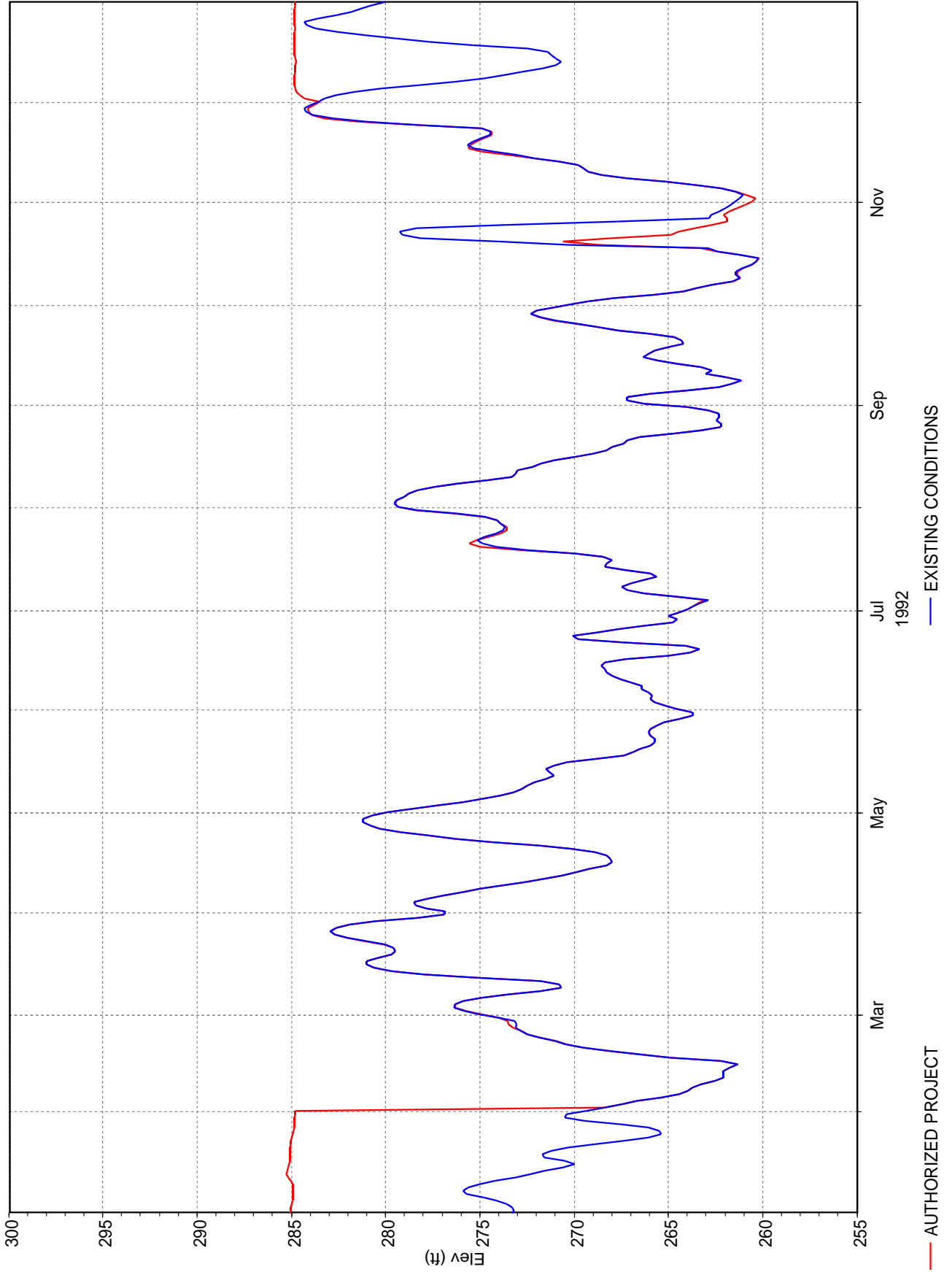
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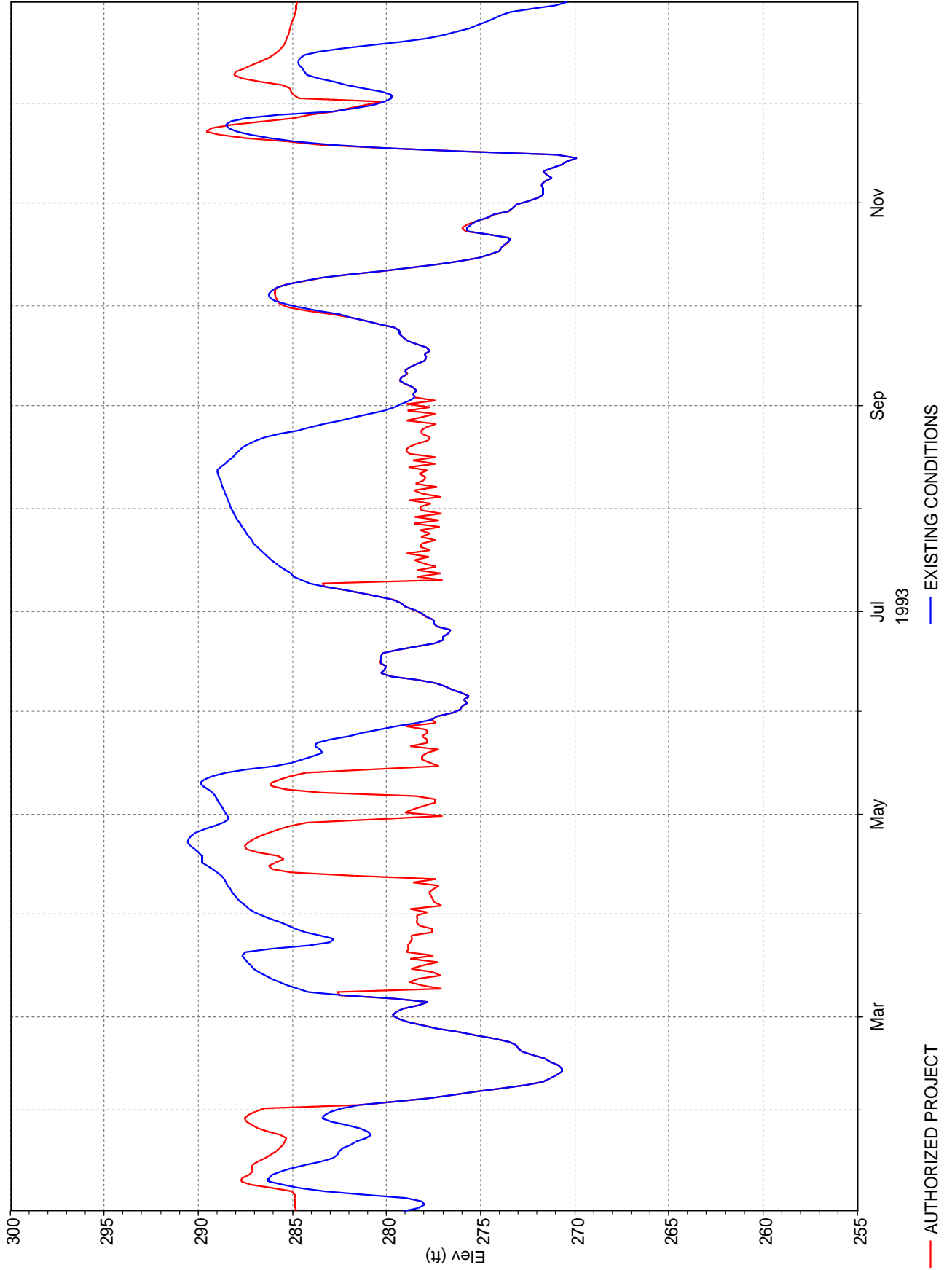
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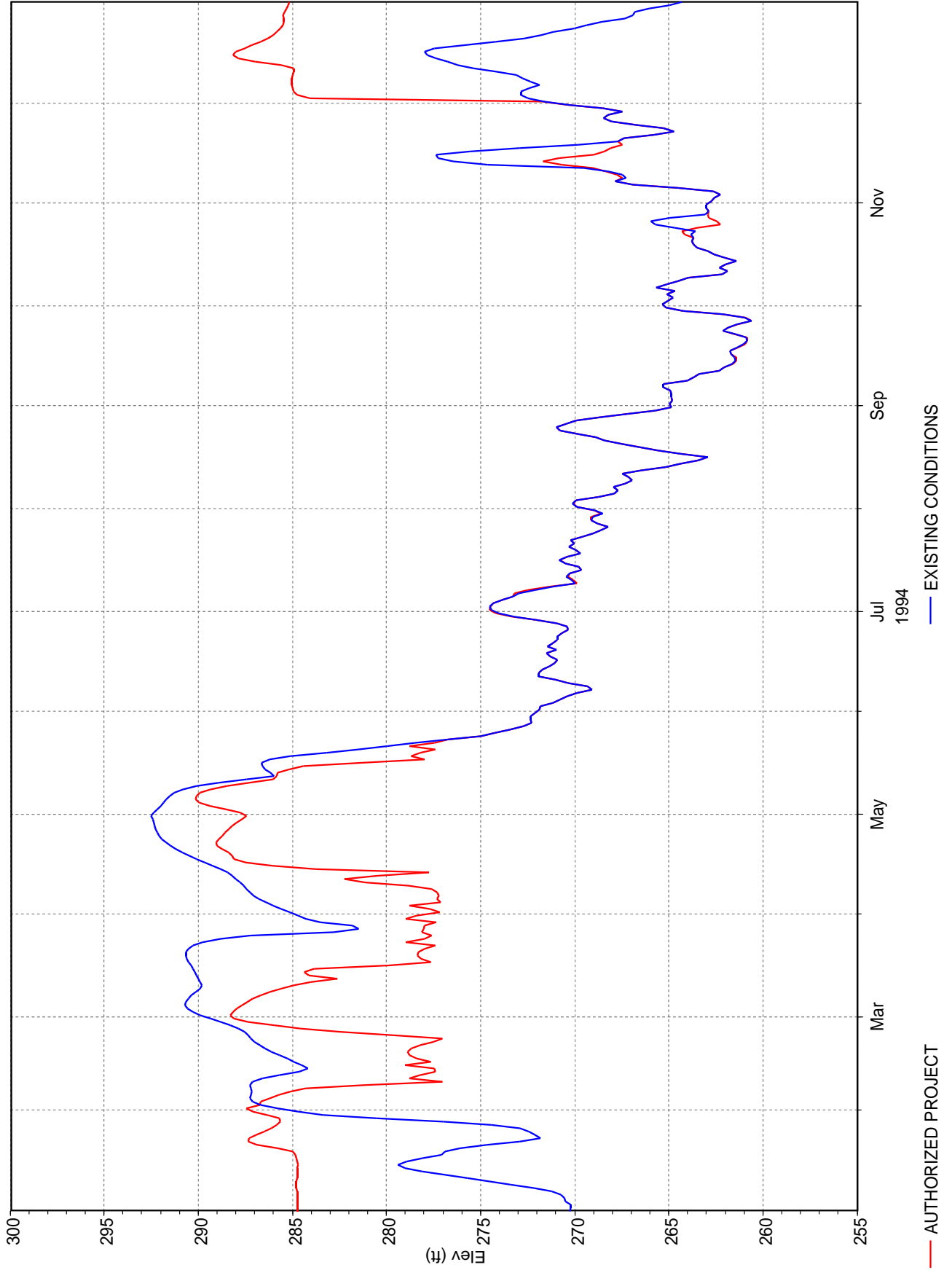
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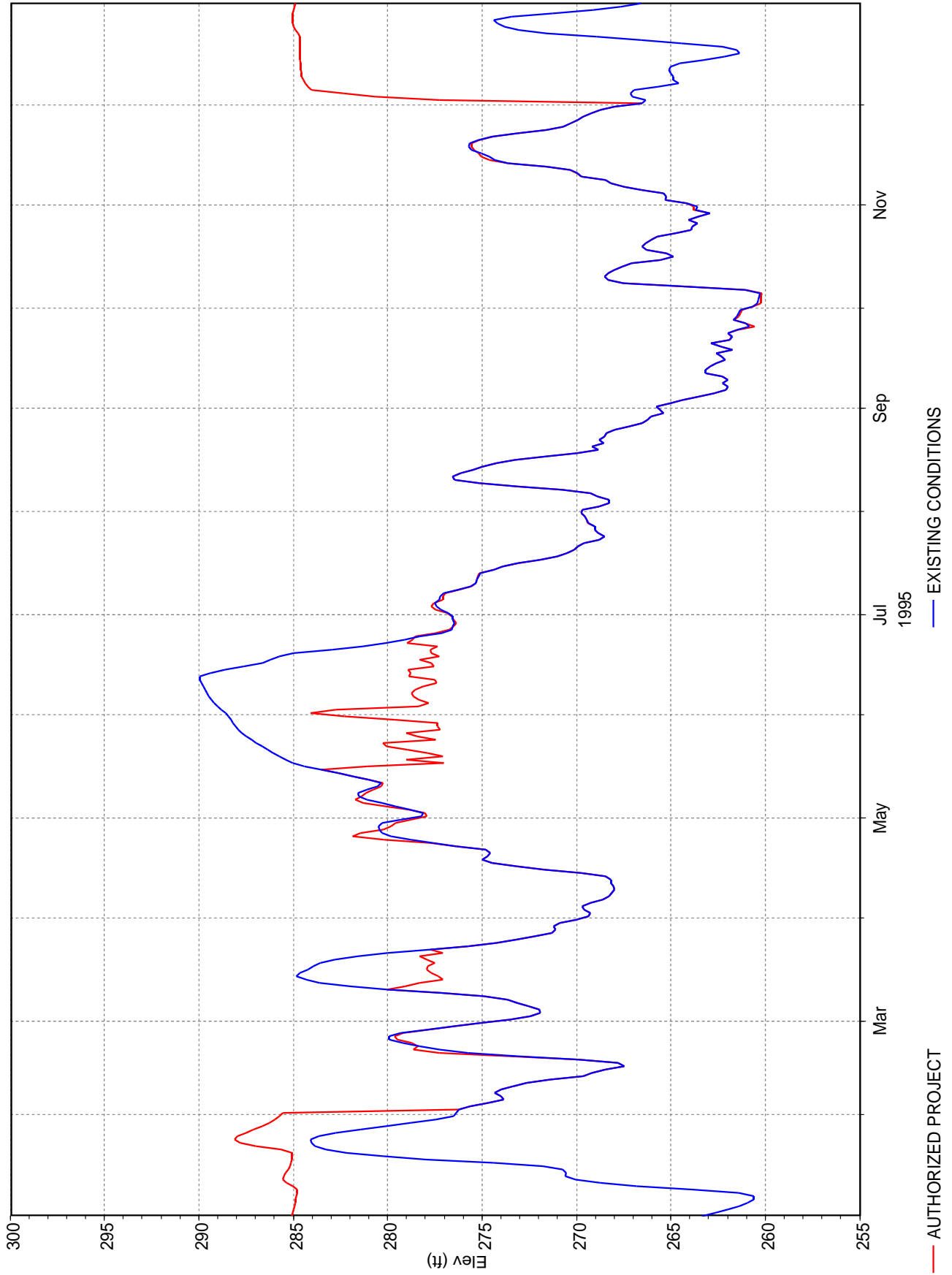


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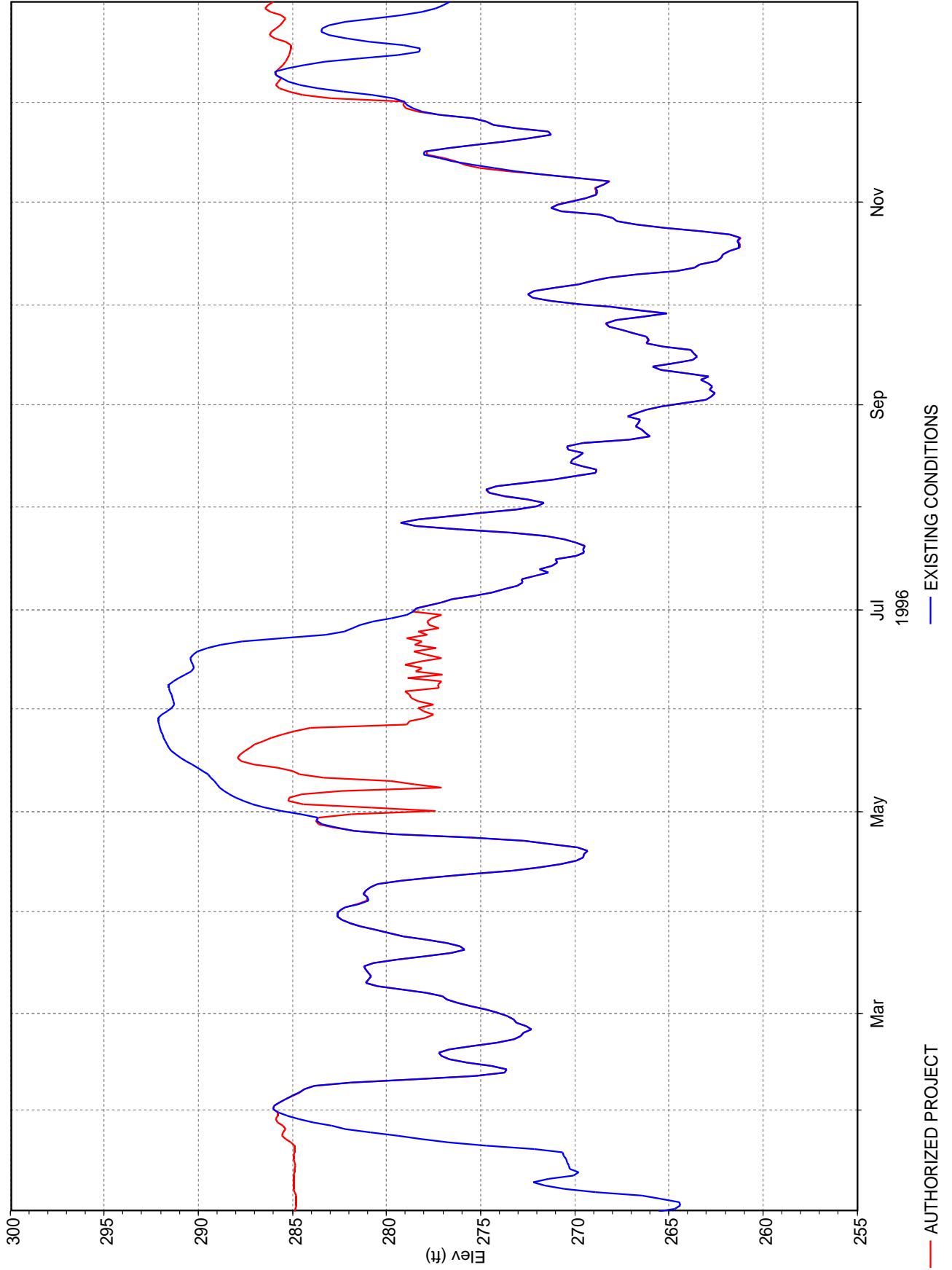


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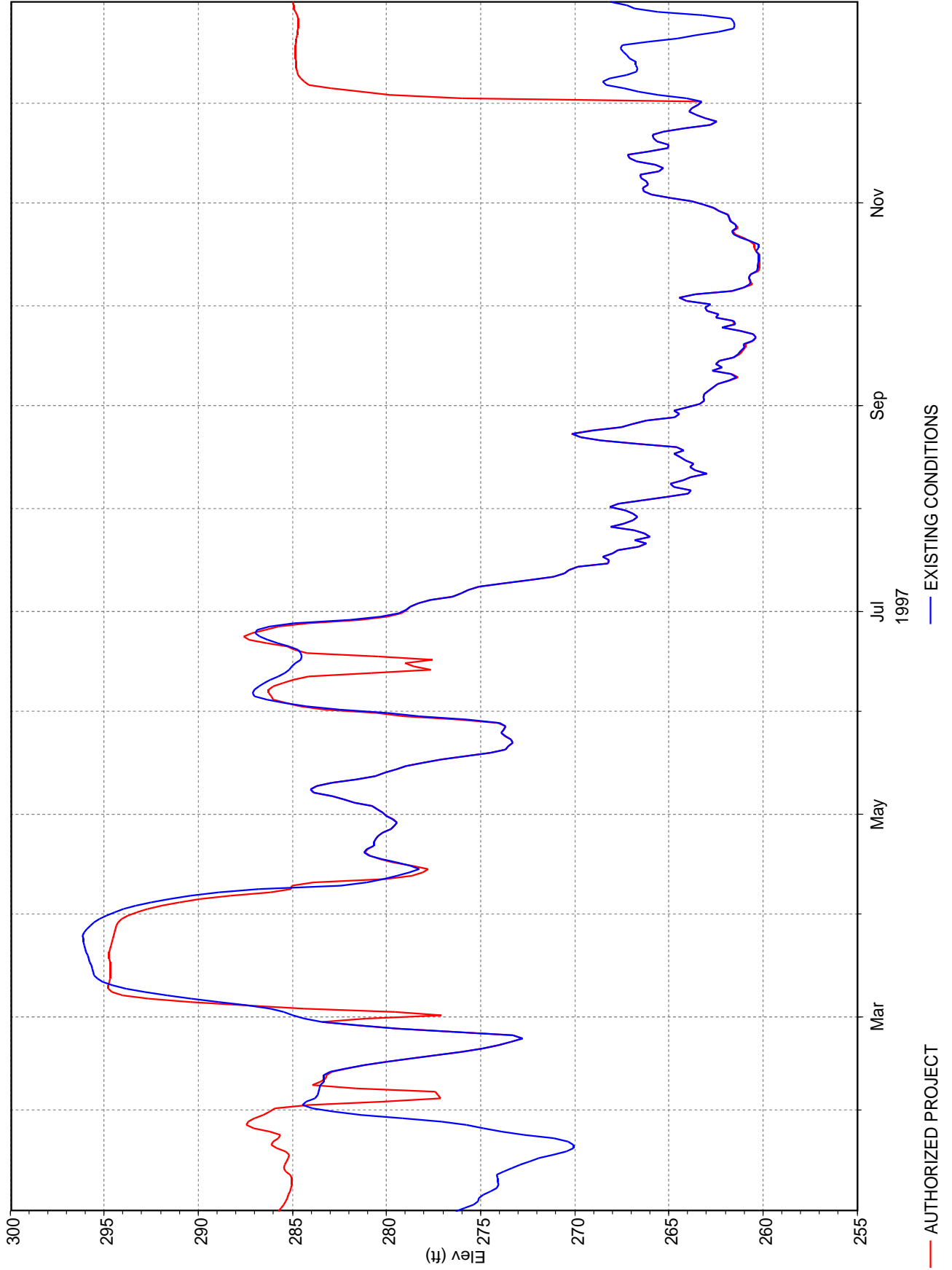
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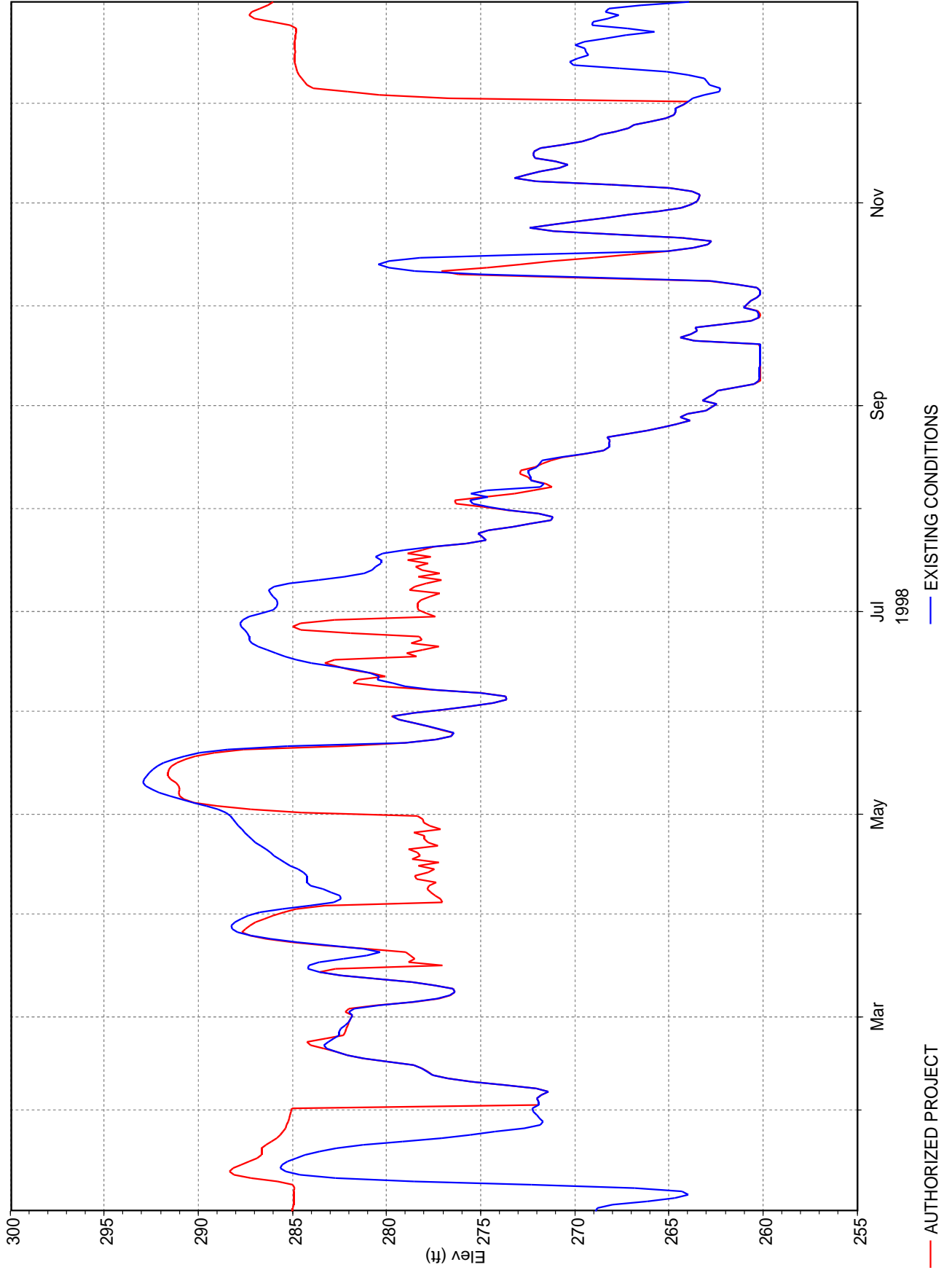
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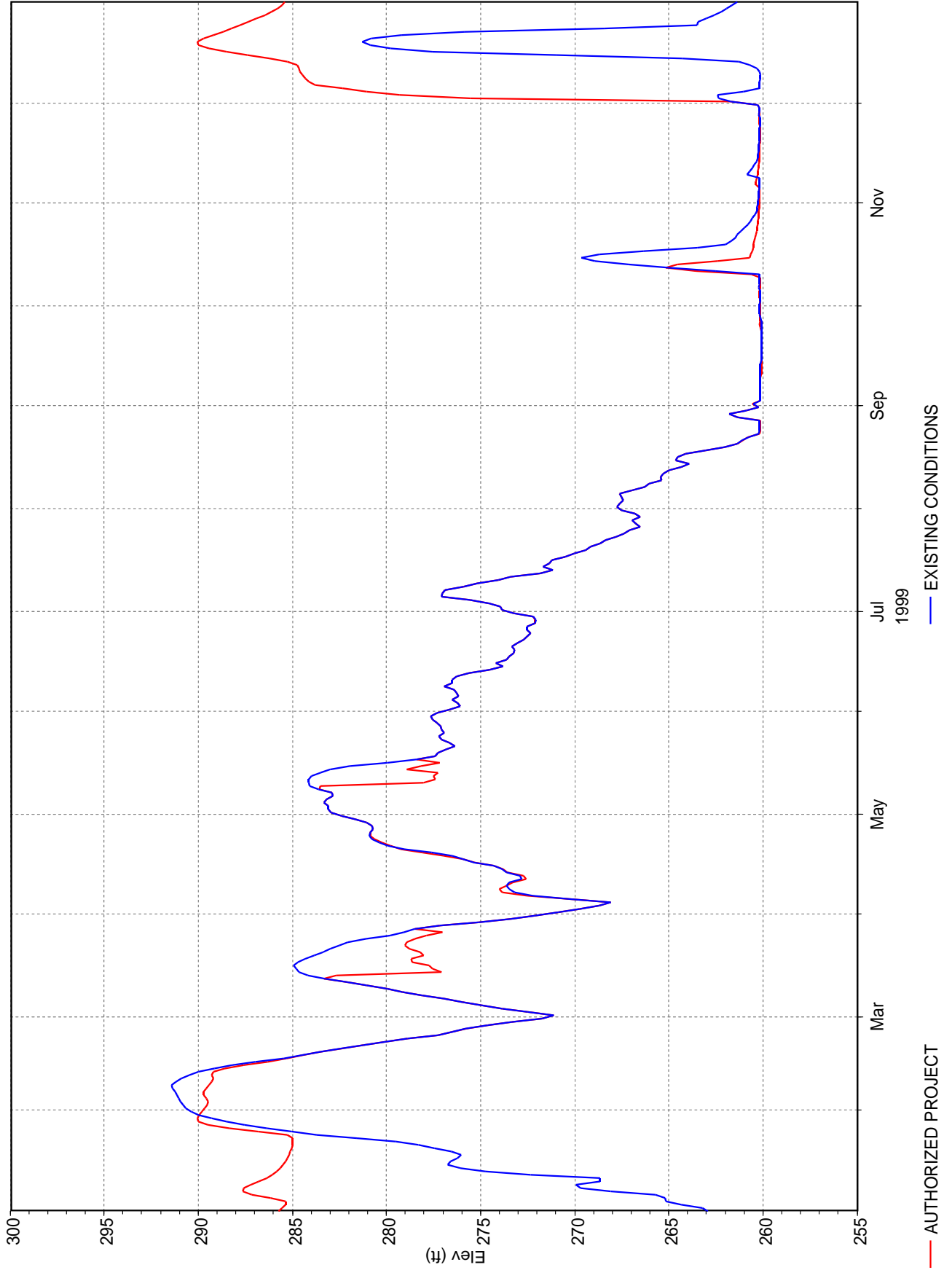
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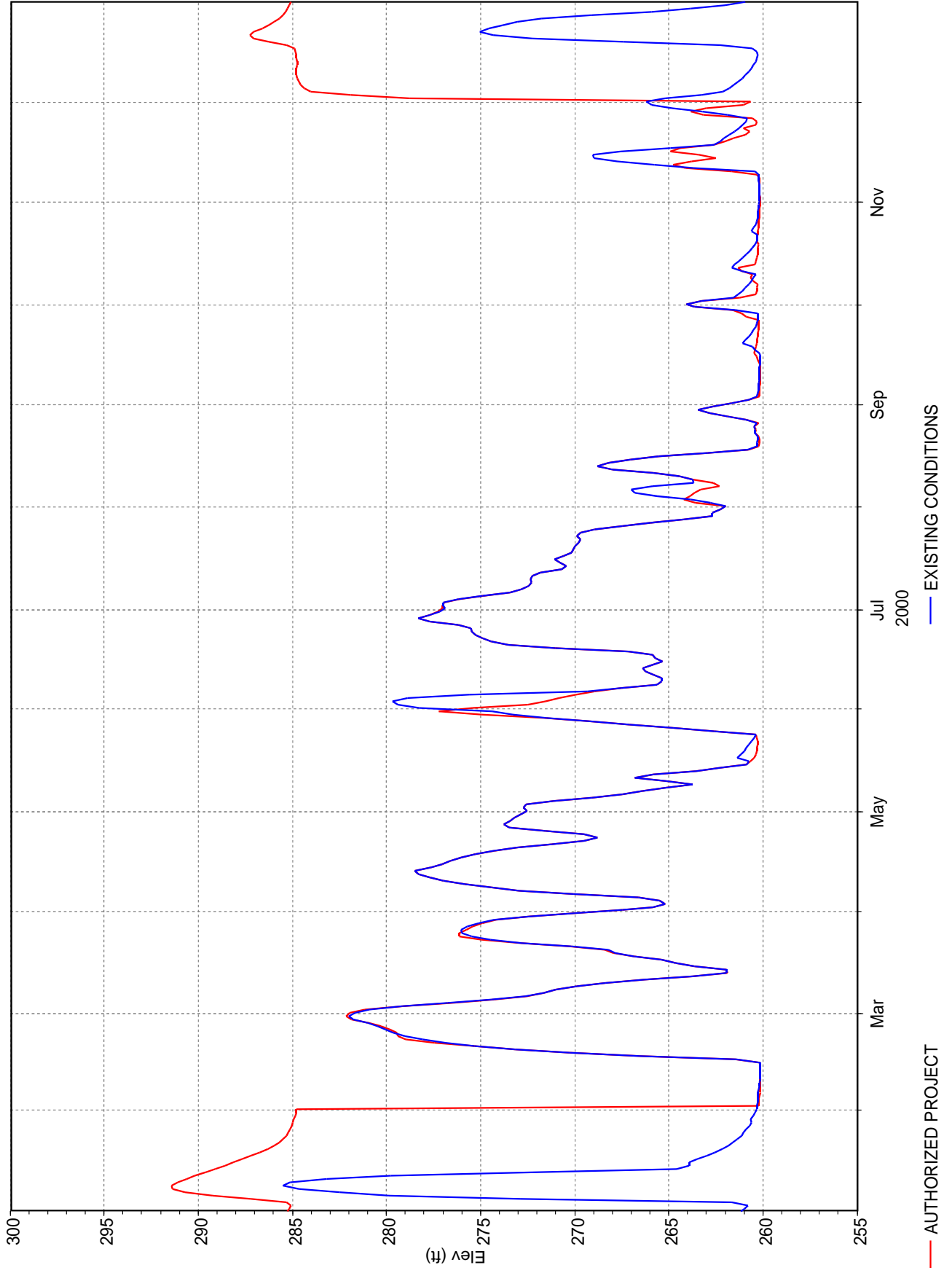
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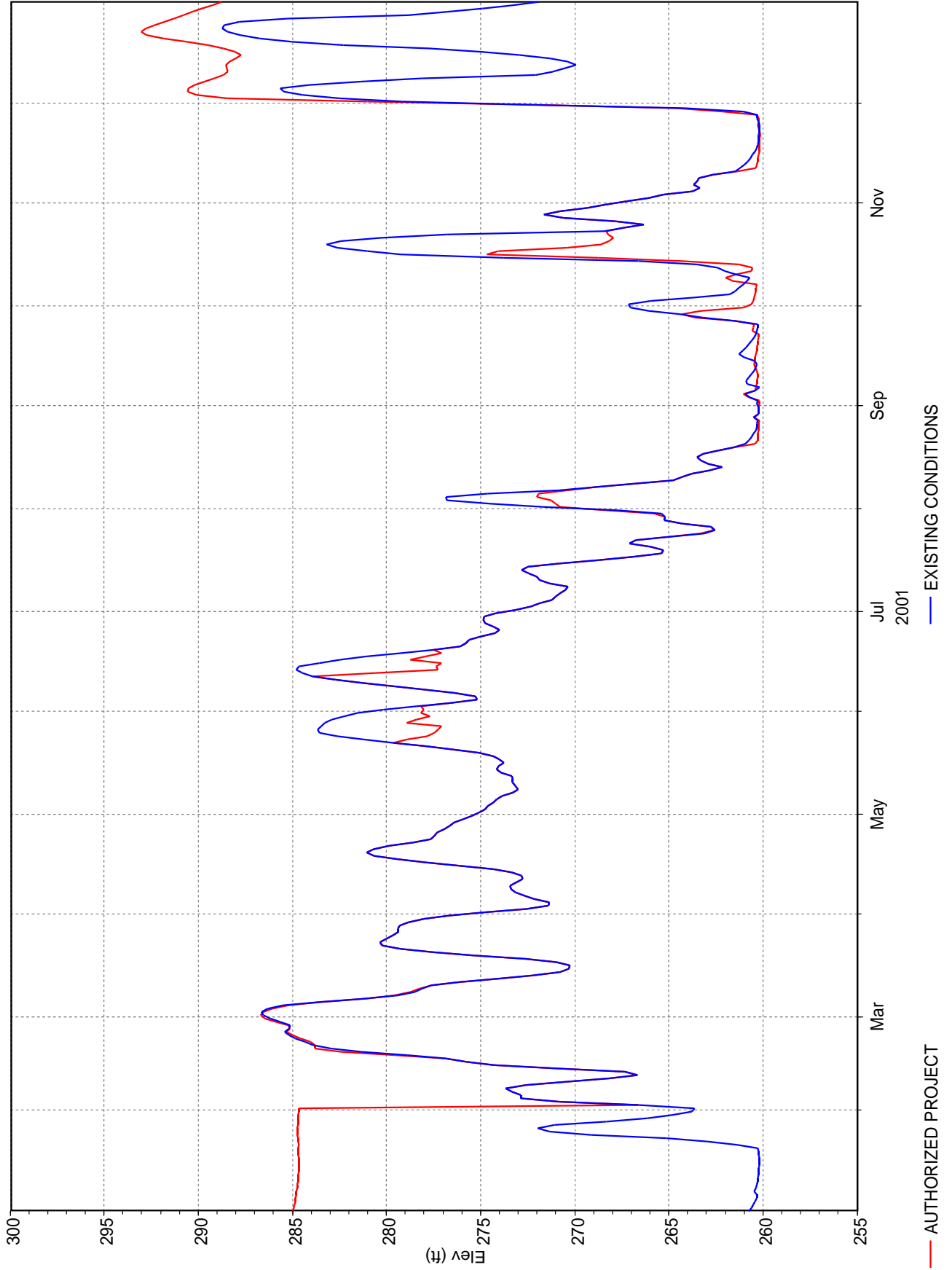
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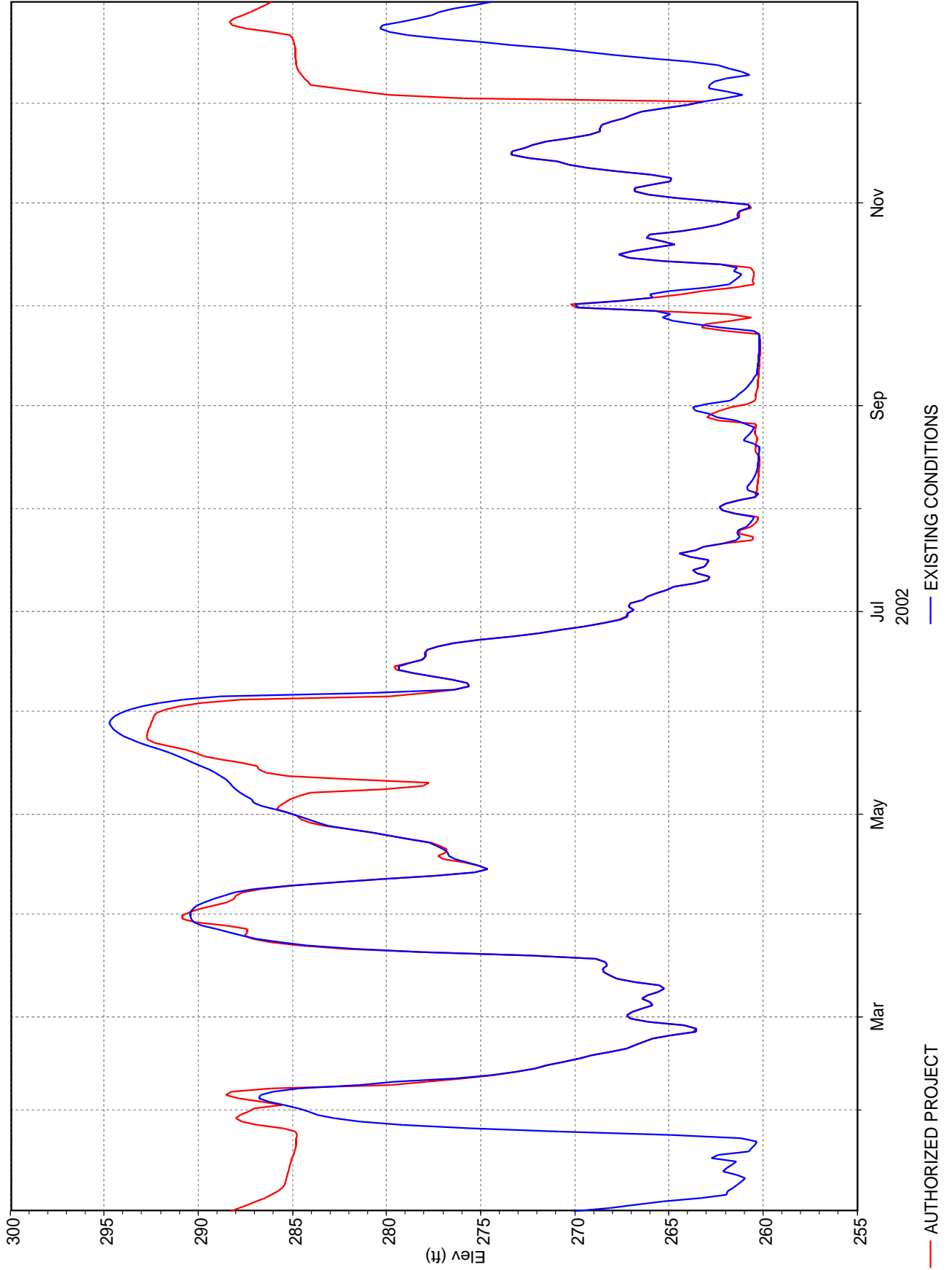
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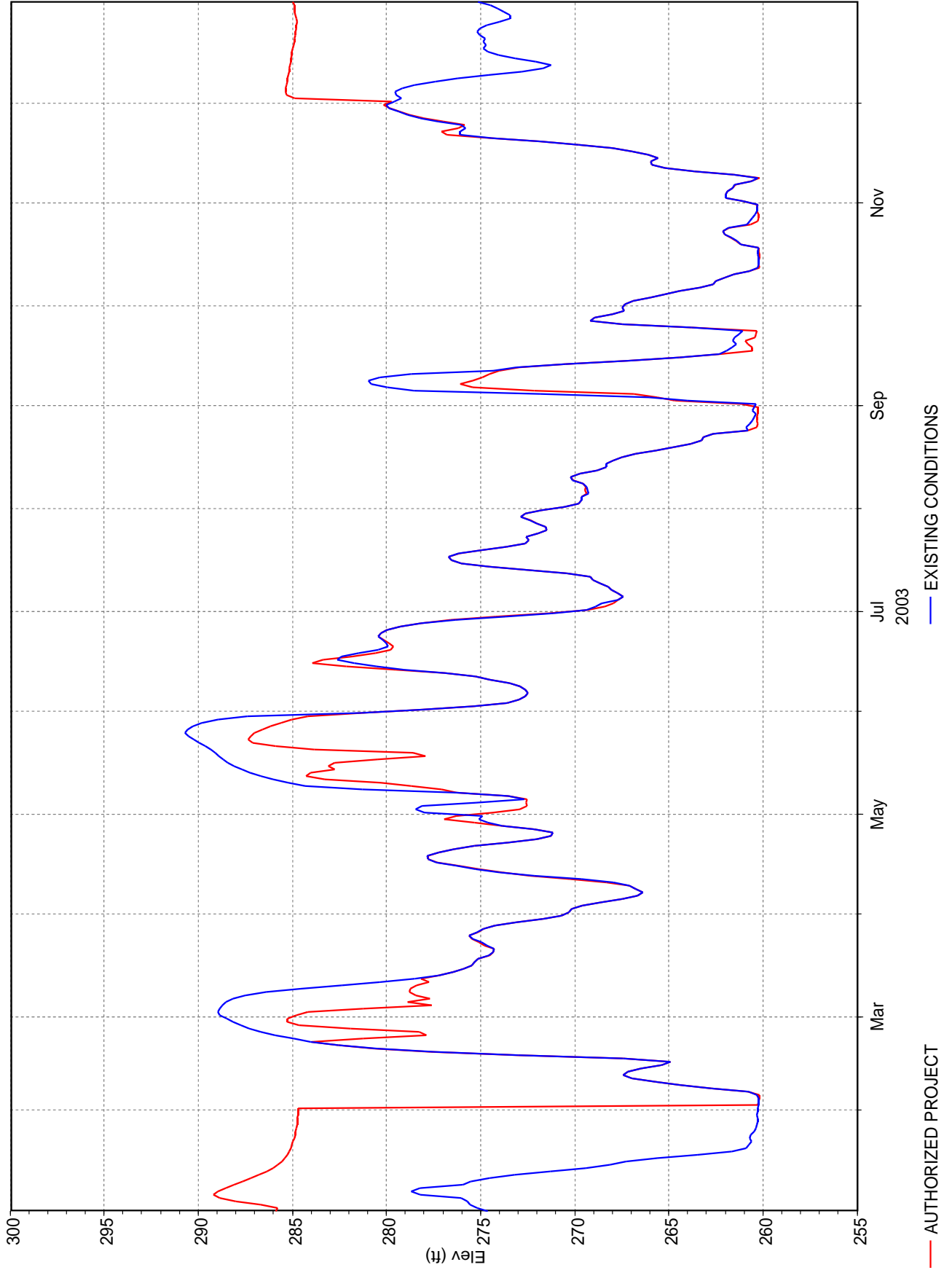
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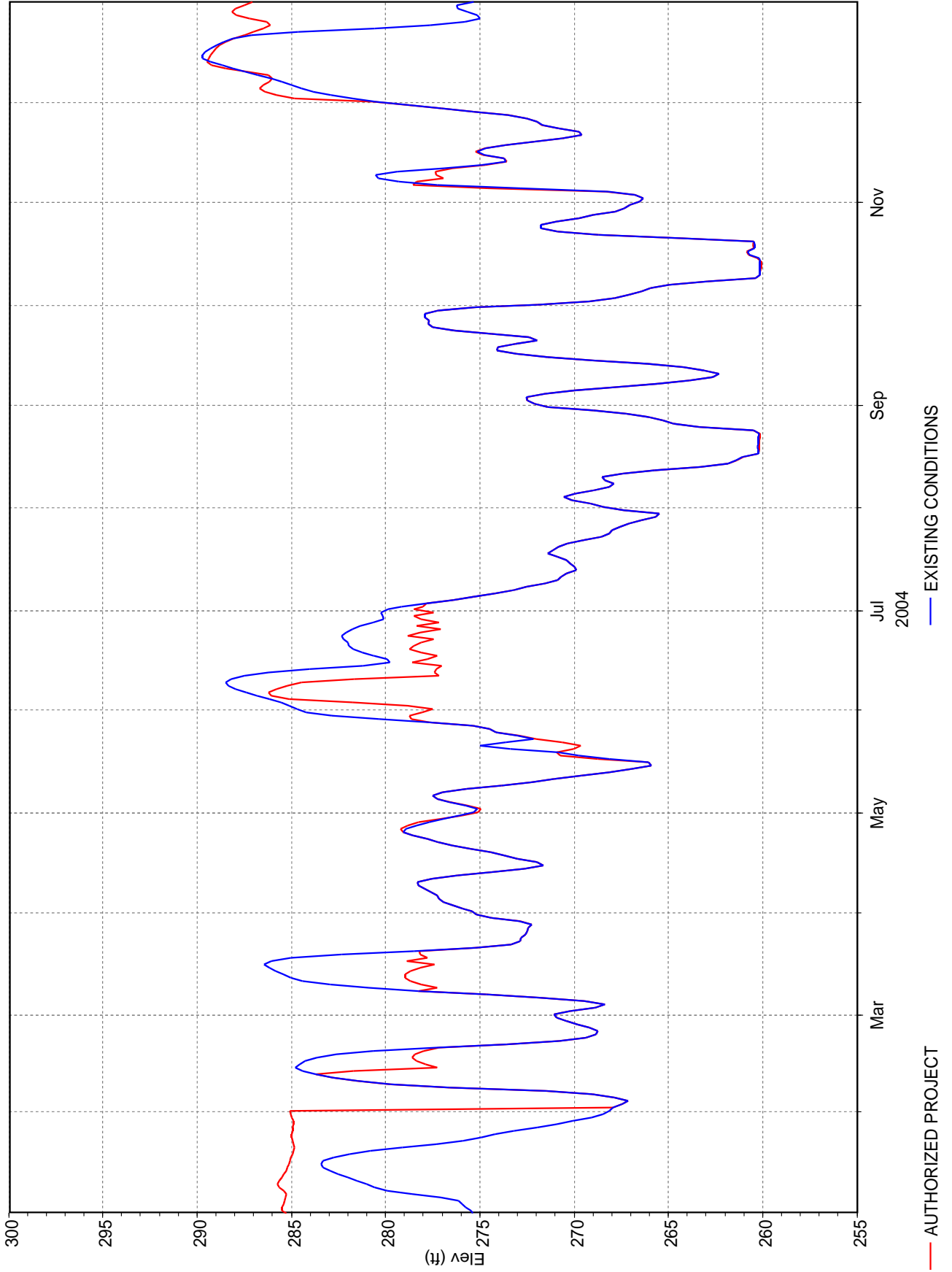
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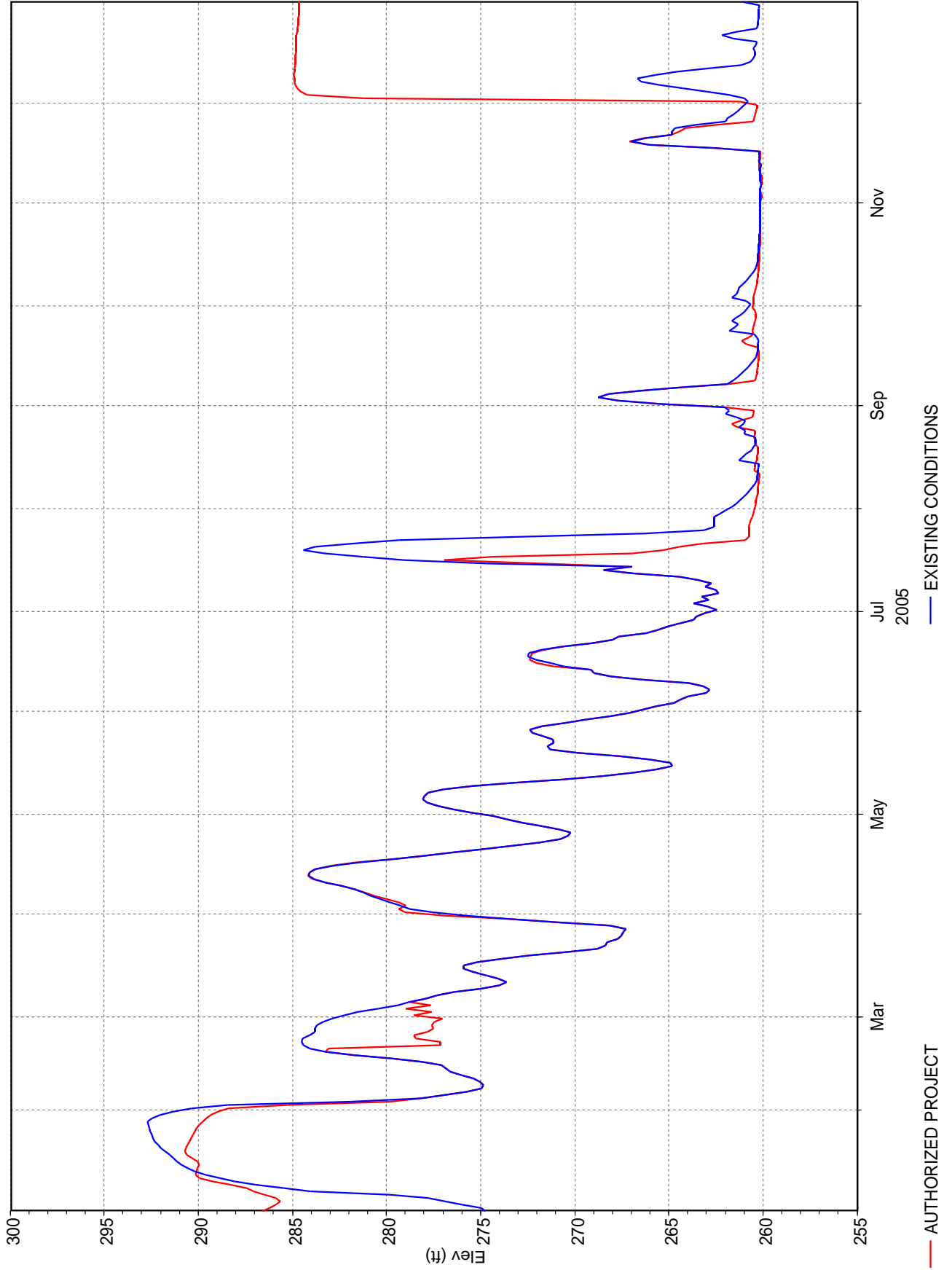


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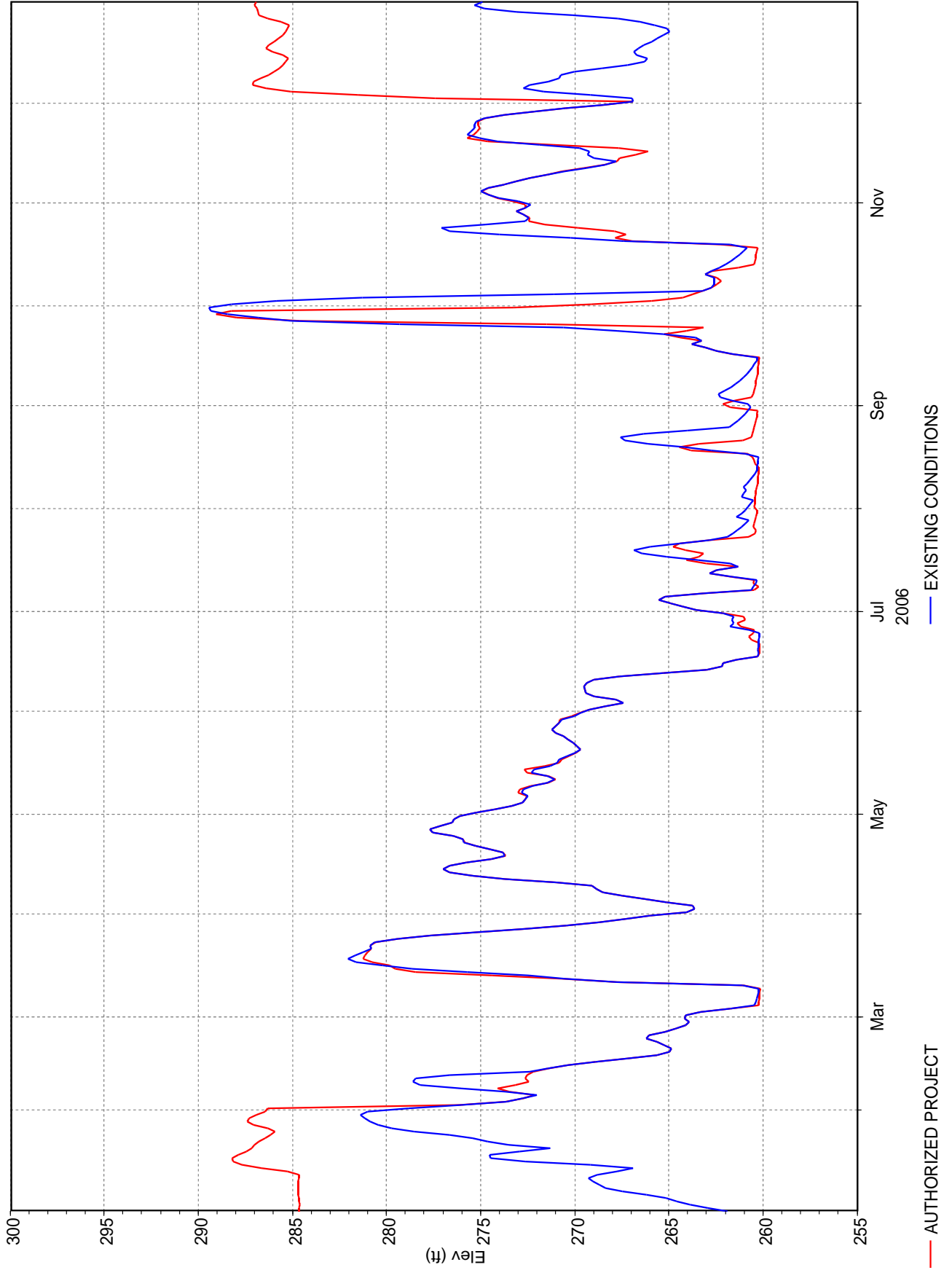


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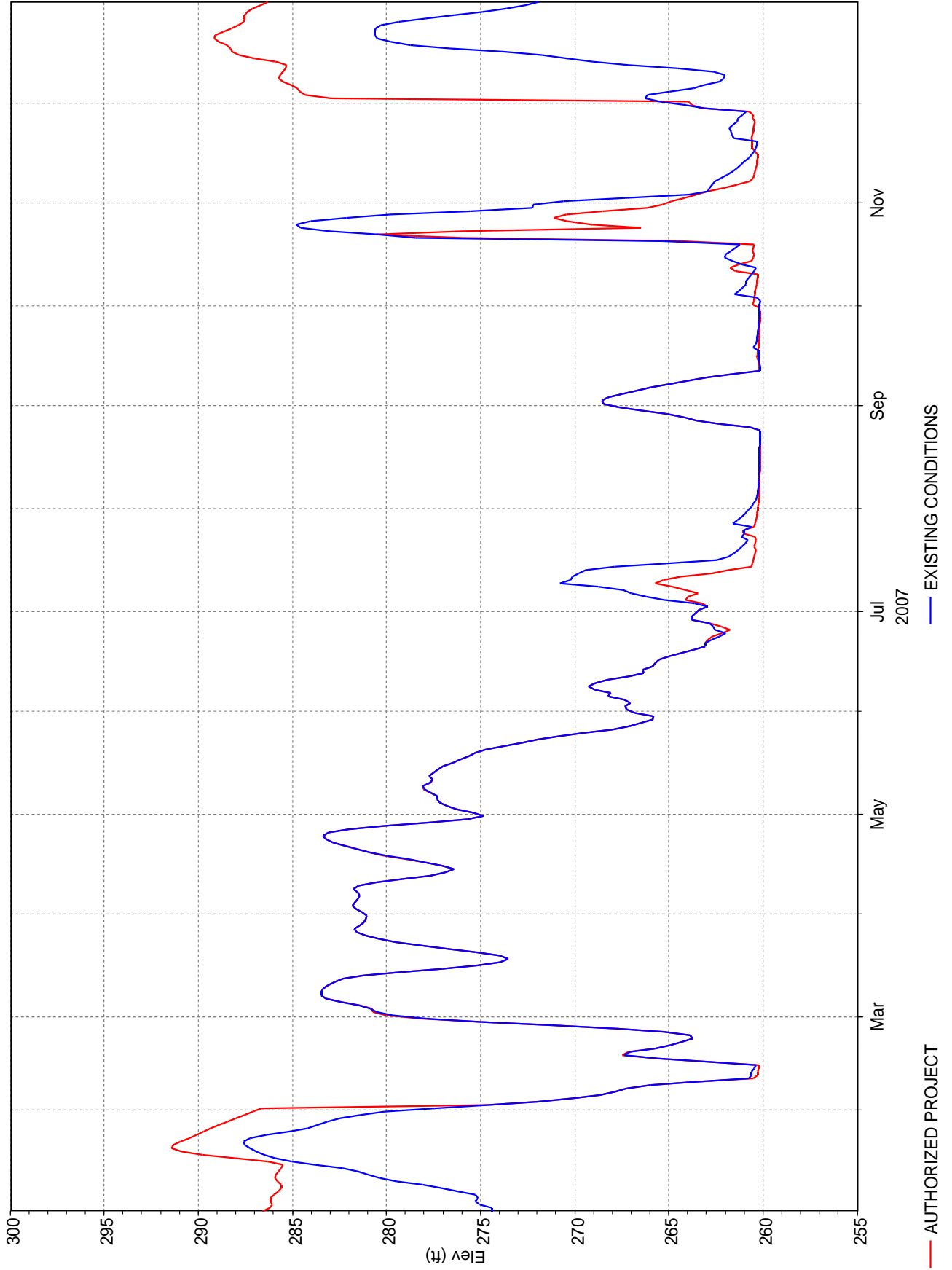
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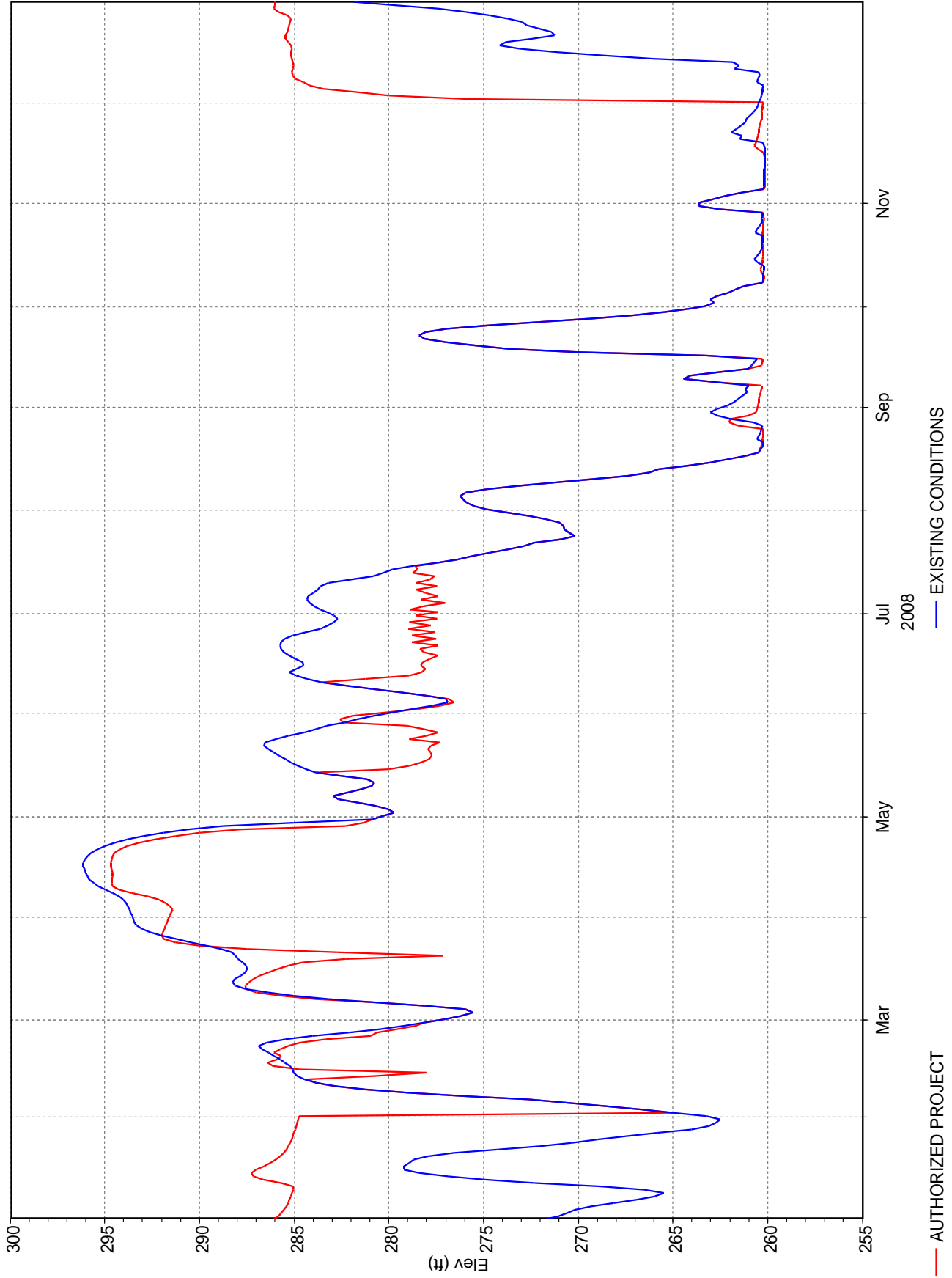
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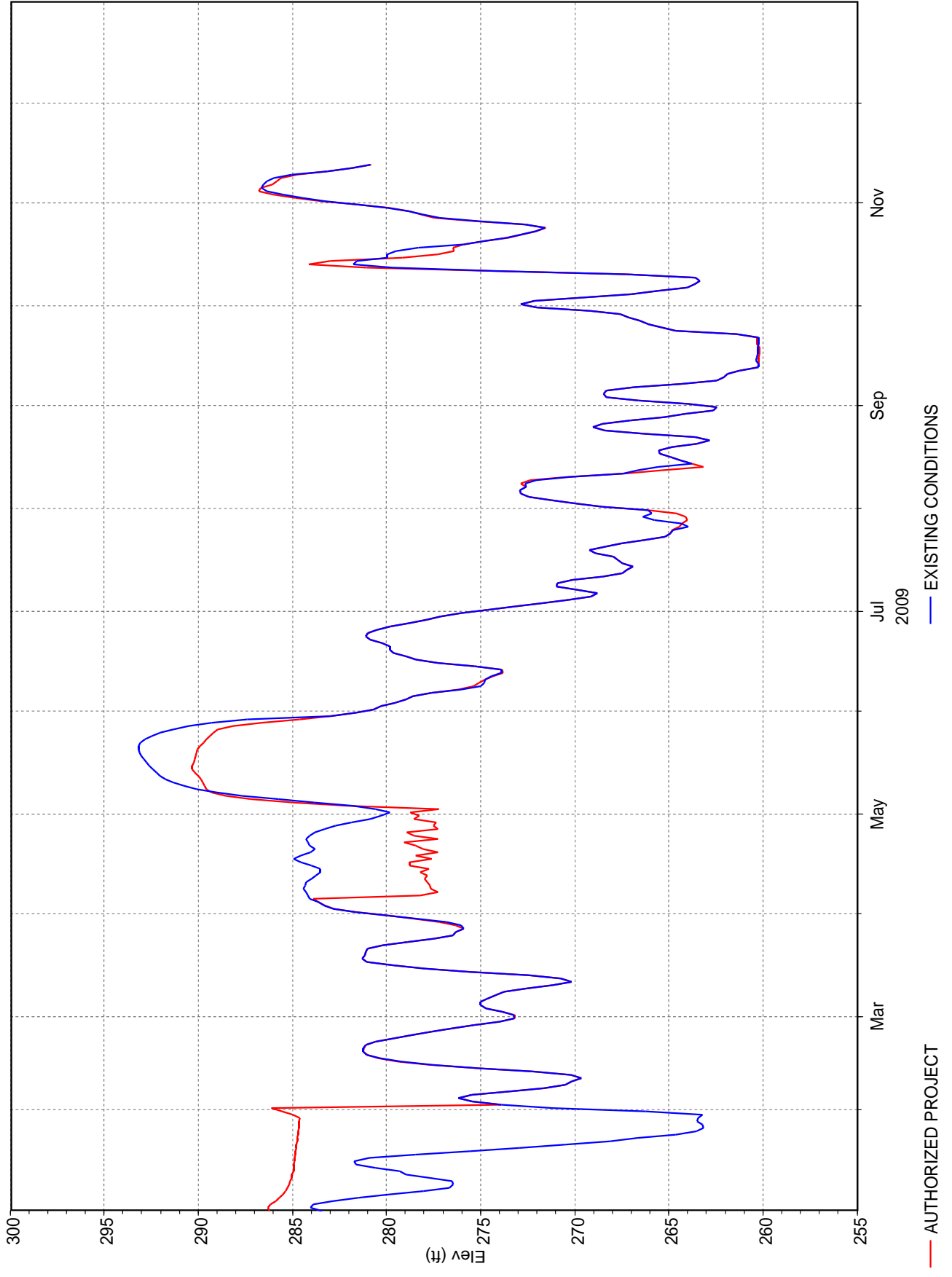
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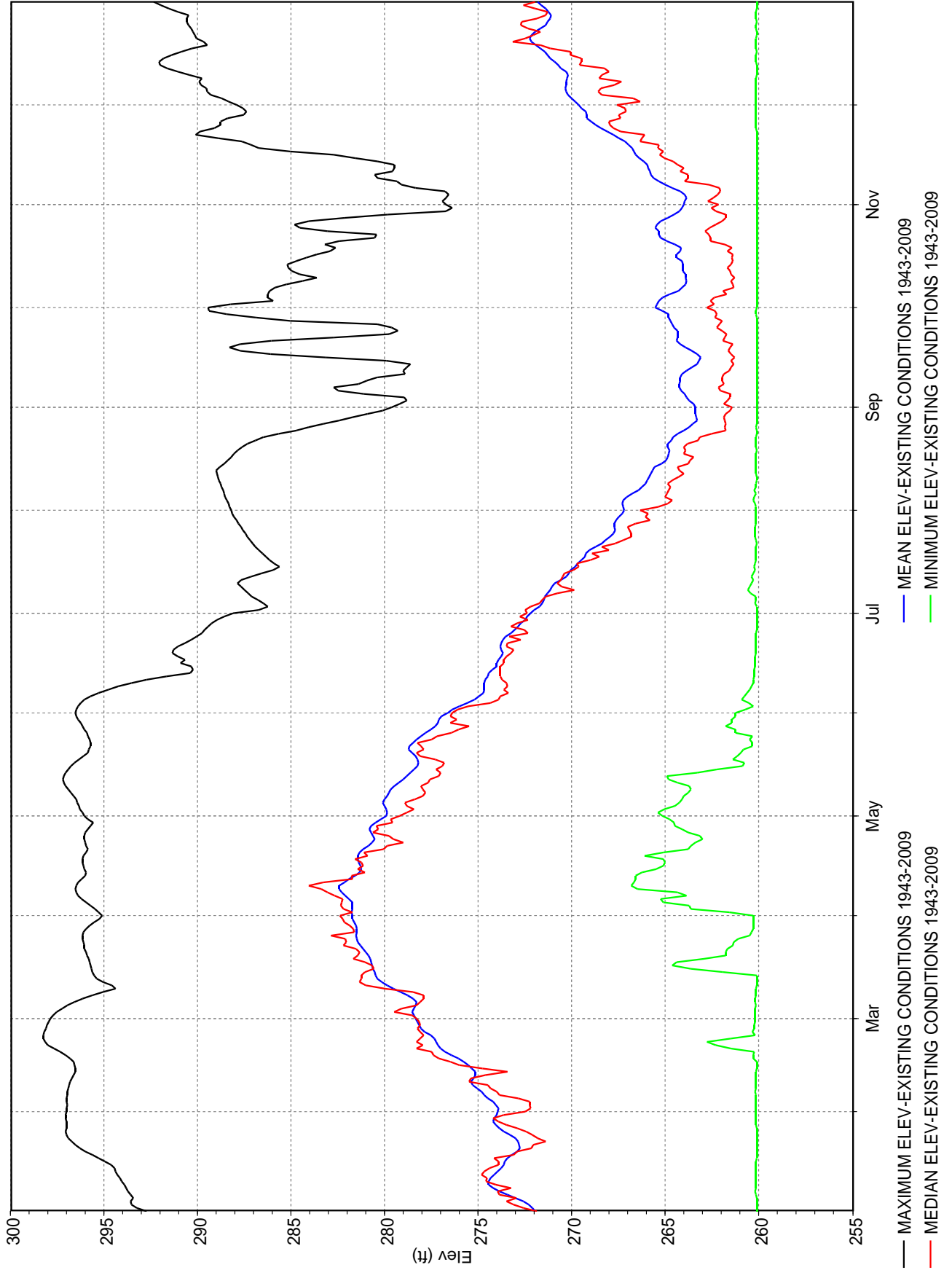


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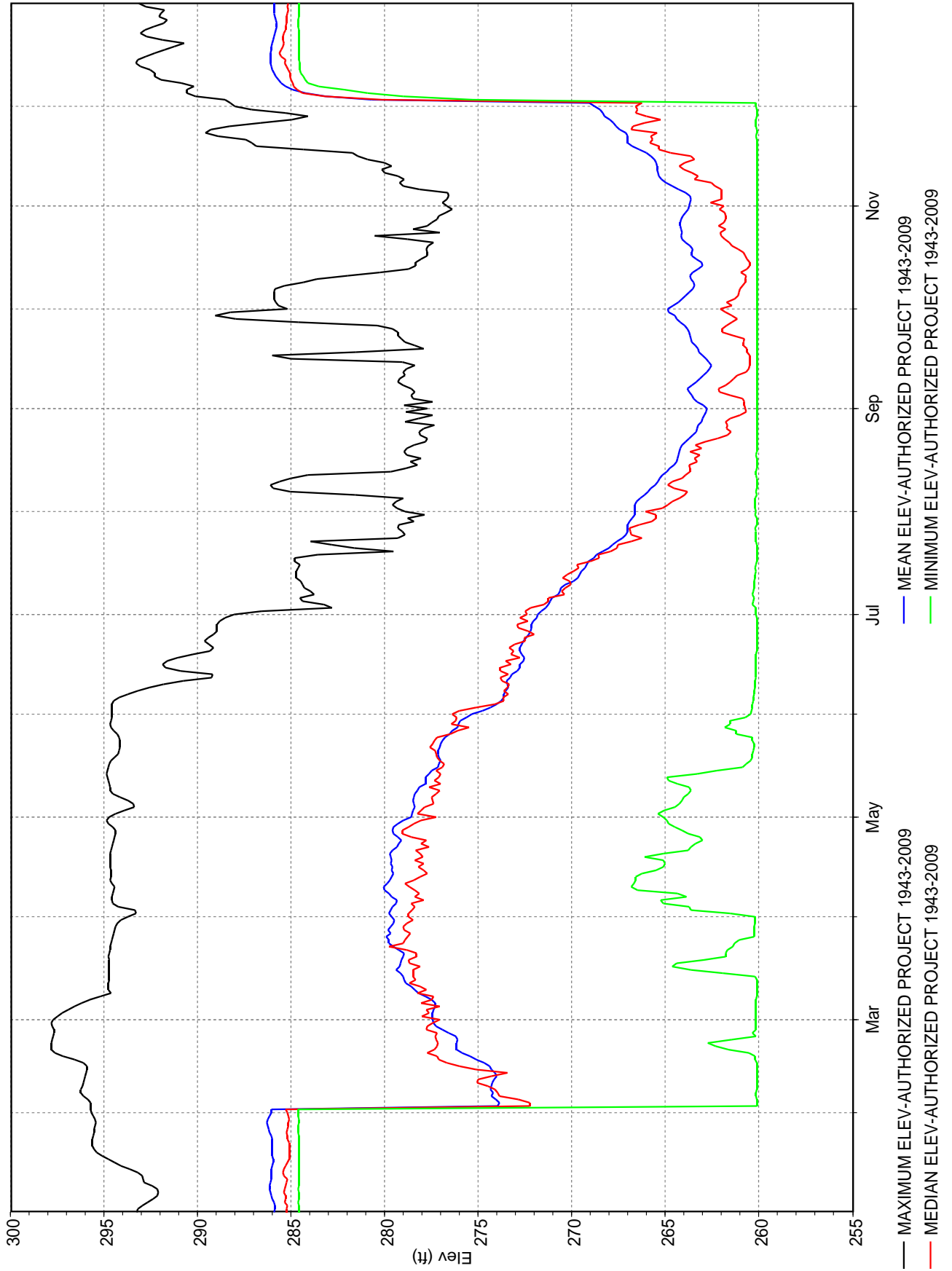


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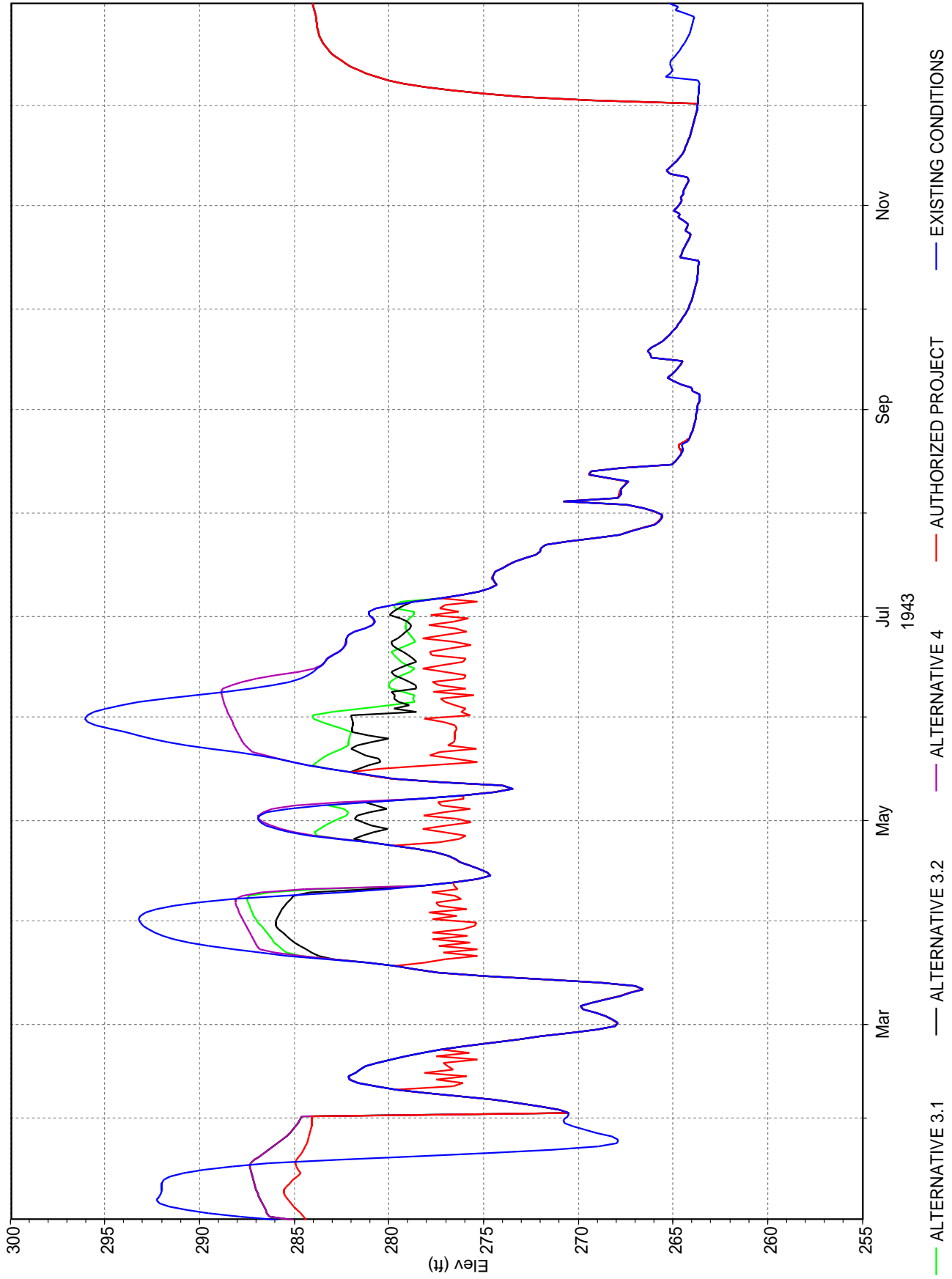
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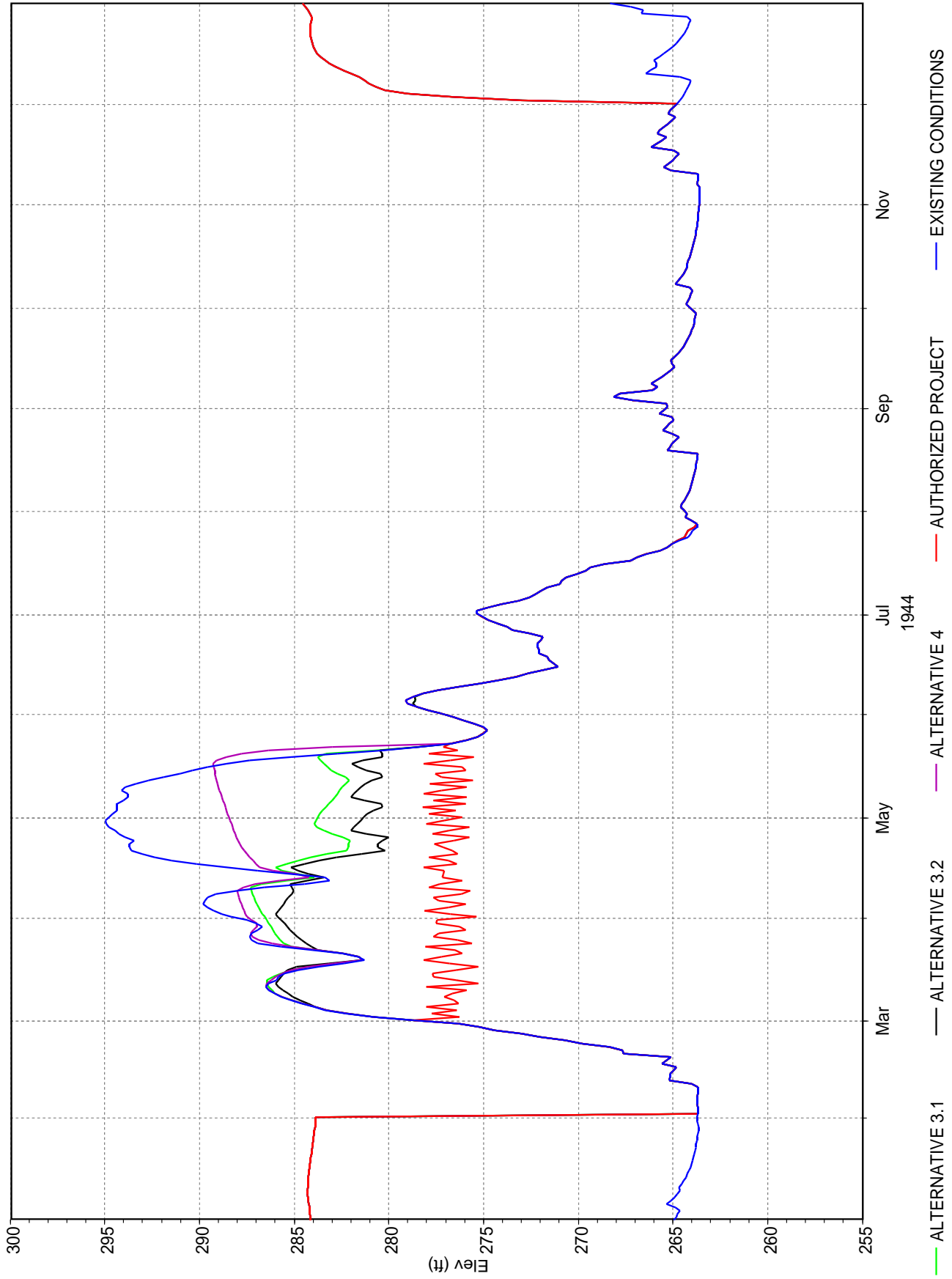
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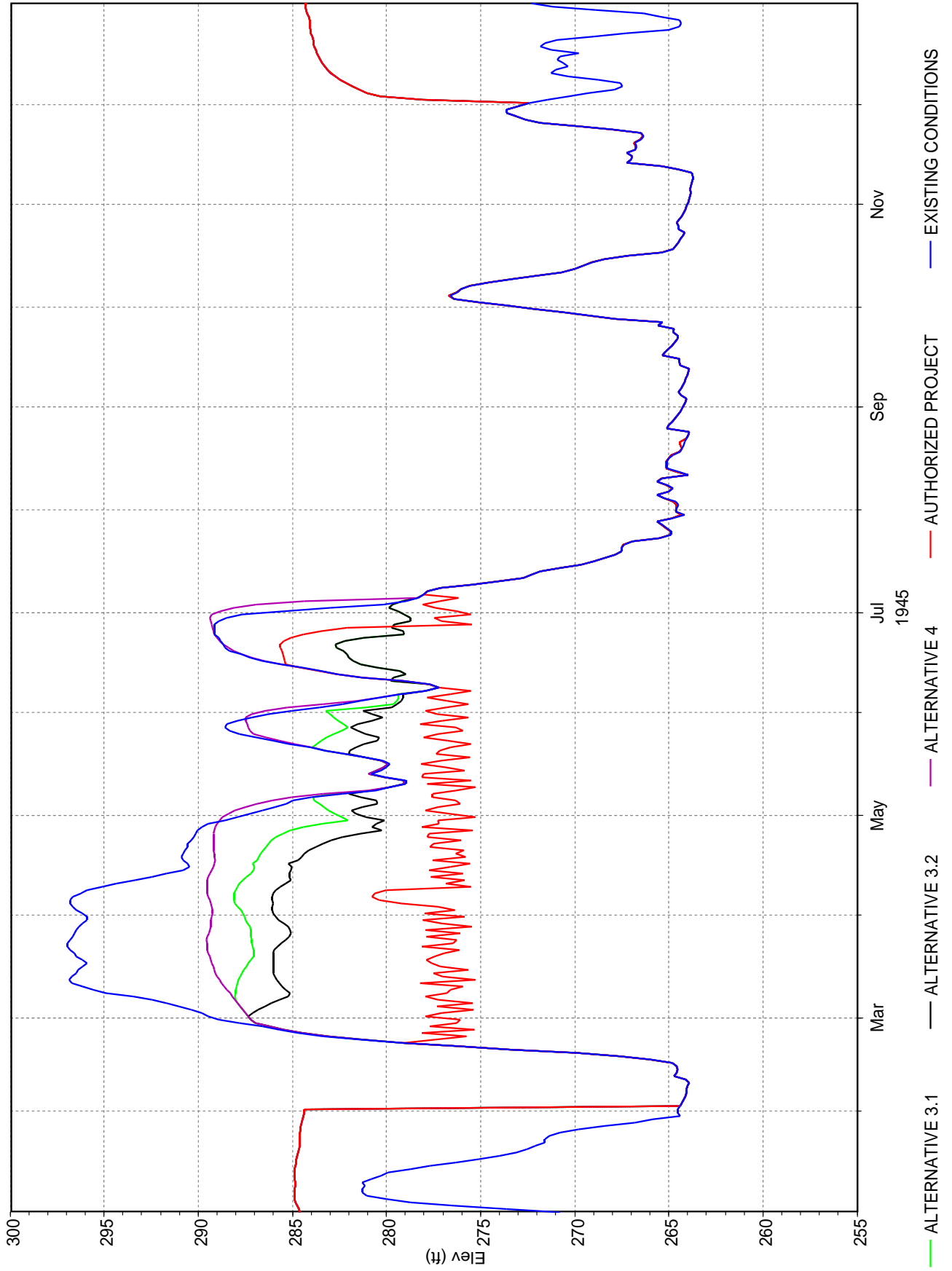
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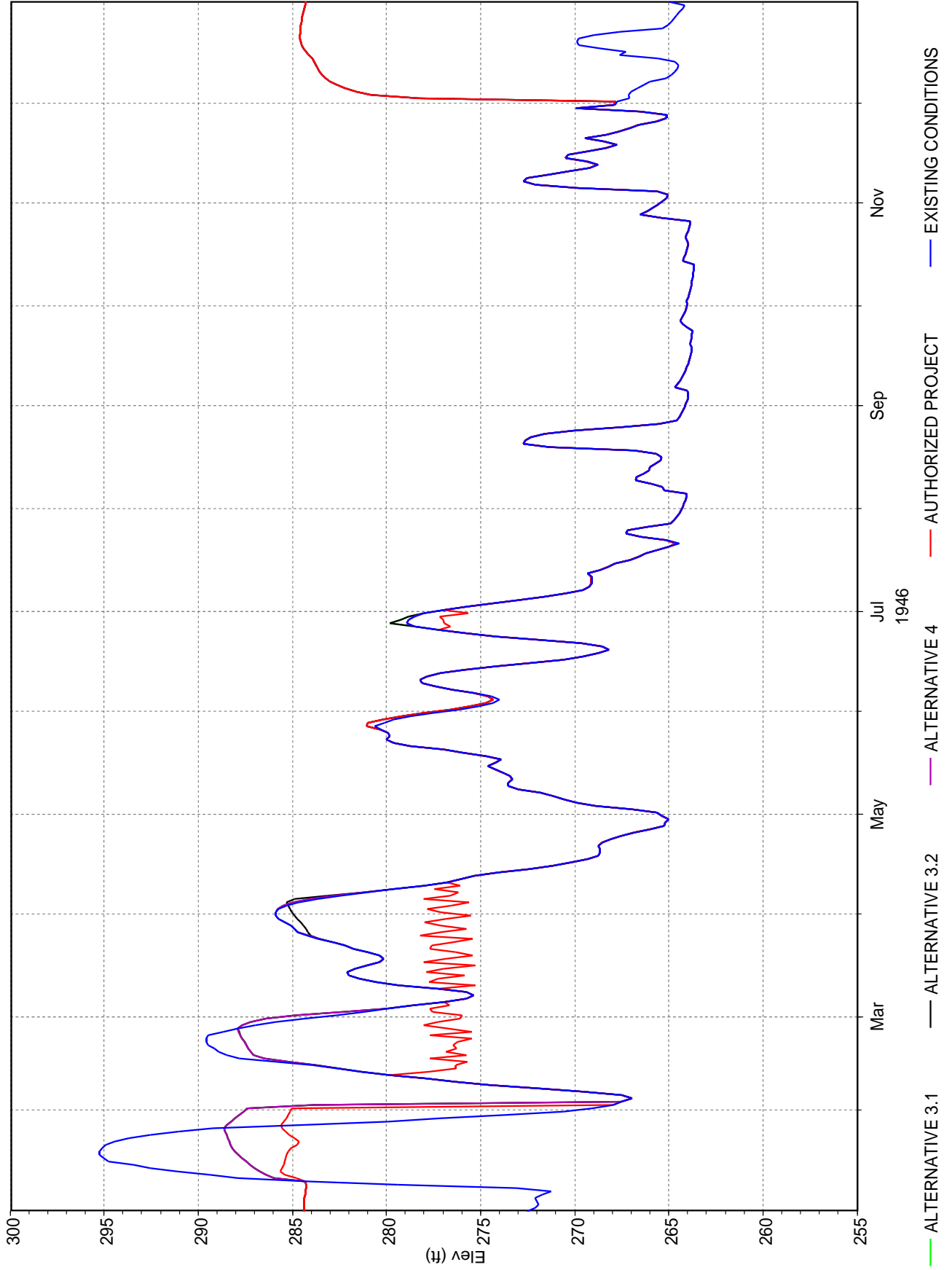
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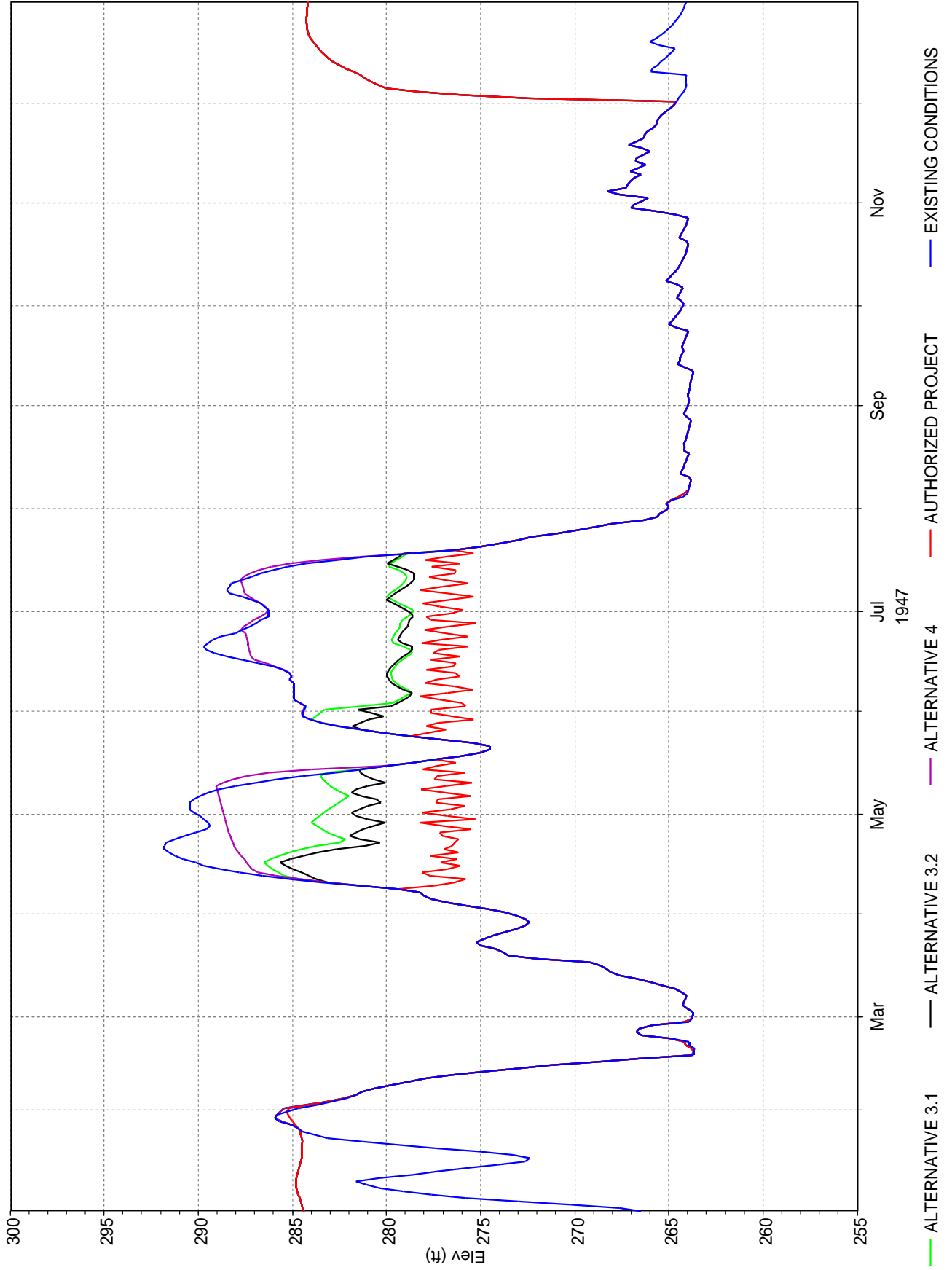
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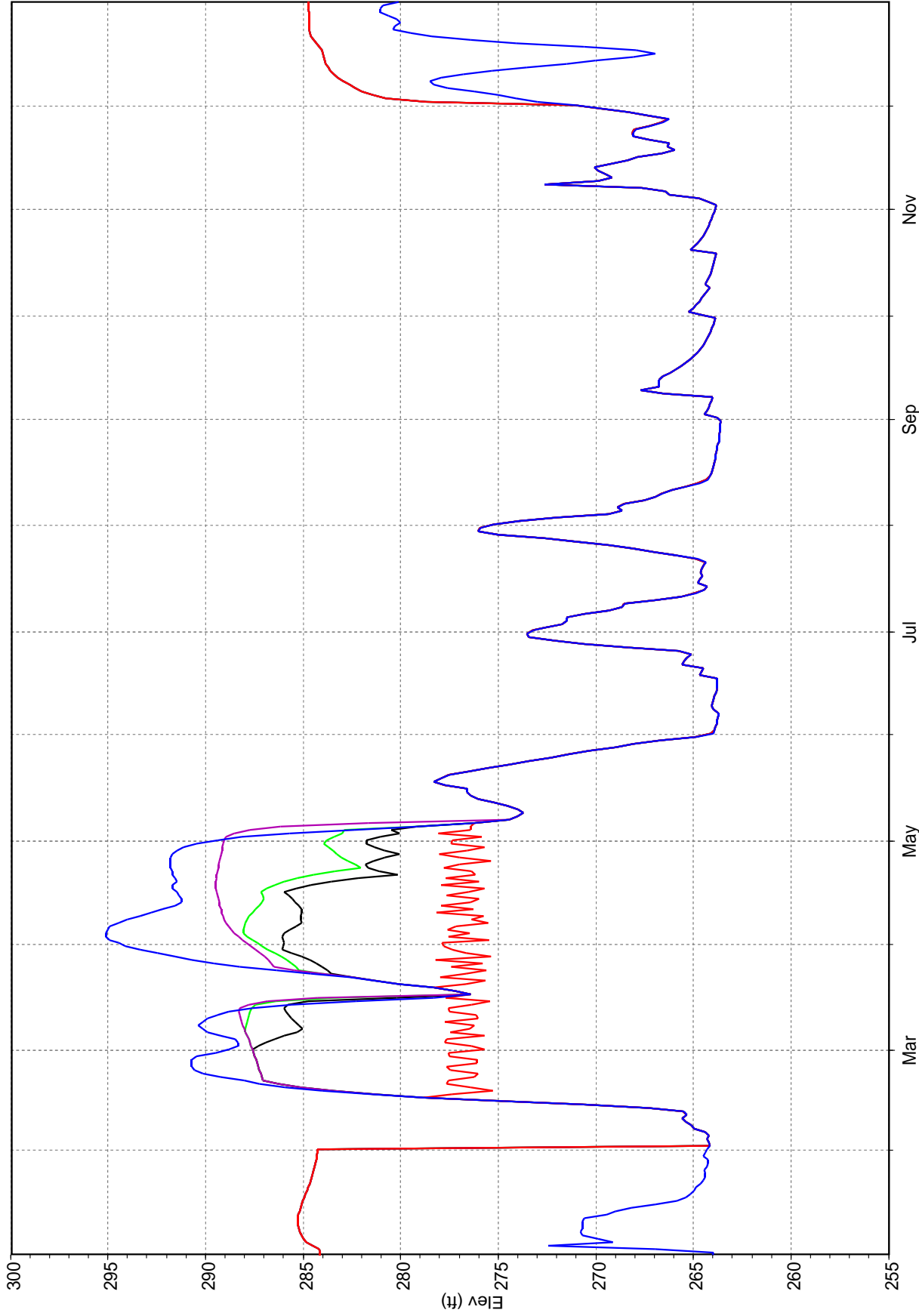
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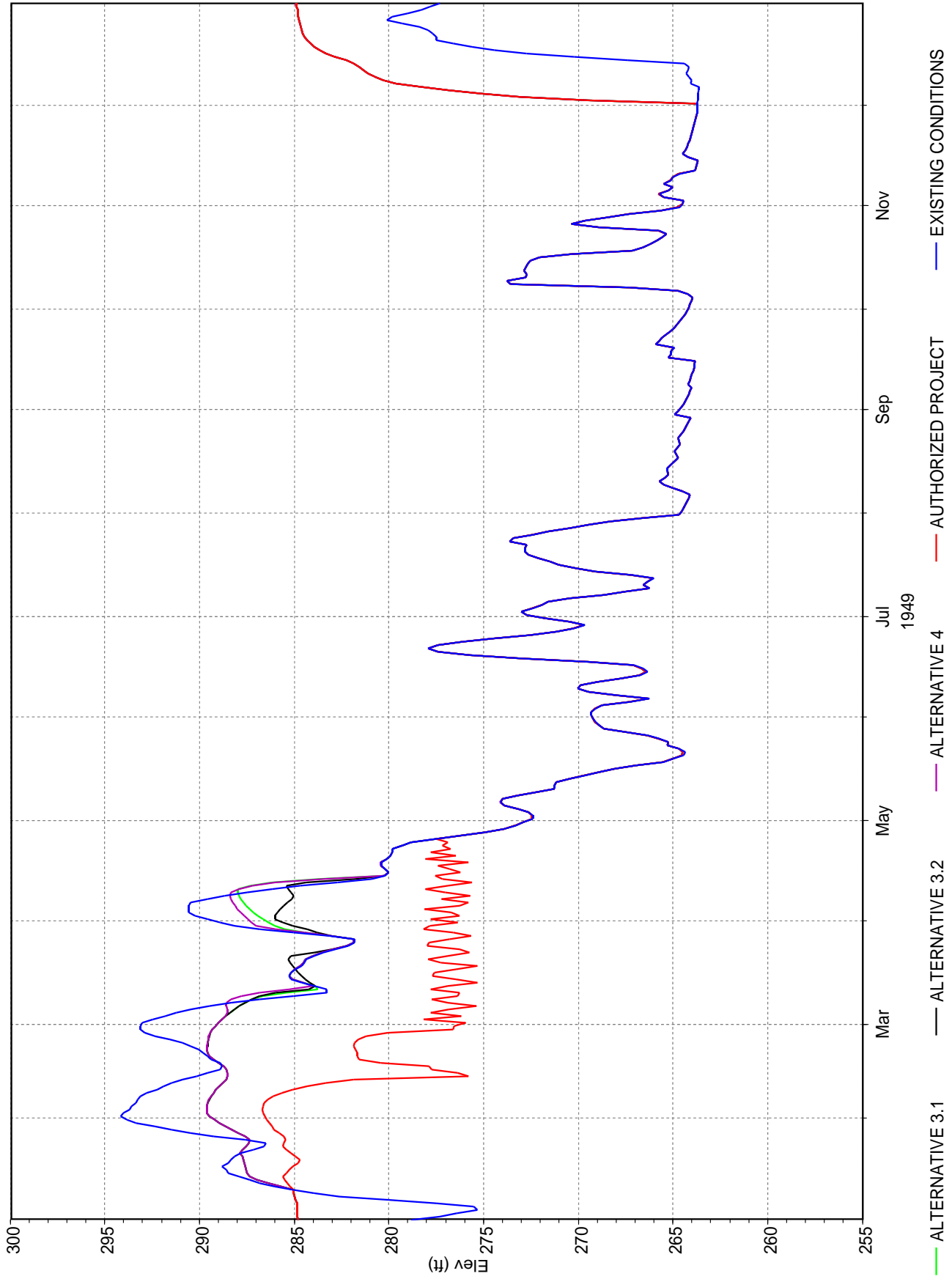


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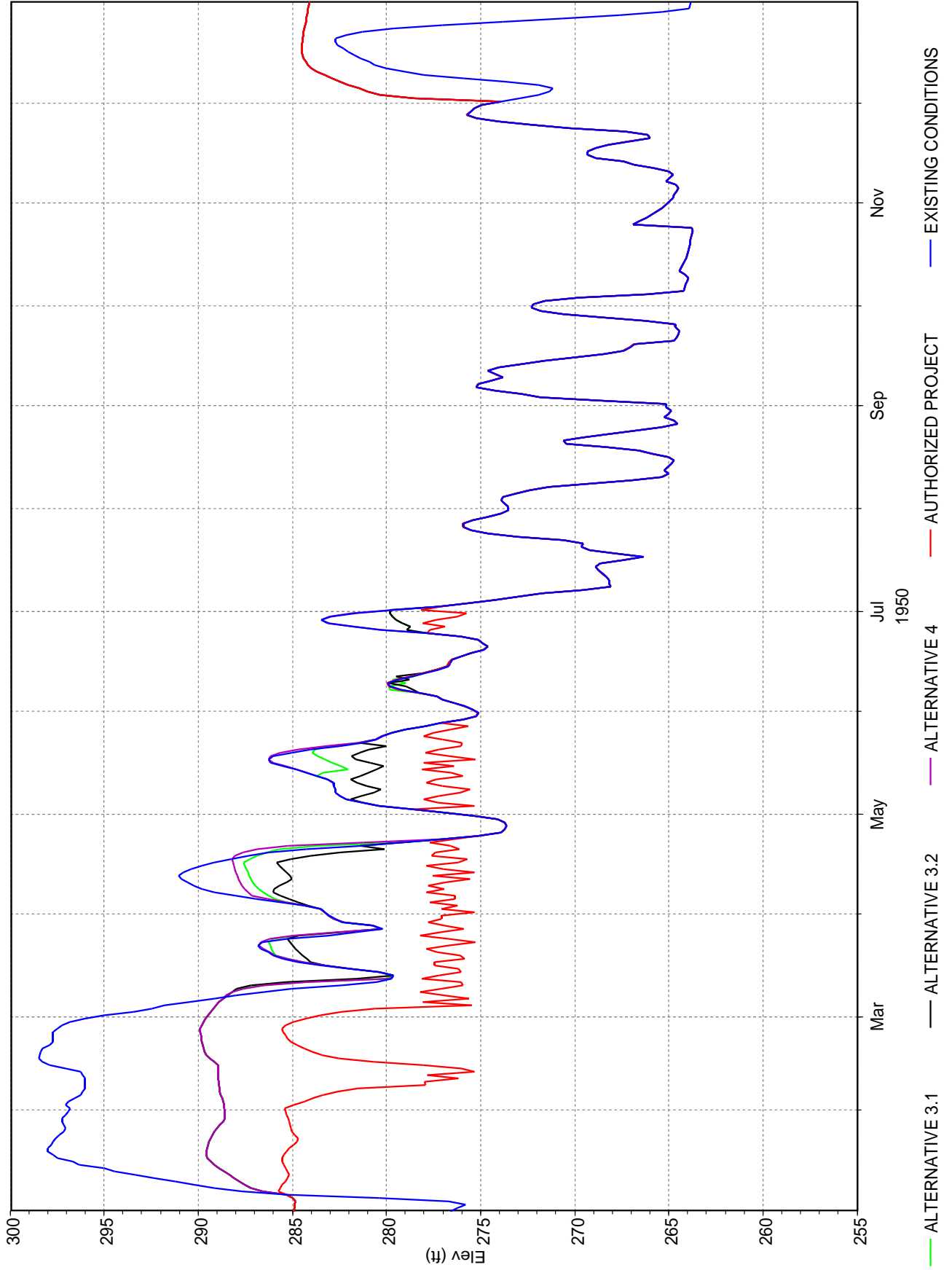
— ALTERNATIVE 3.1 — ALTERNATIVE 3.2 — ALTERNATIVE 4 — AUTHORIZED PROJECT — EXISTING CONDITIONS

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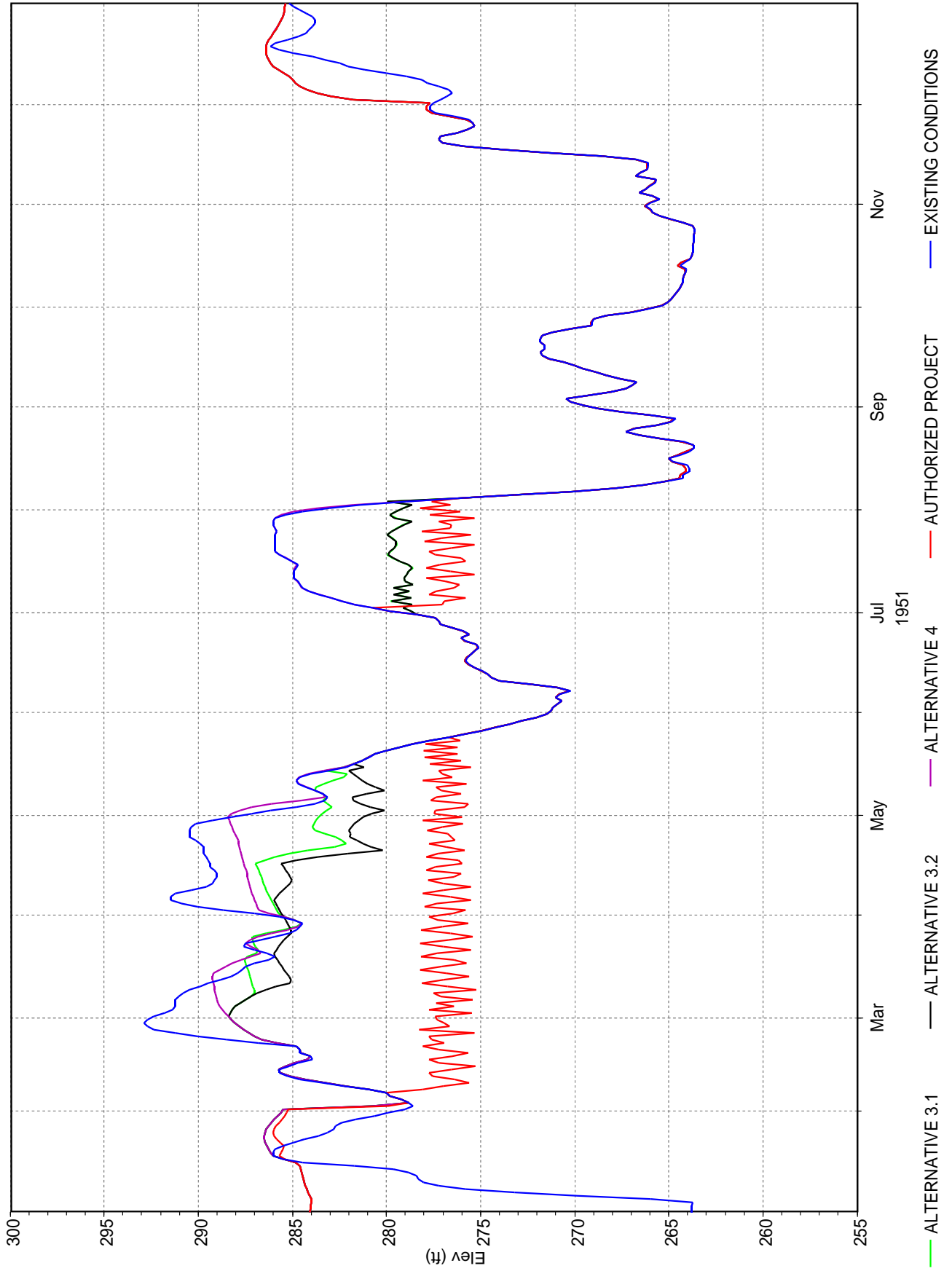


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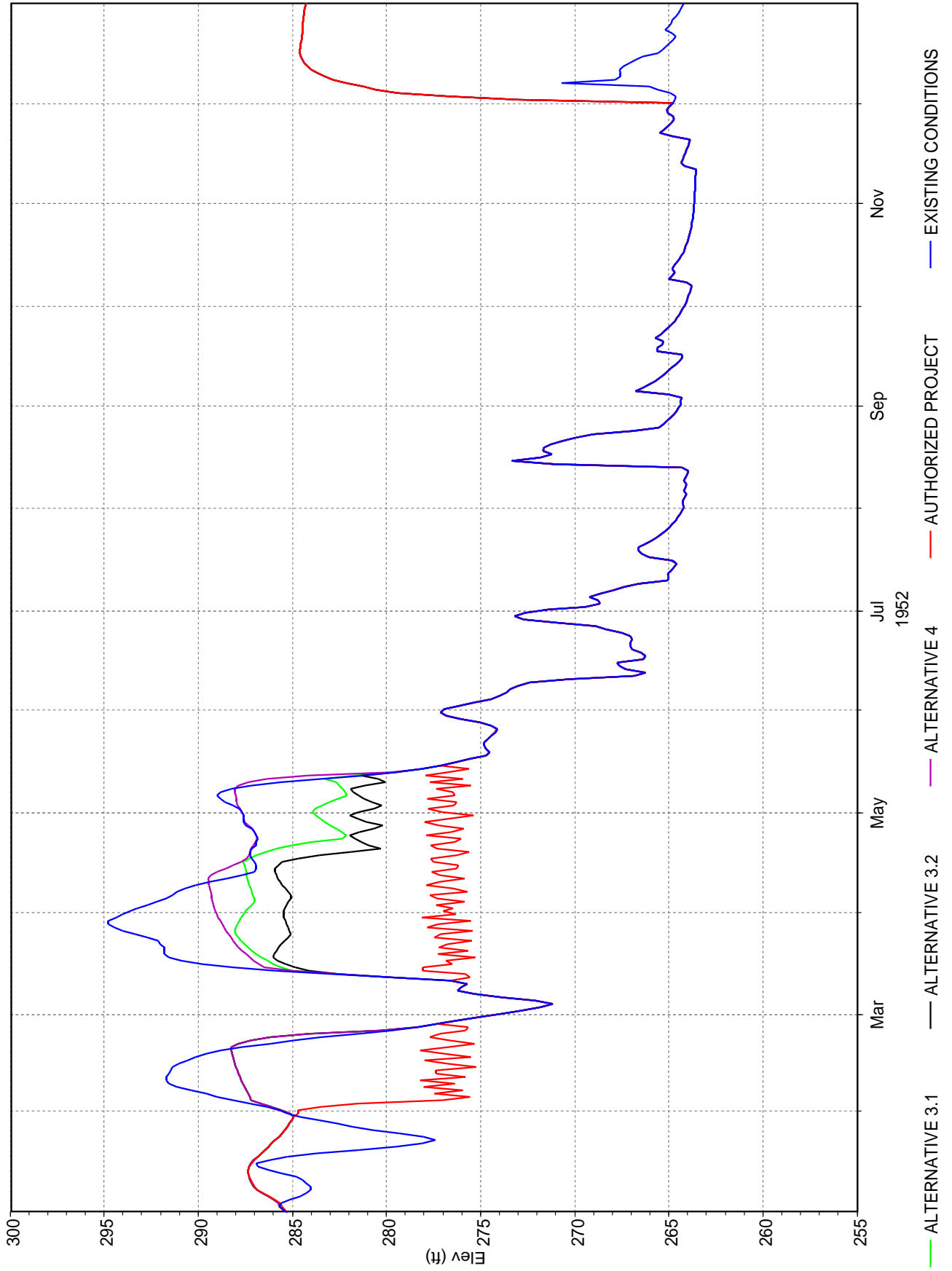
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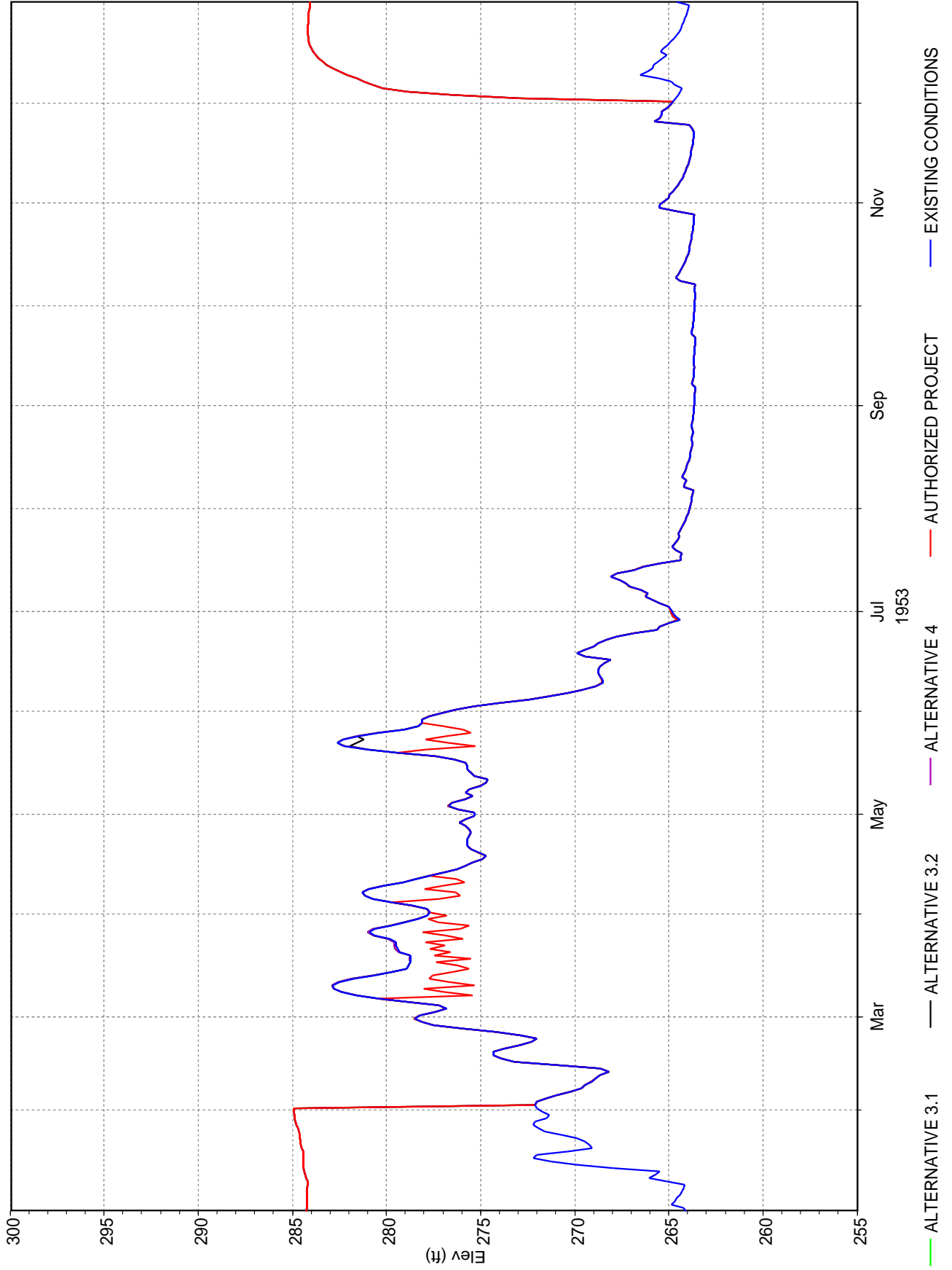
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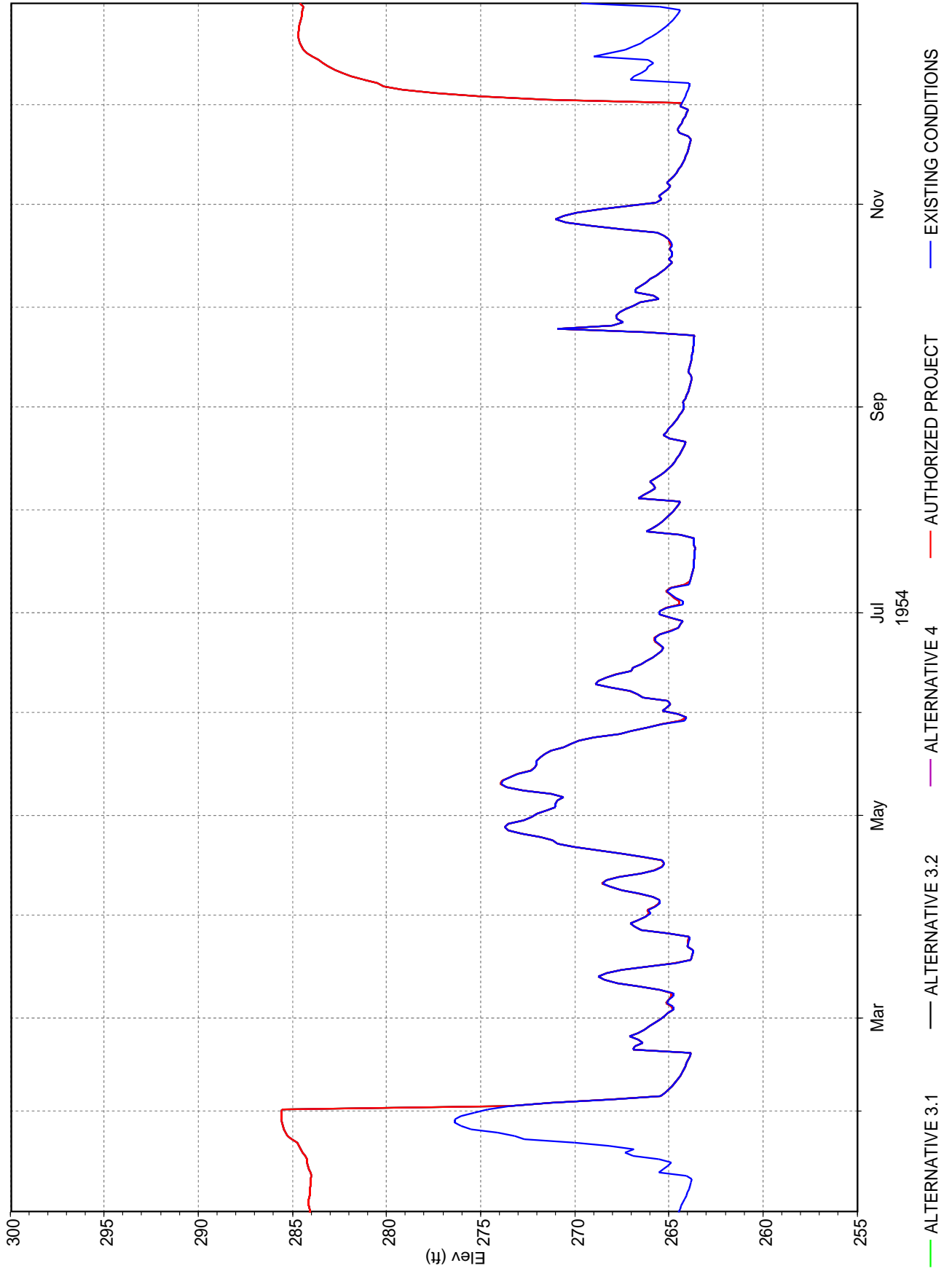
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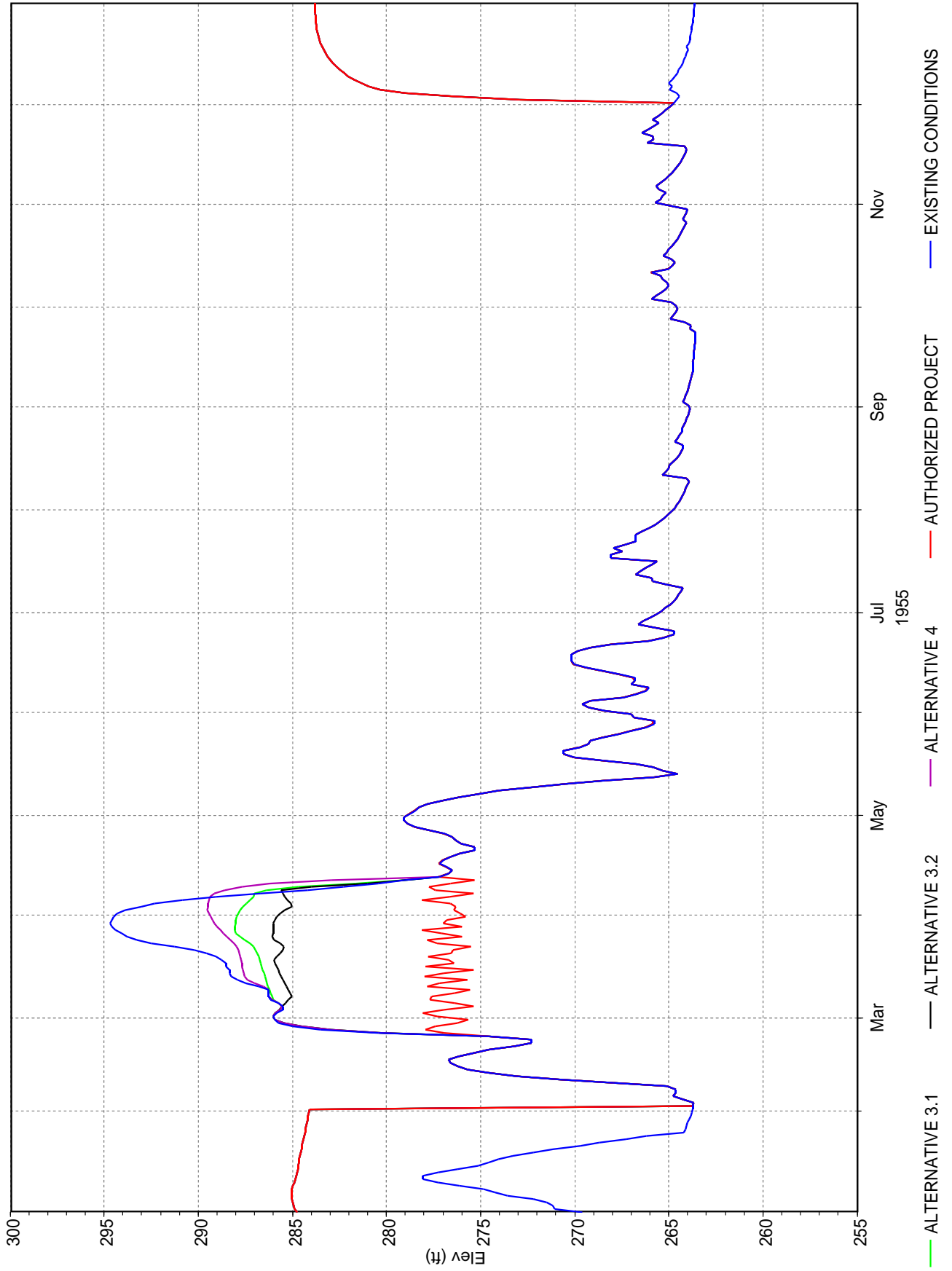
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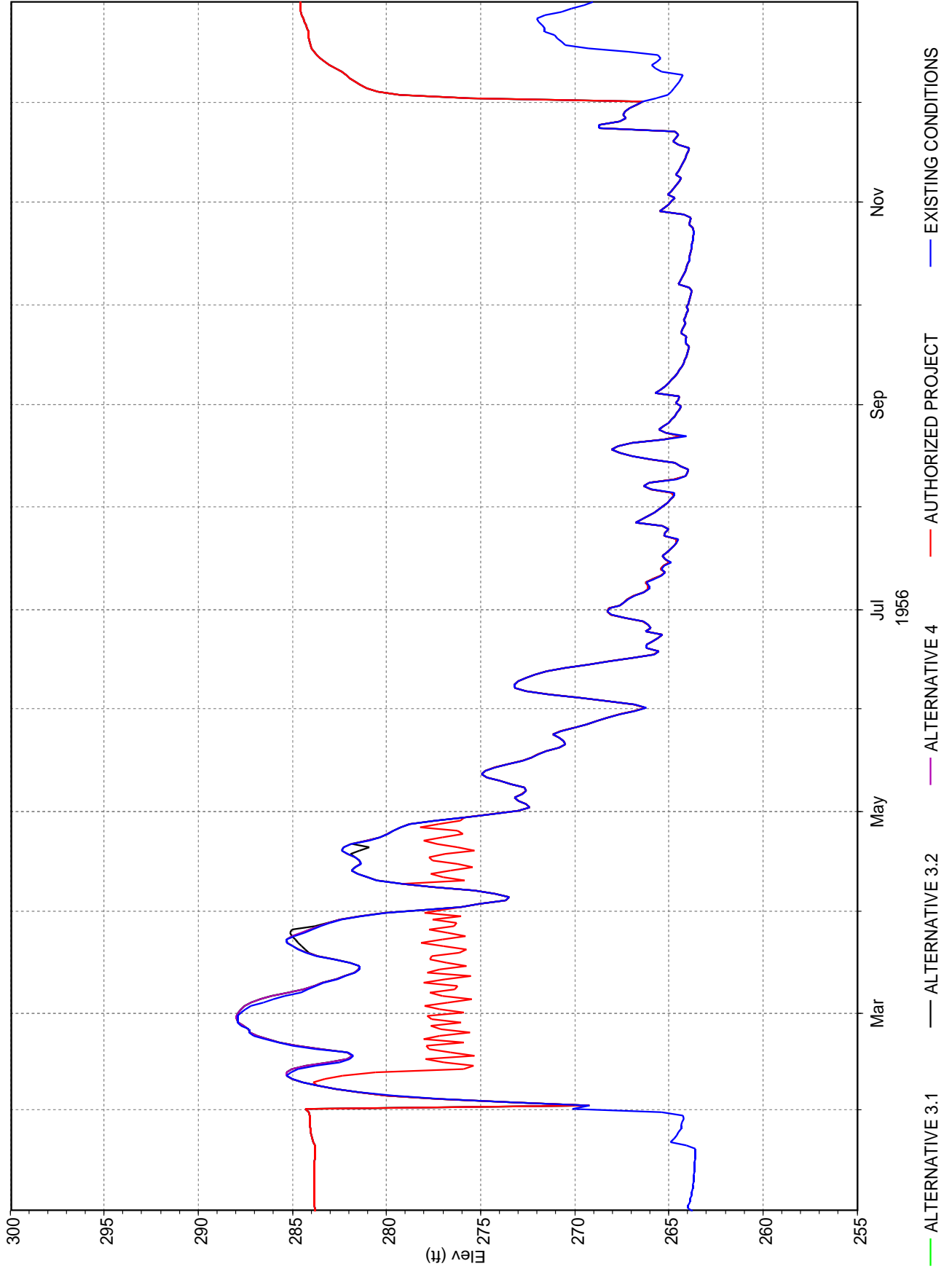
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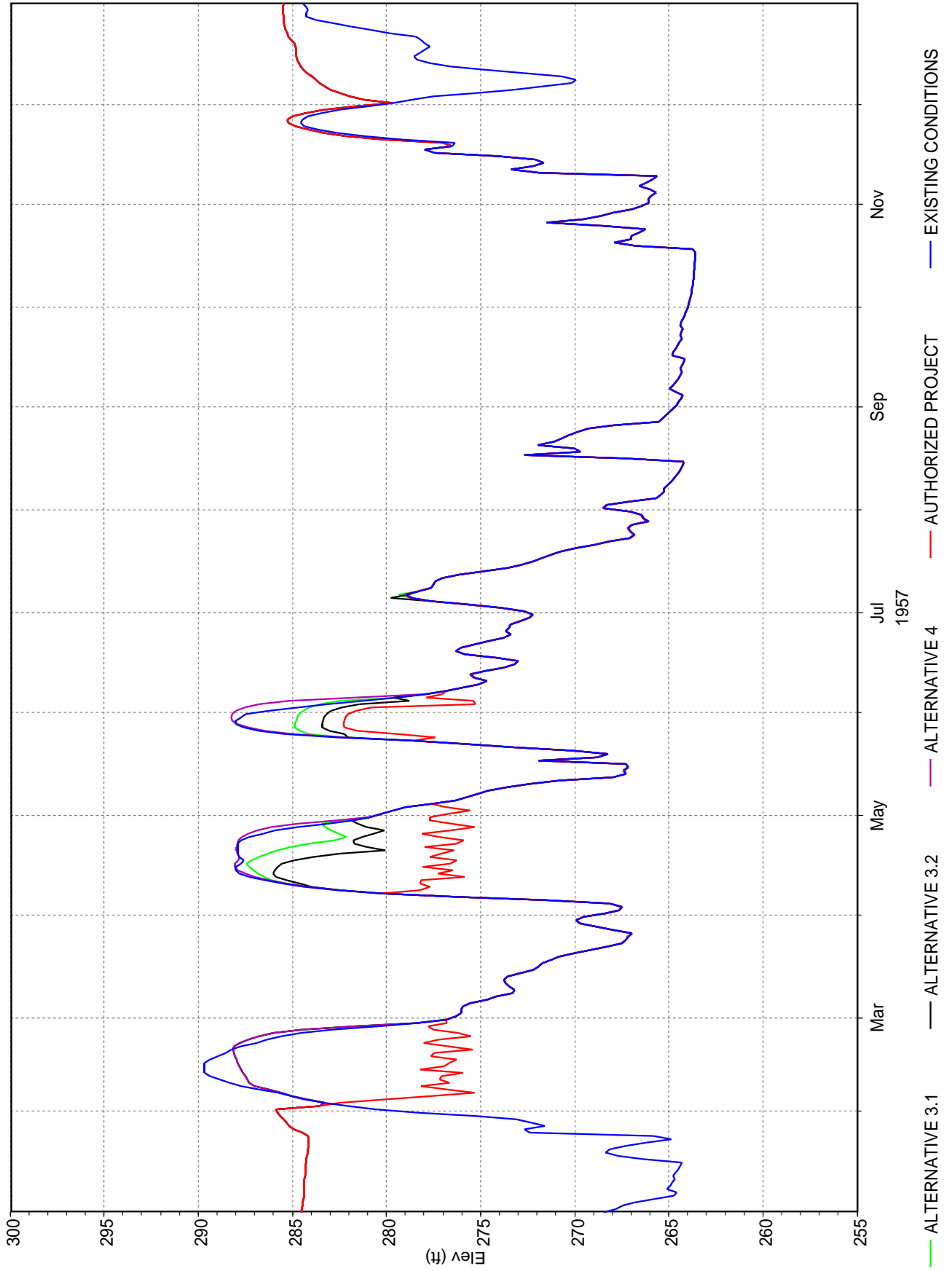
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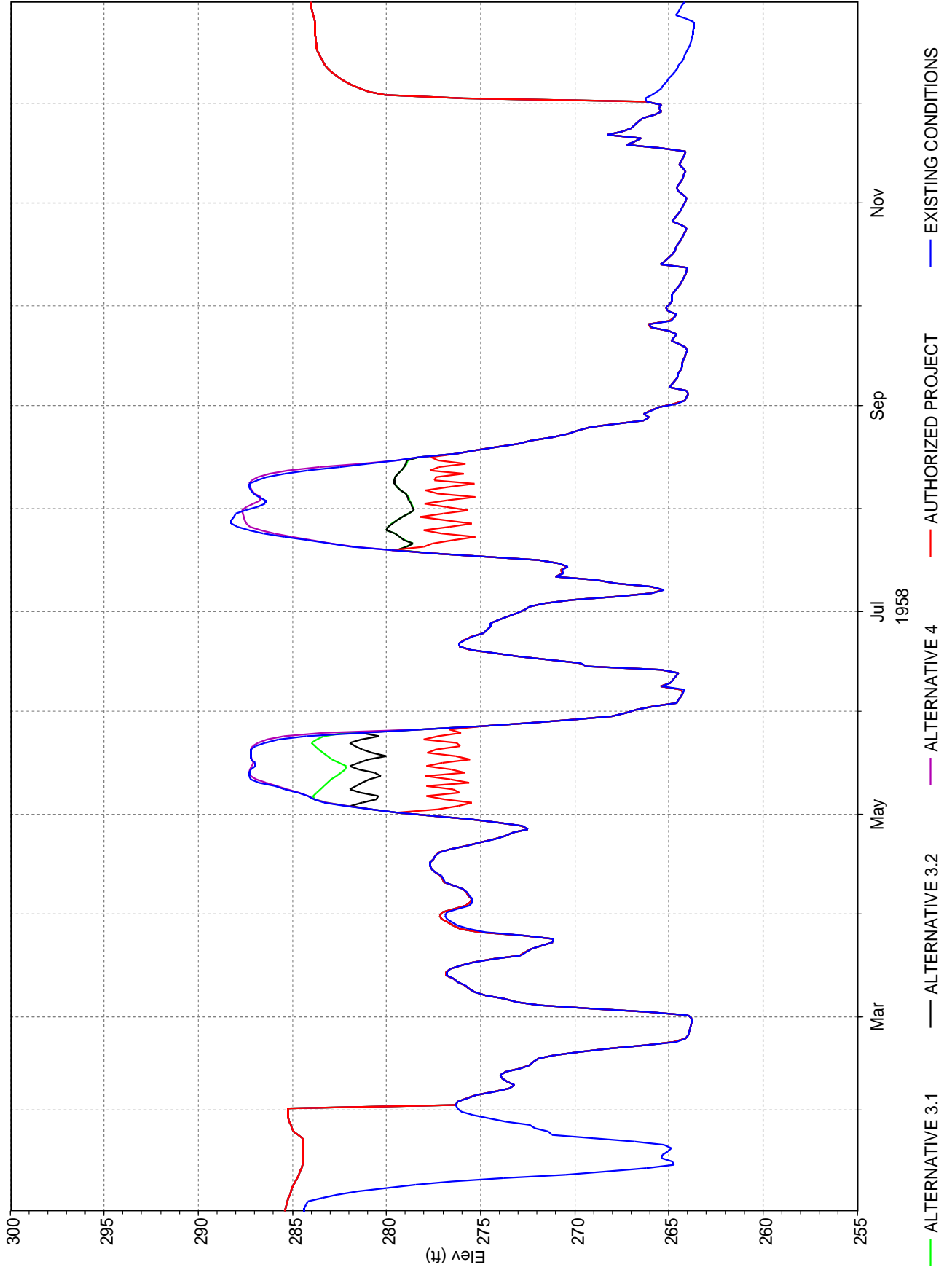
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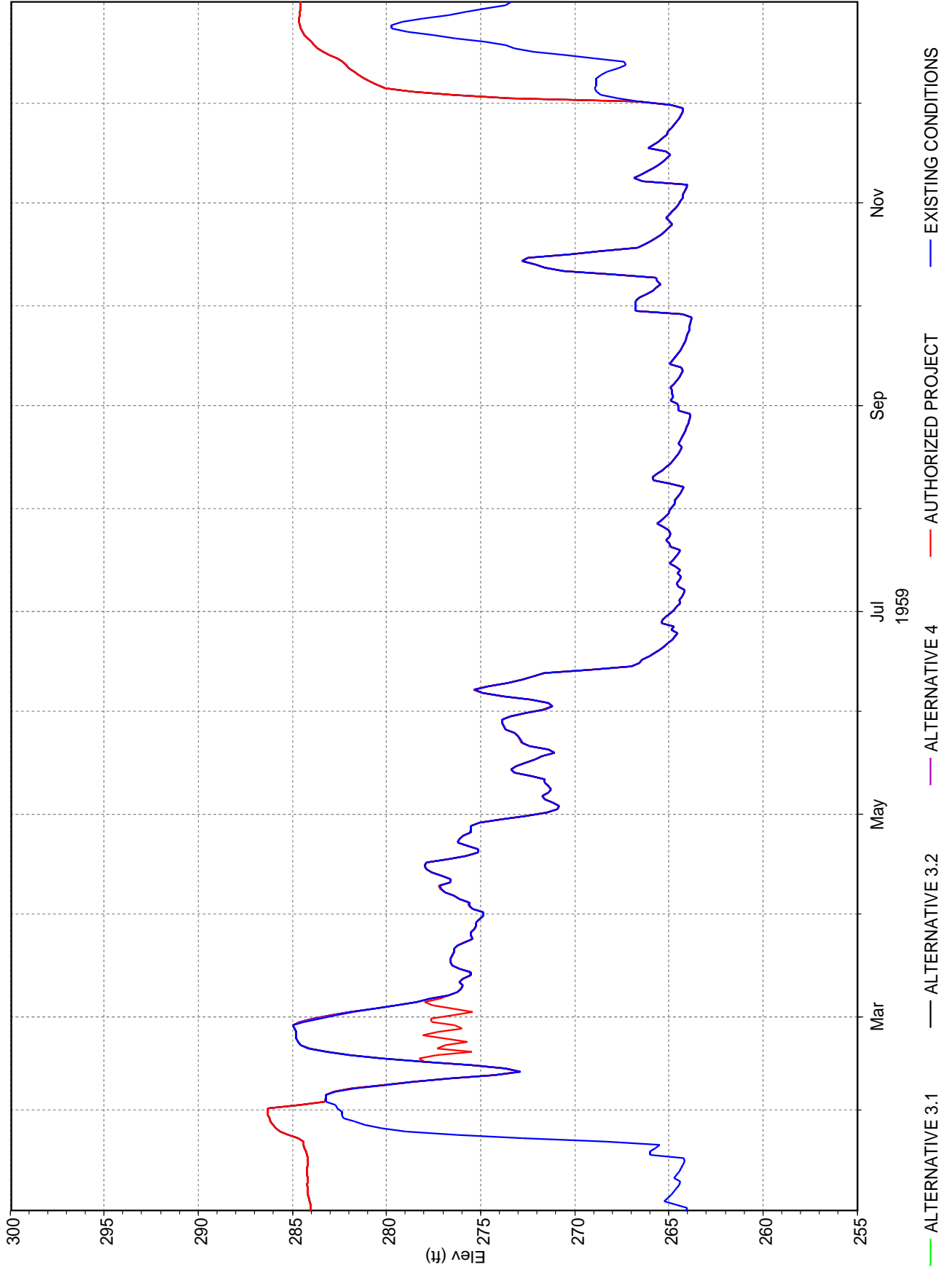
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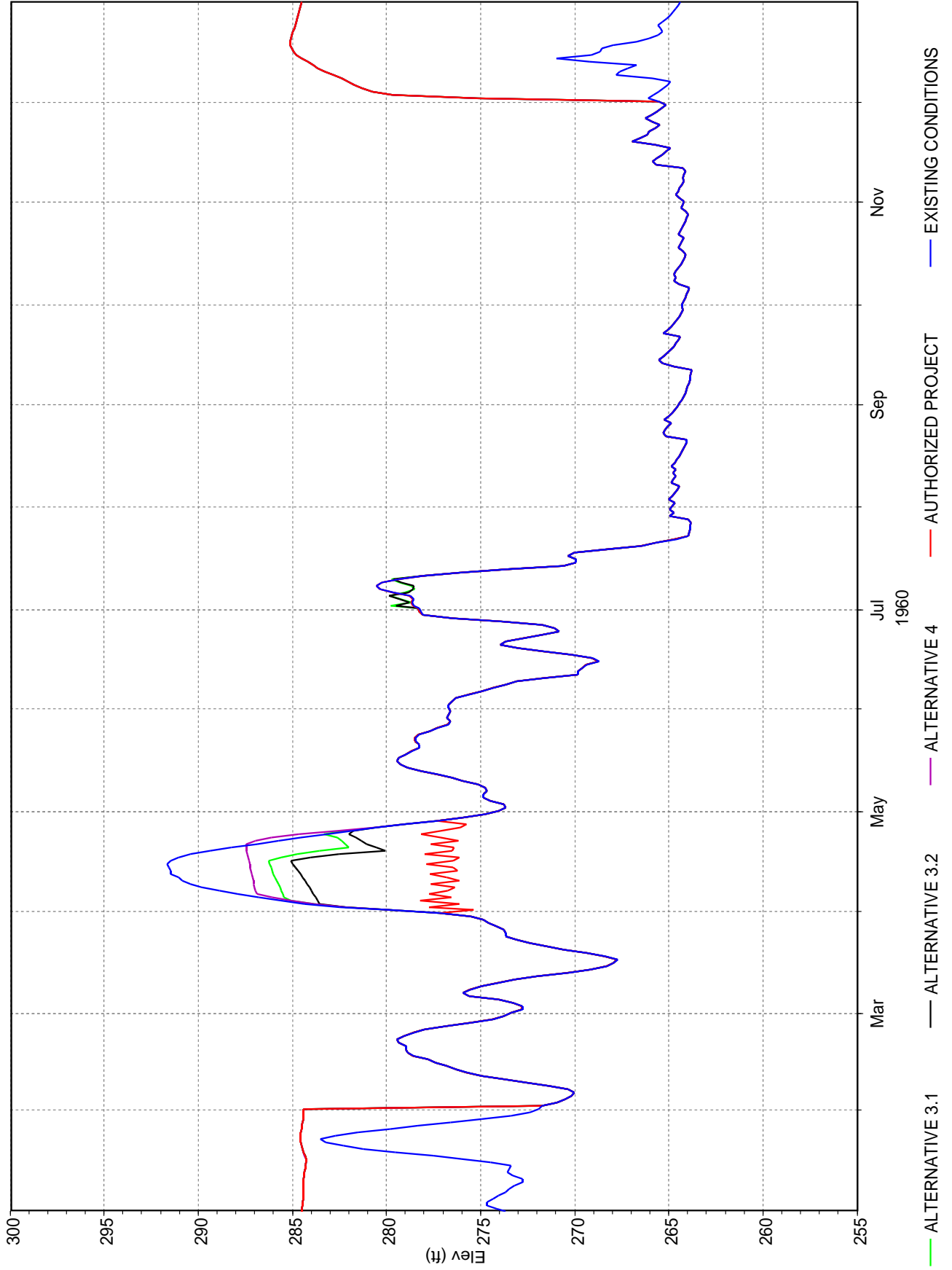
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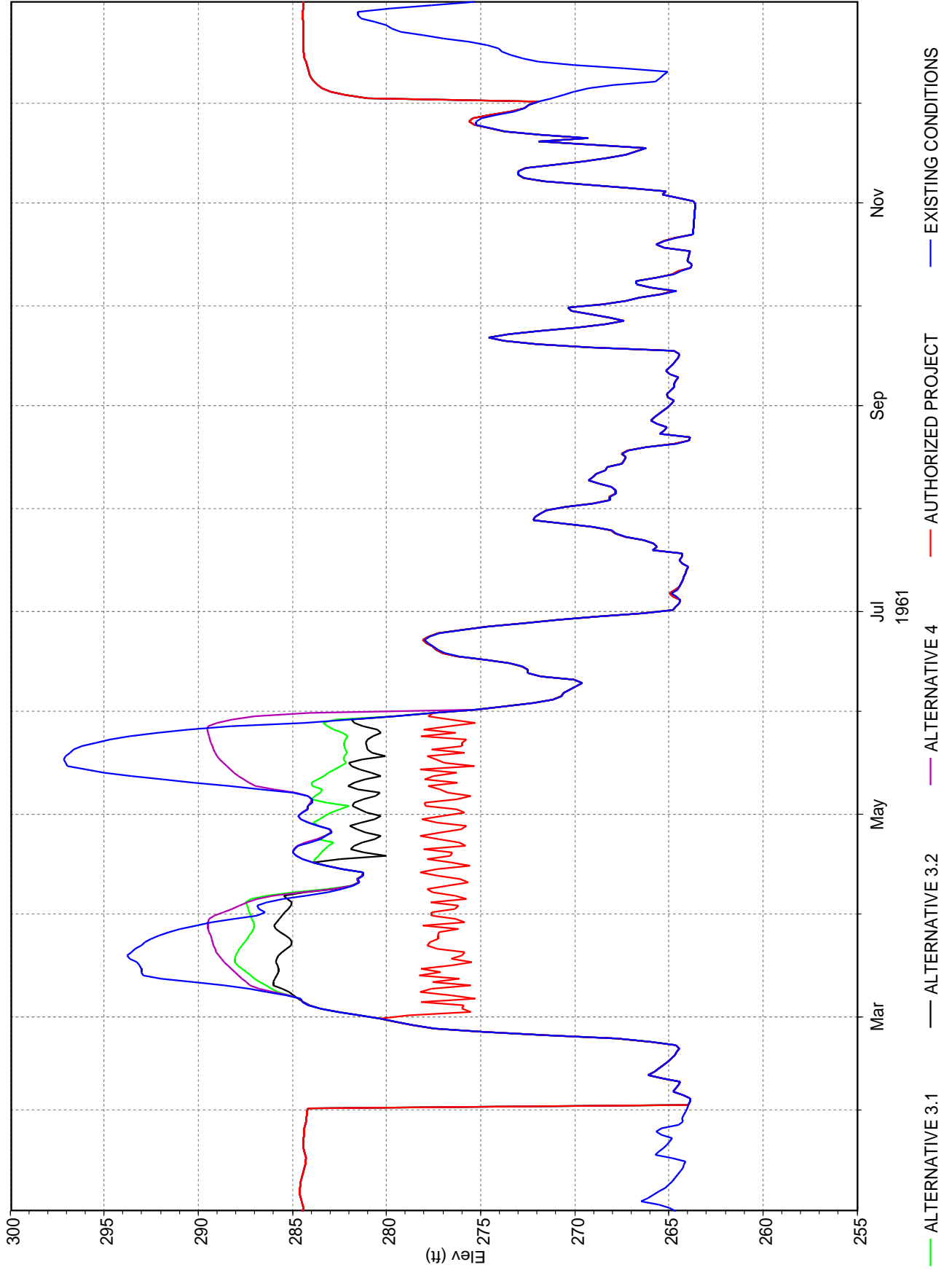
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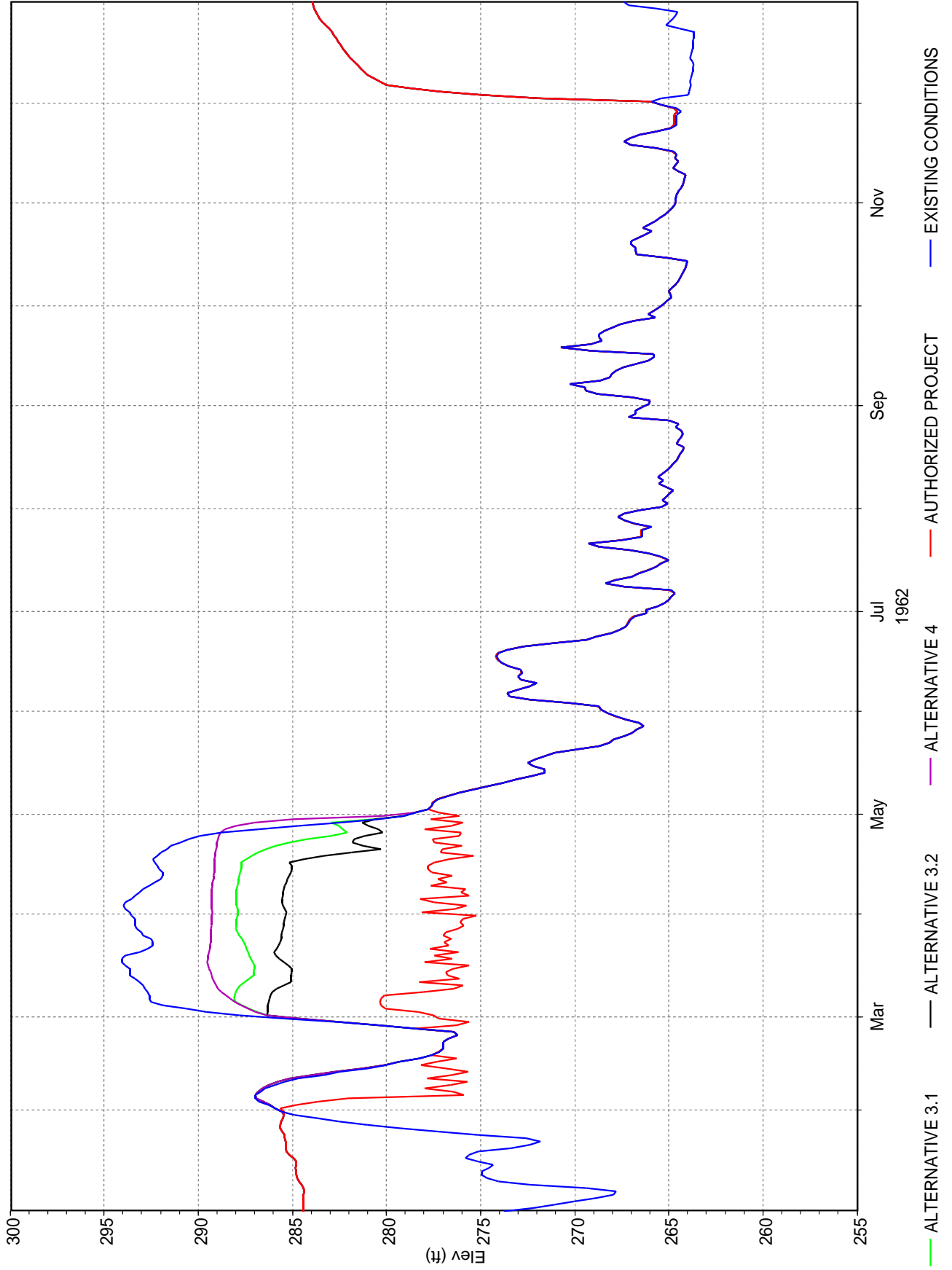
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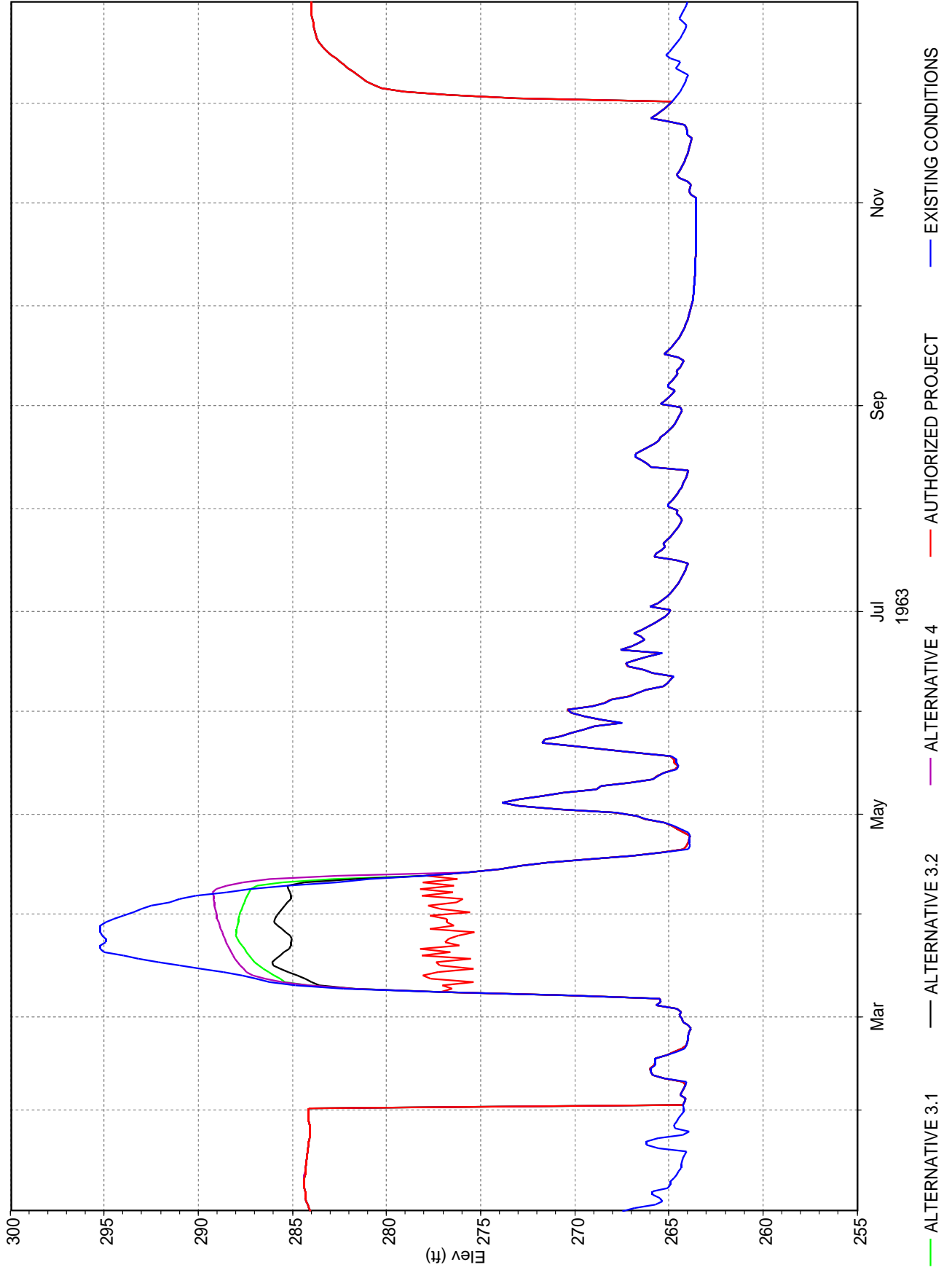
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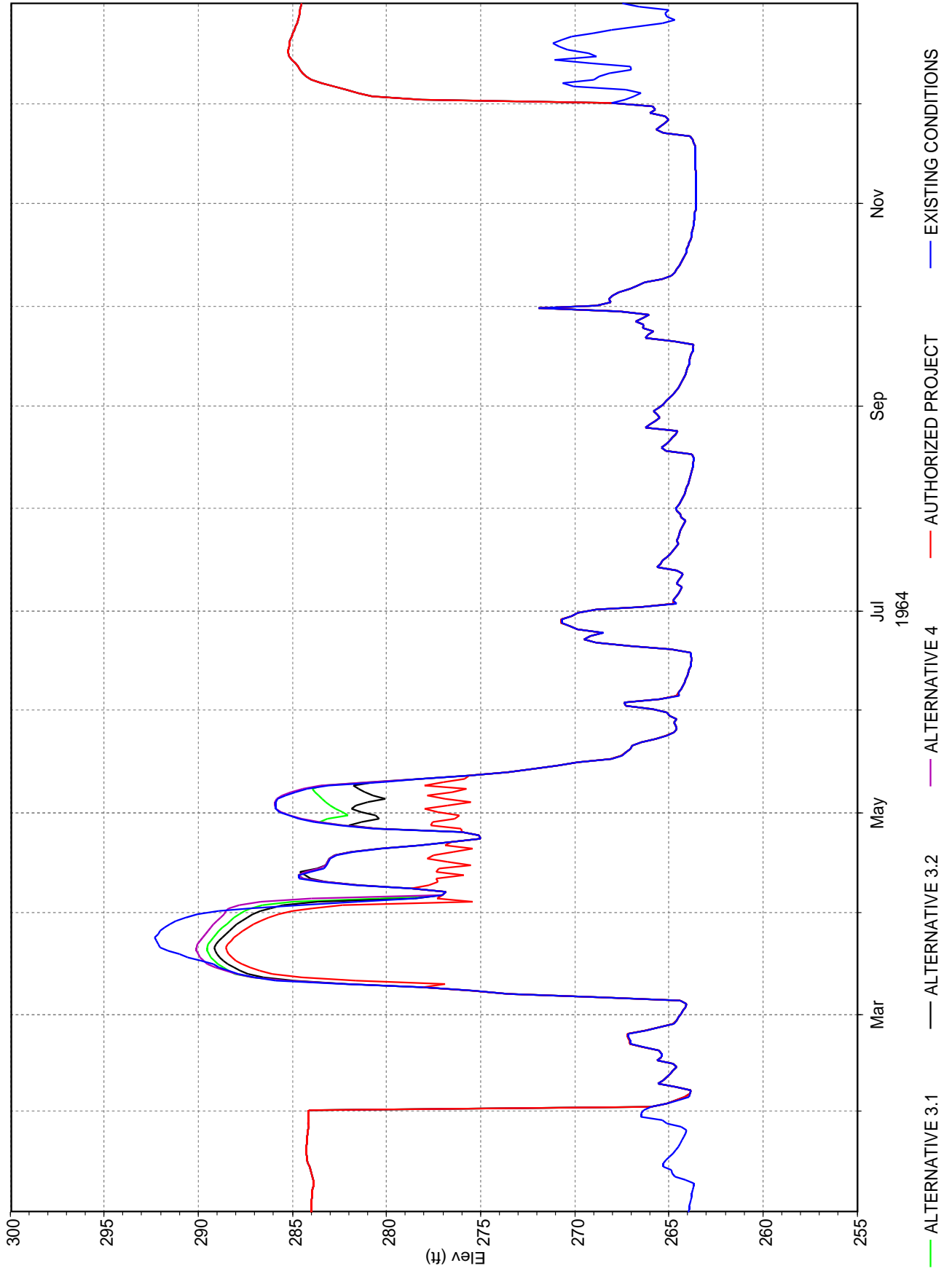
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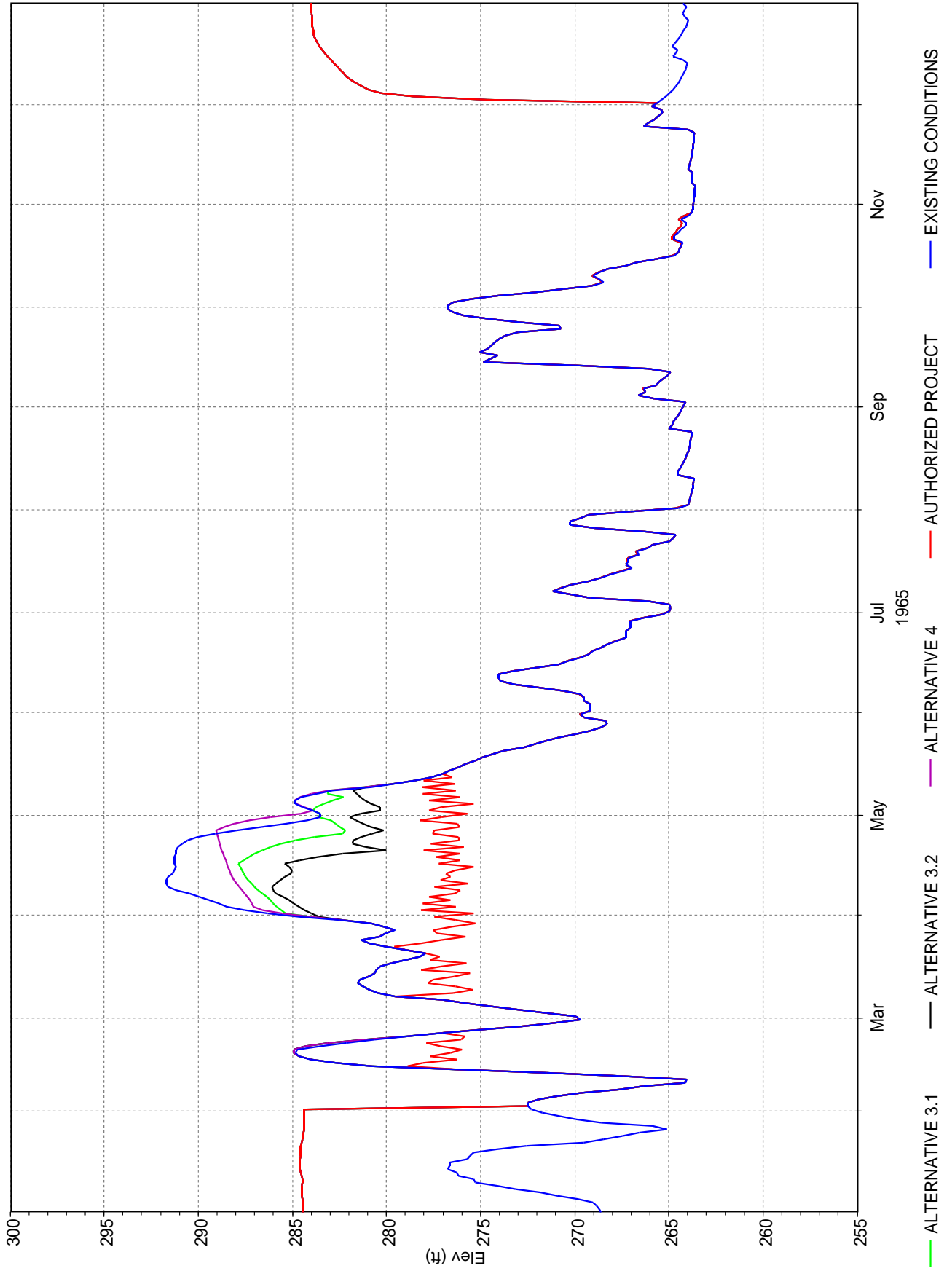
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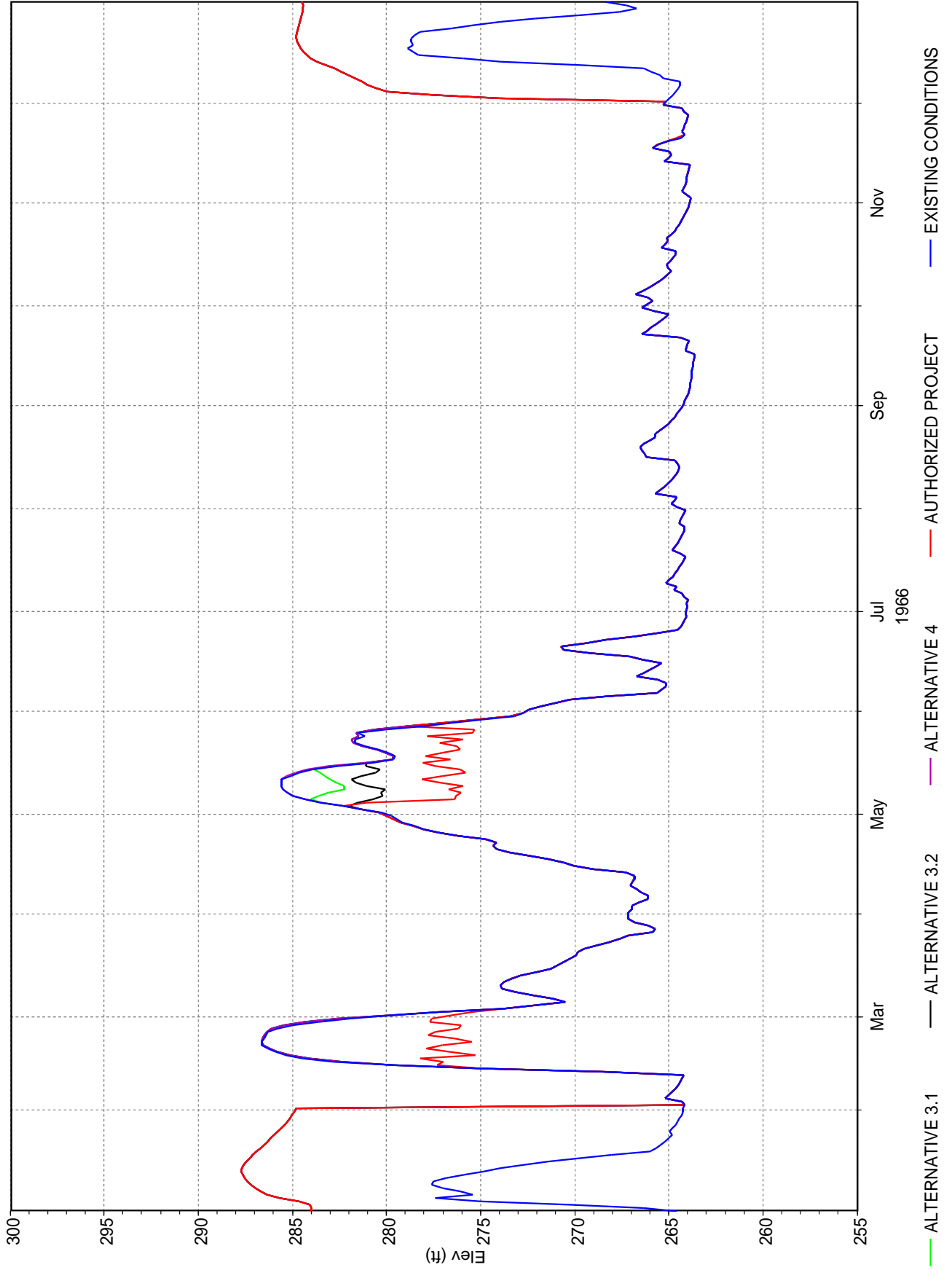
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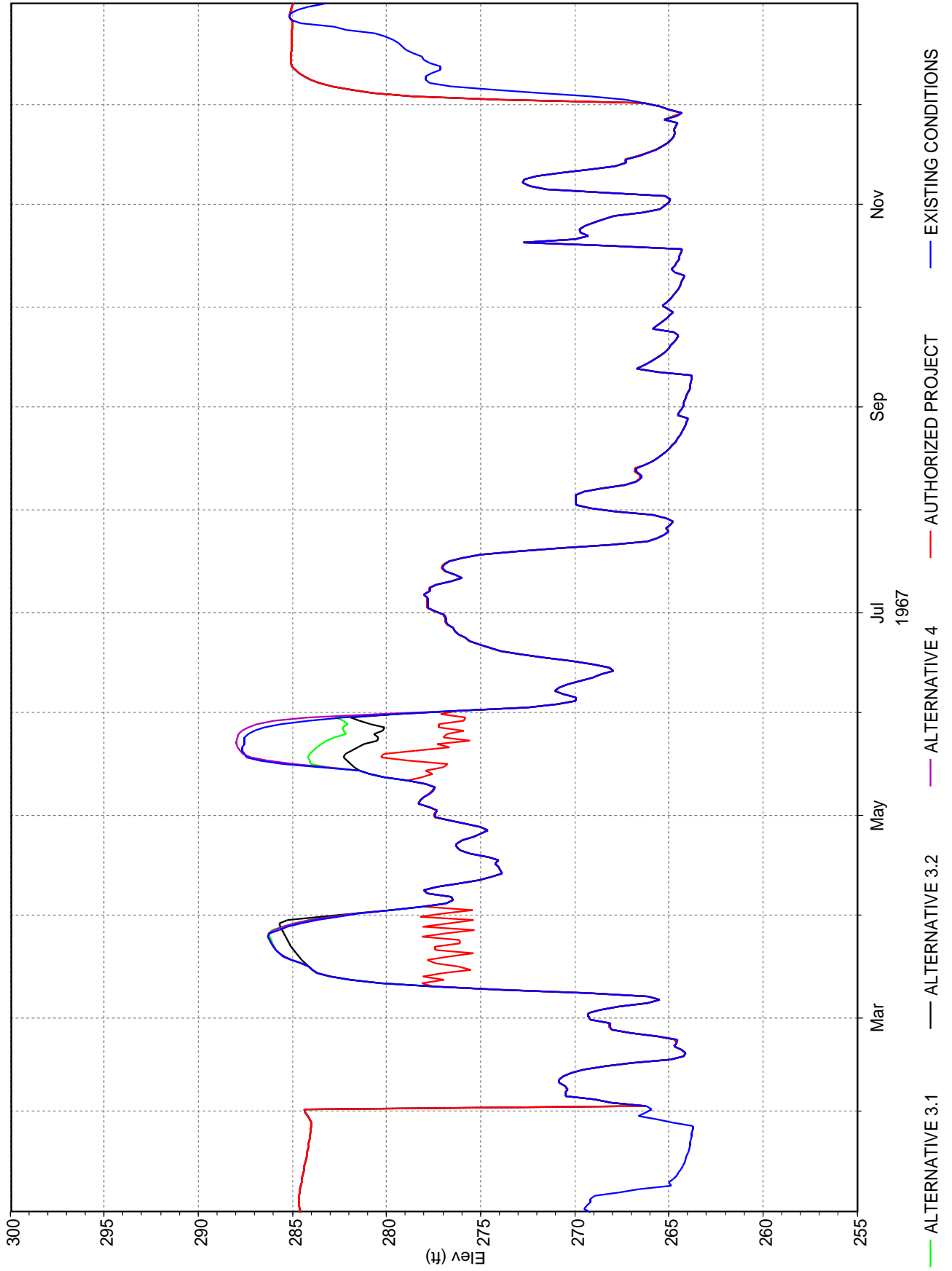
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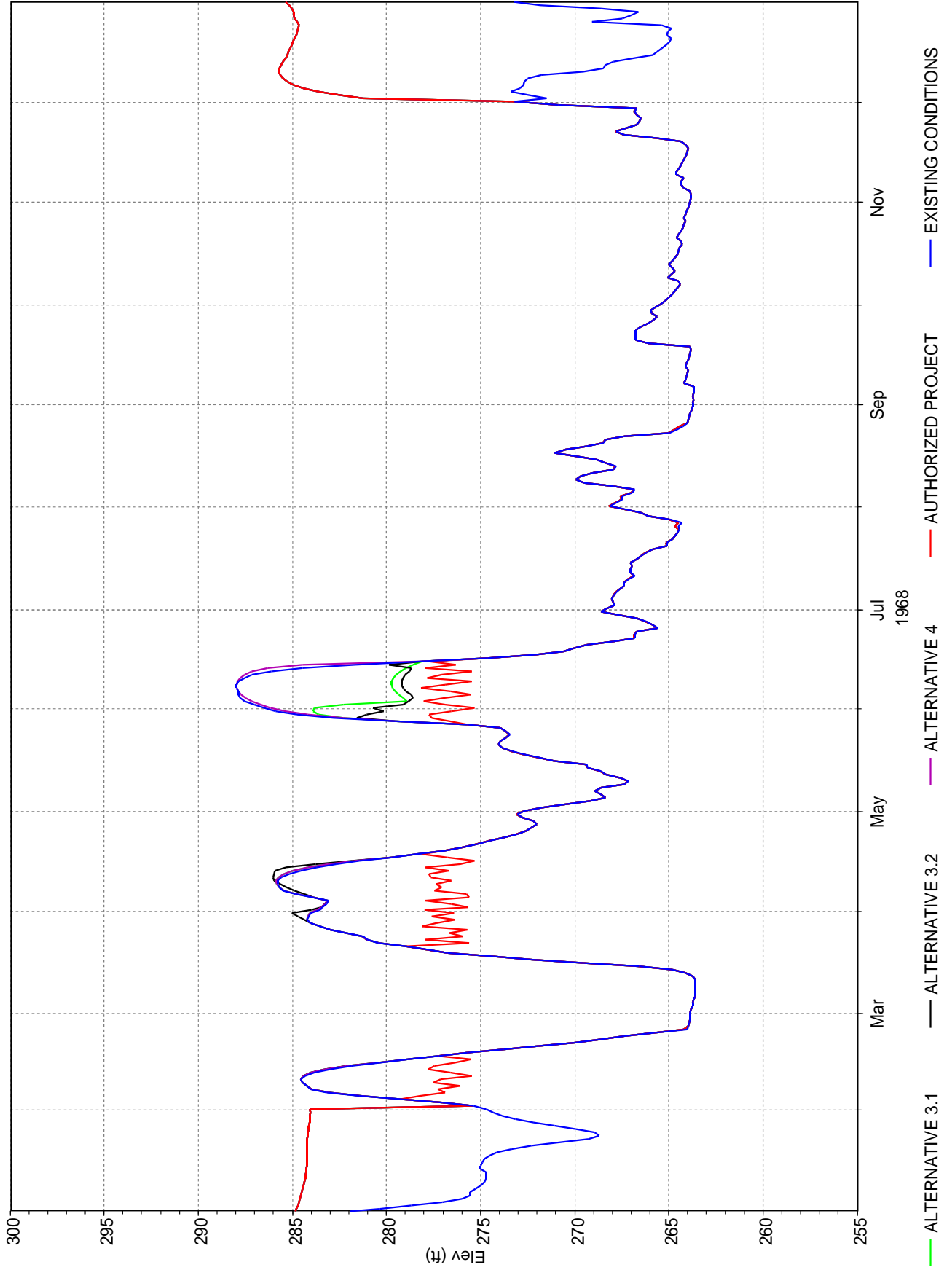
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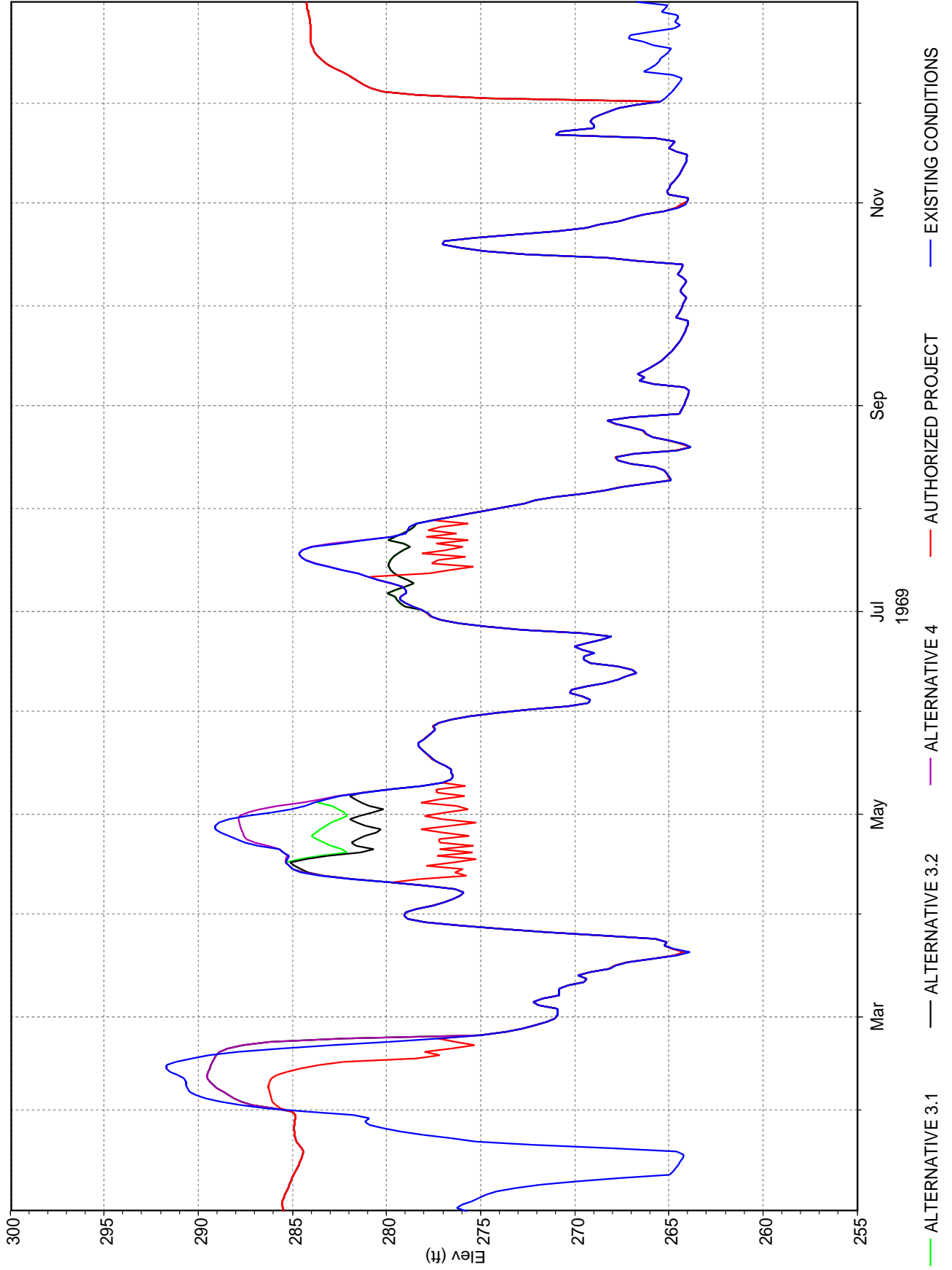
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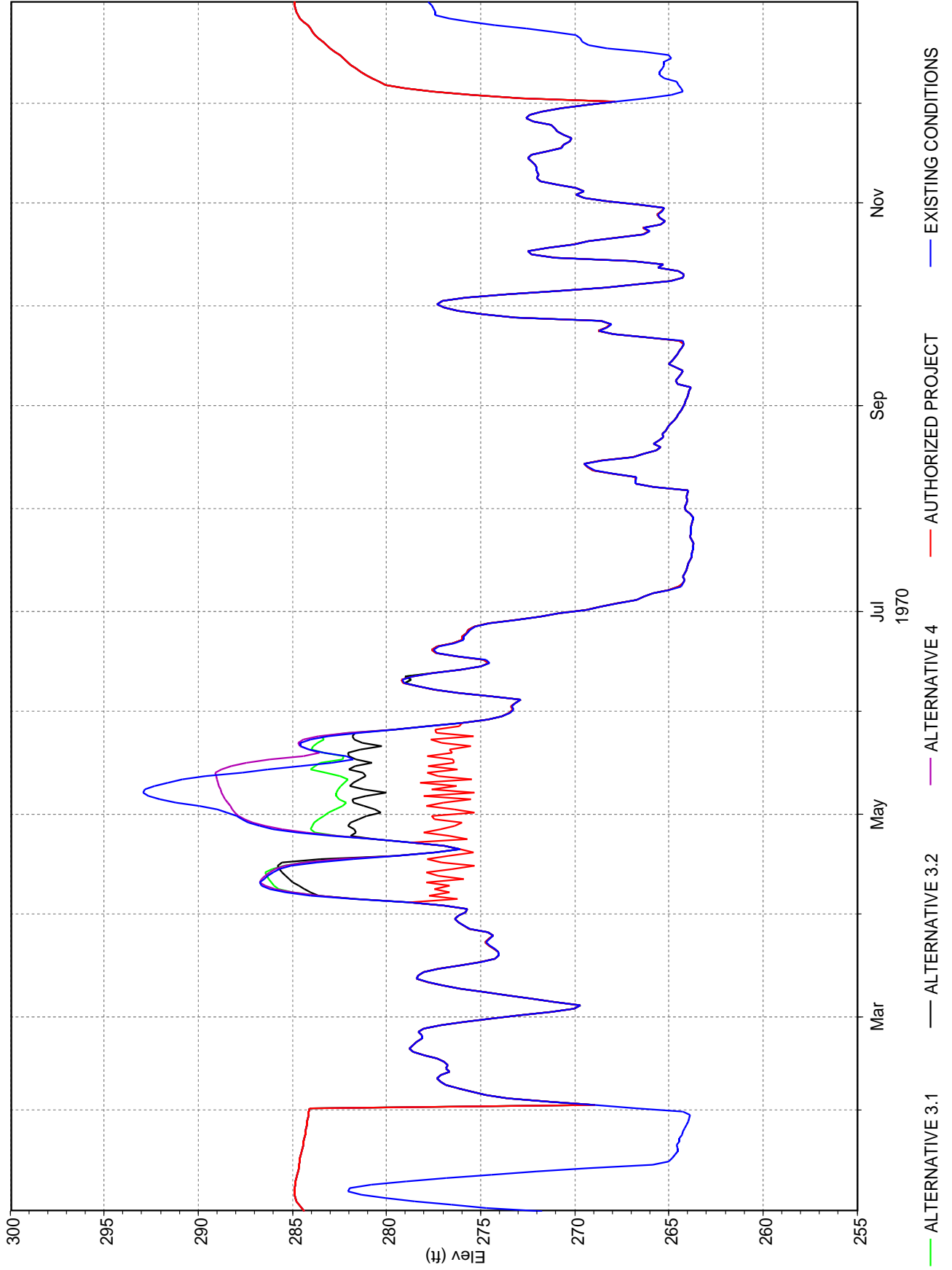
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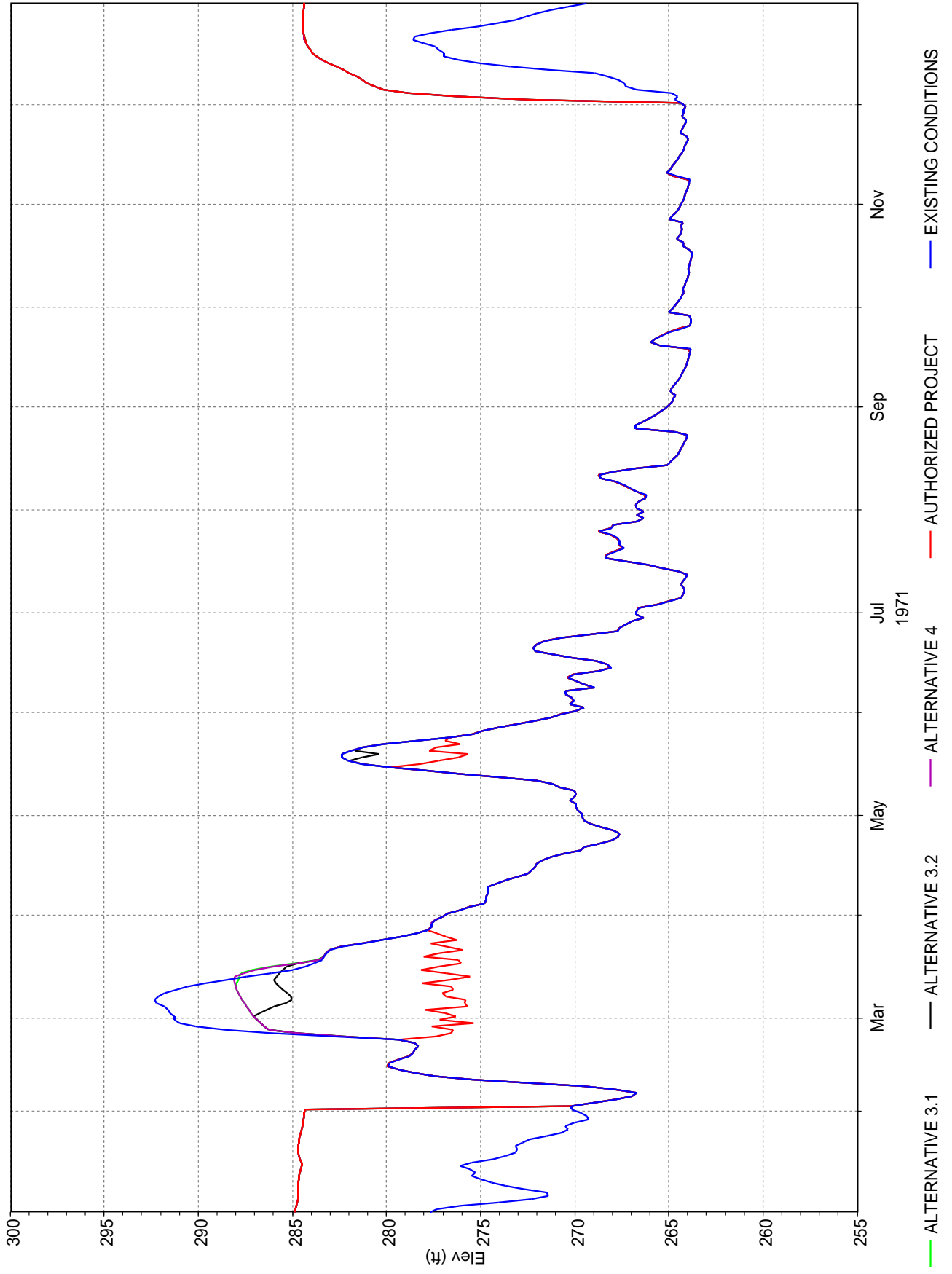
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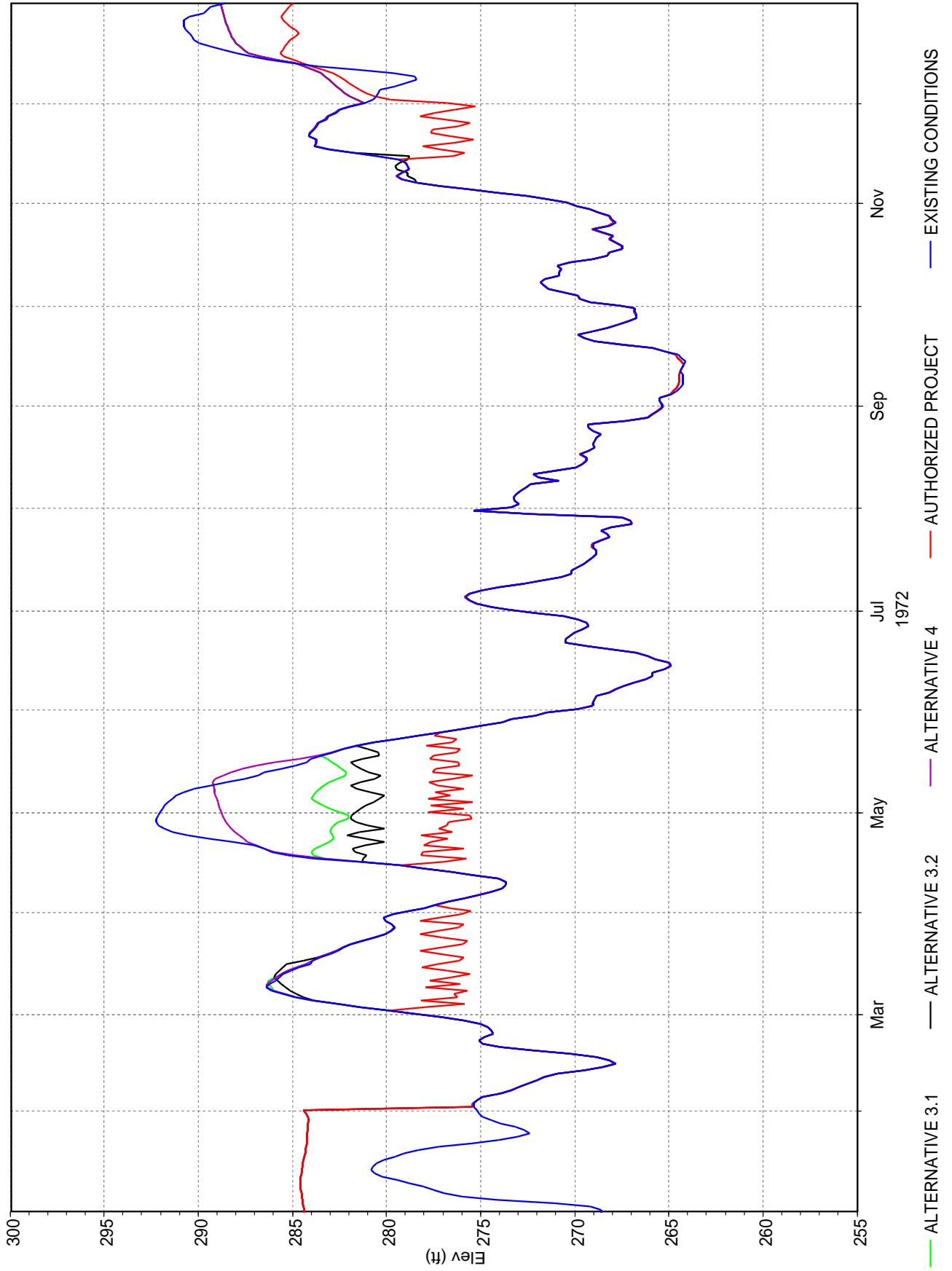
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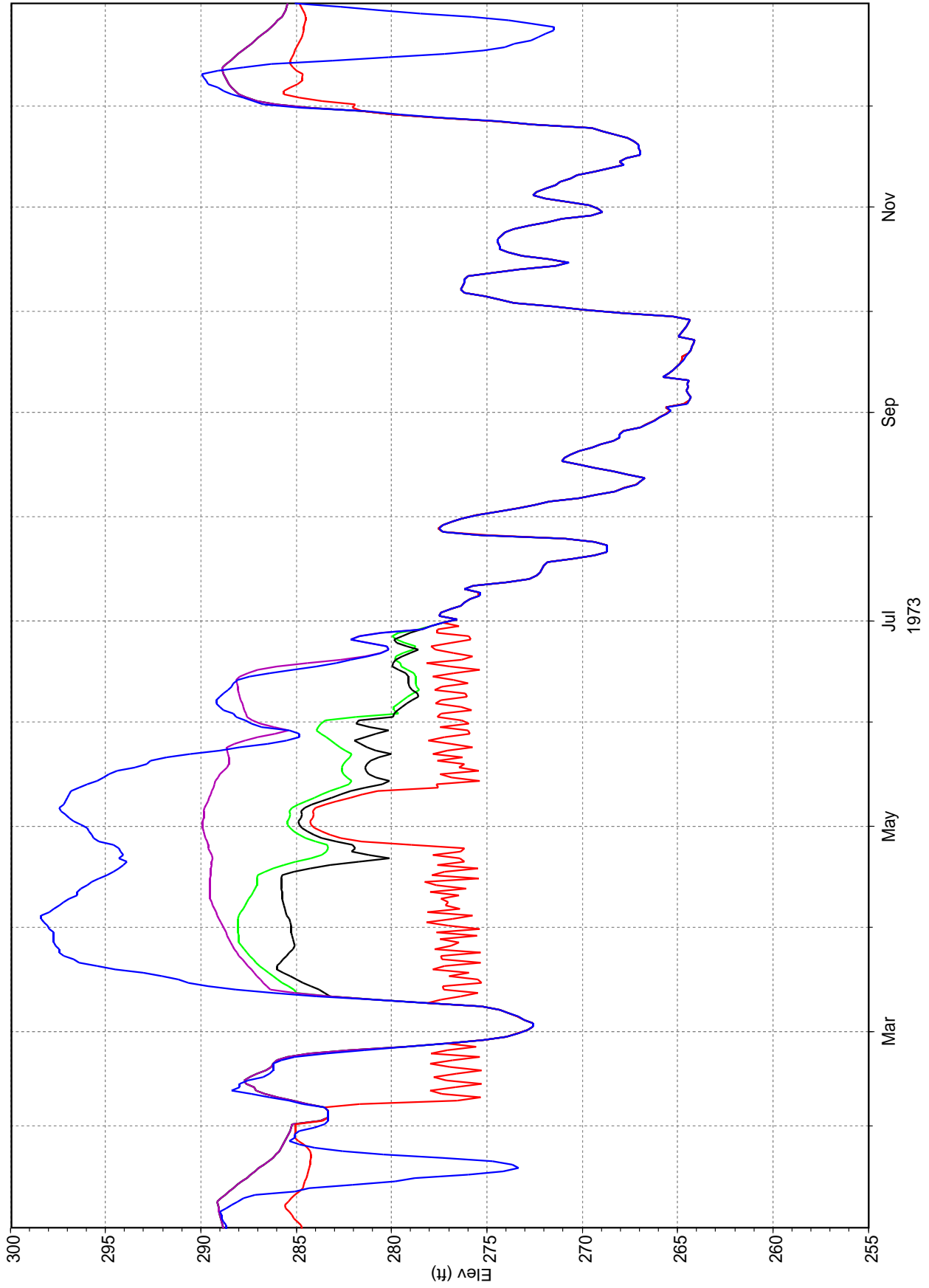
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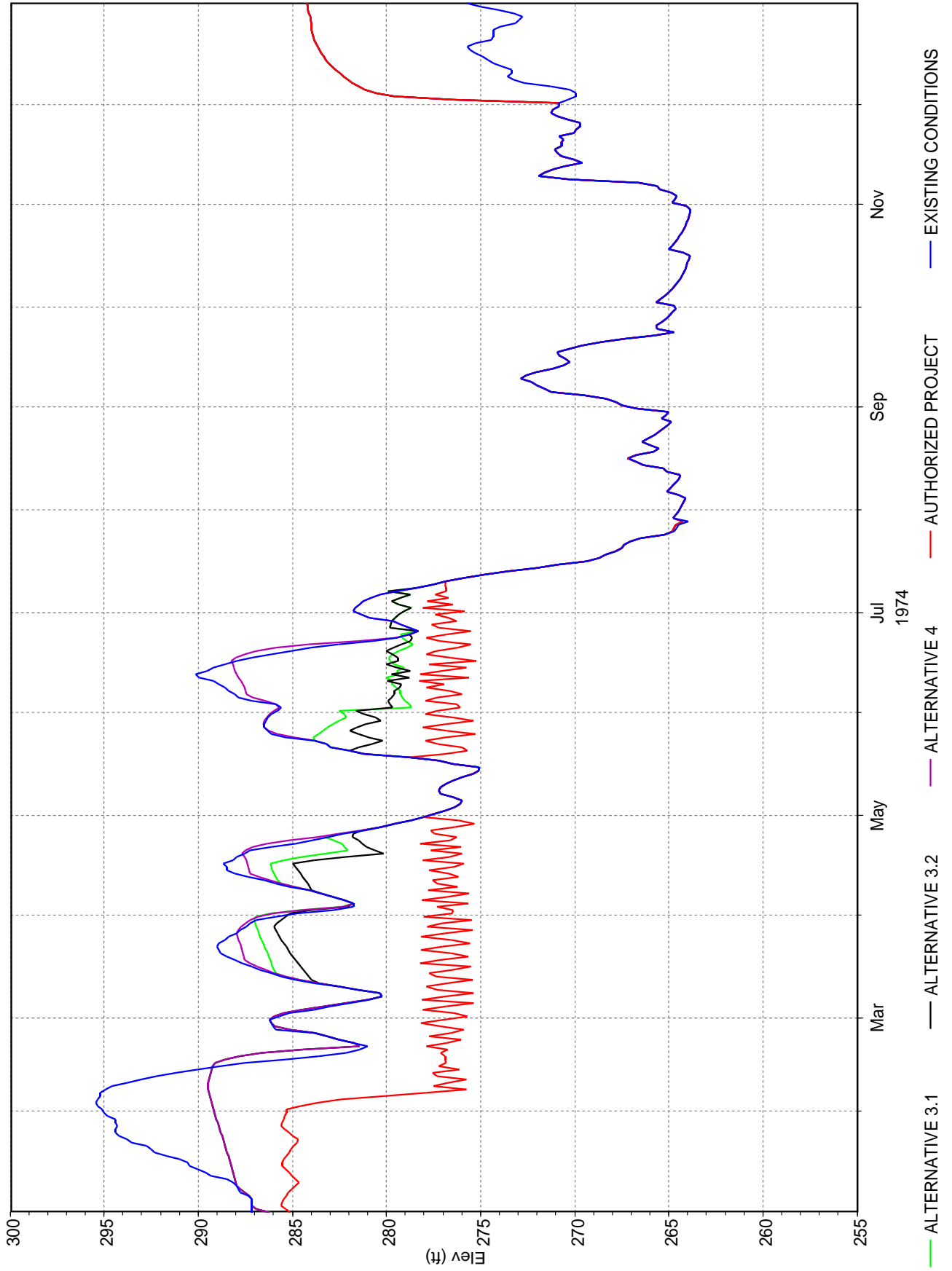


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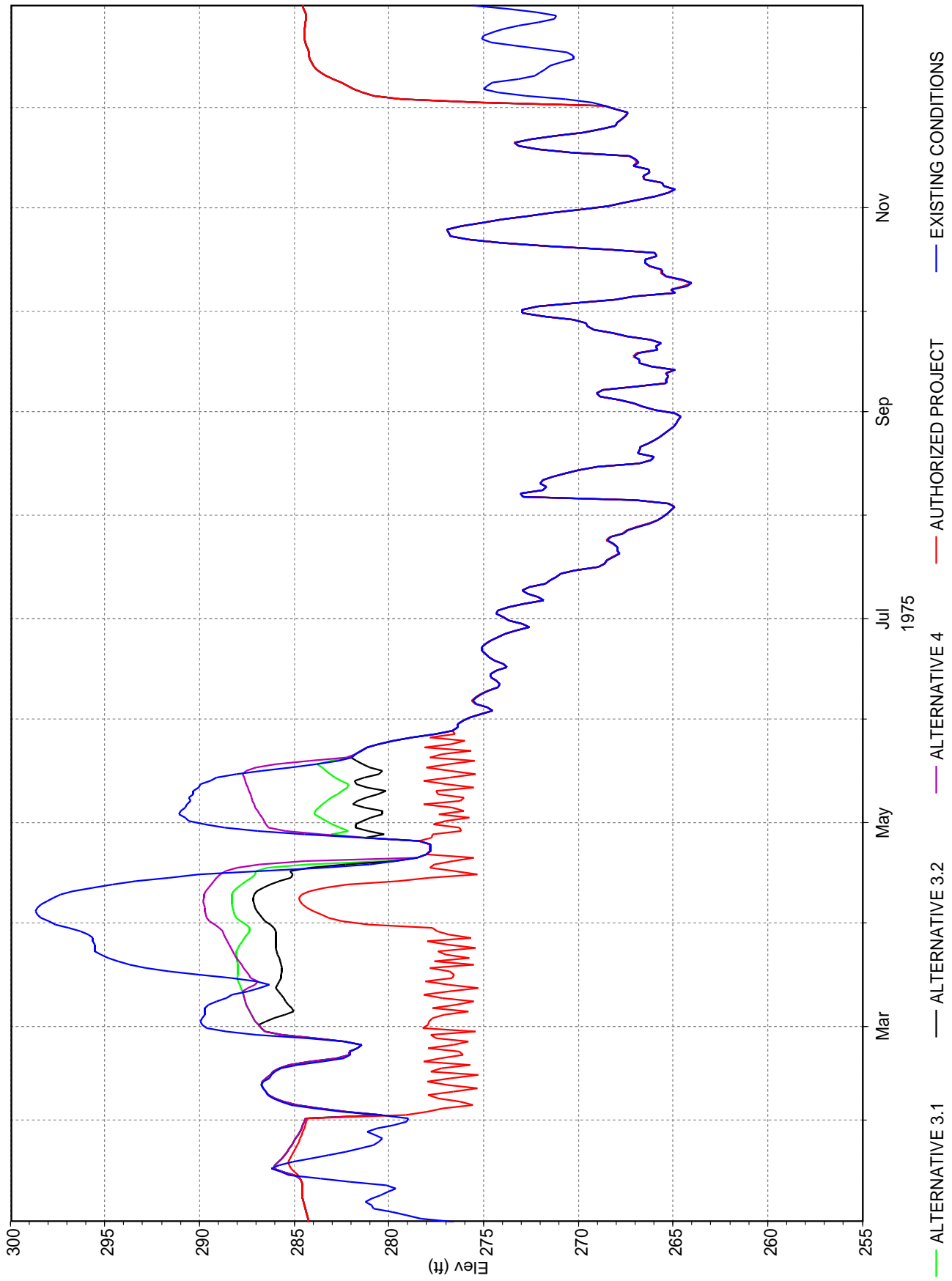


— ALTERNATIVE 3.1 — ALTERNATIVE 3.2 — ALTERNATIVE 4 — AUTHORIZED PROJECT — EXISTING CONDITIONS

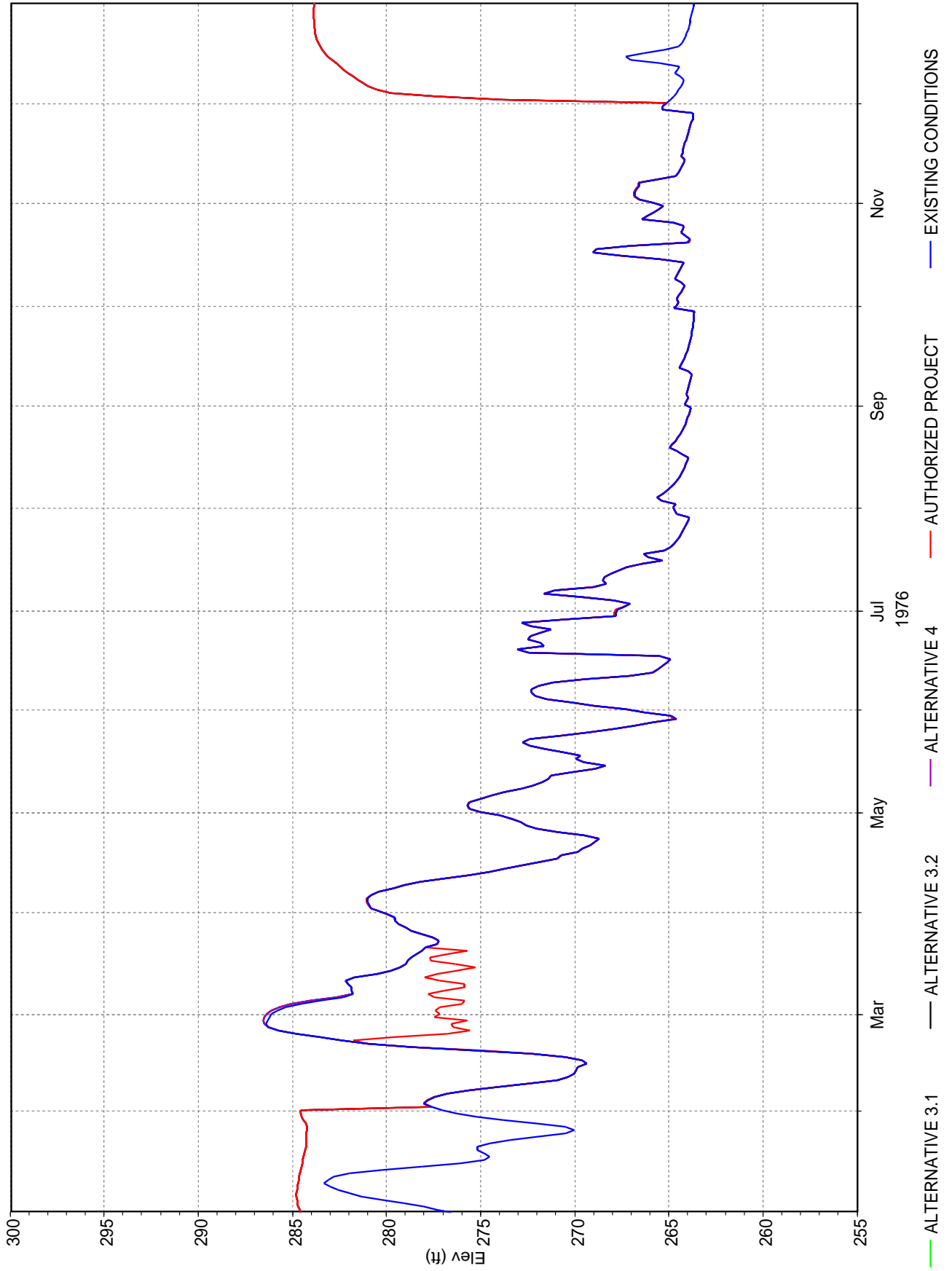
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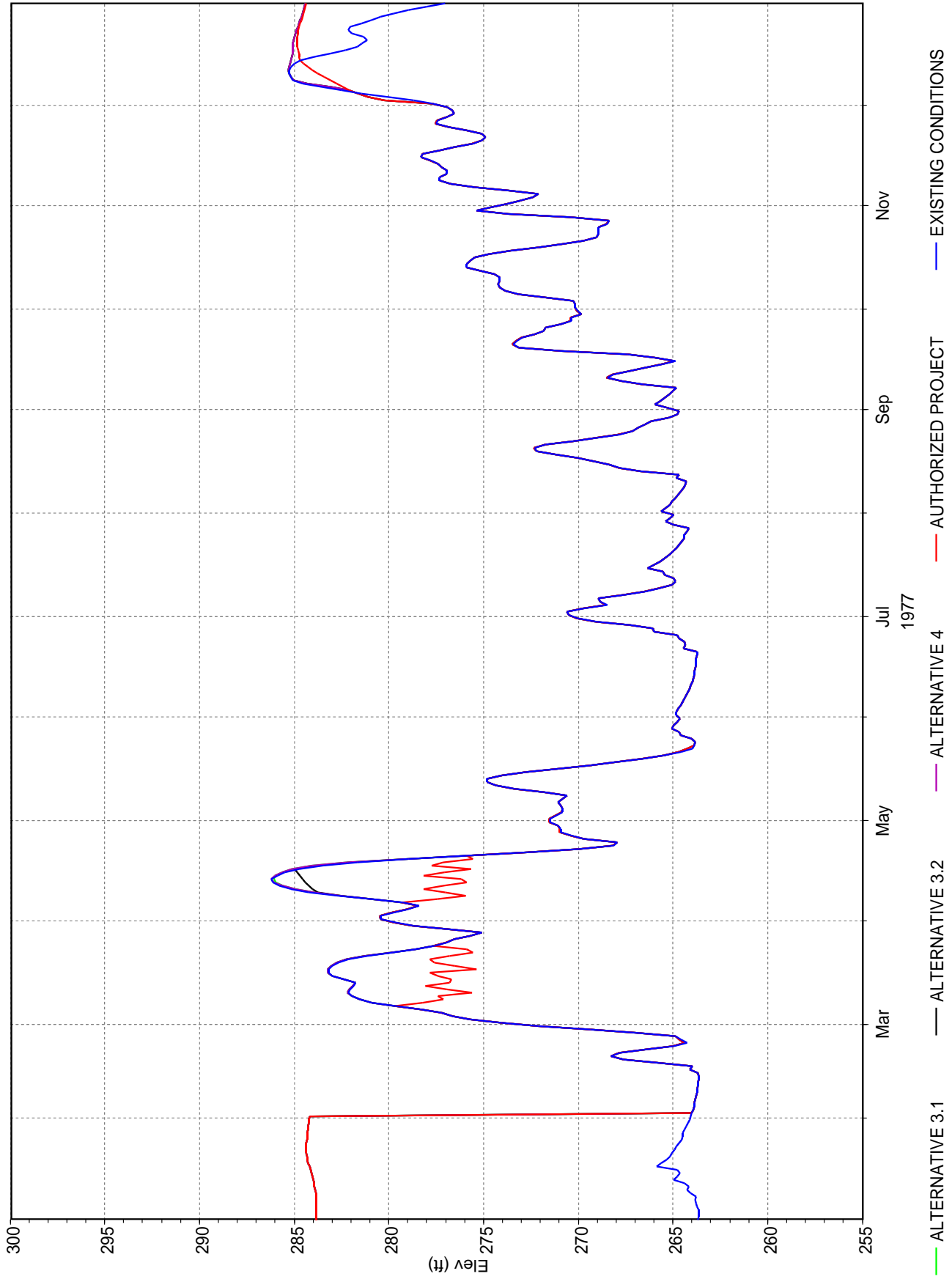
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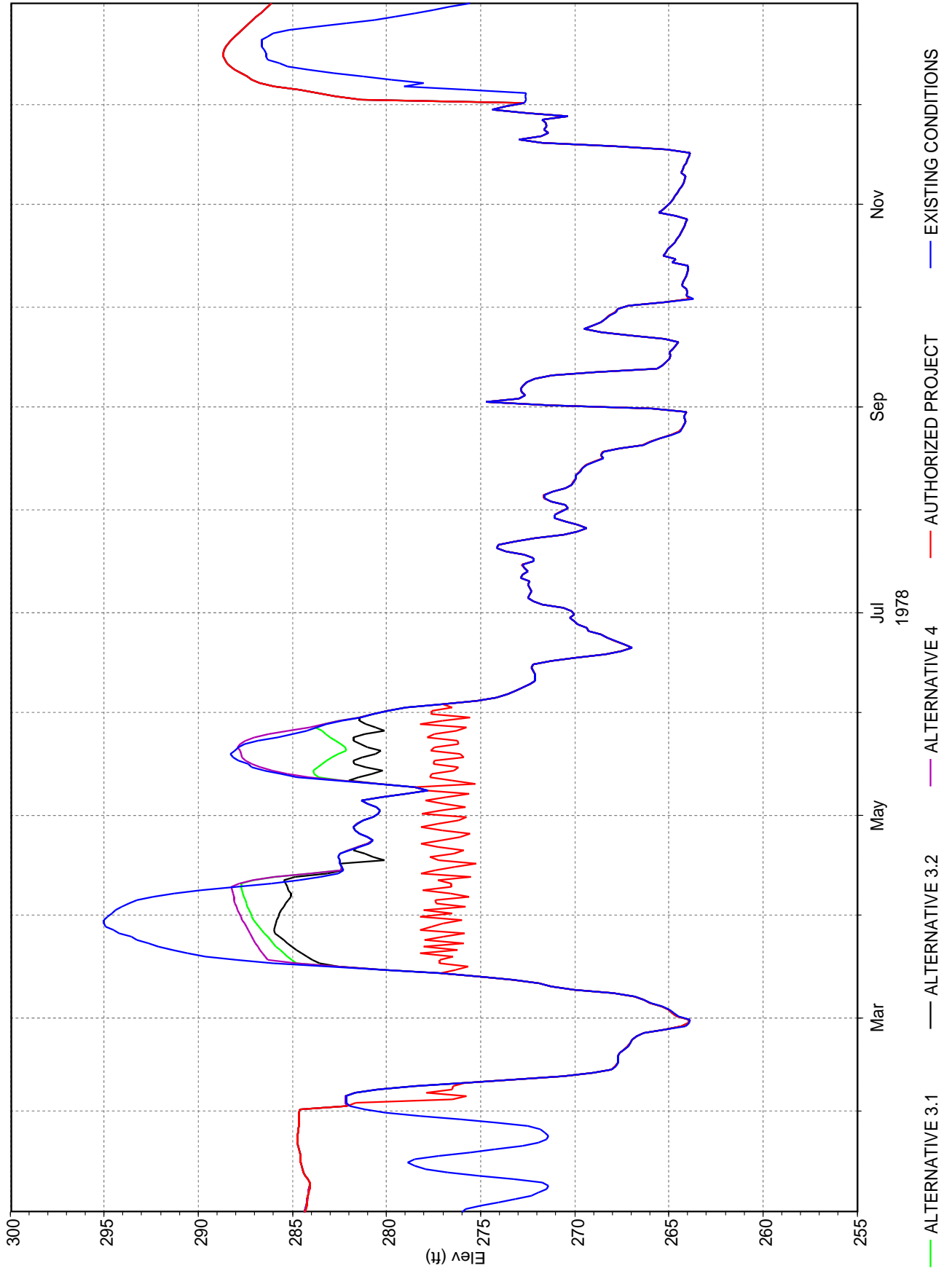
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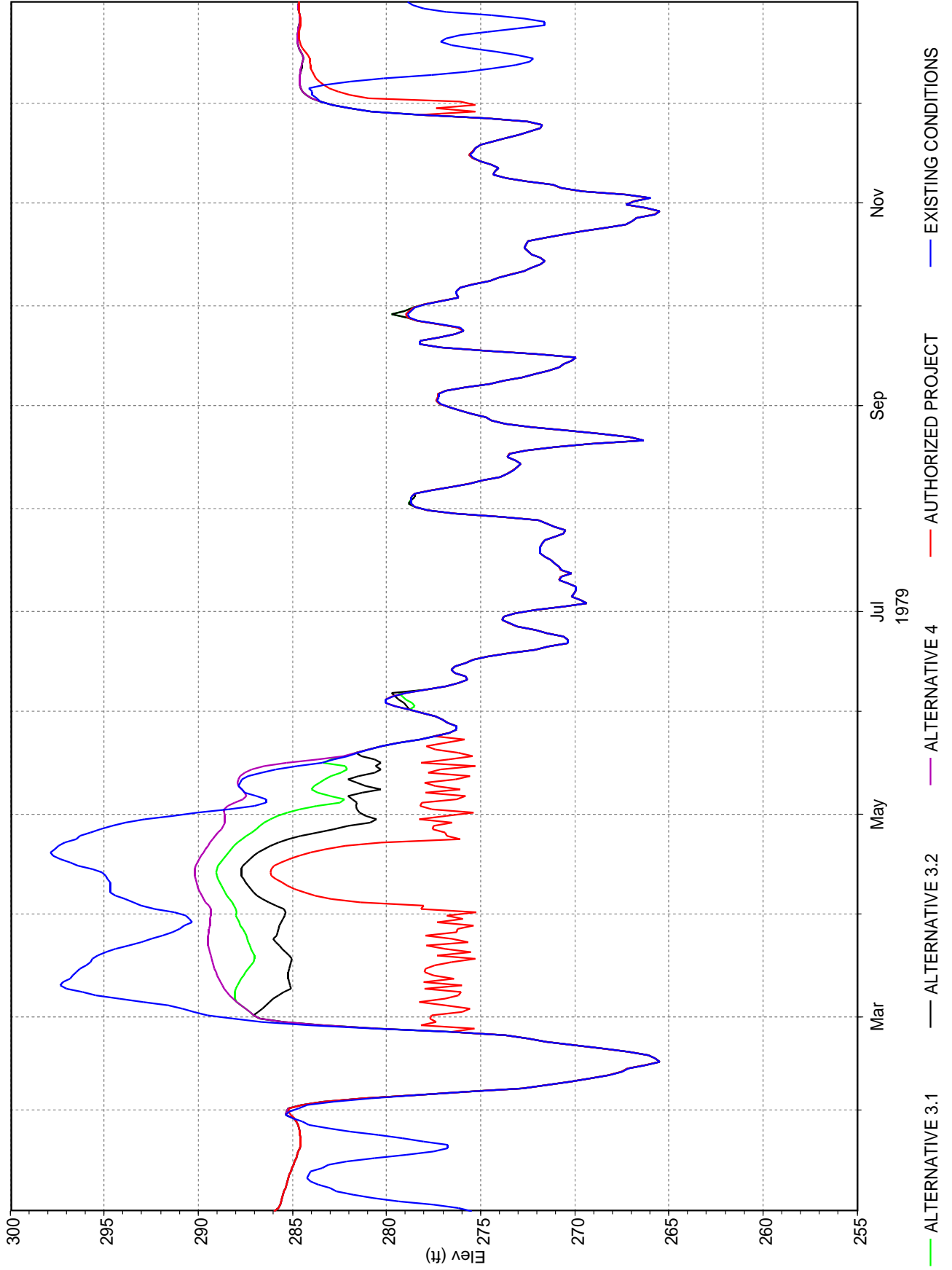
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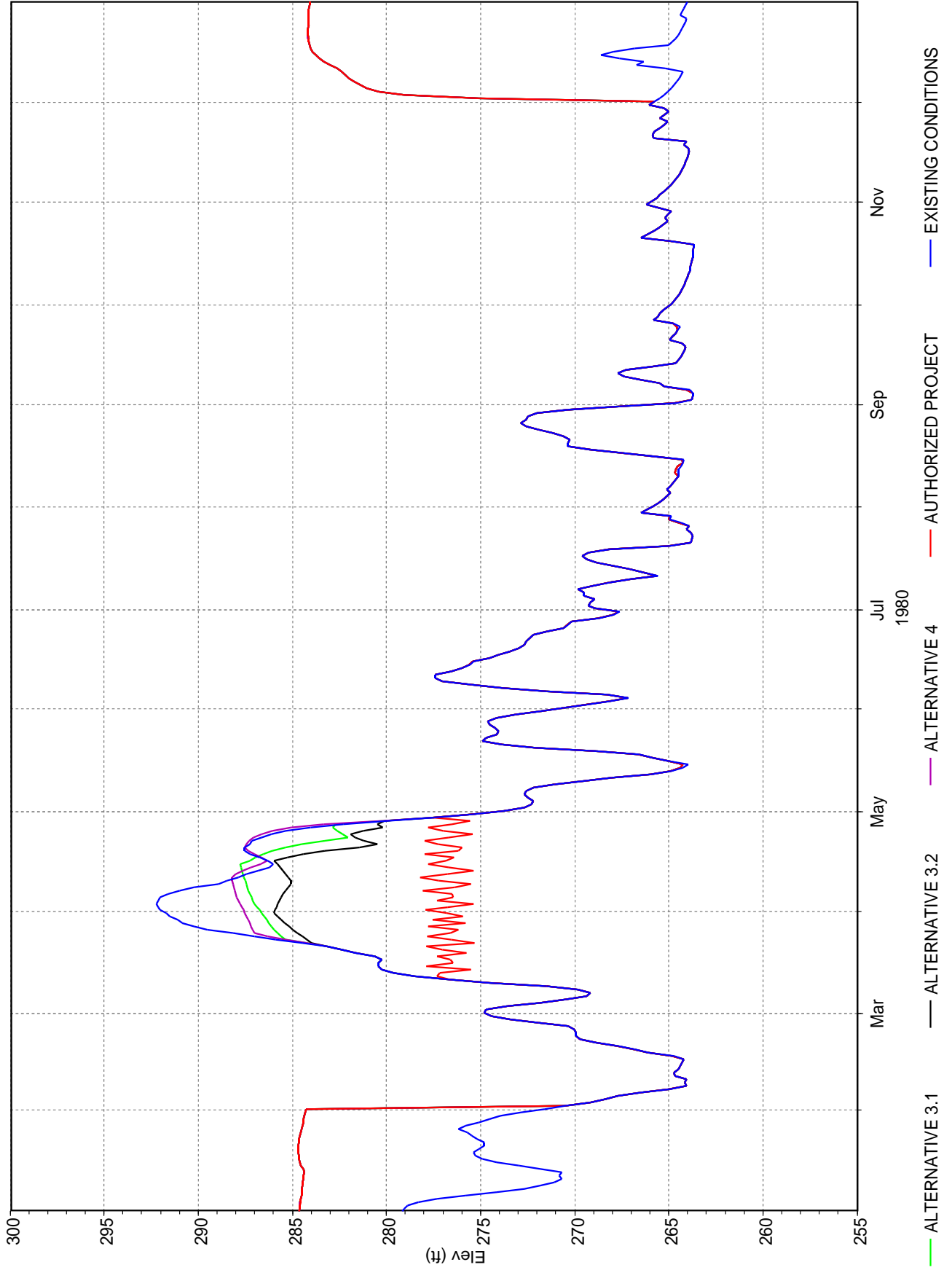
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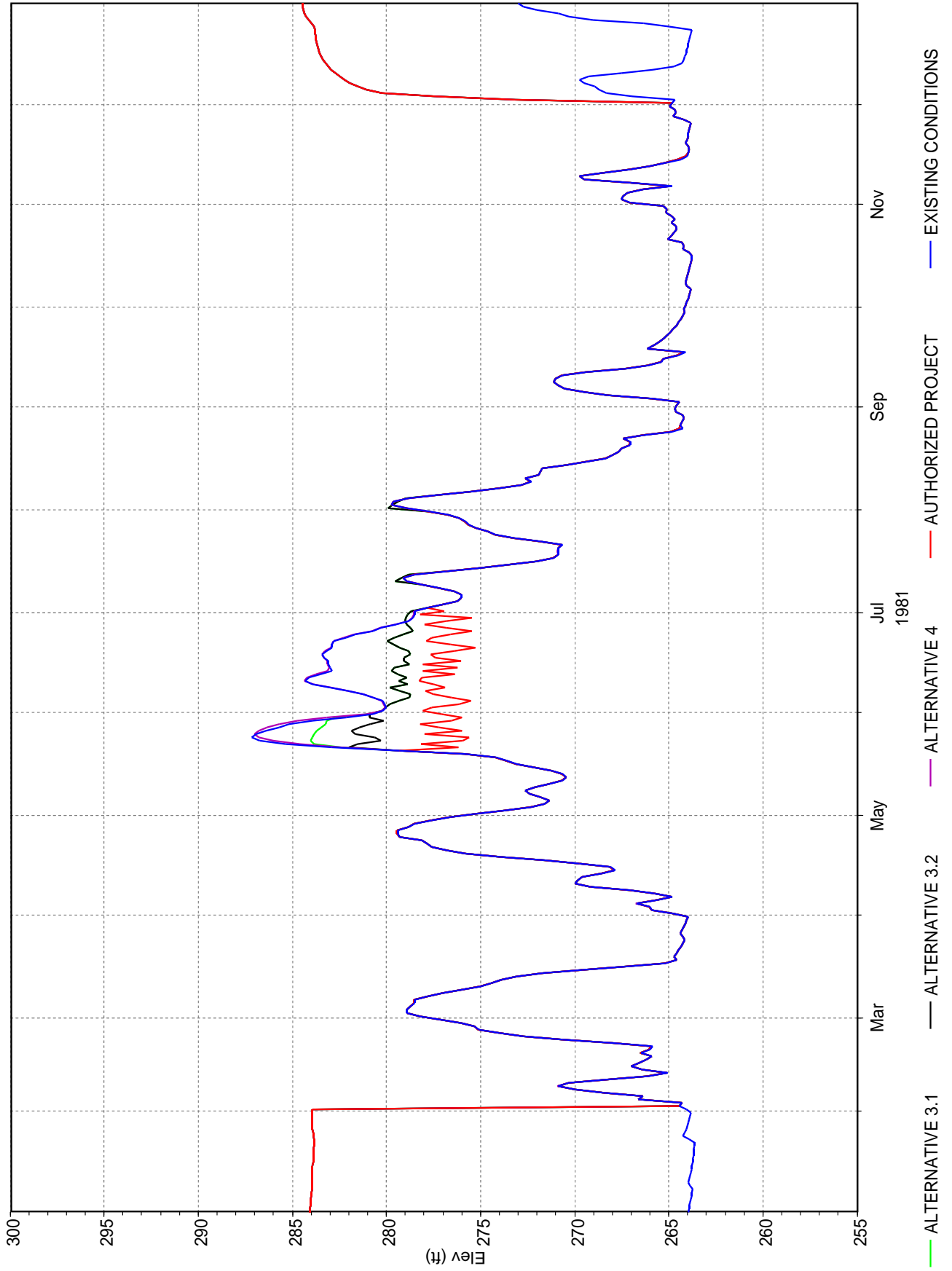
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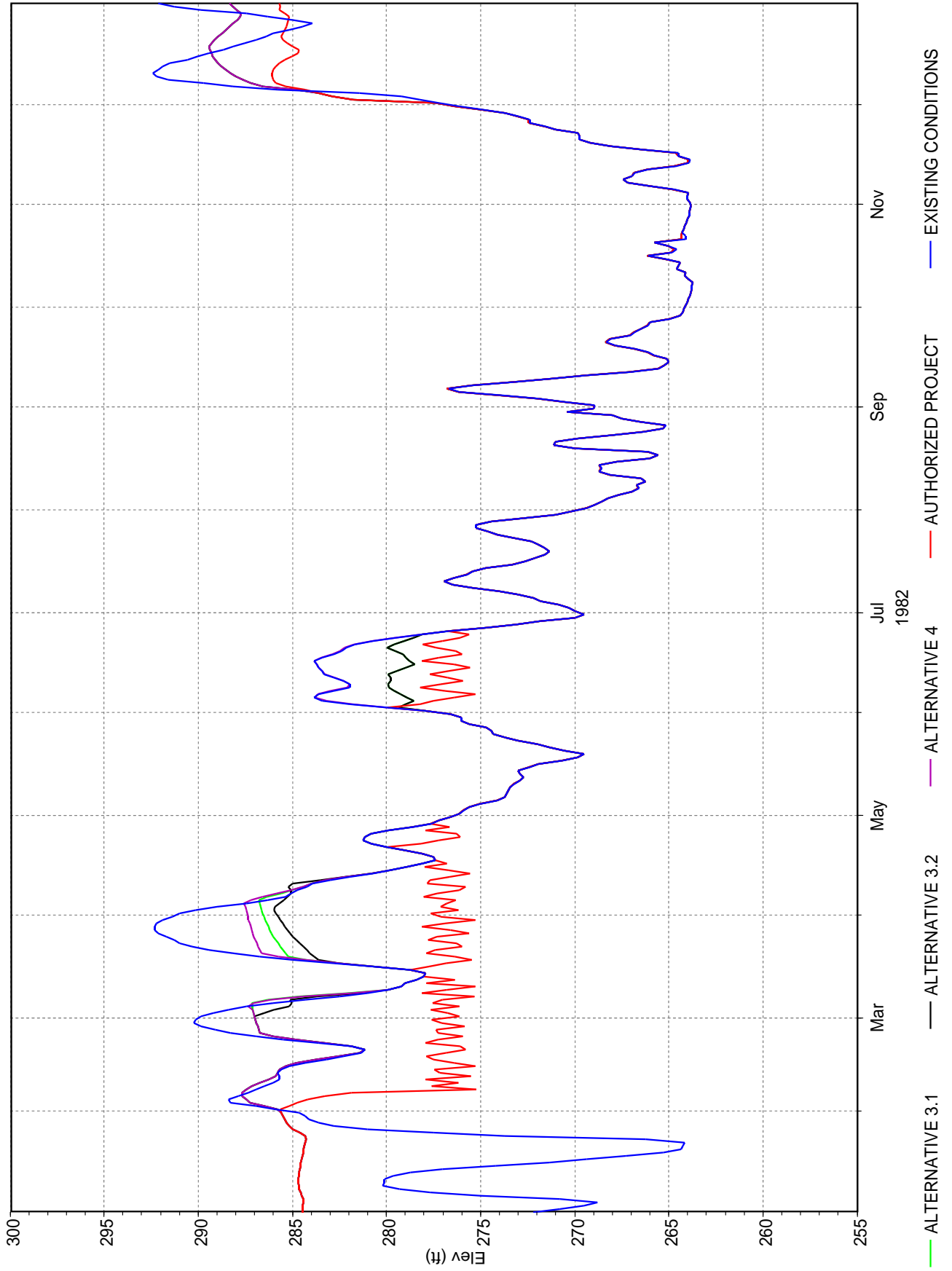
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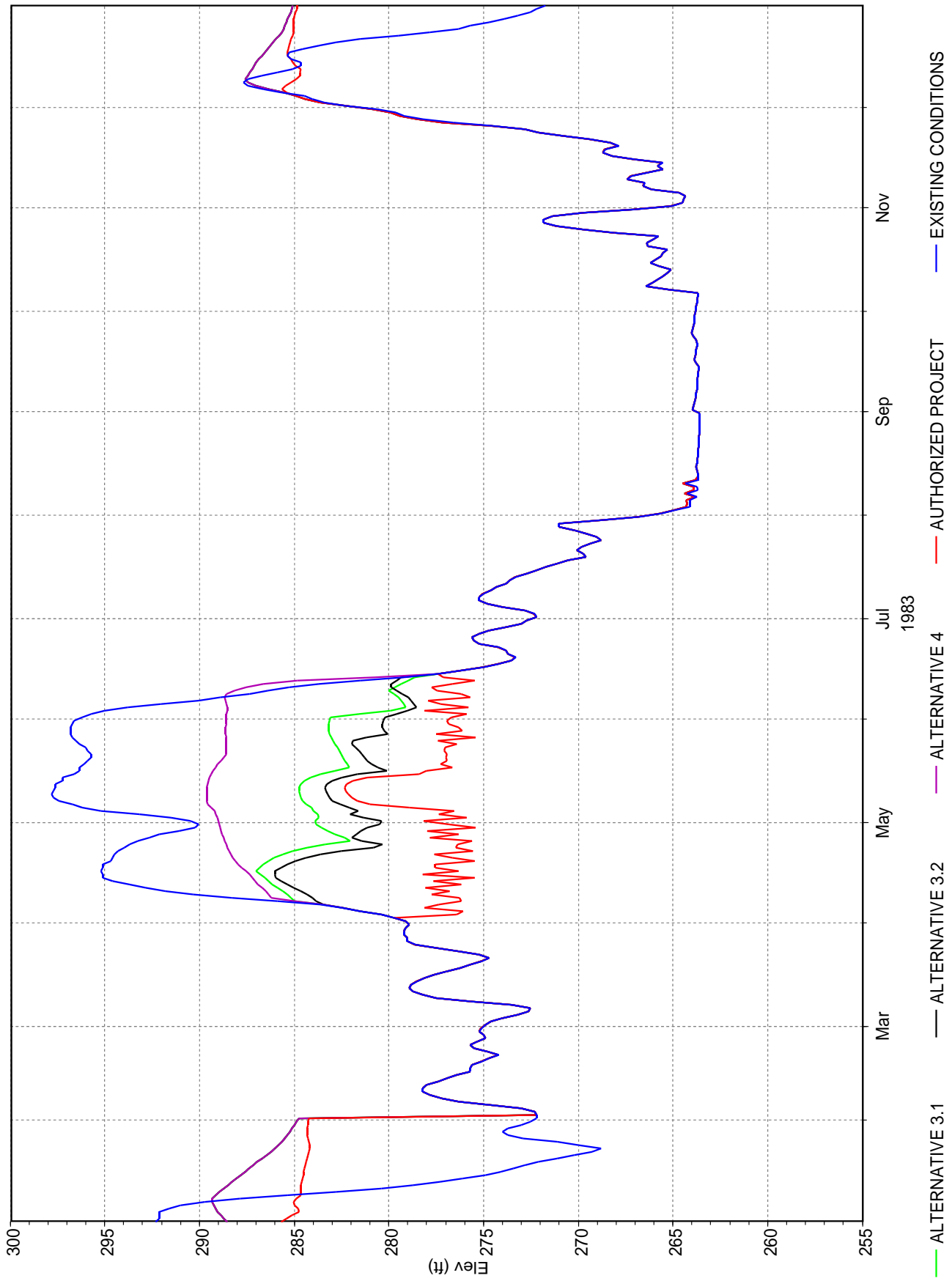
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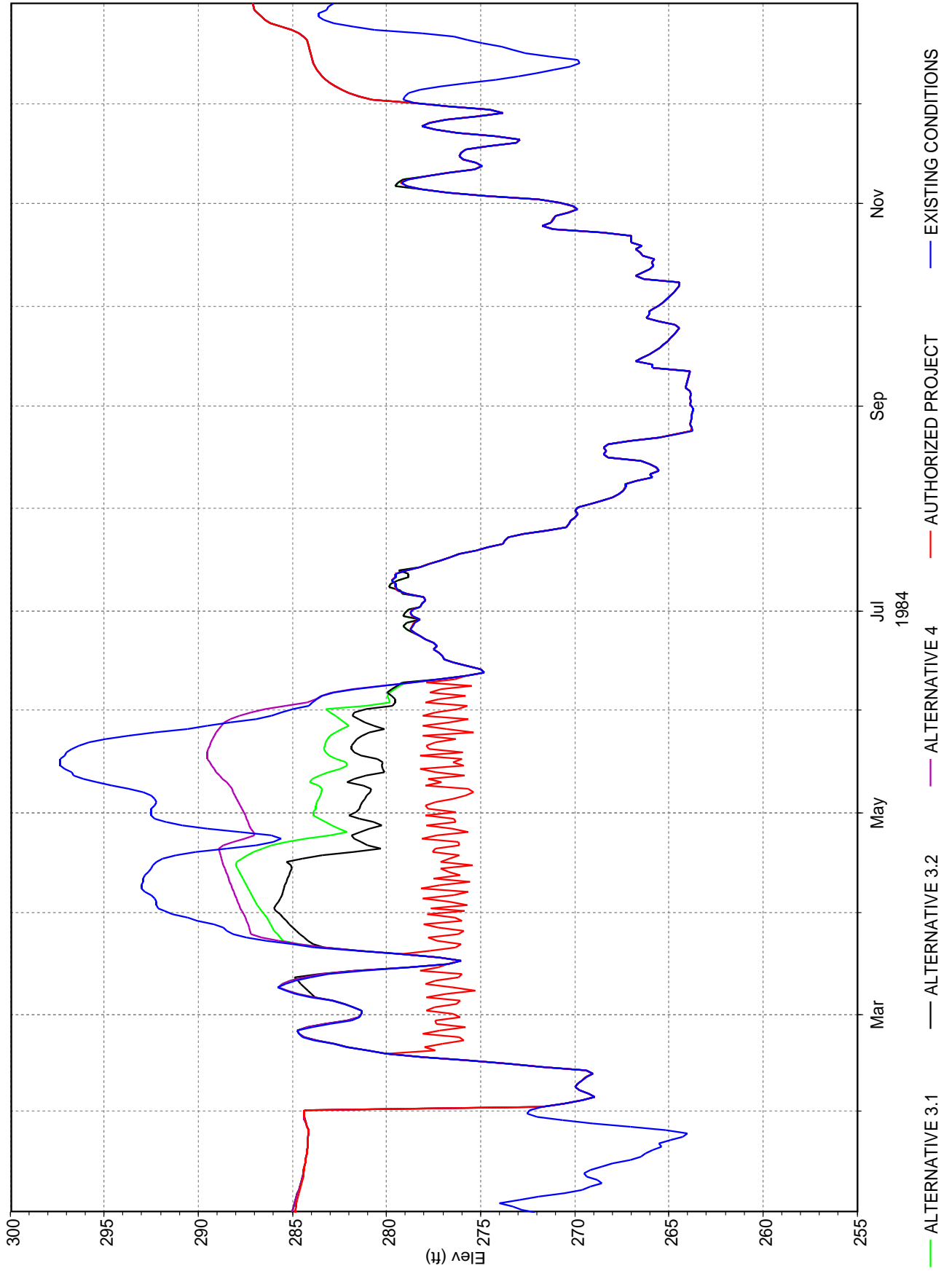
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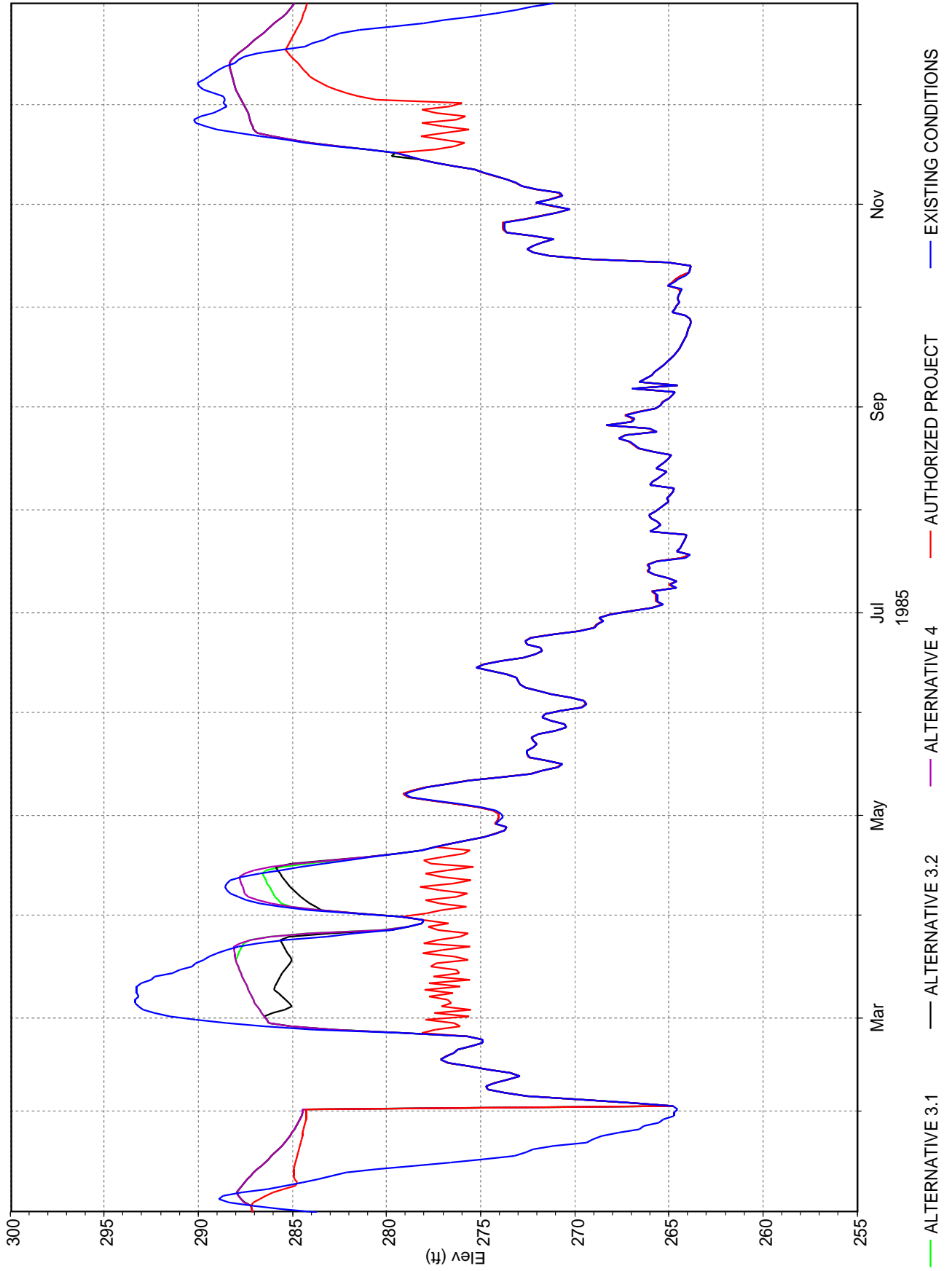
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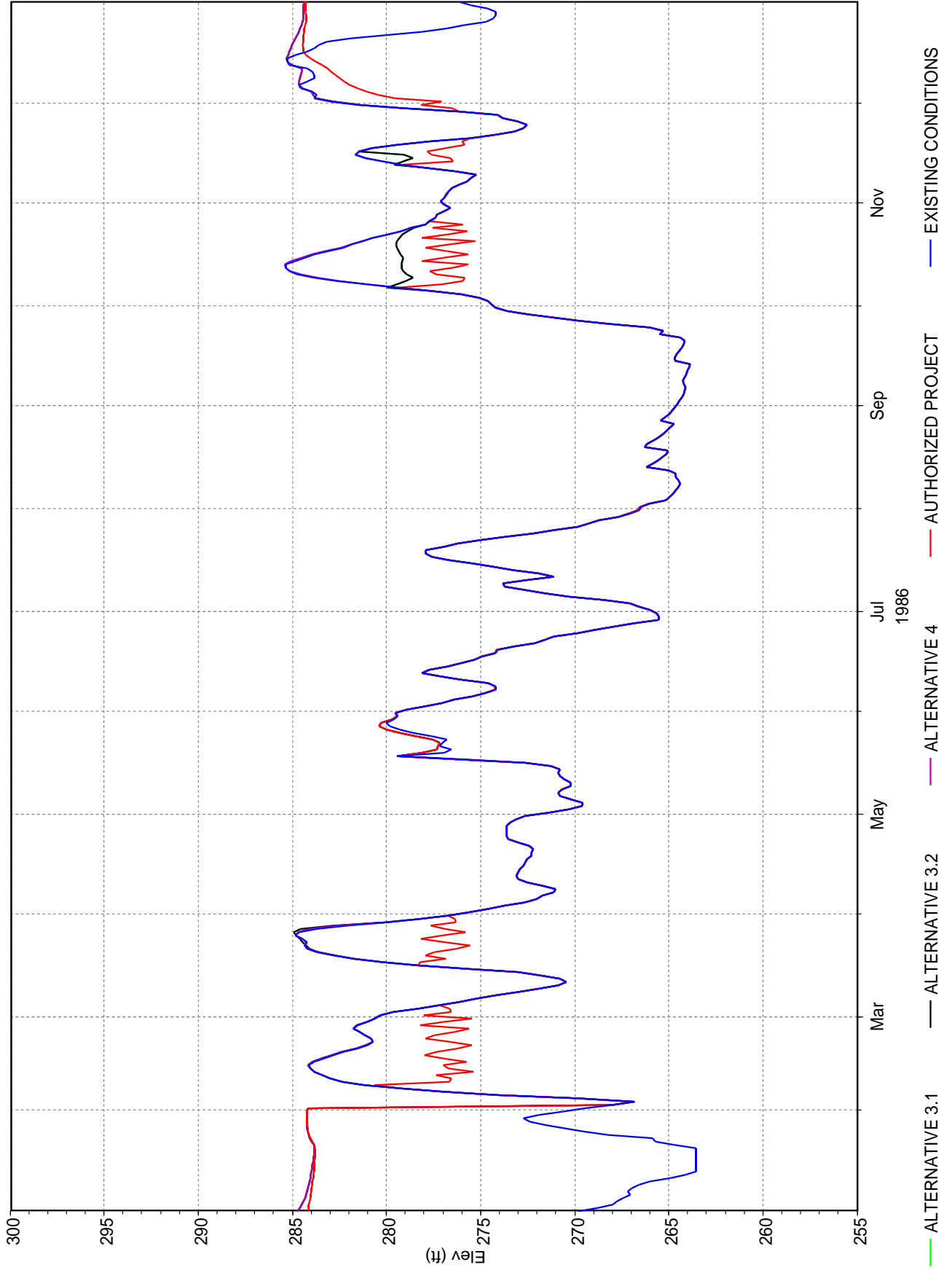
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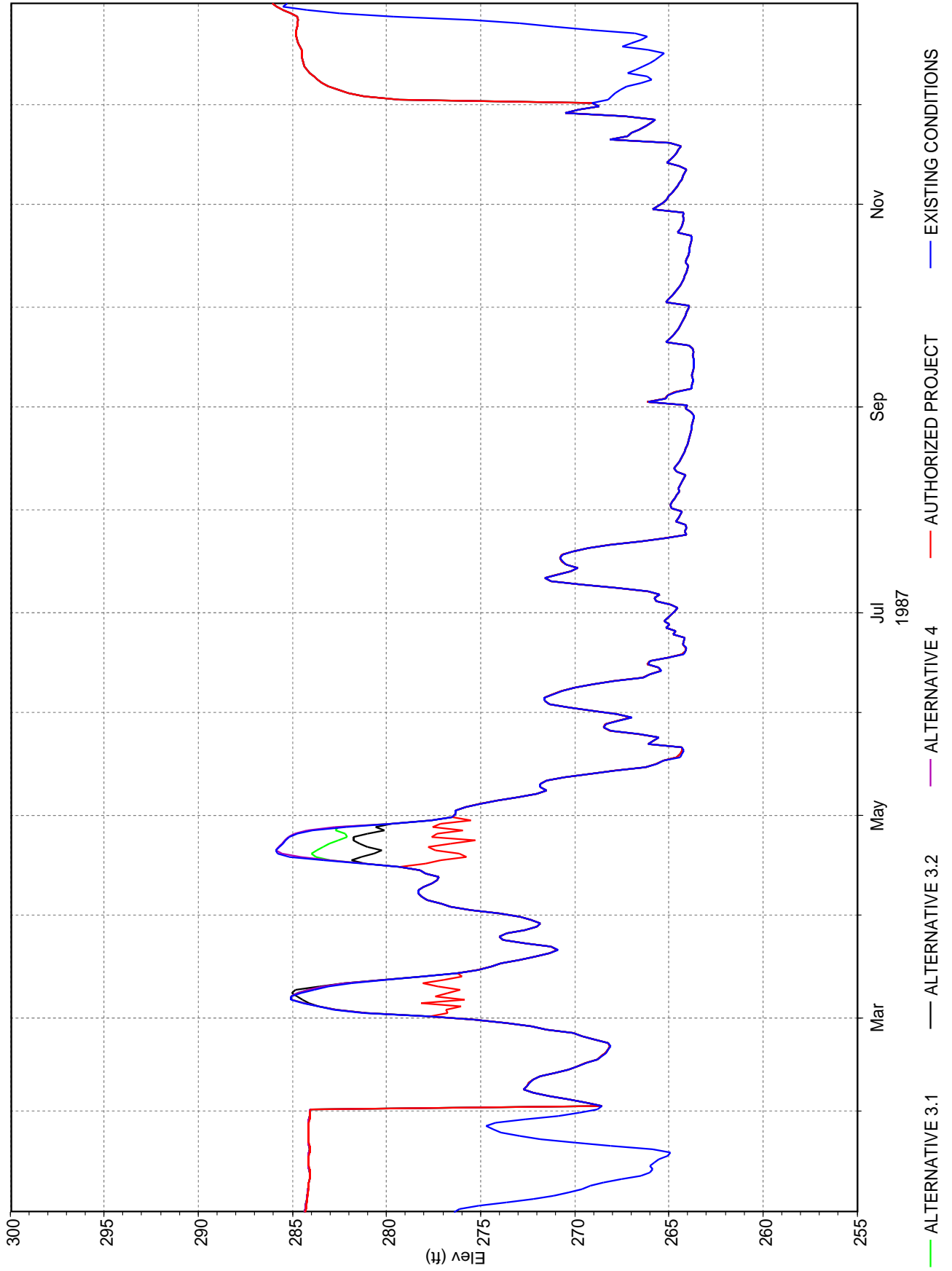
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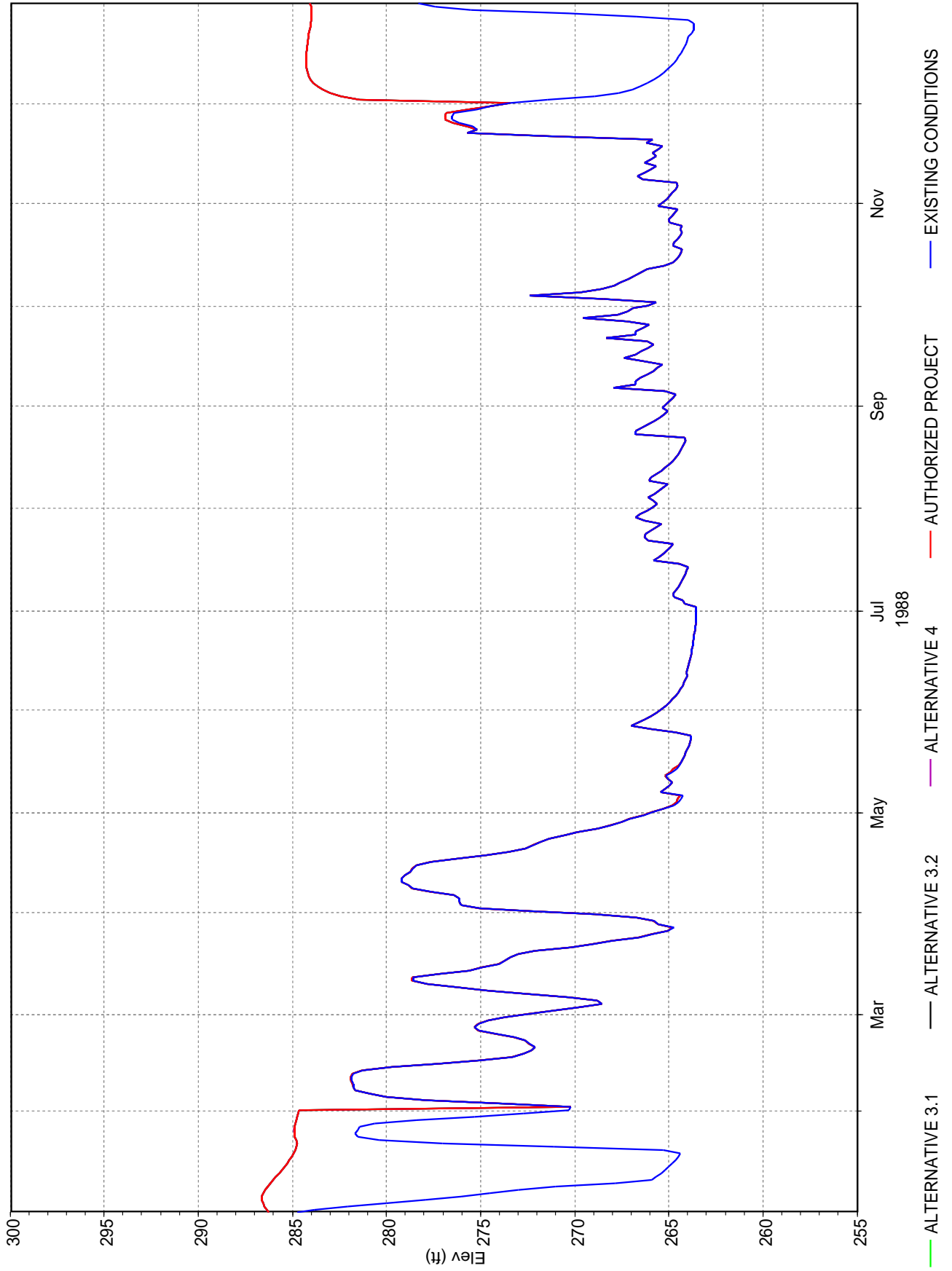
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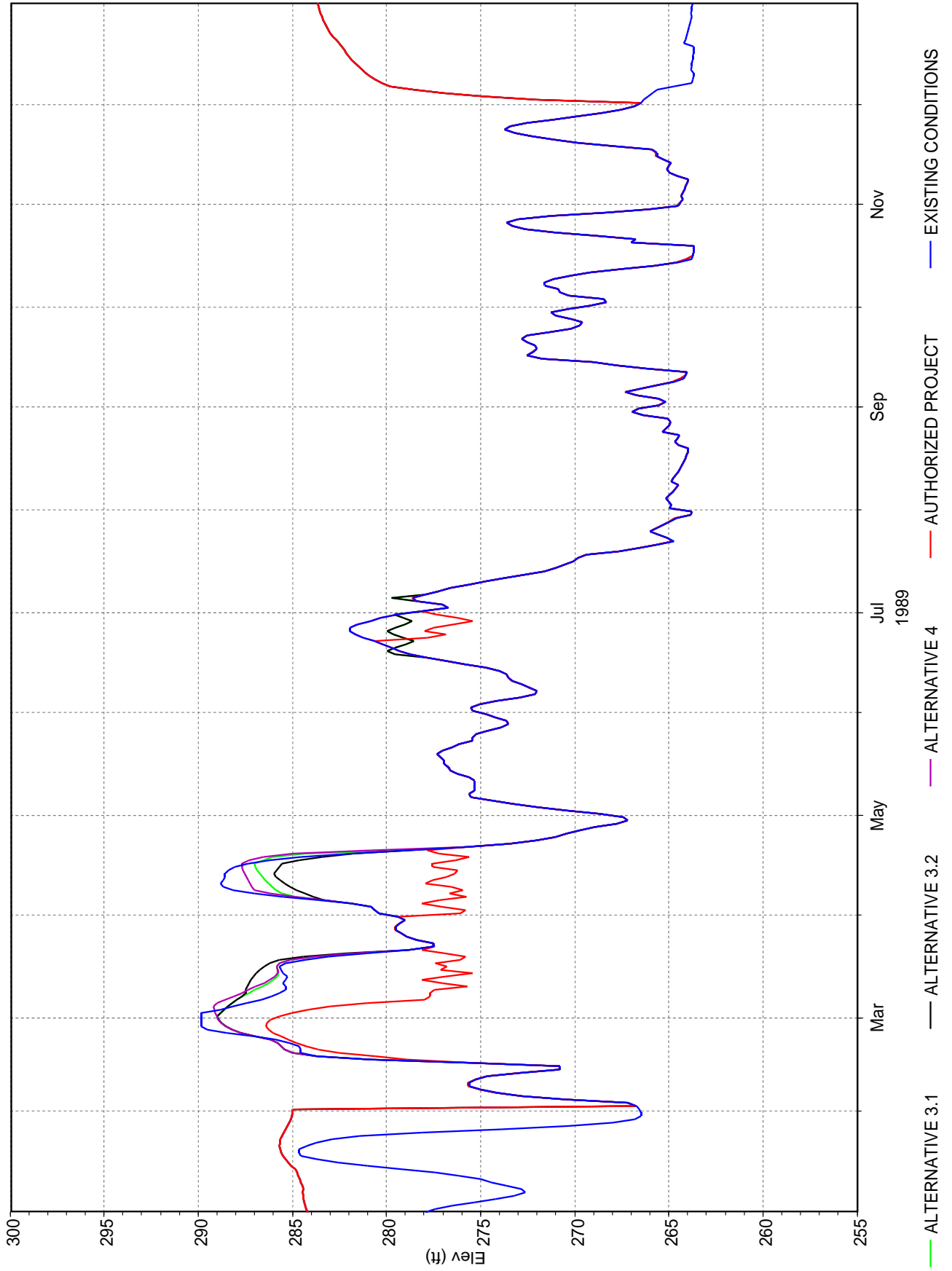
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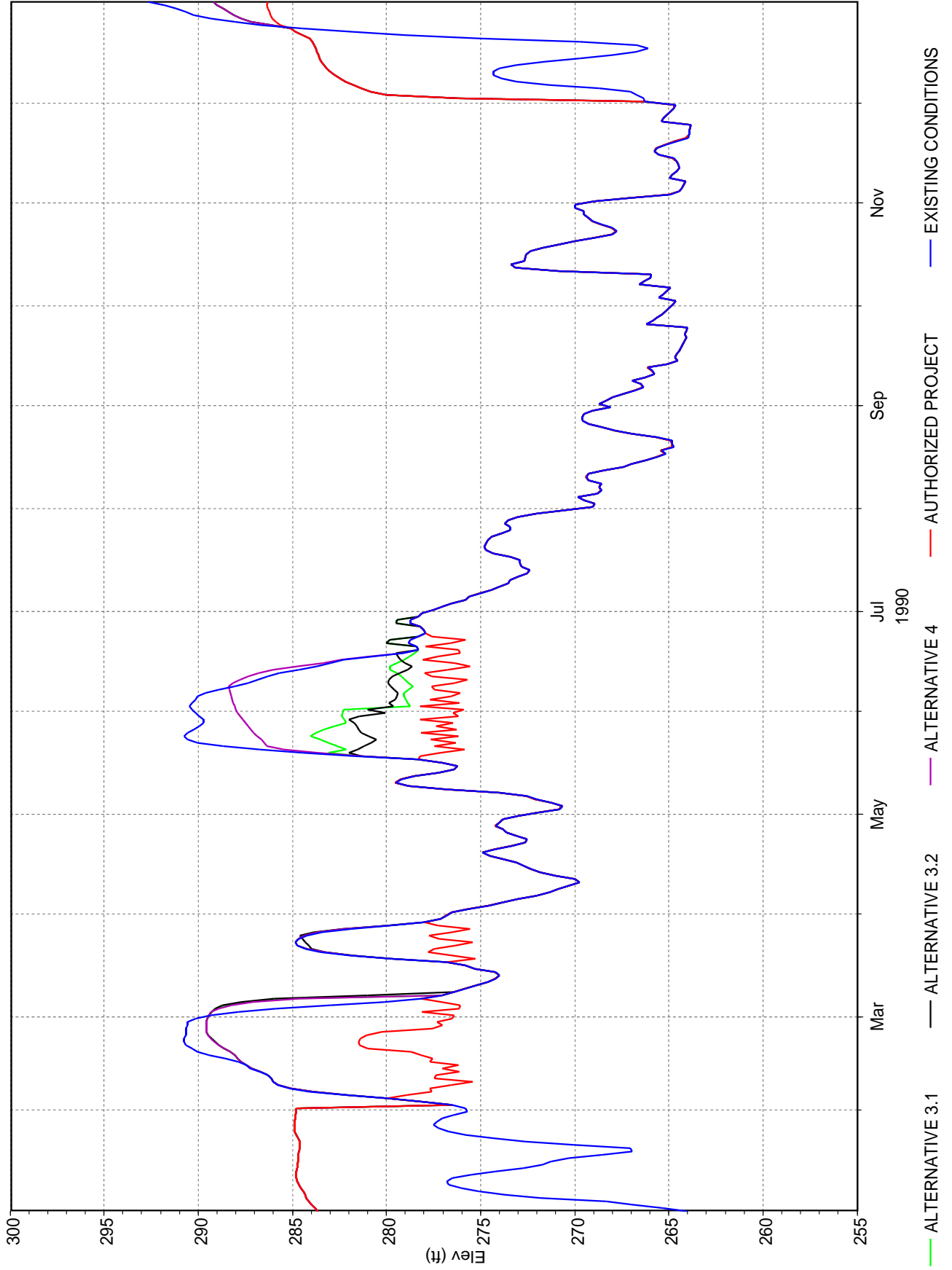
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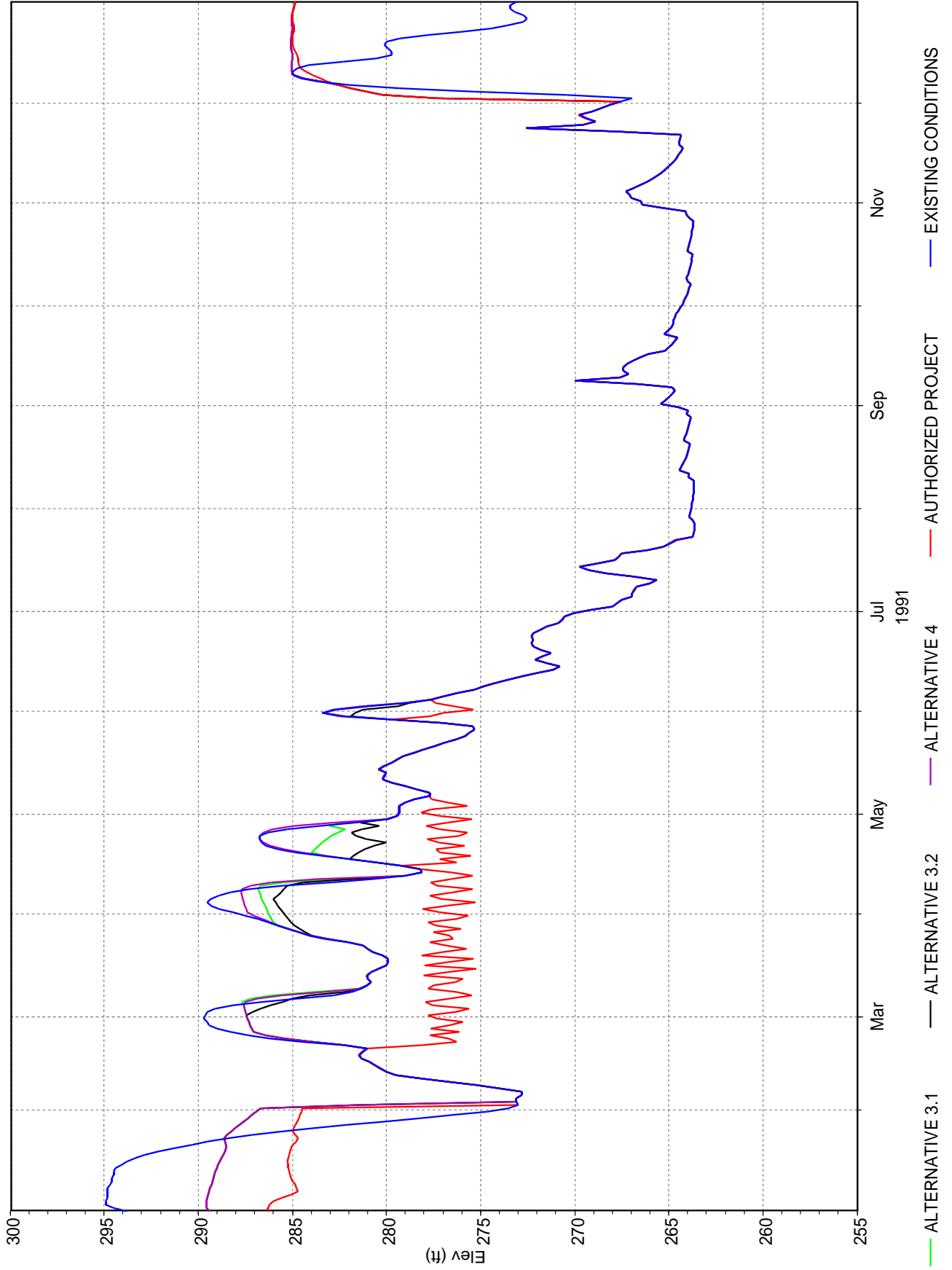
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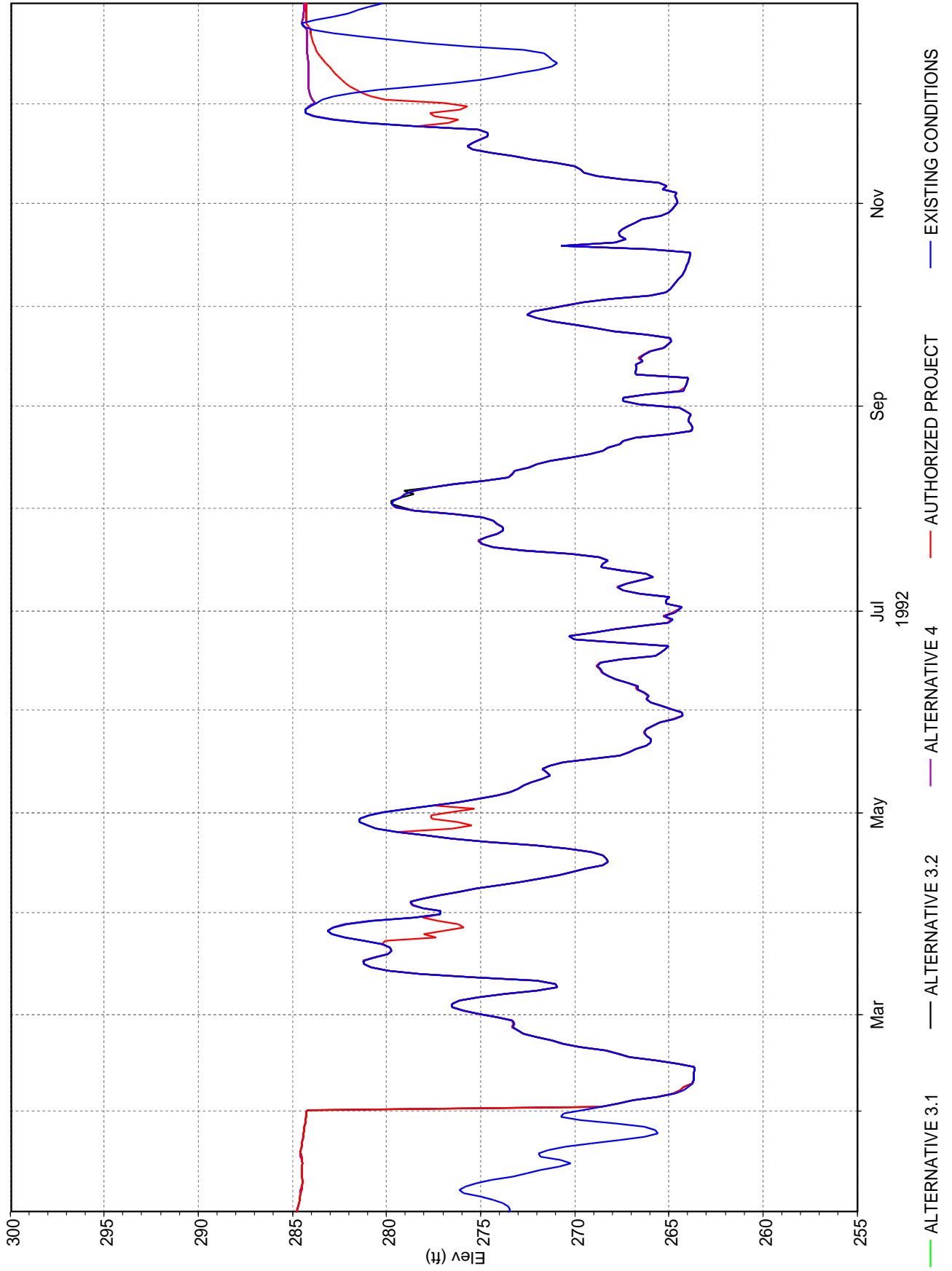
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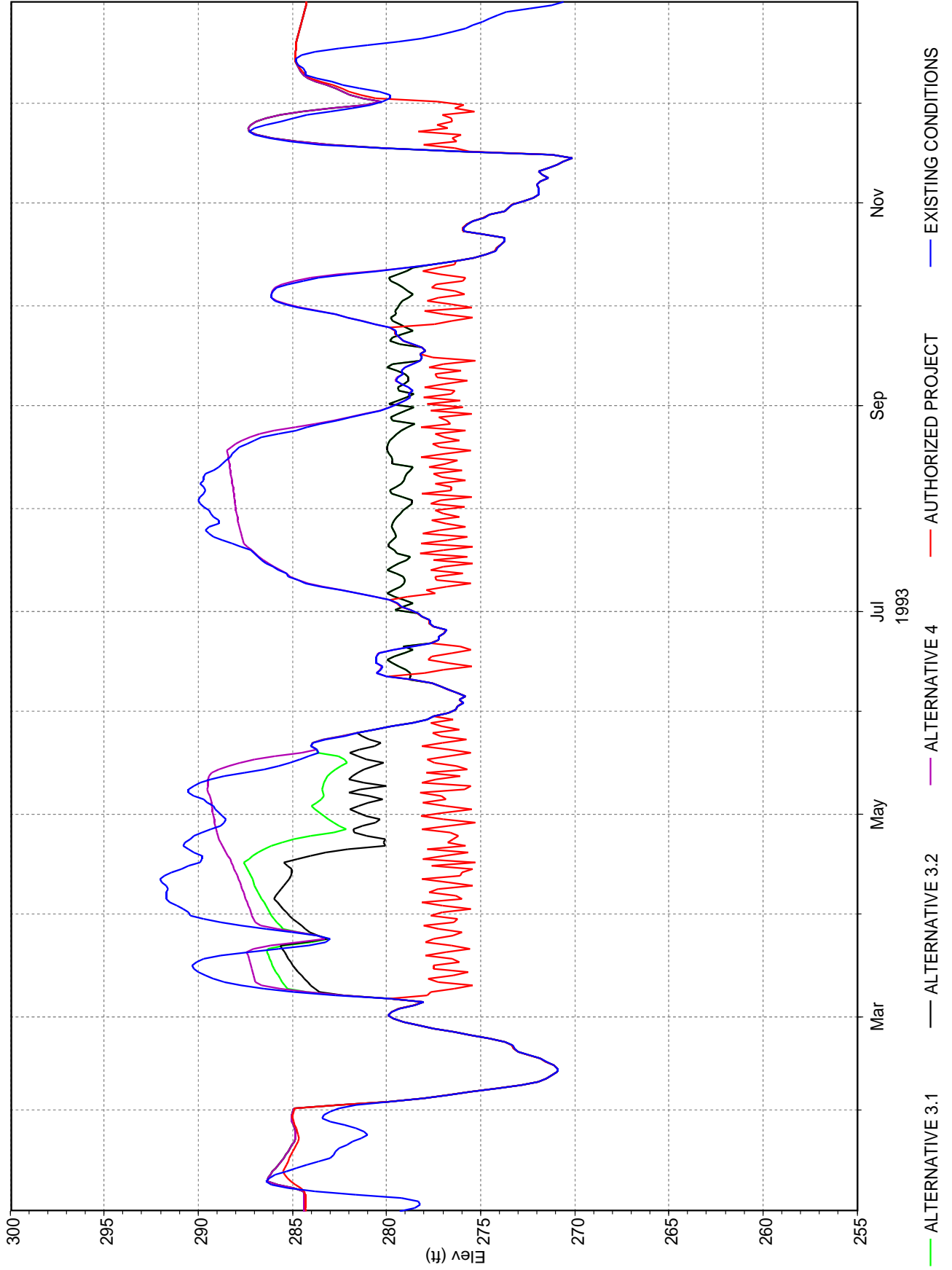
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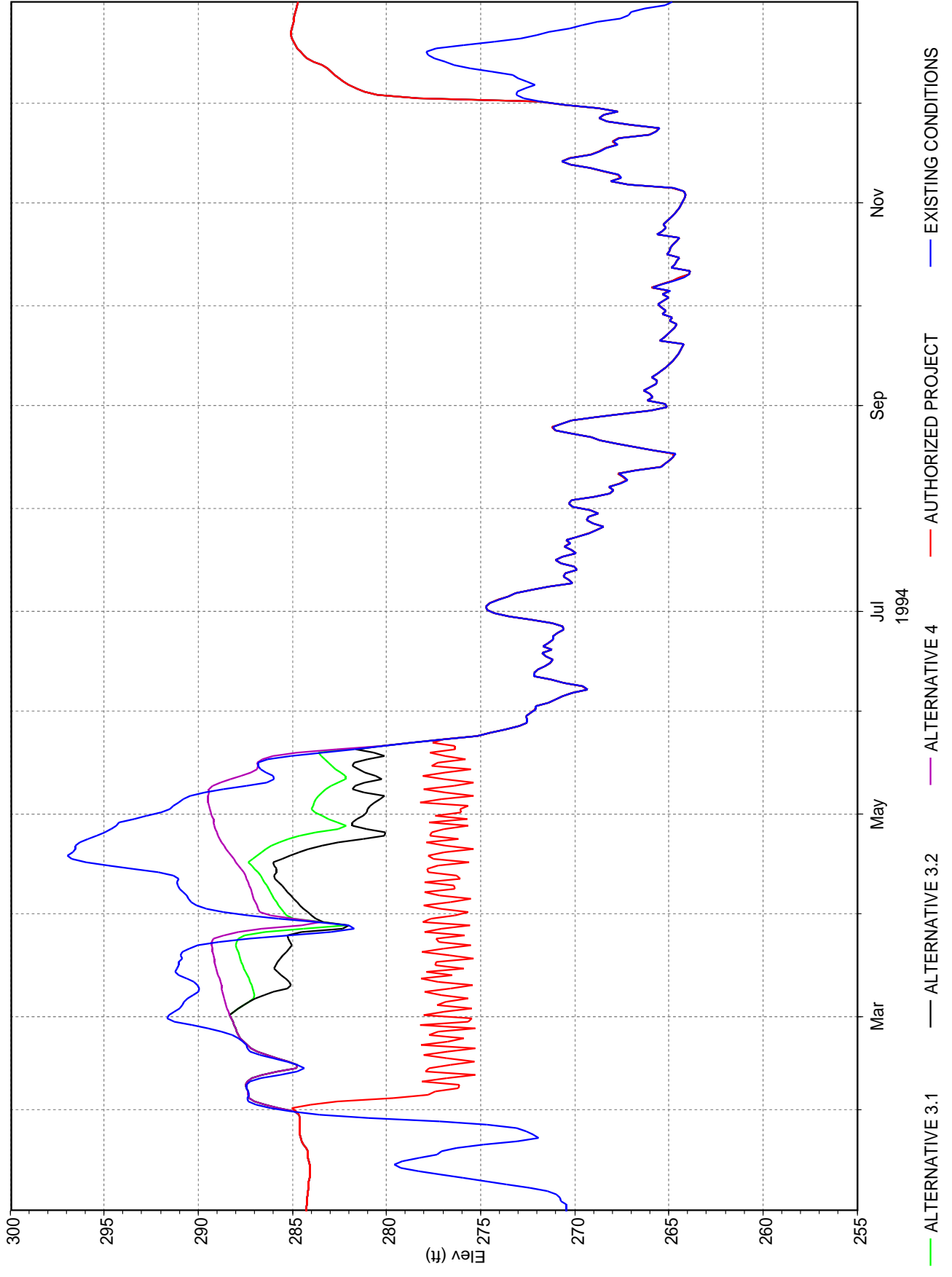
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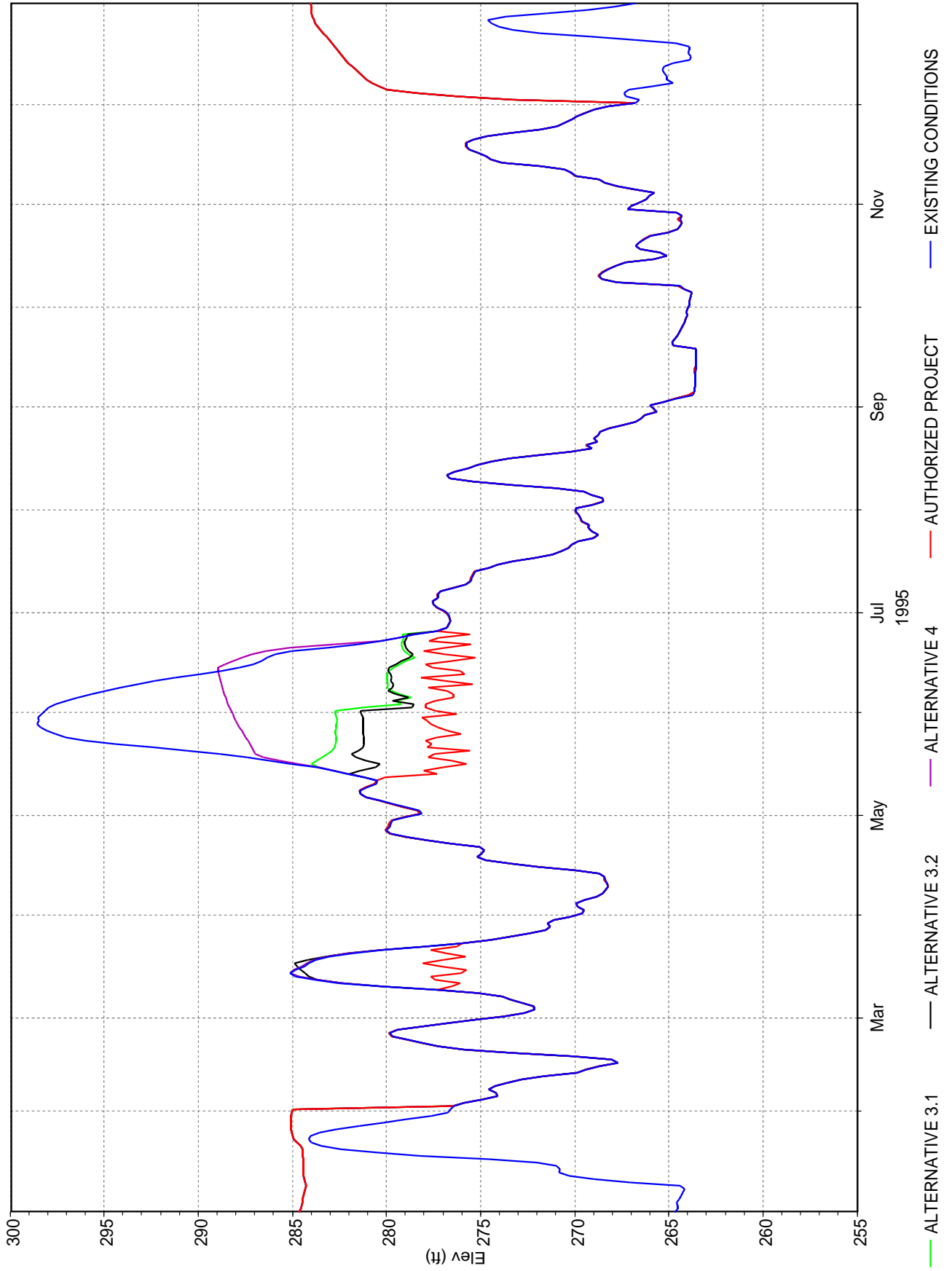
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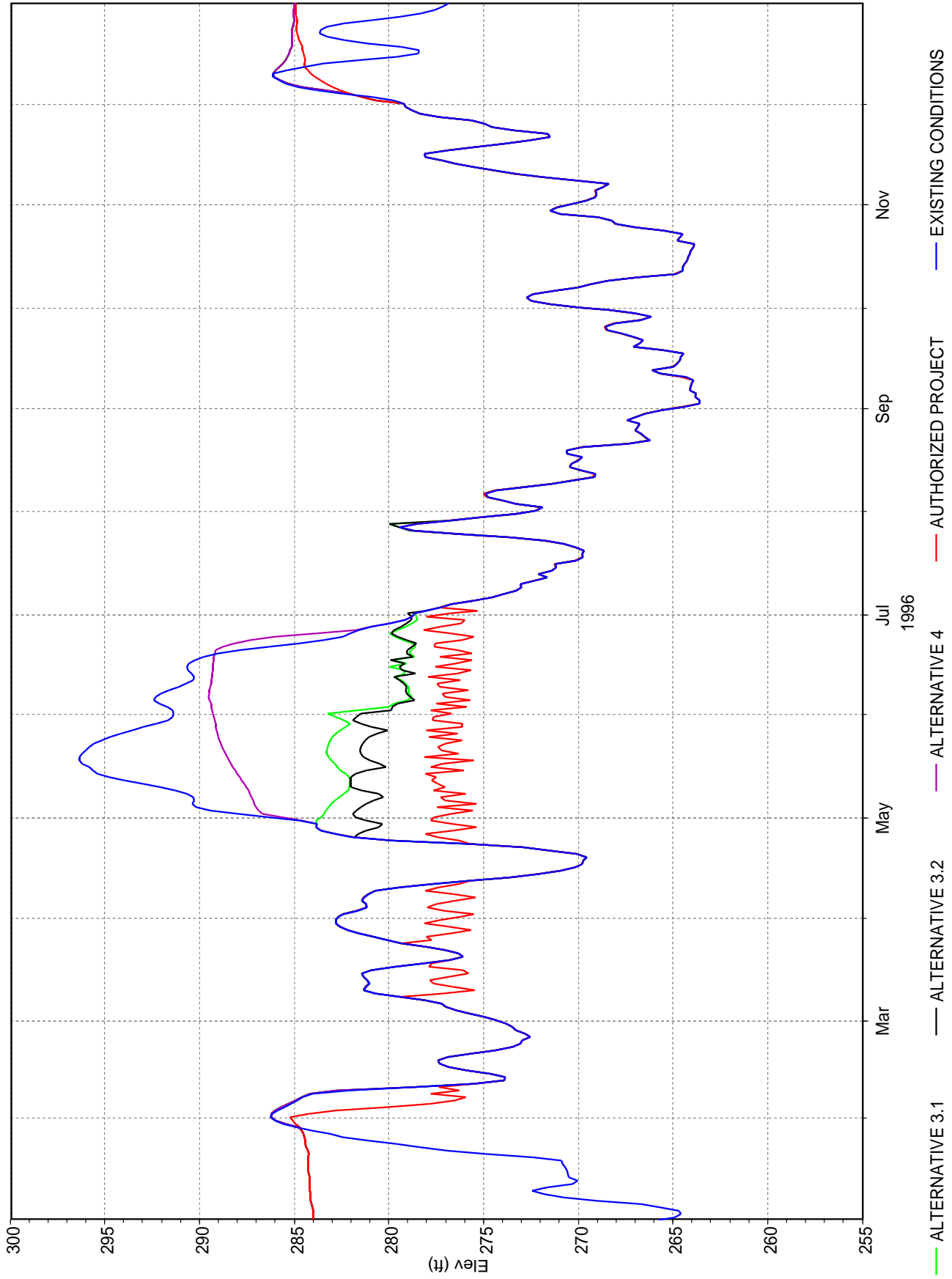
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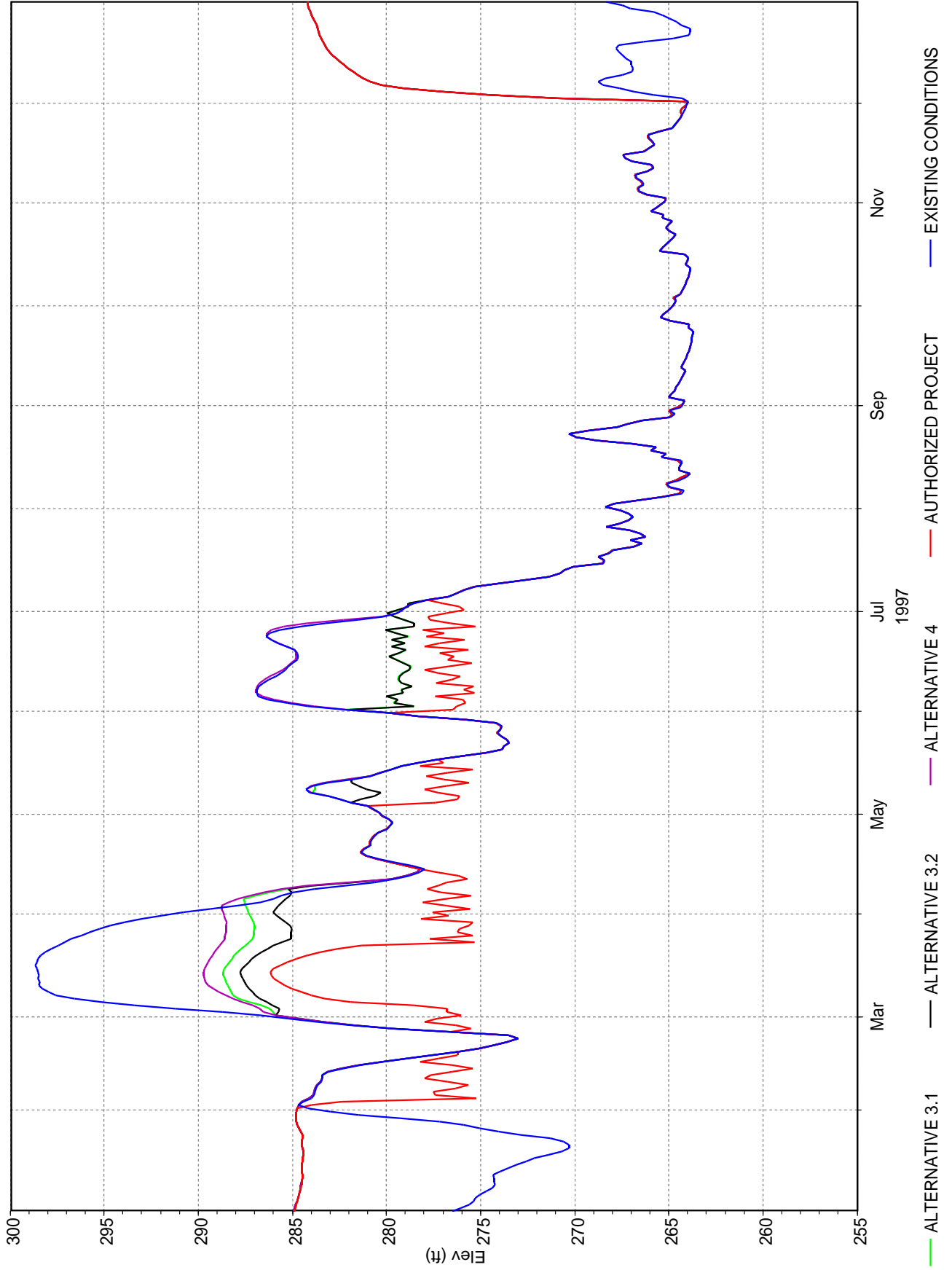
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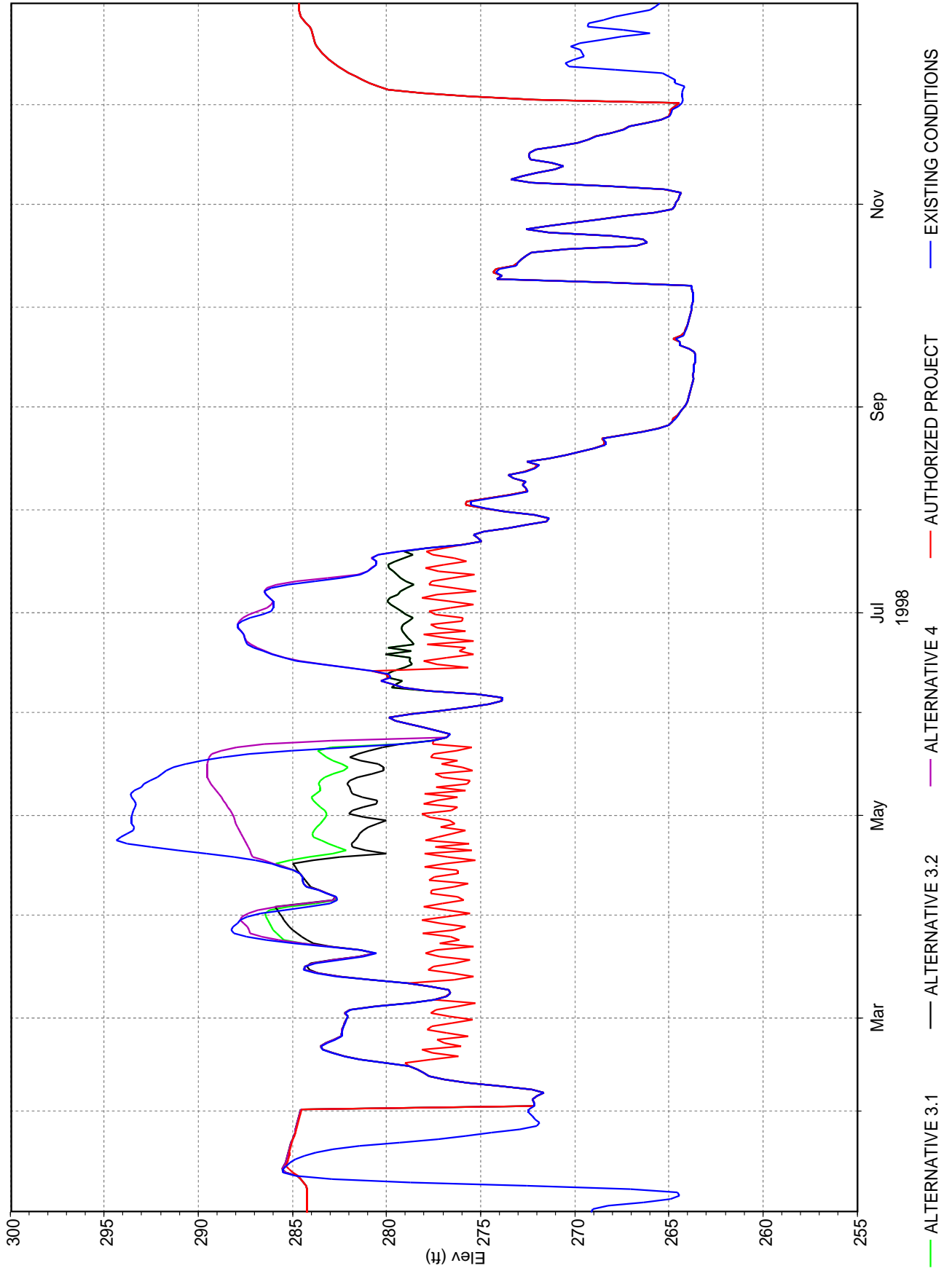
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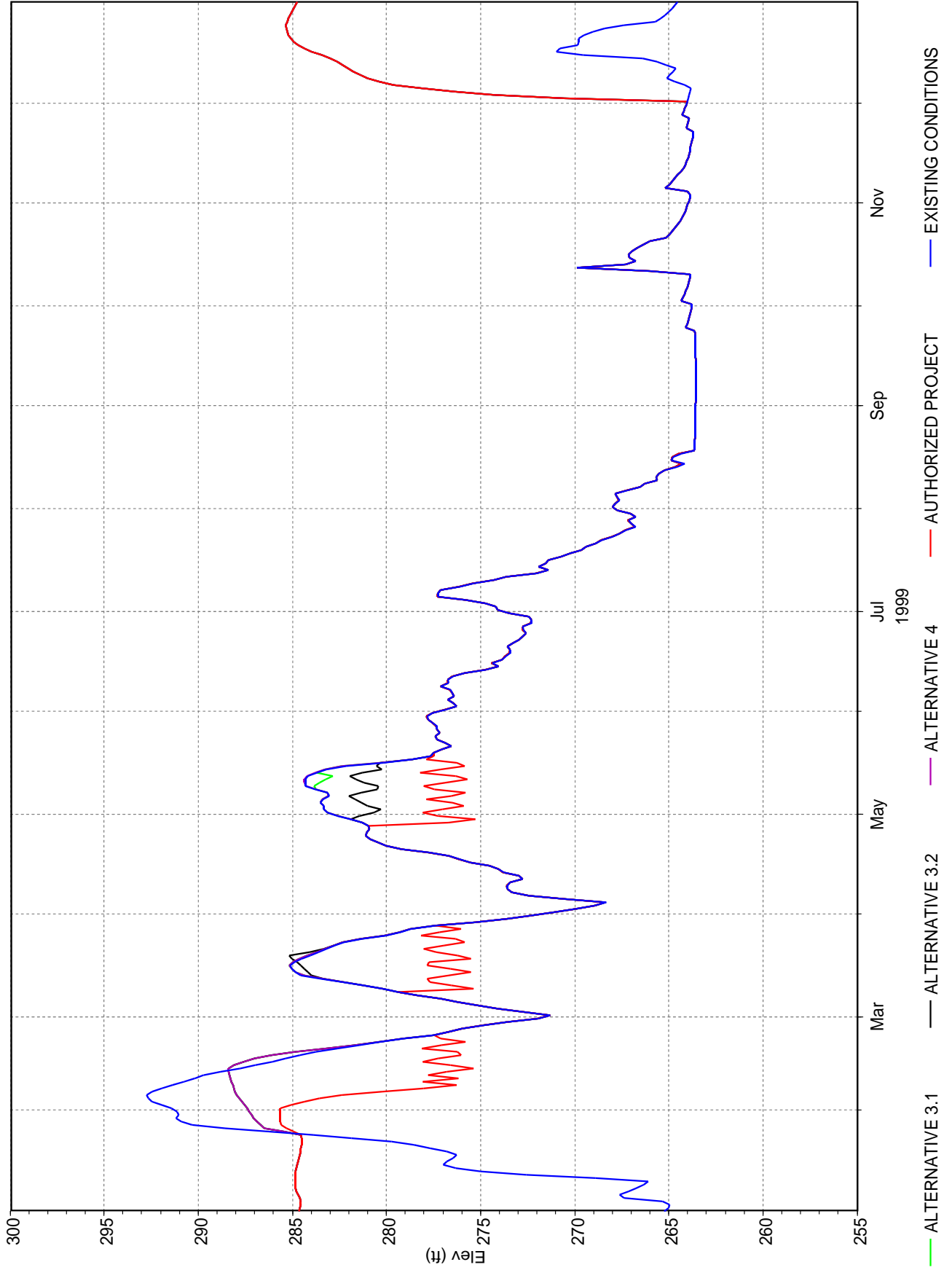
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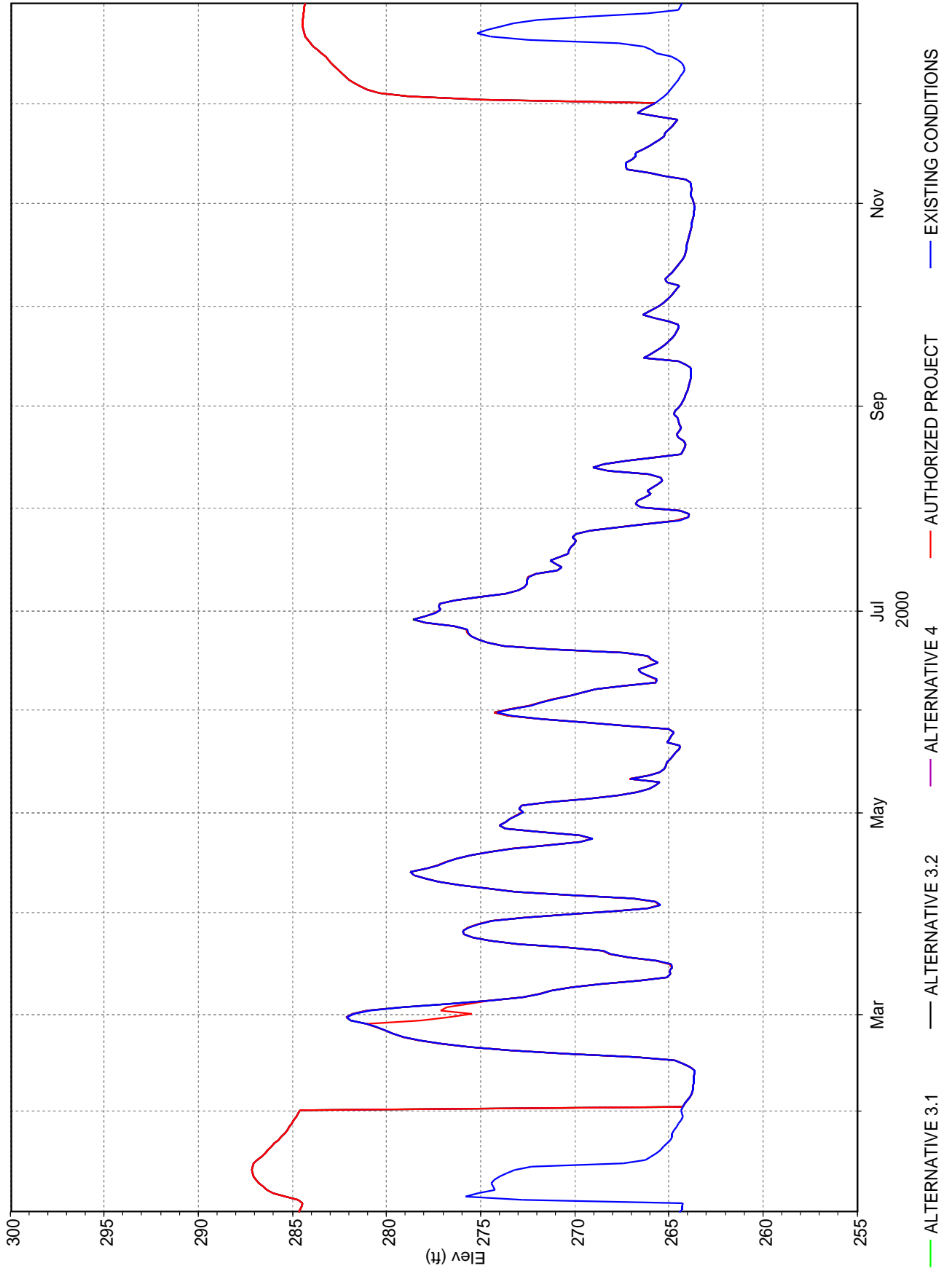
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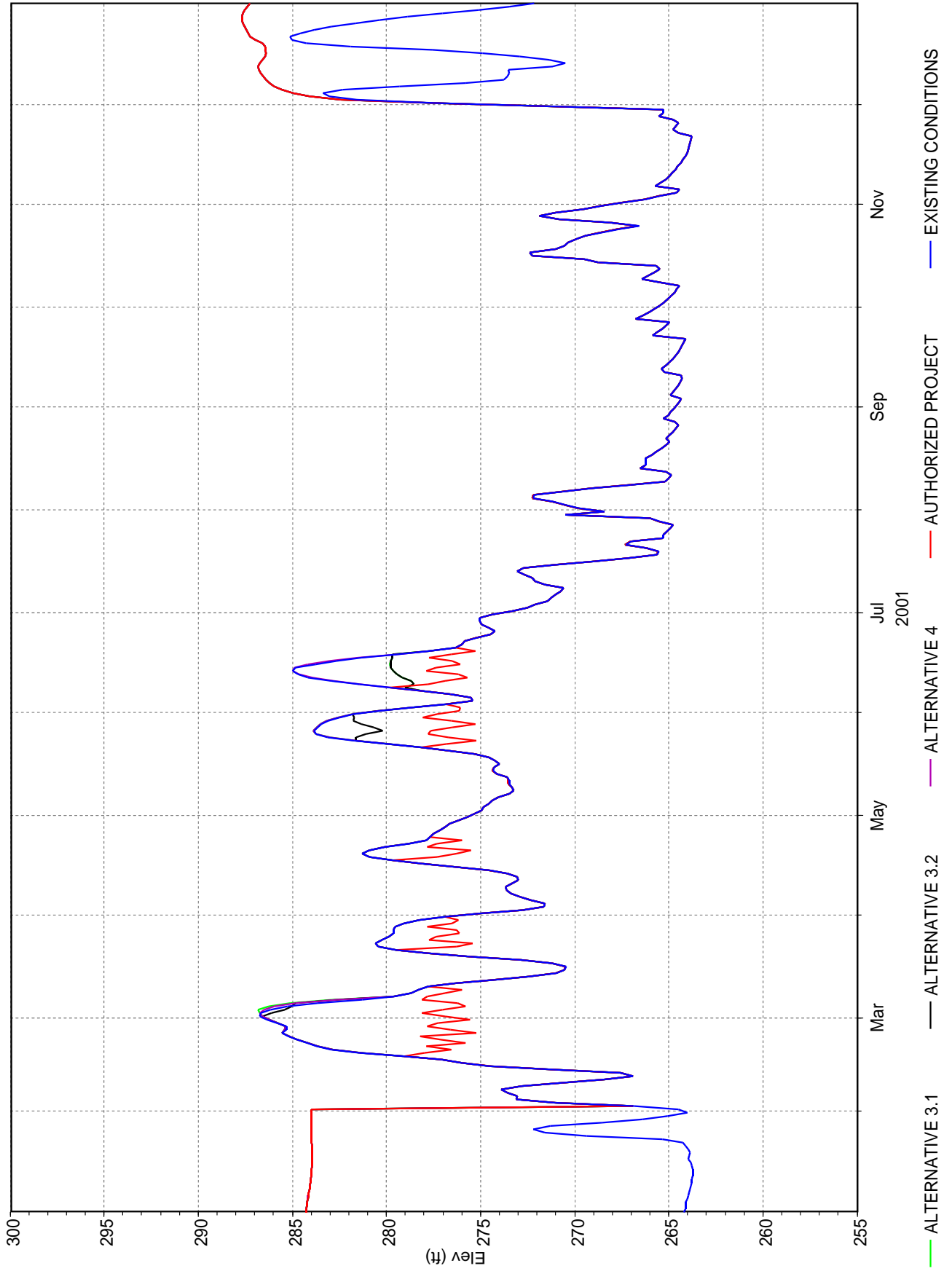
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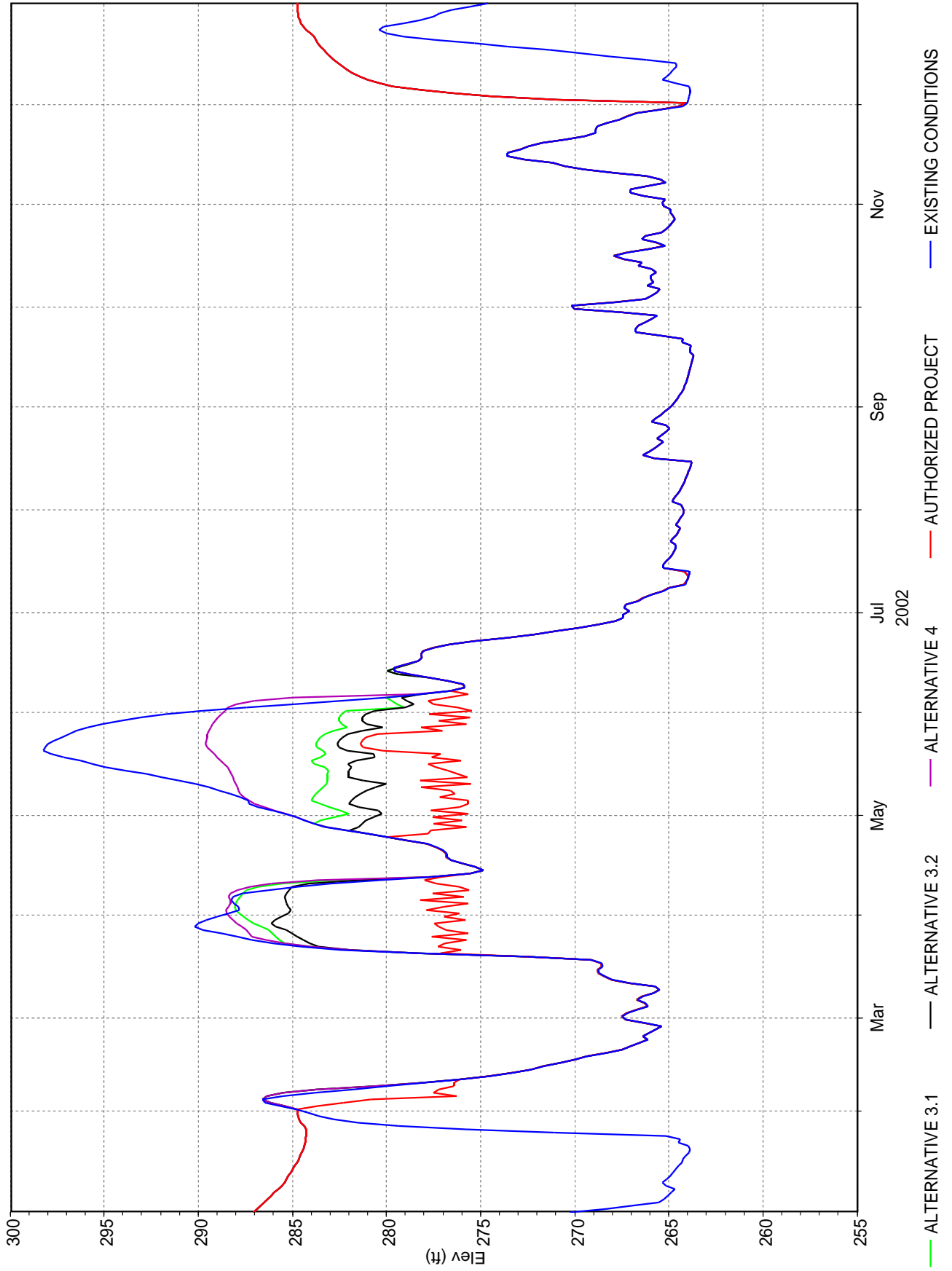
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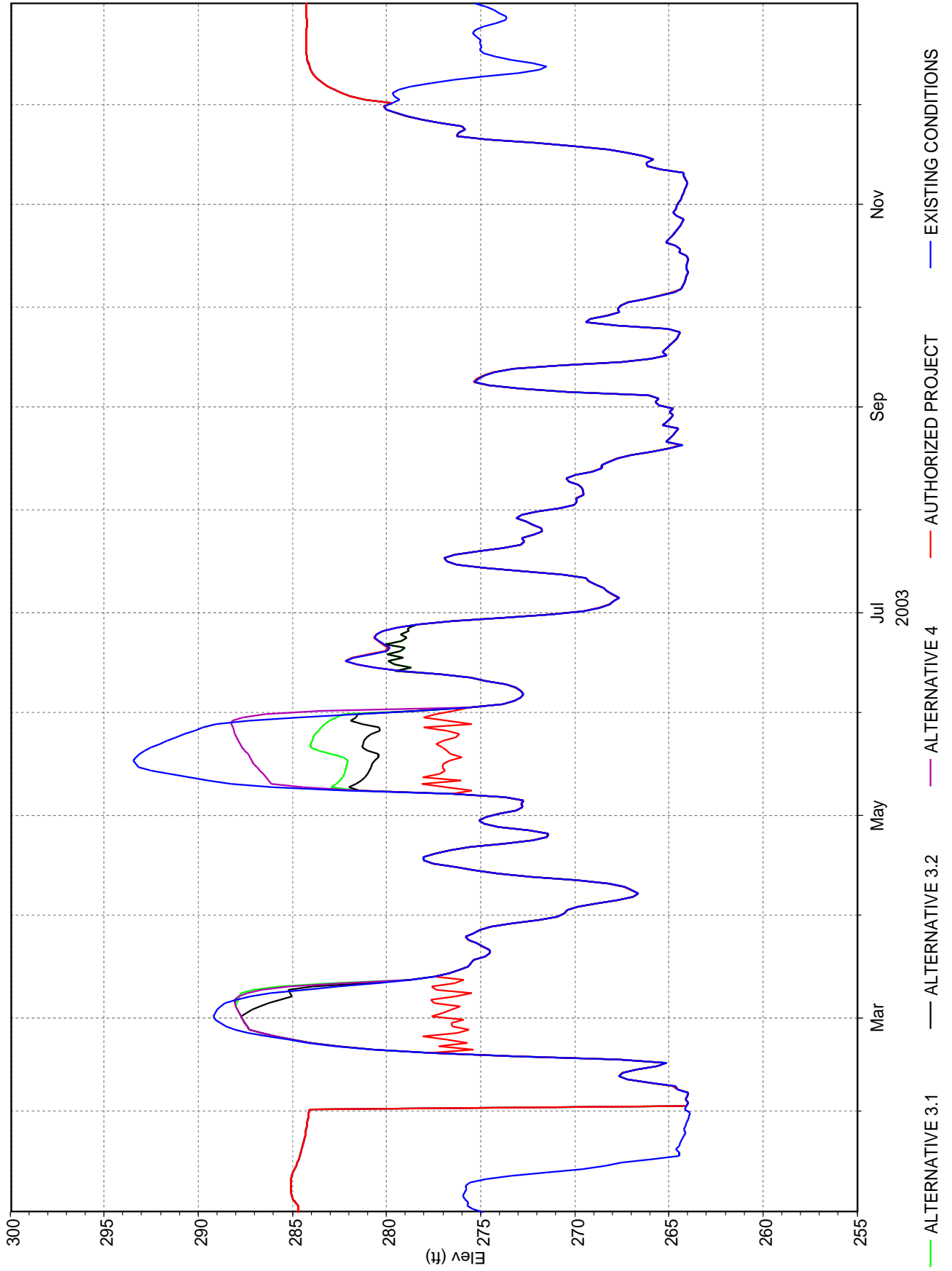
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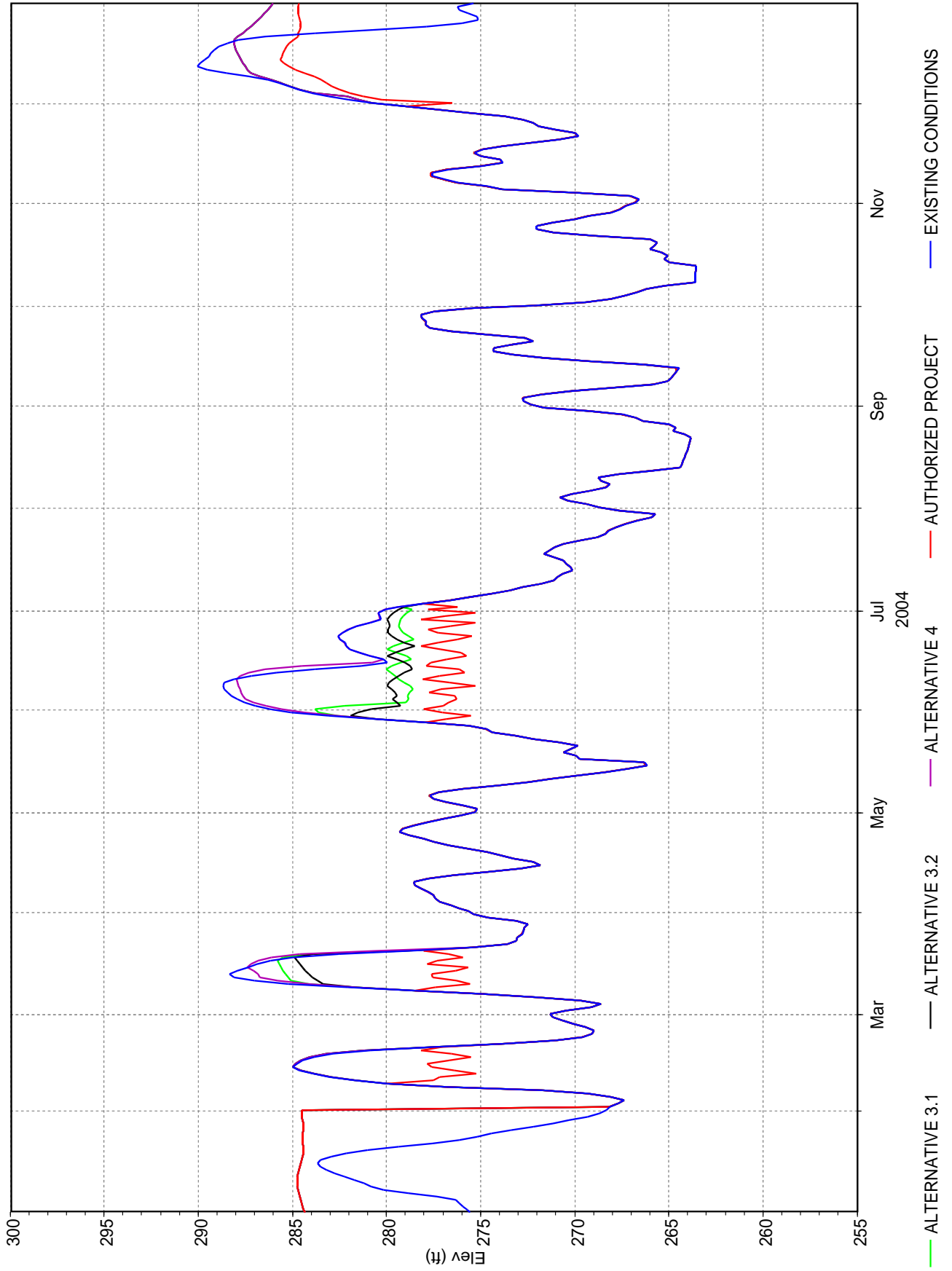
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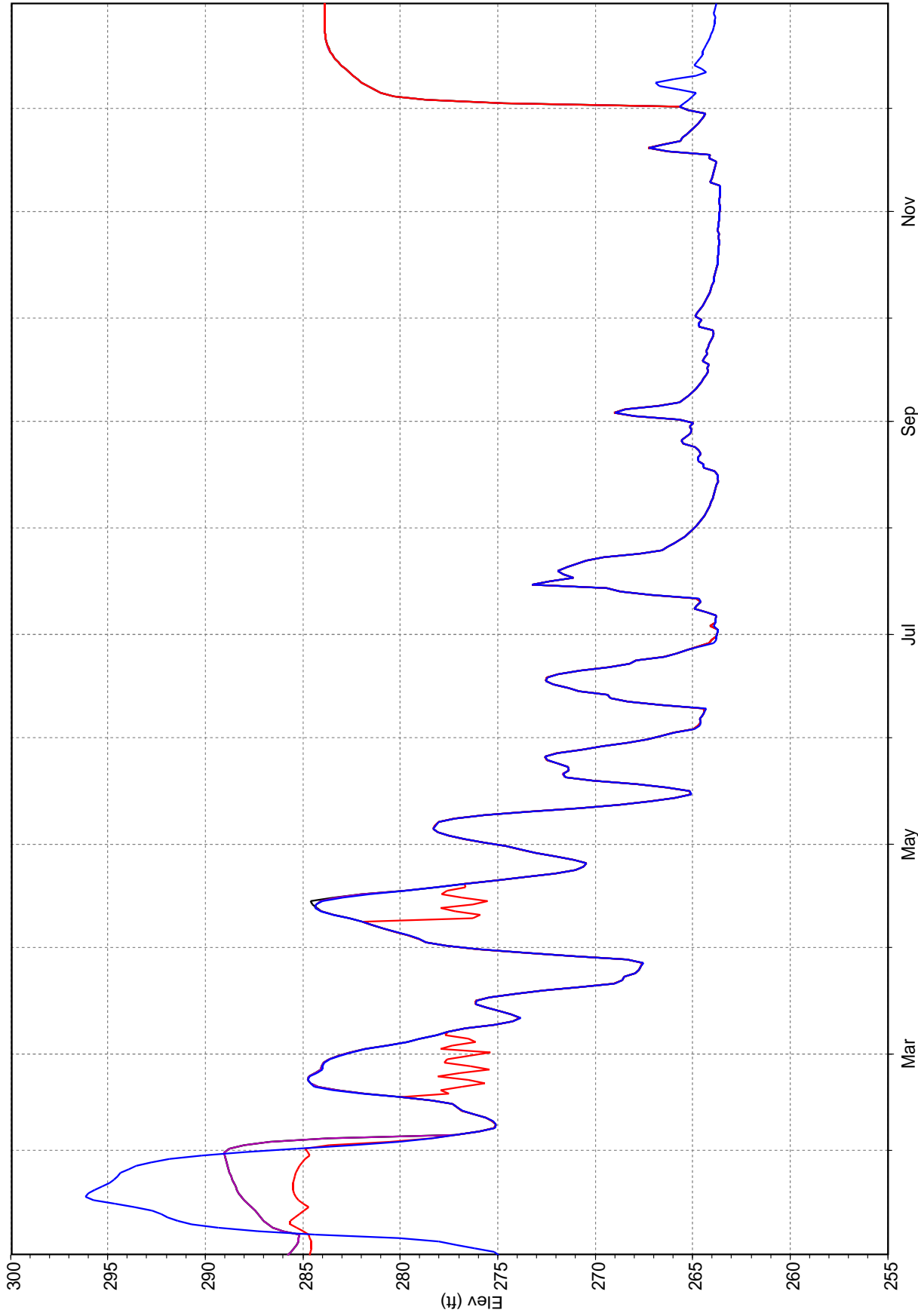
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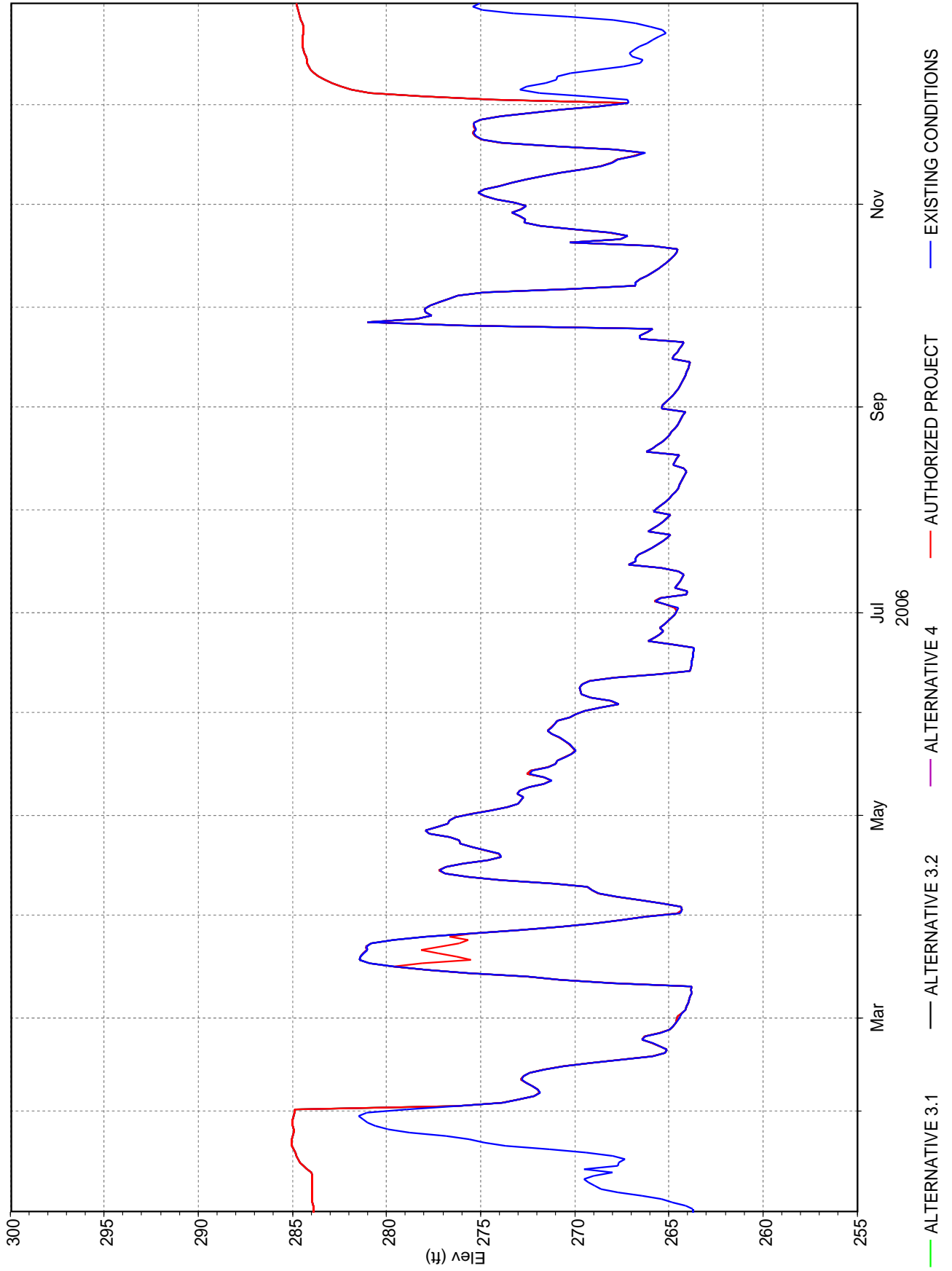


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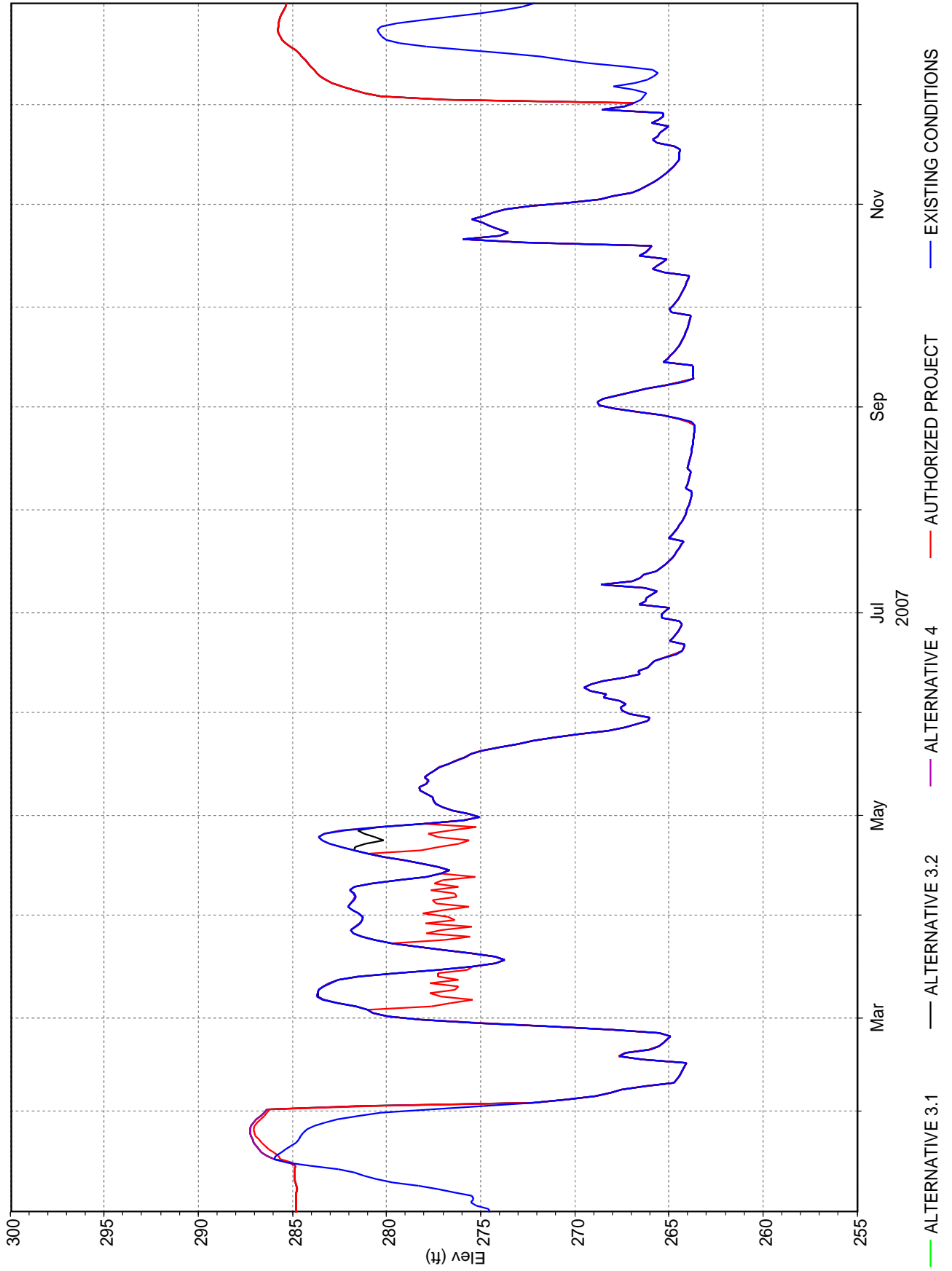


— ALTERNATIVE 3.1 — ALTERNATIVE 3.2 — ALTERNATIVE 4 — AUTHORIZED PROJECT — EXISTING CONDITIONS

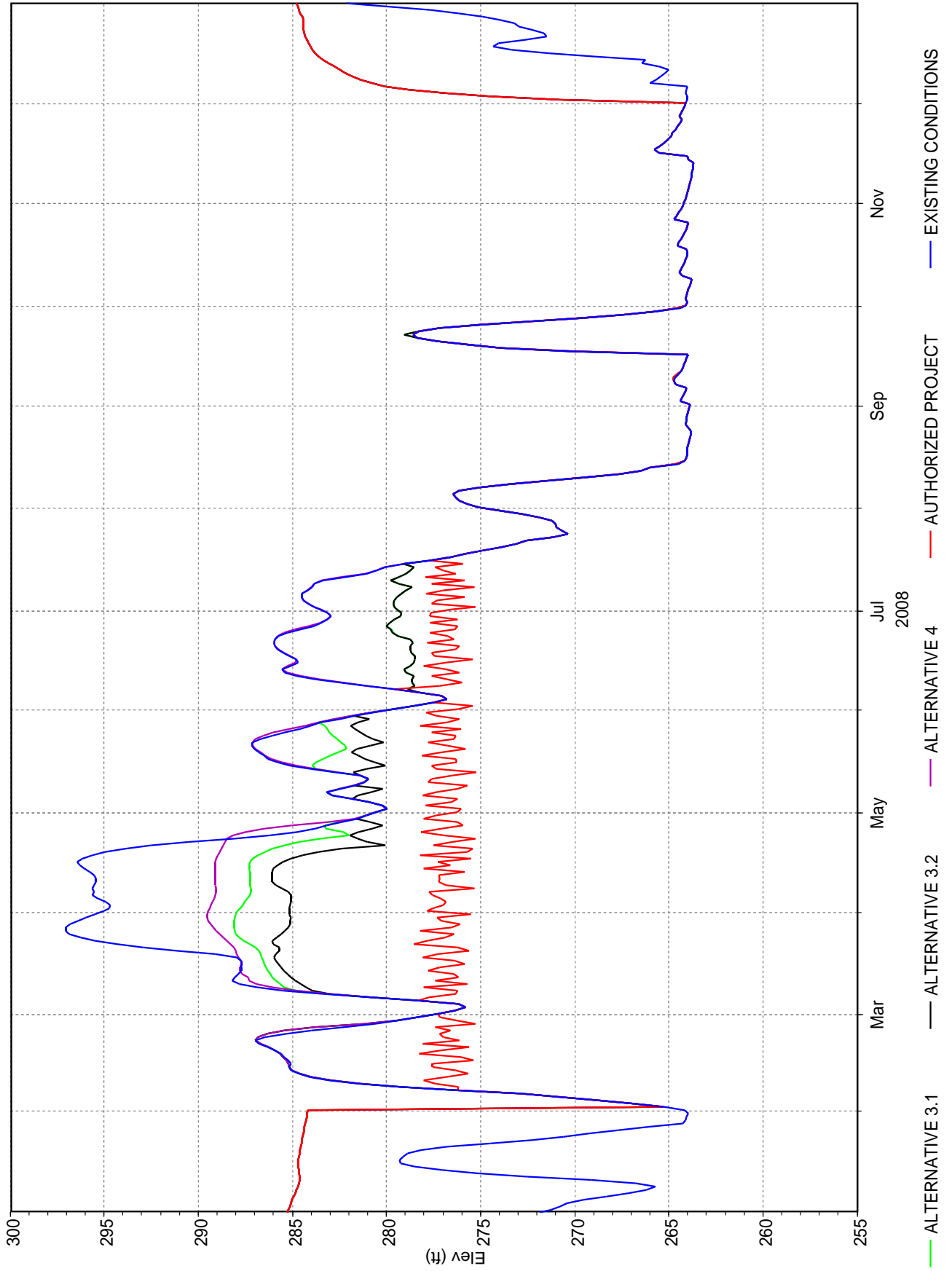
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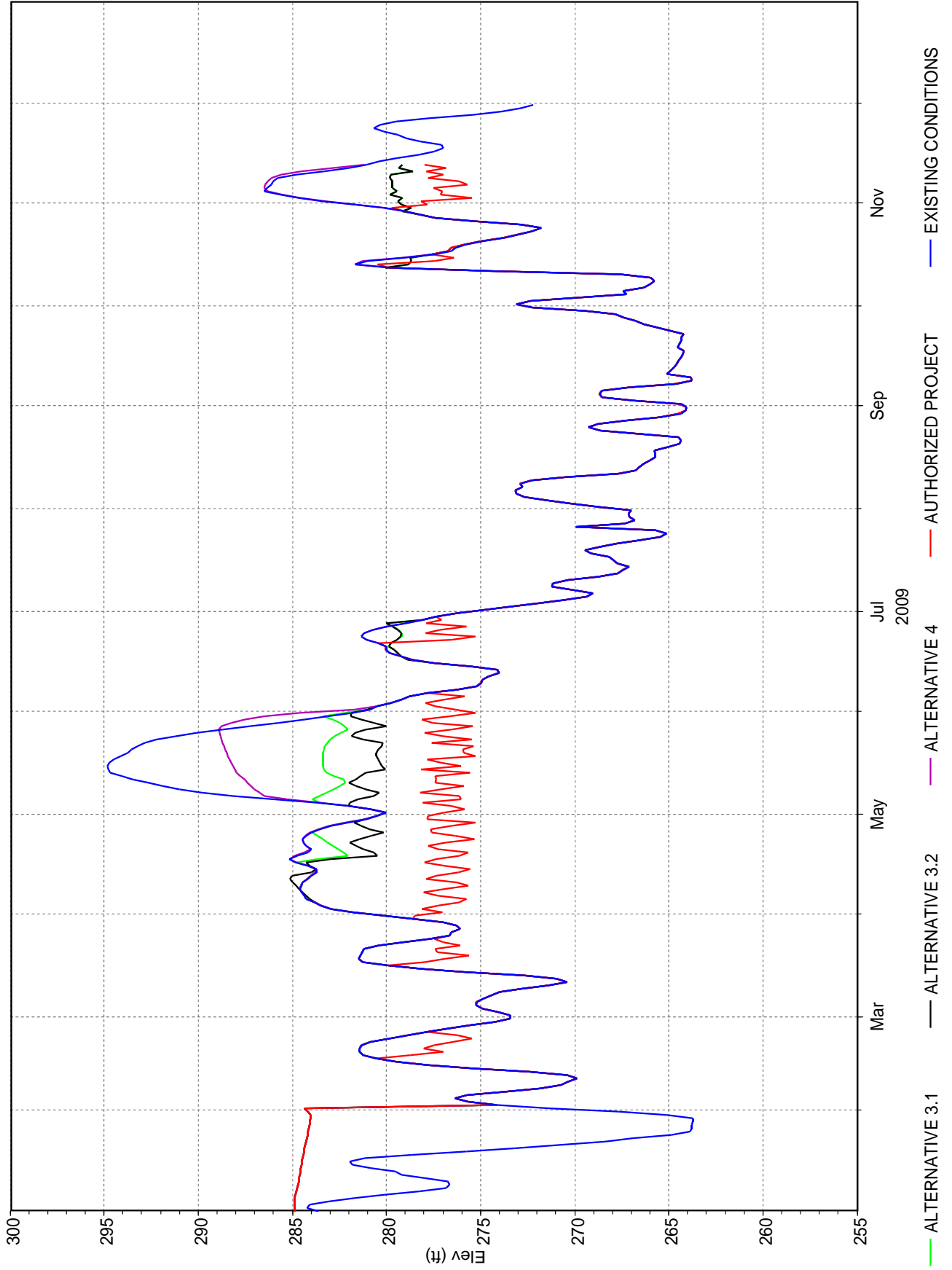
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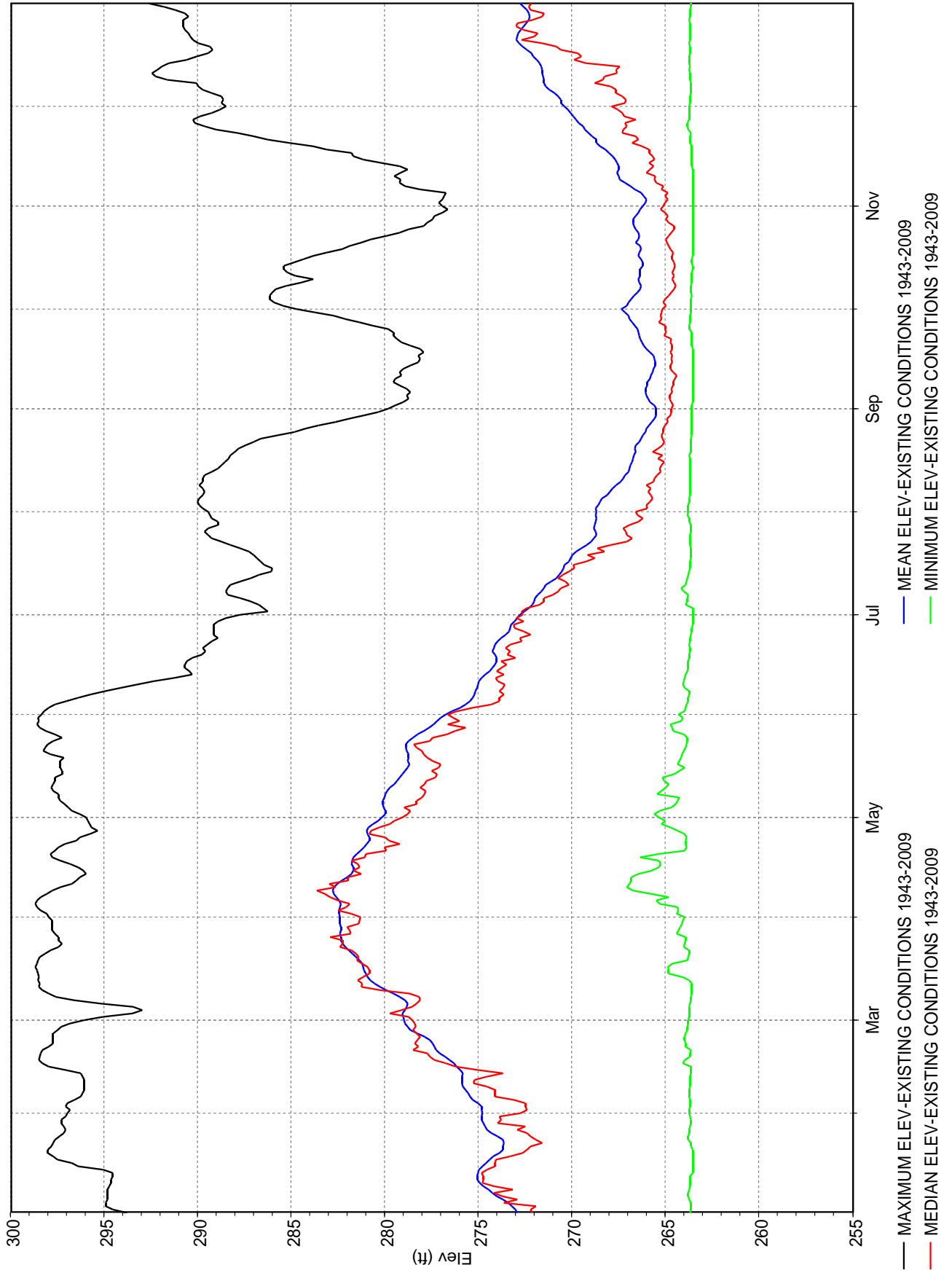
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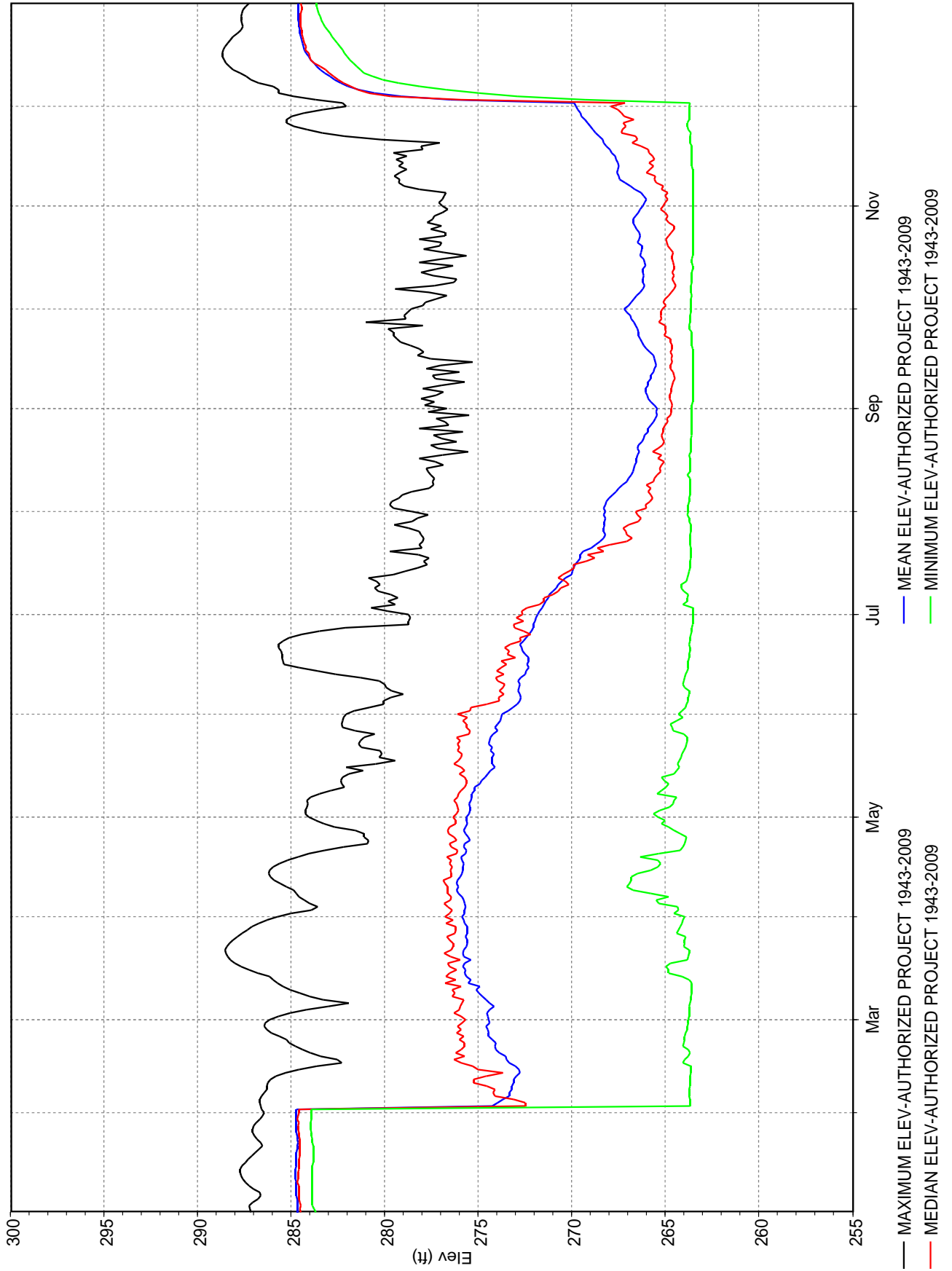
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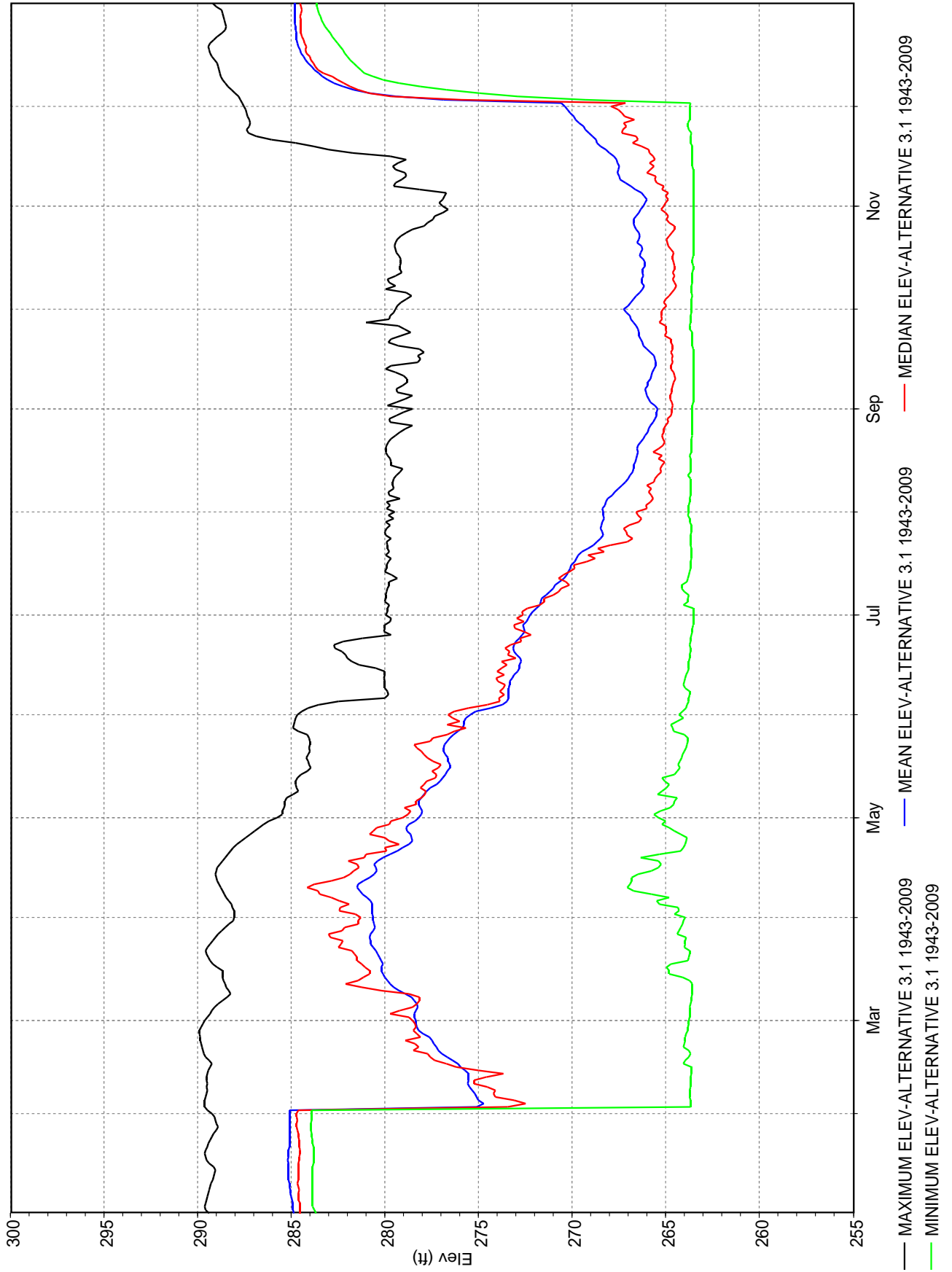
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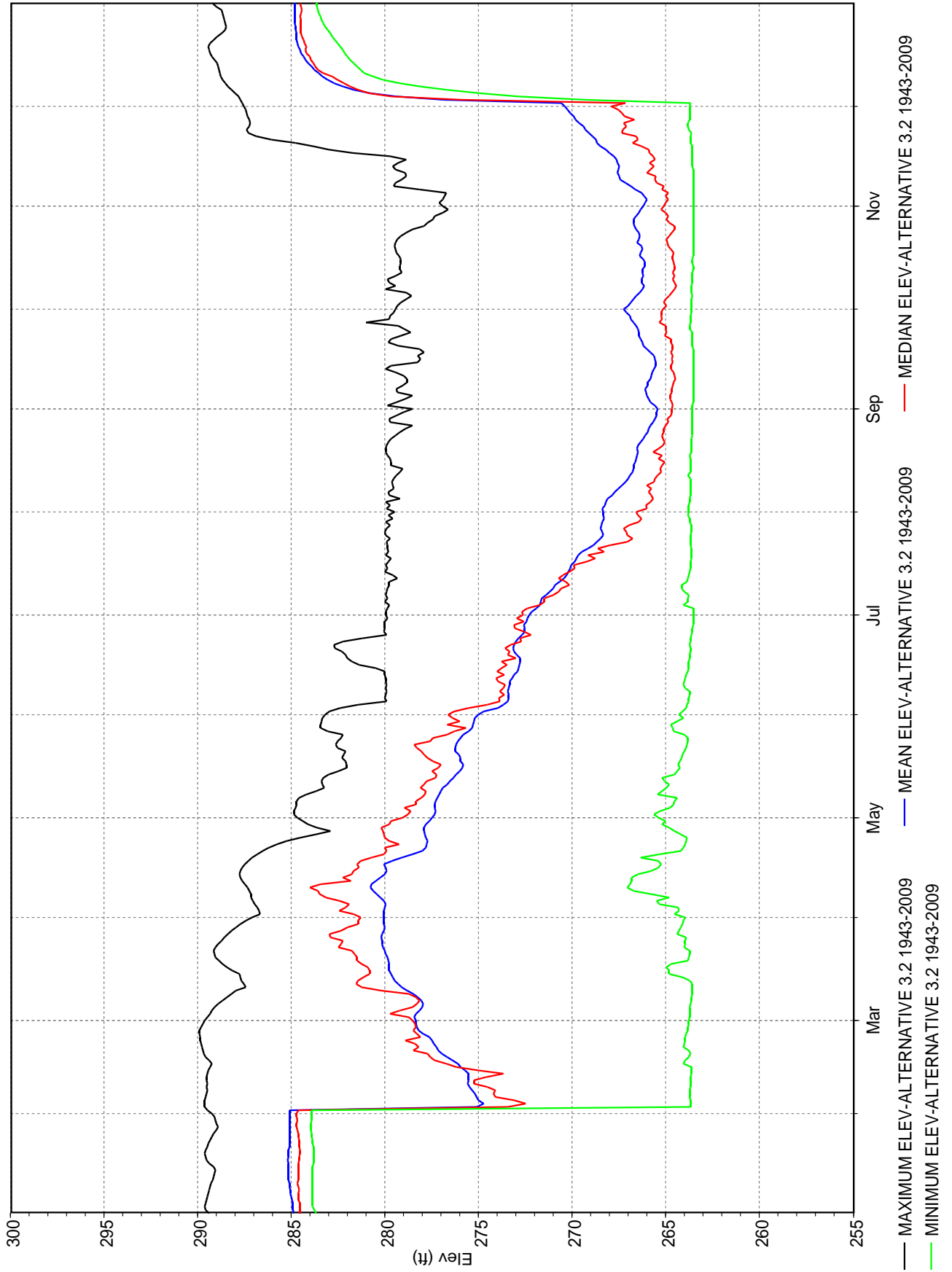
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