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WIPP
Subsidence Monument
Leveling Survey
2023

February 19, 2025

Waste Isolation Pilot Plant

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List of Acronyms

CFR	Code of Federal Regulations
DOE	Department of Energy
DOY	Day of year
FGCS	Federal Geodetic Control Subcommittee
NGS	National Geodetic Survey
SIMCO	Salado Isolation Mining Contractors
WIPP	Waste Isolation Pilot Plant
WP	WIPP Procedure

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1. Introduction

Subsidence monitoring was chosen by DOE as a long-term monitoring tool because it effectively meets the requirements in 40 CFR Part 191.14(b), Assurance Requirements. Subsidence monitoring is conducted to detect substantial and detrimental deviations from expected repository performance by comparing measured subsidence to predicted subsidence.

Subsidence surveys are performed annually throughout the operational period. After closure of the repository, subsidence surveys will be performed at 10-year intervals for 100 years or until no further useful information may be obtained through continued monitoring.

Salado Isolation Mining Contractors Mine Engineering group performs the annual subsidence leveling survey. The WIPP science advisor, Sandia National Laboratories, analyzes the subsidence data to evaluate the repository performance.

Sections 2 through 7 of this report summarize the result of the 2023 subsidence leveling survey at the WIPP site. Approximately 23 miles of leveling was completed through 14 vertical control loops which include five new loops and 29 new monuments installed in 2023. The 2023 survey includes the elevation for 76 of 77 subsidence monuments and the WIPP baseline survey, and 14 of the NGS's vertical control points. Construction activities prevented one monument from being included in this year's survey and report. The leveling surveys were completed between August 2023 and February 2024 by the SIMCO's Mine Engineering.

Digital leveling techniques are utilized to achieve better than Second Order Class II loop closures, as outlined by the FGCS 2004. WIPP Procedure (WP) 09-ES4001, Subsidence Survey Data Acquisition Report, is used to perform the subsidence survey.

Beginning with the survey of the year 2001, Loop 1 and redundant survey connections among the various loops were removed from the survey and report. The redundant connections were used to spot gross errors in the field. After several years of surveying these loops, it was evident that no gross errors occur that are not also evident in the loop closures.

Section 8, Comparison of Elevations, contains Table F, Comparison of Elevations 1987-2023, which summarizes the elevations for all surveys from 1987 through 2023. A detailed listing of the 1986 through 1997 surveys is contained in the report DOE/WIPP 98-2293, WIPP Subsidence Monument Leveling Surveys 1986-1997. A reference to the summary reports for each year after 1997 is listed in the reference section of this document.

2. Equipment

The observations were taken with the Leica LS15 Digital Level (Serial # 707592) manufactured by Leica, and bar-coded leveling staffs. The calibration for the Digital Level is sent to Leica for servicing every two years and is based on Leica's defined procedures. The calibration is valid from June 2023 through June 2025 and the certificate is available upon request. The data were recorded on the digital level's internal memory. In addition to the electronic record, a written field log was maintained to record information not stored in the electronic record.

3. Office Processing

The data were transferred from the digital level's internal memory to the survey group computer. The original raw data files remained intact while further processing was performed on a copy of the original raw data file. The data from each of the leveling loops was processed with Leica Infinity software. The results, as summarized below, were extracted from the Level Summary reports for each loop. The Leica Infinity software was tested, verified, and validated in accordance with WP 16-2 and is in the WIPP controlled software list. The software output was then compared to hand calculation and documented on EA16-2-3-0 for each computation used to perform the leveling data processing.

4. Methodology

The subsidence survey is divided into fourteen loops. Each loop generally takes one day to complete. This allows a loop to be completed in one surveying session and results in a lower probability of error.

The leveling surveys began on August 3, 2023, were completed on February 15, 2024. The weather conditions on days that the leveling surveys were performed were generally mild with moderate temperatures and light to moderate breezes.

The elevations for the 2023 survey are computed from the adjusted observations based on the elevation of the subsidence monument, S-37 (3,423.874 feet). Originally, S-37 was the WIPP monument furthest from the influence of the underground excavations. S-37 has been held fixed for all the subsidence leveling surveys since 1993. The condition of the individual monuments was substantially the same as the previous subsidence survey. However, the condition of monument PT-10 could not be determined due to construction activity.

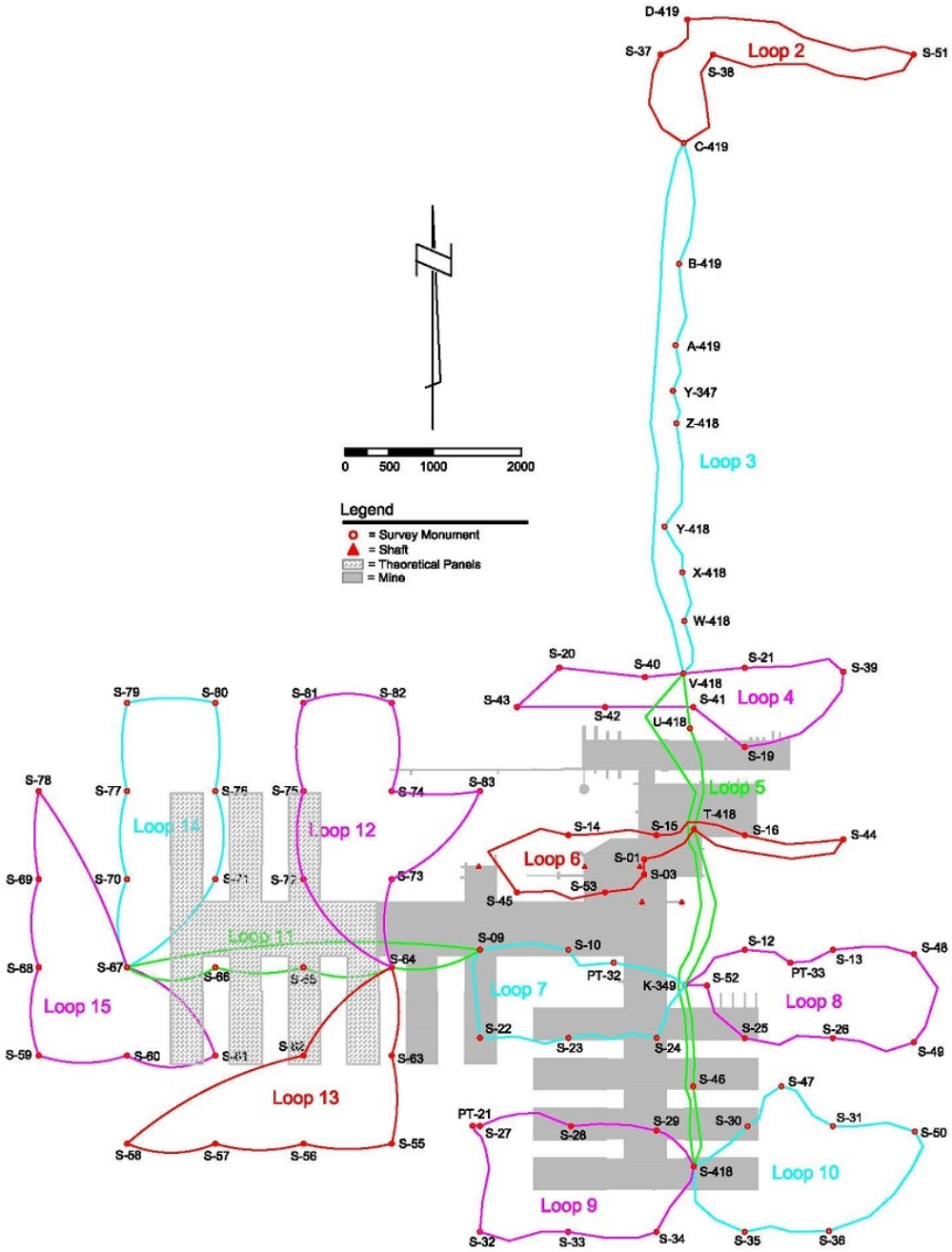
In the 2004 survey, it was noted that the brass cap of monument PT-31 came loose, making it unusable. Monument PT-31 was not replaced because it was a triangulation station and was positioned about 1,000 feet west of the bounds of the subsidence grid.

Monuments S-17 and S-18 no longer exist due to construction of the new salt storage/disposal pad. These monuments cannot be replaced due to the active storage/disposal of salt from mining operations on the new pad. The salt disposal/storage pads are bound on the south by monuments S-14 and S-15 and bound on the north by monuments S-42 and S-43.

Twenty-nine new subsidence monuments, S-55 through S-83, were installed during the months of September and October 2023. The new monuments extend the subsidence grid over the location of planned and possible disposal panels.

For visual reference, Figure 1 is a graphic display of the individual loops, the total survey, and the relationship to the underground excavations.

Figure 1. Individual Loops, Total Survey and Underground Excavations



5. General Summary of Results

Table A below describes the fourteen leveling loops that were measured to obtain the elevations of the subsidence monuments. The table contains the start date of the observations, a loop number, and the points that are contained within the loop. Due to construction east of the site, the fourteen loops were not surveyed in normal acquisitional order.

Table A. Description of 2023 Leveling Loops

Start Date (DOY)	Loop	Monuments
August 3, 2023 (215)	2	D-419, S-37, C-419, S-38, S-51, D-419
August 9, 2023 (221)	3	C-419, B-419, A-419, Y-347, Z-418, Y-418, X-418 W-418, V-418, C-419
January 18, 2024 (018)	4	V-418, S-21, S-39, S-19, S-41, S-42, S-43, S-20, S-40 V-418
August 15, 2023 (227)	5	V-418, U-418, T-418, K-349, S-46, S-418, V-418
August 23, 2023 (235)	6	T-418, S-16, S-44, S-15, S-14, S-45, S-53, S-03, S-01 T-418
December 19, 2023 (353)	7	K-349, S-24, S-23, S-22, S-09, S-10, PT-32, K-349
August 29, 2023 (241)	8	K-349, S-52, S-25, S-26, S-49, S-48, S-13, PT-33, S-12 K-349
September 27, 2023 (270)	9	S-418, S-29, S-28, S-27, PT-21, S-32, S-33, S-34, S-418
October 3, 2023 (276)	10	S-418, S-35, S-36, S-50, S-31, S-47, S-30, S-418
October 16, 2023 (289)	11	S-09, S-64, S-65, S-66, S-67, S-09
February 5, 2024 (036)	12	S-64, S-73, S-83, S-74, S-82, S-81, S-75, S-72, S-64
February 6, 2024 (037)	13	S-64, S-62, S-58, S-57, S-56, S-55, S-63, S-64
February 13, 2024 (044)	14	S-67, S-70, S-77, S-79, S-80, S-76, S-71, S-67
February 15, 2024 (046)	15	S-67, S-60, S-61, S-59, S-68, S-69, S-78, S-67

Table B summarizes the results of leveling loops specific to vertical closure and accuracy. The requirement for Second Order Class II loop closure accuracy was achieved in all cases.

Table B. Summary of Distance and Accuracy for 2023 Leveling Loops

Loop	Cumulative Distance (ft.)	Vertical Closure (ft.)	Accuracy (ft. √mile)	Allowable Accuracy (ft. √mile)
2	7,821.71	0.0007	0.001	0.040
3	12,532.19	0.0041	0.003	0.051
4	8,365.48	0.0038	0.003	0.042
5	11,536.19	0.0058	0.004	0.049
6	8,700.09	0.0128	0.010	0.042
7	6,861.08	-0.0022	0.002	0.038
8	7,408.13	-0.0013	0.001	0.039
9	7,678.65	-0.0065	0.005	0.040
10	7,001.54	-0.0063	0.005	0.038
11	8,423.62	-0.0187	0.015	0.042
12	9,437.10	0.0005	<0.001	0.044
13	9,286.74	-0.0134	0.010	0.044
14	8,221.40	0.0013	0.001	0.041
15	10,464.95	-0.0156	0.011	0.046

5.1 Accuracy Summary by Loop

Table C displays a detailed summary of the observations in the leveling loops for the 2023 survey. All results are displayed in feet. The information in the table for each loop includes:

Between each benchmark in the loop:

- The distance leveled between benchmarks along the loop.
- The number of instrument setups between each of the benchmarks.
- The difference in adjusted elevation from each benchmark to the next.

For each loop as a whole:

- The cumulative, or total, distance of each loop.
- The vertical closure of the loop.
- The accuracy of leveling.
- Allowable accuracy for each loop.

The accuracy of the leveling is given in terms of feet times the square root of the length of the loop in miles. The actual accuracy of leveling is computed by hand and is based on the actual vertical closure of the loop. The maximum allowable accuracy is based on the allowable accuracy of a loop as stated in the FGCS specification for digital leveling. The FGCS specification for Second Order Class II loop closure permits a maximum of 8mm$\sqrt{}$km (8mm times the square root of the length of the loop in km). This converts to 0.033 ft.$\sqrt{}$mile (0.033 feet times the square root of the length of the loop in miles) when stated in the US customary units of length. All values indicated in this summary are expressed in feet.

The following tables show that in every case the actual accuracy is well below the maximum allowable accuracy for each loop. The column in each table that is labeled “Elev. Diff.” is the vertical difference from one point to the next. It is important to note that the elevation difference numbers are calculated from the adjusted point elevations and because of rounding, the algebraic sum of the column may not be zero. The adjusted point elevations are the elevations of each monument with the closure error distributed to each set up of the leveling survey to recalculate the point elevations.

Table C. Detailed Loop Measurements

Loop 2				
From	To	Distance	Setups	Elev. Diff.
D-419	S-37	501.98	4	0.609
S-37	C-419	1,228.43	8	13.807
C-419	S-38	1,072.18	6	-7.916
S-38	S-51	2,289.80	14	7.937
S-51	D-419	2,729.32	16	-14.437
Cumulative Distance:		7,821.71		
Vertical Closure:				0.0007
Accuracy of Leveling:				0.001
Allowable Accuracy:				0.040

Loop 3				
From	To	Distance	Setups	Elev. Diff.
C-419	B-419	1,418.07	8	12.166
B-419	A-419	942.96	6	4.893
A-419	Y-347	535.66	4	0.554
Y-347	Z-418	382.50	4	5.799
Z-418	Y-418	1,263.52	8	4.002
Y-418	X-418	585.96	4	-9.117
X-418	W-418	579.72	4	-6.704
W-418	V-418	608.50	4	-12.827
V-418	C-419	6,215.30	36	1.233
Cumulative Distance:		12,532.19		
Vertical Closure:				0.0041
Accuracy of Leveling:				0.003
Allowable Accuracy:				0.051

Loop 4				
From	To	Distance	Setups	Elev. Diff.
V-418	S-21	731.44	4	5.459
S-21	S-39	1,126.06	8	-3.781
S-39	S-19	1,446.38	10	-12.084
S-19	S-41	792.68	6	4.774
S-41	S-42	1,154.43	8	-2.621
S-42	S-43	1,009.02	6	-4.396
S-43	S-20	671.71	4	10.510
S-20	S-40	987.55	6	0.088
S-40	V-418	446.21	4	2.050
Cumulative Distance:		8,365.48		
Vertical Closure:				0.0038
Accuracy of Leveling:				0.003
Allowable Accuracy:				0.042

Loop 5				
From	To	Distance	Setups	Elev. Diff.
V-418	U-418	656.59	4	-10.246
U-418	T-418	1,203.95	8	-9.484
T-418	K-349	1,791.91	10	-12.910
K-349	S-46	1,189.49	8	-4.646
S-46	S-418	949.27	6	2.051
S-418	V-418	5,744.98	32	35.234
Cumulative Distance:		11,536.19		
Vertical Closure:				0.0058
Accuracy of Leveling:				0.004
Allowable Accuracy:				0.049

Table C. Detailed Loop Measurements (continued)

Loop 6					Loop 7				
From	To	Distance	Setups	Elev. Diff.	From	To	Distance	Setups	Elev. Diff.
T-418	S-16	600.58	4	4.490	K-349	S-24	941.45	6	-2.341
S-16	S-44	1,143.42	8	6.866	S-24	S-23	1,023.61	6	-6.030
S-44	S-15	2,165.52	14	-15.144	S-23	S-22	1,020.87	6	-7.725
S-15	S-14	1,001.75	6	-1.714	S-22	S-09	1,018.61	6	6.270
S-14	S-45	1,065.60	6	-10.871	S-09	S-10	1,324.99	8	8.213
S-45	S-53	1,184.86	8	8.183	S-10	PT-32	597.97	4	1.685
S-53	S-03	585.78	4	0.044	PT-32	K-349	933.58	6	-0.072
S-03	S-01	190.28	2	0.802					
S-01	T-418	762.31	6	7.344					
Cumulative Distance:		8,700.09			Cumulative Distance:		6,861.08		
Vertical Closure:				0.0128	Vertical Closure:				-0.0022
Accuracy of Leveling:				0.010	Accuracy of Leveling:				0.002
Allowable Accuracy:				0.042	Allowable Accuracy:				0.038

Loop 8					Loop 9				
From	To	Distance	Setups	Elev. Diff.	From	To	Distance	Setups	Elev. Diff.
K-349	S-52	252.47	2	3.390	S-418	S-29	803.14	6	-1.822
S-52	S-25	897.20	6	0.247	S-29	S-28	980.70	6	-6.640
S-25	S-26	1,014.76	6	12.346	S-28	S-27	1,048.07	6	-5.619
S-26	S-49	921.12	6	12.780	S-27	PT-21	102.47	2	-3.351
S-49	S-48	1,006.47	6	0.710	PT-21	S-32	1,307.57	8	-10.382
S-48	S-13	939.09	6	-11.038	S-32	S-33	1,071.77	8	5.491
S-13	PT-33	563.41	4	-2.533	S-33	S-34	1,064.39	8	12.991
PT-33	S-12	654.55	4	-8.187	S-34	S-418	1,300.54	8	9.331
S-12	K-349	1,159.08	8	-7.715	Cumulative Distance:		7,678.65		
Cumulative Distance:		7,408.13			Vertical Closure:				-0.0065
Vertical Closure:				-0.0013	Accuracy of Leveling:				0.005
Accuracy of Leveling:				0.001	Allowable Accuracy:				0.040
Allowable Accuracy:				0.039					

Table C. Detailed Loop Measurements (continued)

Loop 10					Loop 11				
From	To	Distance	Setups	Elev. Diff.	From	To	Distance	Setups	Elev. Diff.
S-418	S-35	1,396.35	10	-0.830	S-09	S-64	1,070.16	6	-9.280
S-35	S-36	1,005.97	6	9.134	S-64	S-65	988.55	6	-4.541
S-36	S-50	1,535.84	10	16.310	S-65	S-66	1,107.92	8	1.957
S-50	S-31	950.54	6	-13.647	S-66	S-67	981.99	6	-1.184
S-31	S-47	737.65	4	-3.269	S-67	S-09	4,275.01	24	13.047
S-47	S-30	595.81	4	-5.367					
S-30	S-418	779.39	6	-2.331					
Cumulative Distance:		7,001.54			Cumulative Distance:		8,423.62		
Vertical Closure:				-0.0063	Vertical Closure:				-0.0187
Accuracy of Leveling:				0.005	Accuracy of Leveling:				0.015
Allowable Accuracy:				0.038	Allowable Accuracy:				0.042

Loop 12					Loop 13				
From	To	Distance	Setups	Elev. Diff.	From	To	Distance	Setups	Elev. Diff.
S-64	S-73	1,292.10	8	10.536	S-64	S-62	1,555.38	10	-3.858
S-73	S-83	1,351.18	8	15.220	S-62	S-58	2,325.08	14	-21.110
S-83	S-74	1,003.54	6	-5.245	S-58	S-57	1,037.72	6	2.352
S-74	S-82	1,007.69	6	9.670	S-57	S-56	980.94	6	2.416
S-82	S-81	1,018.08	6	-4.335	S-56	S-55	1,035.83	6	11.875
S-81	S-75	1,010.33	6	-3.797	S-55	S-63	1,243.37	8	-0.385
S-75	S-72	1,011.95	6	-19.645	S-63	S-64	1,108.42	6	8.710
S-72	S-64	1,742.22	10	-2.405					
Cumulative Distance:		9,437.10			Cumulative Distance:		9,286.74		
Vertical Closure:				0.0005	Vertical Closure:				-0.0134
Accuracy of Leveling:				<0.001	Accuracy of Leveling:				0.010
Allowable Accuracy:				0.044	Allowable Accuracy:				0.044

Table C. Detailed Loop Measurements (continued)

Loop 14				
From	To	Distance	Setups	Elev. Diff.
S-67	S-70	1,219.26	8	9.719
S-70	S-77	1,040.39	6	22.018
S-77	S-79	1,041.65	6	3.573
S-79	S-80	1,254.27	8	-11.886
S-80	S-76	1,119.59	8	2.667
S-76	S-71	1,057.18	6	-16.938
S-71	S-67	1,489.07	8	-9.152
Cumulative Distance:		8,221.40		
Vertical Closure:				0.0013
Accuracy of Leveling:				0.001
Allowable Accuracy:				0.041

Loop 15				
From	To	Distance	Setups	Elev. Diff.
S-67	S-60	1,239.40	8	-10.941
S-60	S-61	1,199.83	8	4.936
S-61	S-59	2,368.25	14	-9.801
S-59	S-68	1,137.95	8	21.207
S-68	S-69	1,002.29	6	6.781
S-69	S-78	1,010.82	6	20.874
S-78	S-67	2,506.41	14	-33.056
Cumulative Distance:		10,464.95		
Vertical Closure:				-0.0156
Accuracy of Leveling:				0.011
Allowable Accuracy:				0.046

6. Adjusted Level Loops

Table D is a summary of the adjusted elevations for the fourteen loops measured in 2023. They have been extracted from the output of the Leica Infinity software. These are adjusted elevations within each loop. All elevations are shown in feet. These final adjusted elevations also appear in Table E.

Table D. Adjusted Elevations by Loop

Loop 2	
D-419	3,423.265
S-37	3,423.874
C-419	3,437.681
S-38	3,429.765
S-51	3,437.702
D-419	3,423.265

Loop 3	
C-419	3,437.681
B-419	3,449.846
A-419	3,454.740
Y-347	3,455.294
Z-418	3,461.093
Y-418	3,465.095
X-418	3,455.979
W-418	3,449.275
V-418	3,436.447
C-419	3,437.681

Loop 4	
V-418	3,436.447
S-21	3,441.906
S-39	3,438.126
S-19	3,426.041
S-41	3,430.816
S-42	3,428.195
S-43	3,423.799
S-20	3,434.309
S-40	3,434.397
V-418	3,436.447

Loop 5	
V-418	3,436.447
U-418	3,426.202
T-418	3,416.718
K-349	3,403.808
S-46	3,399.162
S-418	3,401.213
V-418	3,436.447

Loop 6	
T-418	3,416.718
S-16	3,421.208
S-44	3,428.074
S-15	3,412.930
S-14	3,411.216
PT-10	(1)
S-45	3,400.346
S-53	3,408.528
S-03	3,408.573
S-01	3,409.374
T-418	3,416.718

Loop 7	
K-349	3,403.808
S-24	3,401.467
S-23	3,395.437
S-22	3,387.712
S-09	3,393.982
S-10	3,402.195
PT-32	3,403.880
K-349	3,403.808

Loop 8	
K-349	3,403.808
S-52	3,407.199
S-25	3,407.445
S-26	3,419.791
S-49	3,432.571
S-48	3,433.281
S-13	3,422.243
PT-33	3,419.710
S-12	3,411.523
K-349	3,403.808

Loop 9	
S-418	3,401.213
S-29	3,399.391
S-28	3,392.751
S-27	3,387.133
PT-21	3,383.782
S-32	3,373.400
S-33	3,378.891
S-34	3,391.882
S-418	3,401.213

Loop 10	
S-418	3,401.213
S-35	3,400.384
S-36	3,409.517
S-50	3,425.827
S-31	3,412.180
S-47	3,408.911
S-30	3,403.544
S-418	3,401.213

Note: (1) Construction activity in the vicinity of the monument precluded its use in the 2023 annual survey.

Table D. Adjusted Elevations (continued)

Loop 11	
S-09	3,393.982
S-64	3,384.702
S-65	3,380.162
S-66	3,382.119
S-67	3,380.935
S-09	3,393.982

Loop 12	
S-64	3,384.702
S-73	3,395.238
S-83	3,410.458
S-74	3,405.213
S-82	3,414.884
S-81	3,410.549
S-75	3,406.752
S-72	3,387.107
S-64	3,384.702

Loop 13	
S-64	3,384.702
S-62	3,380.845
S-58	3,359.735
S-57	3,362.086
S-56	3,364.502
S-55	3,376.377
S-63	3,375.992
S-64	3,384.702

Loop 14	
S-67	3,380.935
S-70	3,390.654
S-77	3,412.672
S-79	3,416.245
S-80	3,404.359
S-76	3,407.025
S-71	3,390.087
S-67	3,380.935

Loop 15	
S-67	3,380.935
S-60	3,369.994
S-61	3,374.930
S-59	3,365.128
S-68	3,386.335
S-69	3,393.116
S-78	3,413.991
S-67	3,380.935

Note: (1) Construction activity in the vicinity of the monument precluded its use in the 2023 annual survey.

7. Adjusted Elevations (2023)

Table E displays the adjusted elevations for the subsidence monuments and the NGS points contained within the 2023 survey. These elevations are normalized to the monument, S-37. All elevations are shown in feet and are within the WIPP local coordinate system.

Table E. 2023 Adjusted Elevations

Monument	Elevation (ft.)	Monument	Elevation (ft.)
S-01	3409.374	S-57	3362.086
S-03	3408.573	S-58	3359.735
S-09	3393.982	S-59	3365.128
S-10	3402.195	S-60	3369.994
S-12	3411.523	S-61	3374.930
S-13	3422.243	S-62	3380.845
S-14	3411.216	S-63	3375.992
S-15	3412.930	S-64	3384.702
S-16	3421.208	S-65	3380.162
S-19	3426.041	S-66	3382.119
S-20	3434.309	S-67	3380.935
S-21	3441.906	S-68	3386.335
S-22	3387.712	S-69	3393.116
S-23	3395.437	S-70	3390.654
S-24	3401.467	S-71	3390.087
S-25	3407.445	S-72	3387.107
S-26	3419.791	S-73	3395.238
S-27	3387.133	S-74	3405.213
S-28	3392.751	S-75	3406.752
S-29	3399.391	S-76	3407.025
S-30	3403.544	S-77	3412.672
S-31	3412.180	S-78	3413.991
S-32	3373.400	S-79	3416.245
S-33	3378.891	S-80	3404.359
S-34	3391.882	S-81	3410.549
S-35	3400.384	S-82	3414.884
S-36	3409.517	S-83	3410.458
S-37	3423.874	PT-10	(1)
S-38	3429.765	PT-21	3383.782
S-39	3438.126	PT-32	3403.880
S-40	3434.397	K-349	3403.808
S-41	3430.816	PT-33	3419.710
S-42	3428.195	S-418	3401.213
S-43	3423.799	T-418	3416.718
S-44	3428.074	U-418	3426.202
S-45	3400.346	V-418	3436.447
S-46	3399.162	W-418	3449.275
S-47	3408.911	X-418	3455.979
S-48	3433.281	Y-418	3465.095
S-49	3432.571	Z-418	3461.093
S-50	3425.827	Y-347	3455.294
S-51	3437.702	A-419	3454.740
S-52	3407.199	B-419	3449.846
S-53	3408.528	C-419	3437.681
S-55	3376.377	D-419	3423.265
S-56	3364.502		

Note: (1) Construction activity in the vicinity of the monument precluded its use in the 2023 annual survey.

8. Comparison of Elevations

Table F compares the elevations from all the subsidence leveling surveys from 1987 through 2023 (WIPP Subsidence Monument Leveling Survey, 1987-2023). All elevations are displayed in feet.

Table F. Comparison of Elevations 1987-2023

	S-01	S-02	S-03	S-09	S-10	S-11	S-12	S-13	S-14
1987*	3,409.738	3,408.219	3,408.914	3,394.056	3,402.466	3,406.437	3,411.790	3,422.428	3,411.500
1989*	3,409.719	3,411.907	3,408.900	3,394.046	3,402.459	3,406.408	3,411.739	3,422.413	3,411.483
1992*	3,409.695	3,411.904	3,408.875	3,394.053	3,402.440	3,406.372	3,411.727	3,422.412	3,411.439
1993*	3,409.616	(1) (2)	3,408.797	3,393.969	3,402.365	(3)	3,411.630	3,422.324	3,411.382
1994	3,409.626		3,408.806	3,393.988	3,402.374		3,411.653	3,422.348	3,411.372
1995	3,409.613		3,408.795	3,393.986	3,402.373		3,411.650	3,422.345	3,411.376
1996	3,409.615		3,408.795	3,393.994	3,402.373		3,411.645	3,422.340	3,411.369
1997	3,409.610		3,408.793	3,394.002	3,402.379		3,411.656	3,422.349	3,411.368
1998	3,409.617		3,408.802	3,394.011	3,402.388		3,411.653	3,422.352	3,411.374
1999	3,409.613		3,408.798	3,394.004	3,402.385		3,411.650	3,422.358	3,411.365
2000	3,409.607		3,408.792	3,394.003	3,402.381		3,411.644	3,422.352	3,411.364
2001	3,409.599		3,408.786	3,394.006	3402.378		3,411.636	3,422.350	3,411.361
2002	3,409.595		3,408.783	3,394.012	3,402.381		3,411.637	3,422.354	3,411.357
2003	3,409.583		3,408.771	3,394.007	3,402.372		3,411.629	3,422.307	3,411.351
2004	3,409.575		3,408.762	3,394.006	3,402.373		3,411.630	3,422.310	3,411.329
2005	3,409.551		3,408.739	3,393.997	3,402.357		3,411.611	3,422.274	3,411.307
2006	3,409.539		3,408.727	3,393.992	3,402.349		3,411.603	3,422.274	3,411.301
2007	3,409.546		3,408.734	3,394.012	3,402.356		3,411.609	3,422.281	3,411.301
2008	3,409.533		3,408.722	3,394.006	3,402.350		3,411.606	3,422.284	3,411.297
2009	3,409.531		3,408.721	3,394.008	3,402.344		3,411.596	3,422.279	3,411.294
2010	3,409.513		3,408.701	3,393.999	3,402.329		3,411.586	3,422.268	3,411.287
2011	3,409.519		3,408.707	3,394.005	3,402.333		3,411.586	3,422.282	3,411.297
2012	3,409.509		3,408.699	3,393.996	3,402.319		3,411.584	3,422.273	3,411.295
2013	3,409.503		3,408.694	3,394.017	3,402.331		3,411.587	3,422.280	3,411.290
2014	3,409.481		3,408.671	3,394.012	3,402.321		3,411.577	3,422.275	3,411.279
2015	3,409.466		3,408.658	3,394.013	3,402.309		3,411.571	3,422.273	3,411.268
2016	3,409.446		3,408.639	3,394.003	3,402.295		3,411.555	3,422.262	3,411.256
2017	3,409.445		3,408.639	3,394.010	3,402.292		3,411.555	3,422.263	3,411.257
2018	3,409.429		3,408.625	3,394.002	3,402.279		3,411.546	3,422.256	3,411.247
2019	3,409.426		3,408.622	3,394.005	(9)		(9)	(9)	3,411.246
2020	3,409.409		3,408.612	3,393.995	3,402.251		(9)	3,422.254	3,411.244
2021	3,409.411		3,408.613	3,394.008	3,402.250		(9)	(9)	(9)
2022	3,409.378		3,408.575	3,393.991	3,402.221		(9)	(9)	3,411.218
2023	3,409.374		3,408.573	3,393.982	3,402.195		3411.523	3422.243	3,411.216

Note: (1) The subsidence monument, S-02 was relocated in 1989.
(2) The subsidence monument, S-02, no longer exists after the 1992 survey.
(3) The subsidence monument, S-11, no longer exists after the 1992 survey.
(9) Construction activity in the vicinity of the monument precluded its use in the noted year's annual survey.
(*) Data was being tested for accuracy/reliability during these years.

Table F. Comparison of Elevations 1987-2023 (continued)

	S-15	S-16	S-17	S-18	S-19	S-20	S-21	S-22	S-23
1987*	3,413.291	3,421.378	3,422.519	3,425.010	3,426.235	3,434.464	3,442.030	3,387.786	3,395.914
1989*	3,413.291	3,421.341	3,422.482	3,424.974	3,426.217	3,434.452	3,442.005	3,387.795	3,395.970
1992*	3,413.263	3,421.331	3,422.469	3,424.964	3,426.223	3,434.364	3,441.956	3,387.788	3,396.028
1993*	3,413.185	3,421.256	3,422.404	3,424.859	3,426.136	3,434.332	3,441.919	3,387.701	3,395.853
1994	3,413.188	3,421.261	3,422.402	3,424.852	3,426.134	3,434.339	3,441.932	3,387.732	3,395.886
1995	3,413.189	3,421.261	3,422.418	3,424.864	3,426.143	3,434.342	3,441.936	3,387.727	3,395.877
1996	3,413.182	3,421.263	3,422.419	3,424.860	3,426.138	3,434.345	3,441.935	3,387.727	3,395.885
1997	3,413.178	3,421.268	3,422.431	3,424.864	3,426.141	3,434.346	3,441.937	3,387.738	3,395.889
1998	3,413.184	3,421.271	3,422.436	3,424.869	3,426.150	3,434.355	3,441.946	3,387.744	3,395.887
1999	3,413.177	3,421.275	3,422.435	3,424.865	3,426.152	3,434.362	3,441.959	3,387.729	3,395.873
2000	3,413.172	3,421.278	3,422.440	3,424.864	3,426.140	3,434.362	3,441.956	3,387.727	3,395.861
2001	3,413.167	3,421.277	3,422.434	3,424.858	3,426.138	3,434.363	3,441.956	3,387.728	3,395.857
2002	3,413.159	3,421.275	3,422.434	3,424.855	3,426.132	3,434.361	3,441.950	3,387.731	3,395.857
2003	3,413.152	3,421.279	3,422.430	3,424.849	3,426.117	3,434.350	3,441.939	3,387.728	3,395.850
2004	3,413.142	3,421.281	(4)	(5)	3,426.128	3,434.359	3,441.955	3,387.727	3,395.841
2005	3,413.118	3,421.268			3,426.107	3,434.343	3,441.941	3,387.720	3,395.826
2006	3,413.109	3,421.269			3,426.101	3,434.338	3,441.937	3,387.711	3,395.815
2007	3,413.113	3,421.280			3,426.105	3,434.346	3,441.947	3,387.730	3,395.823
2008	3,413.099	3,421.274			3,426.104	3,434.344	3,441.945	3,387.721	3,395.810
2009	3,413.093	3,421.283			3,426.107	3,434.347	3,441.950	3,387.726	3,395.802
2010	3,413.083	3,421.271			3,426.088	3,434.331	3,441.936	3,387.716	3,395.768
2011	3,413.088	3,421.280			3,426.095	3,434.345	3,441.944	3,387.724	3,395.748
2012	3,413.073	3,421.274			3,426.092	3,434.345	3,441.945	3,387.715	3,395.724
2013	3,413.065	3,421.273			3,426.085	3,434.340	3,441.935	3,387.735	3,395.727
2014	3,413.042	3,421.259			3,426.073	3,434.334	3,441.927	3,387.721	3,395.694
2015	3,413.028	3,421.252			3,426.074	3,434.333	3,441.931	3,387.730	3,395.674
2016	3,413.007	3,421.237			3,426.061	3,434.320	3,441.919	3,387.736	3,395.643
2017	3,413.005	3,421.241			3,426.068	3,434.325	3,441.924	3,387.752	3,395.632
2018	3,412.985	3,421.232			3,426.059	3,434.317	3,441.919	3,387.742	3,395.609
2019	3,412.978	3,421.227			3,426.066	3,434.318	3,441.924	3,387.740	3,395.569
2020	3,412.969	3,421.218			3,426.064	3,434.316	3,441.920	3,387.726	3,395.528
2021	3,412.960	3,421.221			3,426.065	3,434.319	3,441.919	3,387.737	3,395.505
2022	3,412.929	3,421.203			3,426.054	3,434.305	3,441.905	3,387.714	3,395.468
2023	3,412.930	3,421.208			3,426.041	3,434.309	3,441.906	3,387.712	3,395.437

Note: (4) The subsidence monument, S-17, no longer exists after the 2003 survey.
(5) The subsidence monument, S-18, no longer exists after the 2003 survey.
(*) Data was being tested for accuracy/reliability during these years.

Table F. Comparison of Elevations 1987-2023 (continued)

	S-24	S-25	S-26	S-27	S-28	S-29	S-30	S-31	S-32
1987*	3,402.201	3,408.036	3,420.010	3,387.280	3,393.414	3,400.111	3,404.082	3,412.315	3,373.513
1989*	3,402.167	3,408.005	3,419.978	3,387.287	3,393.400	3,400.098	3,404.064	3,412.302	3,373.498
1992*	3,402.159	3,407.974	3,419.948	3,387.310	3,393.421	3,400.113	3,404.073	3,412.303	3,373.533
1993*	3,402.042	3,407.870	3,419.854	3,387.181	3,393.287	3,400.008	3,403.958	3,412.206	3,373.396
1994	3,402.072	3,407.907	3,419.883	3,387.225	3,393.312	3,400.038	3,403.984	3,412.234	3,373.427
1995	3,402.062	3,407.895	3,419.871	3,387.216	3,393.309	3,400.031	3,403.978	3,412.230	3,373.425
1996	3,402.074	3,407.897	3,419.875	3,387.213	3,393.316	3,400.037	3,403.979	3,412.221	3,373.411
1997	3,402.077	3,407.897	3,419.883	3,387.229	3,393.330	3,400.050	3,403.994	3,412.248	3,373.438
1998	3,402.076	3,407.902	3,419.883	3,387.248	3,393.338	3,400.059	3,403.998	3,412.248	3,373.452
1999	3,402.067	3,407.898	3,419.886	3,387.229	3,393.322	3,400.053	3,403.990	3,412.252	3,373.429
2000	3,402.051	3,407.876	3,419.871	3,387.226	3,393.316	3,400.045	3,403.980	3,412.252	3,373.428
2001	3,402.035	3,407.862	3,419.872	3,387.231	3,393.318	3,400.040	3,403.972	3,412.255	3,373.431
2002	3,402.029	3,407.858	3,419.877	3,387.231	3,393.316	3,400.034	3,403.968	3,412.258	3,373.433
2003	3,402.012	3,407.840	3,419.871	3,387.233	3,393.311	3,400.016	3,403.951	3,412.252	3,373.433
2004	3,401.995	3,407.822	3,419.870	3,387.231	3,393.310	3,399.996	3,403.932	3,412.254	3,373.439
2005	3,401.976	3,407.786	3,419.853	3,387.221	3,393.294	3,399.961	3,403.902	3,412.235	3,373.426
2006	3,401.956	3,407.762	3,419.857	3,387.207	3,393.278	3,399.930	3,403.870	3,412.221	3,373.413
2007	3,401.958	3,407.764	3,419.850	3,387.226	3,393.280	3,399.928	3,403.872	3,412.237	3,373.431
2008	3,401.929	3,407.739	3,419.850	3,387.217	3,393.260	3,399.910	3,403.848	3,412.222	3,373.421
2009	3,401.910	3,407.725	3,419.840	3,387.218	3,393.235	3,399.888	3,403.834	3,412.225	3,373.423
2010	3,401.868	3,407.700	3,419.832	3,387.202	3,393.190	3,399.846	3,403.811	3,412.218	3,373.413
2011	3,401.836	3,407.685	3,419.835	3,387.200	3,393.153	3,399.819	3,403.795	3,412.223	3,373.423
2012	3,401.804	3,407.663	3,419.830	3,387.191	3,393.118	3,399.780	3,403.768	3,412.215	3,373.413
2013	3,401.795	3,407.662	3,419.837	3,387.212	3,393.112	3,399.767	3,403.767	3,412.226	3,373.442
2014	3,401.752	3,407.634	3,419.828	3,387.190	3,393.068	3,399.718	3,403.735	3,412.216	3,373.432
2015	3,401.732	3,407.617	3,419.829	3,387.191	3,393.044	3,399.688	3,403.722	3,412.227	3,373.433
2016	3,401.694	3,407.586	3,419.816	3,387.174	3,393.000	3,399.639	3,403.688	3,412.200	3,373.424
2017	3,401.678	3,407.573	3,419.819	3,387.175	3,392.976	3,399.613	3,403.677	3,412.208	3,373.419
2018	3,401.642	3,407.549	3,419.811	3,387.162	3,392.938	3,399.572	3,403.655	3,412.201	3,373.410
2019	3,401.609	3,407.525	3,419.811	3,387.157	3,392.896	3,399.538	3,403.632	3,412.197	3,373.410
2020	3,401.568	3,407.493	3,419.794	3,387.148	3,392.846	3,399.495	3,403.603	3,412.183	3,373.399
2021	3,401.539	3,407.480	3419.799	3,387.153	3,392.822	3,399.468	3,403.589	3,412.192	3,373.412
2022	3,401.498	3,407.460	3,419.788	3,387.134	3,392.783	3,399.418	3,403.558	3,412.172	3,373.398
2023	3,401.467	3,407.445	3,419.791	3,387.133	3,392.751	3,399.391	3,403.544	3,412.180	3,373.400

Note: (*) Data was being tested for accuracy/reliability during these years.

Table F. Comparison of Elevations 1987-2023 (continued)

	S-24	S-25	S-26	S-27	S-28	S-29	S-30	S-31	S-32
1987*	3,402.201	3,408.036	3,420.010	3,387.280	3,393.414	3,400.111	3,404.082	3,412.315	3,373.513
1989*	3,402.167	3,408.005	3,419.978	3,387.287	3,393.400	3,400.098	3,404.064	3,412.302	3,373.498
1992*	3,402.159	3,407.974	3,419.948	3,387.310	3,393.421	3,400.113	3,404.073	3,412.303	3,373.533
1993*	3,402.042	3,407.870	3,419.854	3,387.181	3,393.287	3,400.008	3,403.958	3,412.206	3,373.396
1994	3,402.072	3,407.907	3,419.883	3,387.225	3,393.312	3,400.038	3,403.984	3,412.234	3,373.427
1995	3,402.062	3,407.895	3,419.871	3,387.216	3,393.309	3,400.031	3,403.978	3,412.230	3,373.425
1996	3,402.074	3,407.897	3,419.875	3,387.213	3,393.316	3,400.037	3,403.979	3,412.221	3,373.411
1997	3,402.077	3,407.897	3,419.883	3,387.229	3,393.330	3,400.050	3,403.994	3,412.248	3,373.438
1998	3,402.076	3,407.902	3,419.883	3,387.248	3,393.338	3,400.059	3,403.998	3,412.248	3,373.452
1999	3,402.067	3,407.898	3,419.886	3,387.229	3,393.322	3,400.053	3,403.990	3,412.252	3,373.429
2000	3,402.051	3,407.876	3,419.871	3,387.226	3,393.316	3,400.045	3,403.980	3,412.252	3,373.428
2001	3,402.035	3,407.862	3,419.872	3,387.231	3,393.318	3,400.040	3,403.972	3,412.255	3,373.431
2002	3,402.029	3,407.858	3,419.877	3,387.231	3,393.316	3,400.034	3,403.968	3,412.258	3,373.433
2003	3,402.012	3,407.840	3,419.871	3,387.233	3,393.311	3,400.016	3,403.951	3,412.252	3,373.433
2004	3,401.995	3,407.822	3,419.870	3,387.231	3,393.310	3,399.996	3,403.932	3,412.254	3,373.439
2005	3,401.976	3,407.786	3,419.853	3,387.221	3,393.294	3,399.961	3,403.902	3,412.235	3,373.426
2006	3,401.956	3,407.762	3,419.857	3,387.207	3,393.278	3,399.930	3,403.870	3,412.221	3,373.413
2007	3,401.958	3,407.764	3,419.850	3,387.226	3,393.280	3,399.928	3,403.872	3,412.237	3,373.431
2008	3,401.929	3,407.739	3,419.850	3,387.217	3,393.260	3,399.910	3,403.848	3,412.222	3,373.421
2009	3,401.910	3,407.725	3,419.840	3,387.218	3,393.235	3,399.888	3,403.834	3,412.225	3,373.423
2010	3,401.868	3,407.700	3,419.832	3,387.202	3,393.190	3,399.846	3,403.811	3,412.218	3,373.413
2011	3,401.836	3,407.685	3,419.835	3,387.200	3,393.153	3,399.819	3,403.795	3,412.223	3,373.423
2012	3,401.804	3,407.663	3,419.830	3,387.191	3,393.118	3,399.780	3,403.768	3,412.215	3,373.413
2013	3,401.795	3,407.662	3,419.837	3,387.212	3,393.112	3,399.767	3,403.767	3,412.226	3,373.442
2014	3,401.752	3,407.634	3,419.828	3,387.190	3,393.068	3,399.718	3,403.735	3,412.216	3,373.432
2015	3,401.732	3,407.617	3,419.829	3,387.191	3,393.044	3,399.688	3,403.722	3,412.227	3,373.433
2016	3,401.694	3,407.586	3,419.816	3,387.174	3,393.000	3,399.639	3,403.688	3,412.200	3,373.424
2017	3,401.678	3,407.573	3,419.819	3,387.175	3,392.976	3,399.613	3,403.677	3,412.208	3,373.419
2018	3,401.642	3,407.549	3,419.811	3,387.162	3,392.938	3,399.572	3,403.655	3,412.201	3,373.410
2019	3,401.609	3,407.525	3,419.811	3,387.157	3,392.896	3,399.538	3,403.632	3,412.197	3,373.410
2020	3,401.568	3,407.493	3,419.794	3,387.148	3,392.846	3,399.495	3,403.603	3,412.183	3,373.399
2021	3,401.539	3,407.480	3419.799	3,387.153	3,392.822	3,399.468	3,403.589	3,412.192	3,373.412
2022	3,401.498	3,407.460	3,419.788	3,387.134	3,392.783	3,399.418	3,403.558	3,412.172	3,373.398
2023	3,401.467	3,407.445	3,419.791	3,387.133	3,392.751	3,399.391	3,403.544	3,412.180	3,373.400

Note: (*) Data was being tested for accuracy/reliability during these years.

Table F. Comparison of Elevations 1987-2023 (continued)

	S-33	S-34	S-35	S-36	S-37	S-38	S-39	S-40	S-41
1987*	3,379.093	3,392.128	3,400.597	3,409.583	(10)	(10)	(10)	(10)	(10)
1989*	3,379.073	3,392.137	3,400.583	3,409.584	3,423.888	3,429.736	(10)	(10)	(10)
1992*	3,379.090	3,392.138	3,400.591	3,409.605	3,423.874	(10)	3,438.146	3,434.469	3,430.931
1993*	3,378.975	3,392.026	3,400.478	3,409.504	3,423.874	3,429.736	3,438.110	3,434.430	3,430.888
1994	3,379.006	3,392.042	3,400.490	3,409.518	3,423.874	3,429.740	3,438.115	3,434.425	3,430.888
1995	3,379.009	3,392.042	3,400.495	3,409.520	3,423.874	3,429.739	3,438.124	3,434.437	3,430.899
1996	3,378.992	3,392.028	3,400.483	3,409.501	3,423.874	3,429.744	3,438.118	3,434.436	3,430.891
1997	3,379.019	3,392.057	3,400.516	3,409.533	3,423.874	3,429.745	3,438.127	3,434.444	3,430.894
1998	3,379.028	3,392.066	3,400.516	3,409.539	3,423.874	3,429.750	3,438.134	3,434.442	3,430.901
1999	3,379.011	3,392.056	3,400.507	3,409.539	3,423.874	3,429.751	3,438.149	3,434.445	3,430.900
2000	3,379.012	3,392.053	3,400.505	3,409.541	3,423.874	3,429.754	3,438.145	3,434.445	3,430.902
2001	3,379.014	3,392.057	3,400.509	3,409.546	3,423.874	3,429.756	3,438.145	3,434.436	3,430.898
2002	3,379.017	3,392.060	3,400.513	3,409.550	3,423.874	3,429.757	3,438.142	3,434.437	3,430.897
2003	3,379.016	3,392.057	3,400.511	3,409.546	3,423.874	3,429.760	3,438.130	3,434.425	3,430.892
2004	3,379.020	3,392.055	3,400.514	3,409.549	3,423.874	3429.761	3,438.152	3,434.449	3,430.900
2005	3,379.011	3,392.035	3,400.505	3,409.536	3,423.874	3,429.757	3,438.144	3,434.449	3,430.882
2006	3,378.994	3,392.017	3,400.484	3,409.524	3,423.874	3,429.757	3,438.145	3,434.448	3,430.881
2007	3,379.001	3,392.022	3,400.492	3,409.536	3,423.874	3,429.763	3,438.143	3,434.450	3,430.882
2008	3,378.988	3,392.006	3,400.476	3,409.530	3,423.874	3,429.759	3,438.145	3,434.442	3,430.878
2009	3,378.979	3,391.999	3,400.469	3,409.535	3,423.874	3,429.758	3,438.150	3,434.439	3,430.884
2010	3,378.961	3,391.982	3,400.464	3,409.532	3,423.874	3,429.751	3,438.135	3,434.426	3,430.864
2011	3,378.962	3,391.981	3,400.454	3,409.540	3,423.874	3,429.760	3,438.145	3,434.411	3,430.872
2012	3,378.949	3,391.967	3,400.446	3,409.532	3,423.874	3,429.760	3,438.152	3,434.416	3,430.871
2013	3,378.972	3,391.982	3,400.457	3,409.543	3,423.874	3,429.757	3,438.142	3,434.416	3,430.862
2014	3,378.959	3,391.965	3,400.451	3,409.537	3,423.874	3,429.757	3,438.148	3,434.422	3,430.859
2015	3,378.957	3,391.961	3,400.451	3,409.538	3,423.874	3,429.763	3,438.142	3,434.426	3,430.854
2016	3,378.937	3,391.939	3,400.439	3,409.522	3,423.874	3,429.761	3,438.139	3,434.426	3,430.846
2017	3,378.935	3,391.937	3,400.434	3,409.527	3,423.874	3,429.762	3,438.134	3,434.424	3,430.846
2018	3,378.923	3,391.923	3,400.426	3,409.524	3,423.874	3,429.762	3,438.134	3,434.416	3,430.839
2019	3,378.916	3,391.918	3,400.410	3,409.523	3,423.874	3,429.765	3,438.133	3,434.397	3,430.841
2020	3,378.900	3,391.901	3,400.389	3,409.515	3,423.874	3,429.762	3,438.131	3,434.402	3,430.837
2021	3,378.912	3,391.905	3,400.398	3,409.524	3,423.874	3,429.769	3,438.137	3,434.409	3,430.834
2022	3,378.896	3,391.885	3,400.389	3,409.509	3,423.874	3,429.769	3,438.125	3,434.393	3,430.824
2023	3,378.891	3,391.882	3,400.384	3,409.517	3,423.874	3,429.765	3,438.126	3,434.397	3,430.816

Note: (10) The monument was not use in the noted year's annual survey.
(*) Data was being tested for accuracy/reliability during these years.

Table F. Comparison of Elevations 1987-2023 (continued)

	S-42	S-43	S-44	S-45	S-46	S-47	S-48	S-49	S-50
1987*	(10)	(10)	(10)	(10)	(10)	(10)	(10)	(10)	(10)
1989*	(10)	(10)	(10)	(10)	(10)	(10)	(10)	(10)	(10)
1992*	3,428.279	3,423.849	3,428.146	3,400.501	3,399.946	3,409.236	3,433.308	3,432.635	3,425.868
1993*	3,428.230	3,423.813	3,428.070	3,400.406	3,399.837	3,409.133	3,433.238	3,432.572	3,425.809
1994	3,428.228	3,423.820	3,428.066	3,400.419	3,399.865	3,409.163	3,433.264	3,432.596	3,425.830
1995	3,428.238	3,423.826	3,428.071	3,400.424	3,399.856	3,409.158	3,433.258	3,432.588	3,425.830
1996	3,428.238	3,423.823	3,428.078	3,400.423	3,399.856	3,409.157	3,433.256	3,432.585	3,425.816
1997	3,428.249	3,423.815	3,428.084	3,400.428	3,399.877	3,409.181	3,433.274	3,432.600	3,425.846
1998	3,428.252	3,423.822	3,428.086	3,400.440	3,399.876	3,409.178	3,433.276	3,432.598	3,425.838
1999	3,428.255	3,423.825	3,428.091	3,400.435	3,399.866	3,409.176	3,433.289	3,432.611	3,425.851
2000	3,428.254	3,423.820	3,428.095	3,400.434	3,399.842	3,409.168	3,433.288	3,432.606	3,425.854
2001	3,428.247	3,423.818	3,428.094	3,400.433	3,399.824	3,409.163	3,433.290	3,432.606	3,425.858
2002	3,428.246	3,423.815	3,428.097	3,400.435	3,399.818	3,409.160	3,433.297	3,432.613	3,425.863
2003	3,428.236	3,423.805	3,428.090	3,400.430	3,399.790	3,409.147	3,433.294	3,432.610	3,425.857
2004	3,428.254	3,423.814	3,428.105	3,400.440	3,399.770	3,409.149	3,433.311	3,432.620	3,425.876
2005	3,428.243	3,423.798	3,428.093	3,400.421	3,399.745	3,409.114	3,433.297	3,432.603	3,425.855
2006	3,428.242	3,423.795	3,428.097	3,400.415	3,399.718	3,409.096	3,433.310	3,432.617	3,425.854
2007	3,428.244	3,423.802	3,428.099	3,400.417	3,399.705	3,409.095	3,433.306	3,432.612	3,425.866
2008	3,428.242	3,423.802	3,428.100	3,400.415	3,399.675	3,409.079	3,433.321	3,432.623	3,425.859
2009	3,428.245	3,423.818	3,428.099	3,400.414	3,399.643	3,409.064	3,433.306	3,432.611	3,425.856
2010	3,428.227	3,423.819	3,428.087	3,400.399	3,399.605	3,409.048	3,433.301	3,432.608	3,425.852
2011	3,428.236	3,423.832	3,428.094	3,400.412	3,399.565	3,409.041	3,433.310	3,432.616	3,425.860
2012	3,428.236	3,423.833	3,428.097	3,400.414	3,399.526	3,409.027	3,433.308	3,432.610	3425.857
2013	3,428.228	3,423.830	3,428.096	3,400.419	3,399.519	3,409.030	3,433.307	3,432.611	3,425.860
2014	3,428.229	3,423.825	3,428.098	3,400.414	3,399.485	3,409.022	3,433.314	3,432.612	3,425.864
2015	3,428.224	3,423.823	3,428.100	3,400.405	3,399.453	3,409.020	3,433.309	3,432.611	3,425.876
2016	3,428.217	3,423.811	3,428.090	3,400.381	3,399.420	3,408.993	3,433.310	3,432.604	3,425.851
2017	3,428.218	3,423.817	3,428.094	3,400.380	3,399.386	3,408.981	3,433.306	3,432.606	3,425.852
2018	3,428.213	3,423.809	3,428.091	3,400.374	3,399.352	3,408.973	3,433.304	3,432.600	3,425.850
2019	3,428.209	3,423.811	3,428.095	3,400.373	3,399.305	3,408.957	3,433.310	3,432.601	3,425.843
2020	3,428.206	3,423.816	3,428.084	3,400.365	3,399.254	3,408.936	3,433.294	3,432.586	3,425.831
2021	3,428.200	3,423.815	3,428.083	3,400.374	3,399.234	3,408.937	3433.299	3432.587	3,425.837
2022	3,428.203	3,423.802	3,428.071	3,400.351	3,399.191	3,408.922	3,433.290	3,432.579	3,425.827
2023	3,428.195	3,423.799	3,428.074	3,400.346	3,399.162	3,408.911	3,433.281	3,432.571	3,425.827

Note: (10) The monument was not use in the noted year's annual survey.
(*) Data was being tested for accuracy/reliability during these years.

Table F. Comparison of Elevations 1987-2023 (continued)

	S-51	S-52	S-53	S-54	PT-10	PT-21	PT-30	PT-31	PT-32
1987*	(10)	(10)	(10)	(10)	(10)	(10)	(10)	(10)	(10)
1989*	(10)	(10)	(10)	(10)	(10)	(10)	(10)	(10)	(10)
1992*	3,437.765	3,407.611	3,408.775	3,411.085	3,407.722	(10)	3,392.914	3,385.117	3,404.370
1993*	3,437.746	3,407.523	3,408.670	(6)	3,407.664	3,383.821	3,392.823	3,385.027	3,404.296
1994	3,437.749	3,407.542	3,408.709		3,407.672	3,383.868	3,392.843	3,385.051	3,404.311
1995	3,437.746	3,407.542	3,408.702		3,407.671	3,383.862	3,392.844	3,385.050	3,404.322
1996	3,437.729	3,407.536	3,408.704		3,407.669	3,383.858	3,392.852	3,385.053	3,404.312
1997	3,437.725	3,407.544	3,408.702		3,407.675	3,383.874	3,392.857	3,385.063	3,404.321
1998	3,437.724	3,407.549	3,408.714		3,407.687	3,383.887	(7)	3,385.067	3,404.322
1999	3,437.729	3,407.544	3,408.709		3,407.689	3,383.868		3,385.053	3,404.315
2000	3,437.729	3,407.531	3,408.704		3,407.685	3,383.868		3,385.053	3,404.306
2001	3,437.731	3,407.522	3,408.701		3,407.687	3,383.874		3,385.053	3,404.259
2002	3,437.733	3,407.521	3,408.700		3,407.688	3,383.871		3,385.057	3,404.250
2003	3,437.731	3,407.507	3,408.690		3,407.685	3,383.874		3,385.054	3,404.234
2004	3,437.730	3,407.501	3,408.686		3,407.685	3,383.874		(8)	3,404.172
2005	3,437.720	3,407.473	3,408.667		3,407.669	3,383.862			3,404.152
2006	3,437.720	3,407.461	3,408.659		3,407.667	3,383.848			3,404.138
2007	3,437.720	3,407.458	3,408.666		3,407.670	3,383.866			3,404.146
2008	3,437.720	3,407.445	3,408.659		3,407.669	3,383.857			3,404.132
2009	3,437.721	3,407.432	3,408.656		3,407.673	3,383.858			3,404.124
2010	3,437.705	3,407.408	3,408.640		3,407.665	3,383.841			3,404.101
2011	3,437.717	3,407.407	3,408.650		3,407.678	3,383.838			3,404.097
2012	3,437.715	3,407.388	3,408.645		3,407.681	3,383.834			3,404.076
2013	3,437.708	3,407.386	3,408.644		3,407.685	3,383.857			3,404.079
2014	3,437.710	3,407.367	3,408.625		3,407.677	3,383.840			3,404.058
2015	3,437.708	3,407.342	3,408.614		3,407.673	3,383.841			3,404.045
2016	3,437.700	3,407.322	3,408.597		3,407.662	3,383.825			3,404.019
2017	3,437.704	3,407.307	3,408.597		3,407.668	3,383.823			3,404.013
2018	3,437.702	3,407.286	3,408.583		3,407.660	3,383.811			3,403.992
2019	3,437.705	3,407.272	3,408.584		(9)	3,383.805			(9)
2020	3,437.705	3,407.244	3,408.565		(9)	3,383.793			3,403.949
2021	3,437.713	3,407.242	3,408.567		(9)	3,383.801			3,403.942
2022	3,437.701	3,407.212	3,408.527		(9)	3,383.779			3,403.908
2023	3,437.702	3,407.199	3,408.528		(9)	3,383.782			3,403.880

Note: (6) The subsidence monument, S-54, no longer exists after the 1992 survey.
(7) The monument, PT-30, has been physically disturbed and was removed from the 1998 survey.
(8) The monument, PT-31, has been physically disturbed and was removed from the 2004 survey.
(9) Construction activity in the vicinity of the monument precluded its use in the noted year's annual survey.
(10) The monument was not use in the noted year's annual survey.
(*) Data was being tested for accuracy/reliability during these years.

Table F. Comparison of Elevations 1987-2023 (continued)

	PT-33	S-418	T-418	U-418	V-418	W-418	X-418	Y-347	Y-418
1987*	(10)	(10)	(10)	(10)	(10)	(10)	(10)	(10)	(10)
1989*	(10)	(10)	(10)	(10)	(10)	(10)	(10)	(10)	(10)
1992*	3,419.939	(10)	(10)	(10)	(10)	(10)	(10)	(10)	(10)
1993*	3,419.853	(10)	(10)	(10)	(10)	(10)	(10)	(10)	(10)
1994	3,419.884	(10)	(10)	(10)	(10)	(10)	(10)	(10)	(10)
1995	3,419.869	(10)	(10)	(10)	(10)	(10)	(10)	(10)	(10)
1996	3,419.865	3,401.696	3,416.902	3,426.267	3,436.481	3,449.276	3,455.969	3,455.274	3,465.080
1997	3,419.873	3,401.708	3,416.906	3,426.272	3,436.487	3,449.282	3,455.976	3,455.281	3,465.091
1998	3,419.879	3,401.715	3,416.915	3,426.279	3,436.497	3,449.292	3,455.987	3,455.291	3,465.101
1999	3,419.880	3,401.707	3,416.913	3,426.275	3,436.500	3,449.304	3,456.000	3,455.304	3,465.117
2000	3,419.872	3,401.702	3,416.911	3,426.273	3,436.502	3,449.307	3,456.005	3,455.309	3,465.123
2001	3,419.866	3,401.702	3,416.905	3,426.270	3,436.502	3,449.310	3,456.007	3,455.312	3,465.125
2002	3,419.868	3,401.701	3,416.901	3,426.269	3,436.502	3,449.311	3,456.009	3,455.314	3,465.126
2003	3,419.866	3,401.685	3,416.892	3,426.264	3,436.500	3,449.308	3,456.007	3,455.312	3,465.125
2004	3,419.855	3,401.670	3,416.887	3,426.265	3,436.499	3,449.310	3,456.009	3,455.315	3,465.126
2005	3,419.789	3,401.634	3,416.868	3,426.252	3,436.485	3,449.295	3,455.993	3,455.301	3,465.113
2006	3,419.784	3,401.605	3,416.860	3,426.247	3,436.481	3,449.290	3,455.991	3,455.300	3,465.111
2007	3,419.788	3,401.604	3,416.865	3,426.258	3,436.491	3,449.302	3,456.003	3,455.311	3,465.122
2008	3,419.785	3,401.580	3,416.857	3,426.259	3,436.490	3,449.301	3,456.000	3,455.307	3,465.120
2009	3,419.783	3,401.562	3,416.853	3,426.261	3,436.493	3,449.307	3,456.006	3,455.312	3,465.125
2010	3,419.771	3,401.531	3,416.840	3,426.246	3,436.477	3,449.293	3,455.994	3,455.301	3,465.113
2011	3,419.778	3,401.515	3,416.841	3,426.259	3,436.487	3,449.306	3,456.006	3,455.317	3,465.125
2012	3,419.765	3,401.487	3,416.828	3,426.257	3,436.488	3,449.308	3,456.009	3,455.317	3,465.129
2013	3,419.776	3,401.480	3,416.819	3,426.249	3,436.479	3,449.296	3,455.995	3,455.303	3,465.110
2014	3,419.763	3,401.446	3,416.801	3,426.240	3,436.473	3,449.294	3,455.995	3,455.305	3,465.111
2015	3,419.754	3,401.426	3,416.789	3,426.235	3,436.473	3,449.291	3,455.992	3,455.302	3,465.109
2016	3,419.736	3,401.388	3,416.770	3,426.219	3,436.459	3,449.279	3,455.982	3,455.293	3,465.100
2017	3,419.736	3,401.372	3,416.772	3,426.226	3,436.466	3,449.286	3,455.989	3,455.299	3,465.105
2018	3,419.730	3,401.342	3,416.757	3,426.217	3,436.459	3,449.281	3,455.982	3,455.294	3,465.100
2019	(9)	3,401.316	3,416.754	3,426.222	3,436.464	3,449.287	3,455.990	3,455.301	3,465.108
2020	3,419.721	3,401.285	3,416.741	3,426.221	3,436.463	3,449.289	3,455.991	3,455.303	3,465.107
2021	(9)	3,401.270	3,416.739	3,426.217	3,436.462	3,449.288	3,455.990	3,455.306	3,465.107
2022	(9)	3,401.232	3,416.719	3,426.200	3,436.448	3,449.278	3,455.980	3,455.294	3,465.093
2023	3419.710	3,401.213	3,416.718	3,426.202	3,436.447	3,449.275	3,455.979	3,455.294	3,465.095

Note:

(9) Construction activity in the vicinity of the monument precluded its use in the noted year's annual survey.
(10) The monument was not use in the noted year's annual survey.
(*) Data was being tested for accuracy/reliability during these years.

Table F. Comparison of Elevations 1987-2023 (continued)

	Z-418	A-419	B-419	C-419	D-419	K-349
1987*	(10)	(10)	(10)	(10)	(10)	(10)
1989*	(10)	(10)	(10)	(10)	(10)	(10)
1992*	(10)	(10)	(10)	(10)	(10)	(10)
1993*	(10)	(10)	(10)	(10)	(10)	(10)
1994	(10)	(10)	(10)	(10)	(10)	(10)
1995	(10)	(10)	(10)	(10)	(10)	(10)
1996	3,461.073	3,454.714	3,449.825	3,437.633	3,423.234	3,404.152
1997	3,461.082	3,454.720	3,449.829	3,437.642	3,423.238	3,404.162
1998	3,461.091	3,454.730	3,449.835	3,437.648	3,423.242	3,404.173
1999	3,461.105	3,454.744	3,449.848	3,437.657	3,423.247	3,404.169
2000	3,461.109	3,454.749	3,449.853	3,437.660	3,423.250	3,404.157
2001	3,461.111	3,454.752	3,449.856	3,437.663	3,423.254	3,404.152
2002	3,461.113	3,454.754	3,449.857	3,437.665	3,423.256	3,404.150
2003	3,461.112	3,454.752	3,449.856	3,437.665	3,423.256	3,404.137
2004	3,461.117	3,454.754	3,449.858	3,437.668	3,423.257	3,404.127
2005	3,461.108	3,454.742	3,449.848	3,437.663	3,423.243	3,404.105
2006	3,461.108	3,454.739	3,449.846	3,437.664	3,423.243	3,404.091
2007	3,461.117	3,454.749	3,449.855	3,437.673	3,423.248	3,404.096
2008	3,461.112	3,454.747	3,449.854	3,437.673	3,423.250	3,404.081
2009	3,461.117	3,454.752	3,449.857	3,437.675	3,423.251	3,404.073
2010	3,461.109	3,454.741	3,449.846	3,437.666	3,423.240	3,404.047
2011	3,461.122	3,454.757	3,449.861	3,437.682	3,423.253	3,404.042
2012	3,461.124	3,454.758	3,449.861	3,437.682	3,423.255	3,404.022
2013	3,461.106	3,454.744	3,449.850	3,437.674	3,423.251	3,404.020
2014	3,461.107	3,454.743	3,449.849	3,437.673	3,423.255	3,403.990
2015	3,461.106	3,454.742	3,449.849	3,437.677	3,423.254	3,403.971
2016	3,461.098	3,454.731	3,449.838	3,437.668	3,423.243	3,403.941
2017	3,461.104	3,454.740	3,449.848	3,437.679	3,423.253	3,403.932
2018	3,461.098	3,454.734	3,449.843	3,437.676	3,423.253	3,403.909
2019	3,461.105	3,454.744	3,449.851	3,437.684	3,423.257	3,403.894
2020	3,461.105	3,454.746	3,449.852	3,437.684	3,423.262	3,403.866
2021	3,461.106	3,454.751	3,449.851	3,437.688	3,423.264	3,403.859
2022	3,461.092	3,454.738	3,449.847	3,437.680	3,423.262	3,403.826
2023	3,461.093	3,454.740	3,449.846	3,437.681	3,423.265	3,403.808

	S-55	S-56	S-57	S-58	S-59	S-60	S-61	S-62	S-63
2023	3376.377	3364.502	3362.086	3359.735	3365.128	3369.994	3374.930	3380.845	3375.992

	S-64	S-65	S-66	S-67	S-68	S-69	S-70	S-71	S-72
2023	3,384.702	3,380.162	3,382.119	3,380.935	3,386.335	3,393.116	3,390.654	3,390.087	3,387.107

	S-73	S-74	S-75	S-76	S-77	S-78	S-79	S=80	S-81
2023	3,395.238	3,405.213	3,406.752	3,407.025	3,412.672	3,413.991	3,416.245	3,404.359	3,410.549

	S-82	S-83
2023	3,414.884	3,410.458

Note: (10) The monument was not use in the noted year's annual survey.
(*) Data was being tested for accuracy/reliability during these years.

For figures 2 through 63 data is not shown from (1987-1993) for the cumulative/ elevation charts because at the time, the data was being tested for accuracy/reliability. By the time it was 1993 there was more confidence in the data being consistent because that's when the WIPP group started surveying. For the initial year that WIPP surveyors started surveying the subsidence loops the data will have zero for all the delta values since there is no change in delta, so all the charts will start at year 1994. Figures 2 through 63 were made from data collected from Table F.

Figure 64 shows the expected surface subsidence compared to the actual surface subsidence as reported in 2008 and 2023. The expected surface subsidence contours are derived from (Backfill Engineering Analysis Report, IT Corporation, August 1994; Estimation of Surface Subsidence at the Waste Isolation Pilot Plant, DOE/WIPP-95-2097, 1995).

The contours show the Influence Function Method of subsidence estimation and assumes waste only emplacement (no back fill) in the disposal panels. The four profiles show that the actual reported subsidence is developing towards the expected subsidence. Profile 1and Profile 2 run east-west over the disposal panels. Profile 3 runs about 500 feet south of the disposal panels. Profile 4 runs north-south from the shaft pillar area to the disposal panels. The shaft pillar area has a lower extraction ratio as compared to the disposal panels and thus the subsidence over the shaft pillar area is less than the subsidence over the disposal panels.

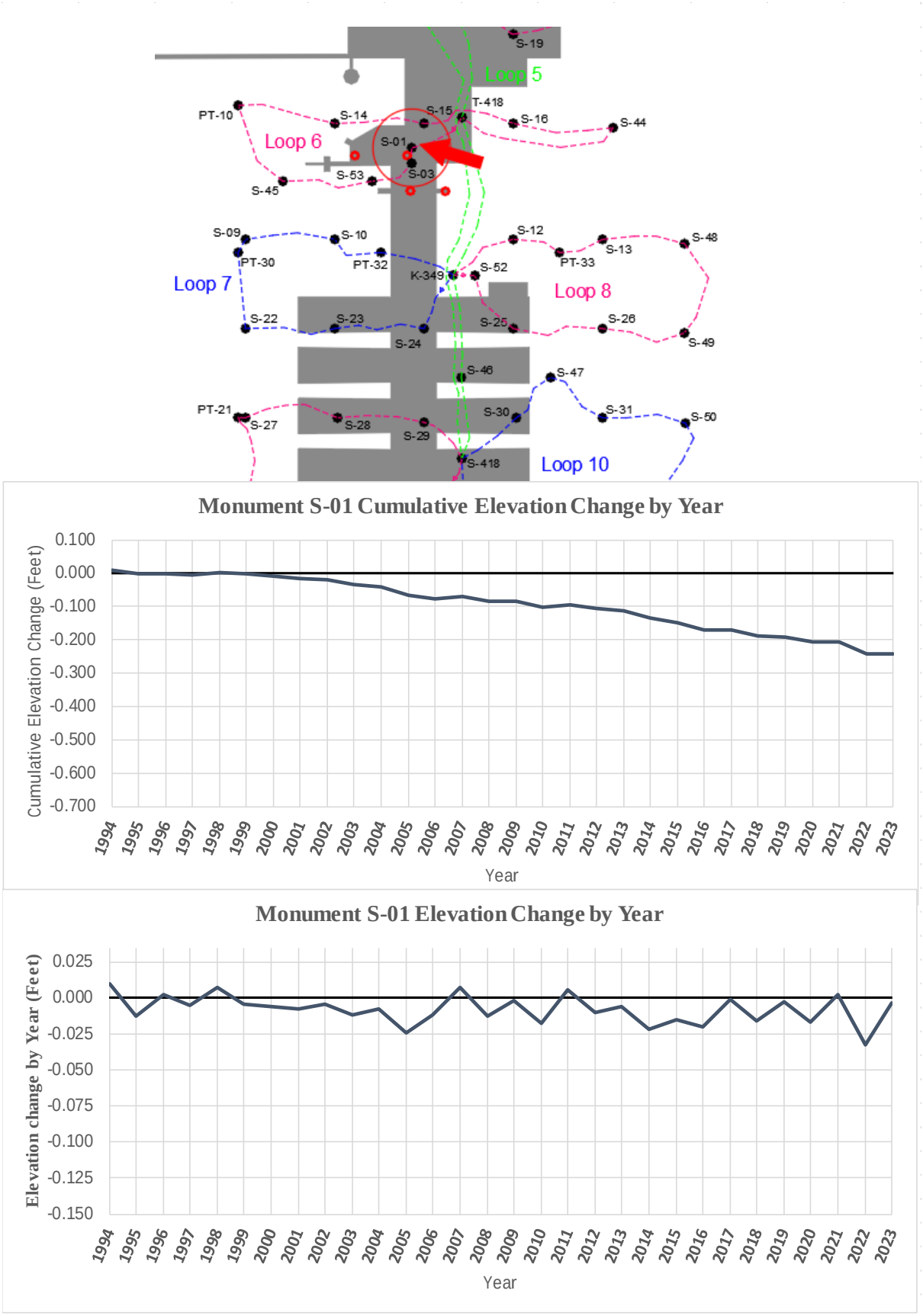


Figure 2. Monument S-01 Elevation Data Graphs

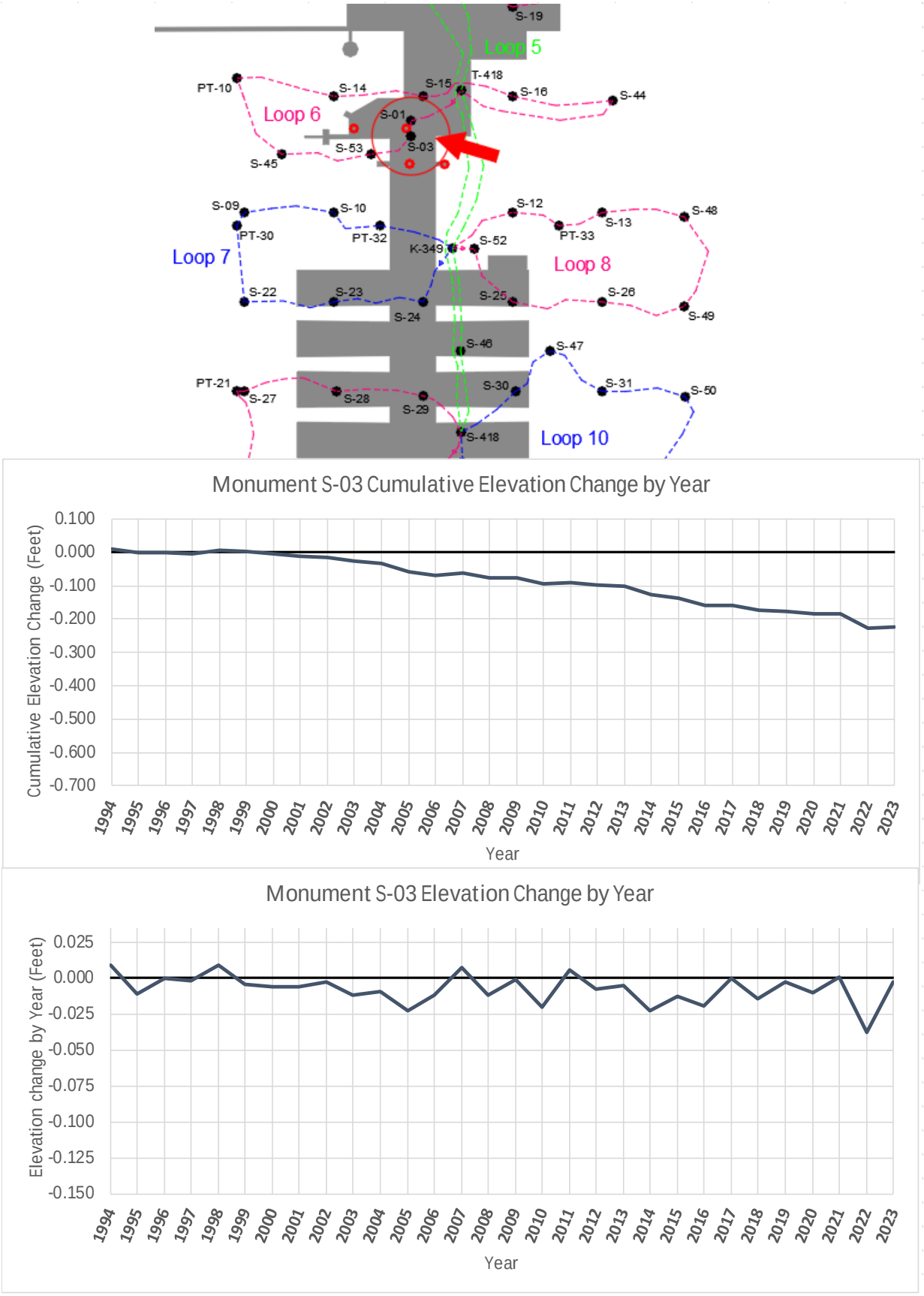


Figure 3. Monument S-03 Elevation Data Graphs

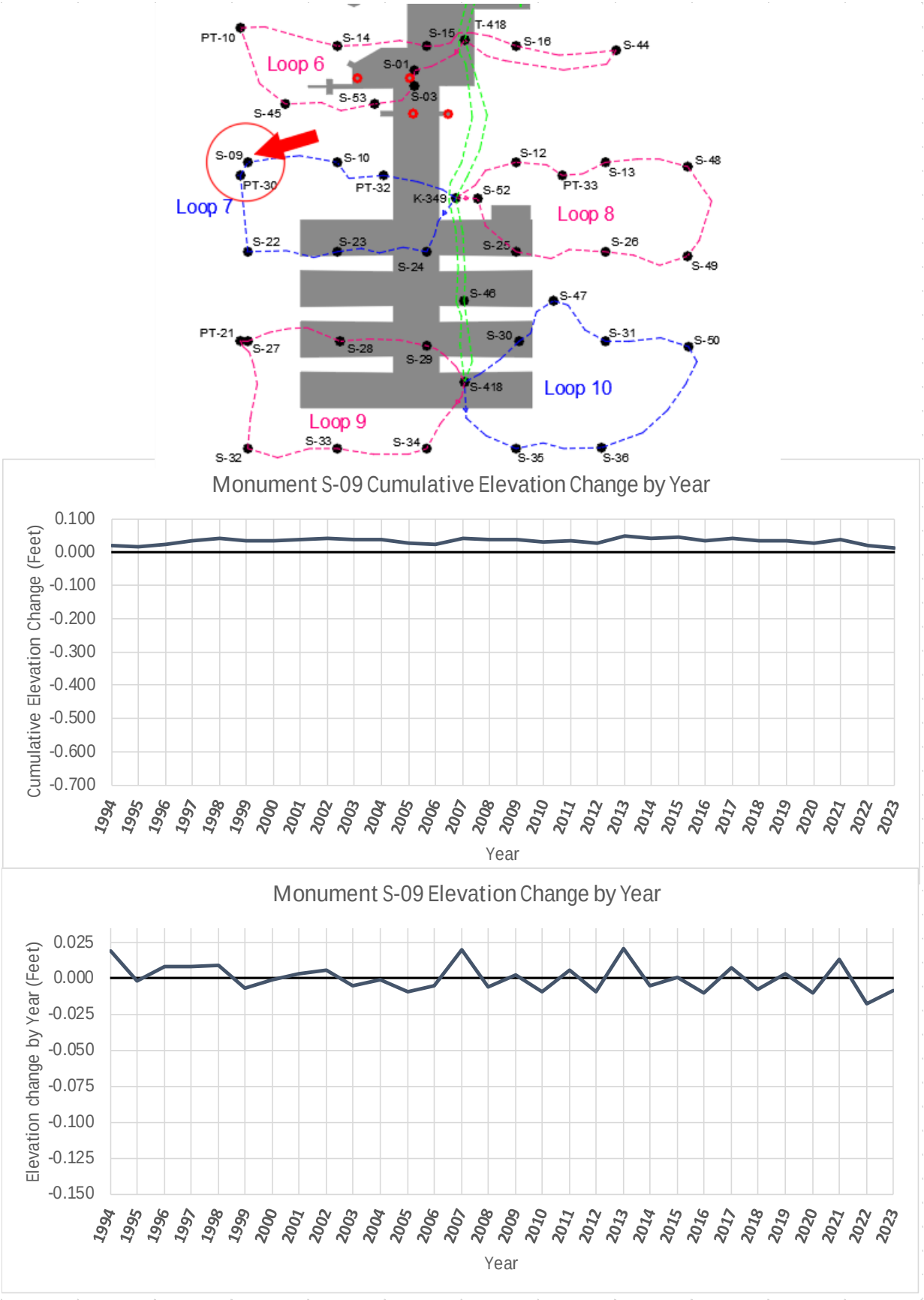


Figure 4. Monument S-09 Elevation Data Graphs

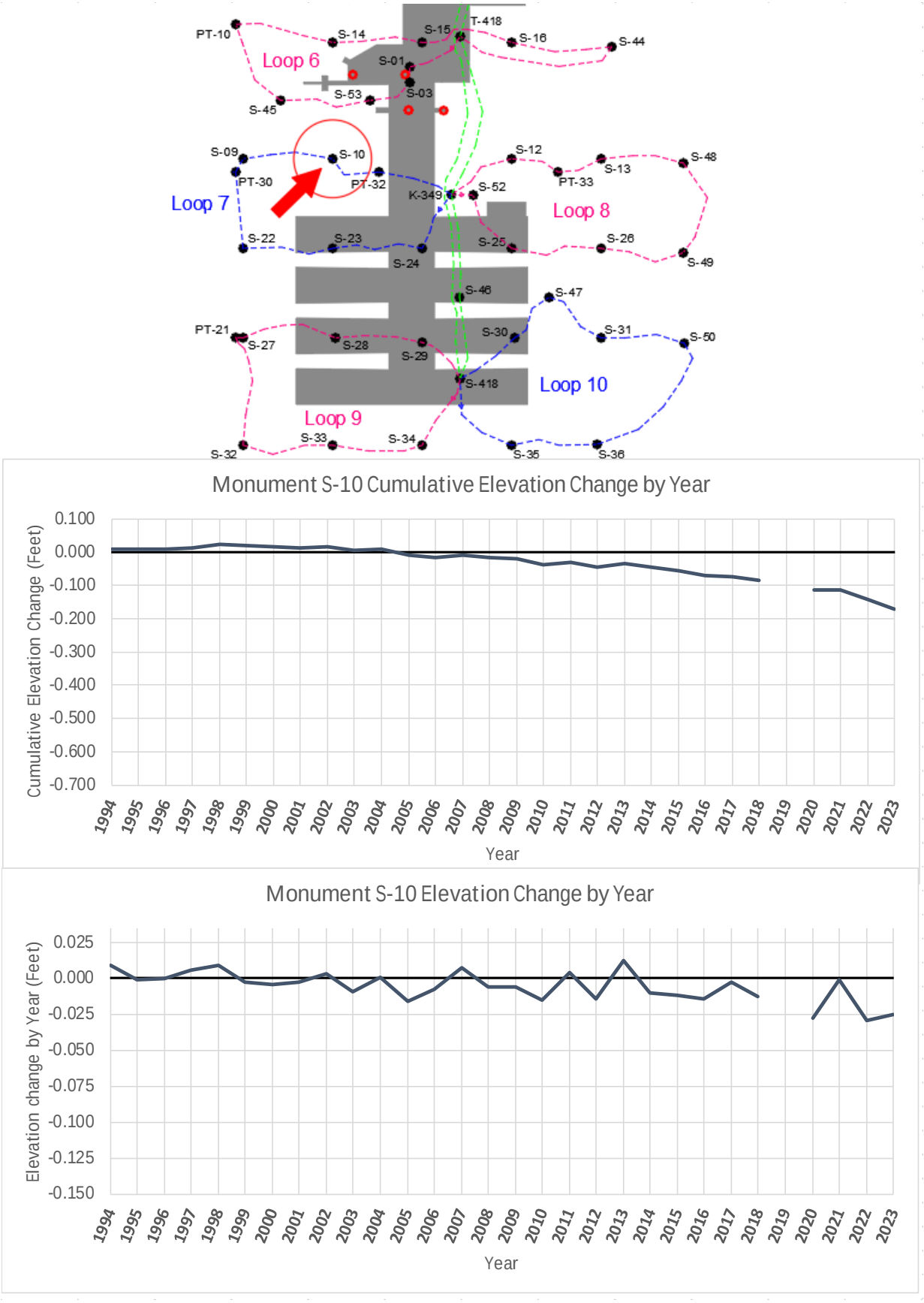


Figure 5. Monument S-10 Elevation Data Graphs

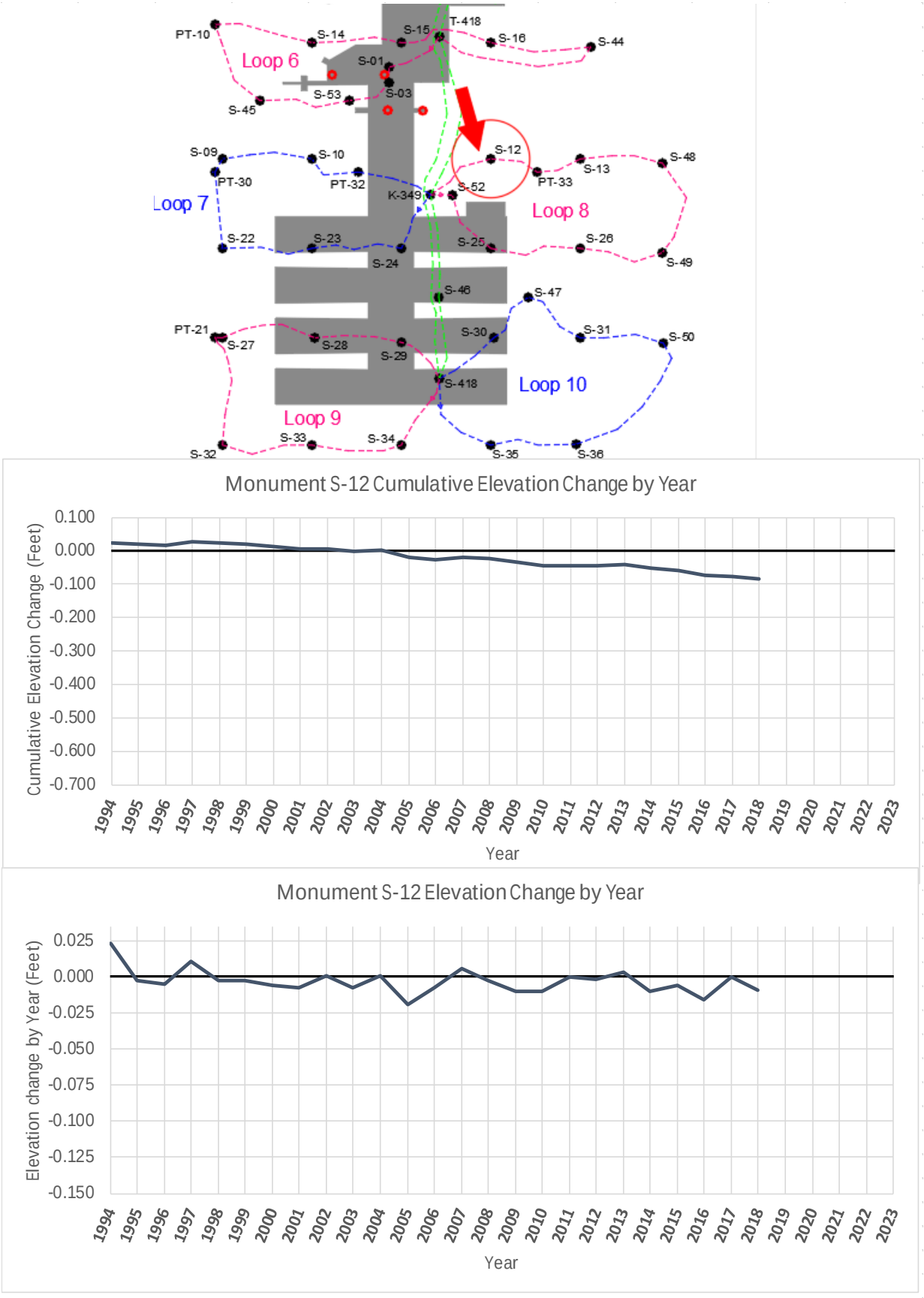


Figure 6. Monument S-12 Elevation Data Graphs

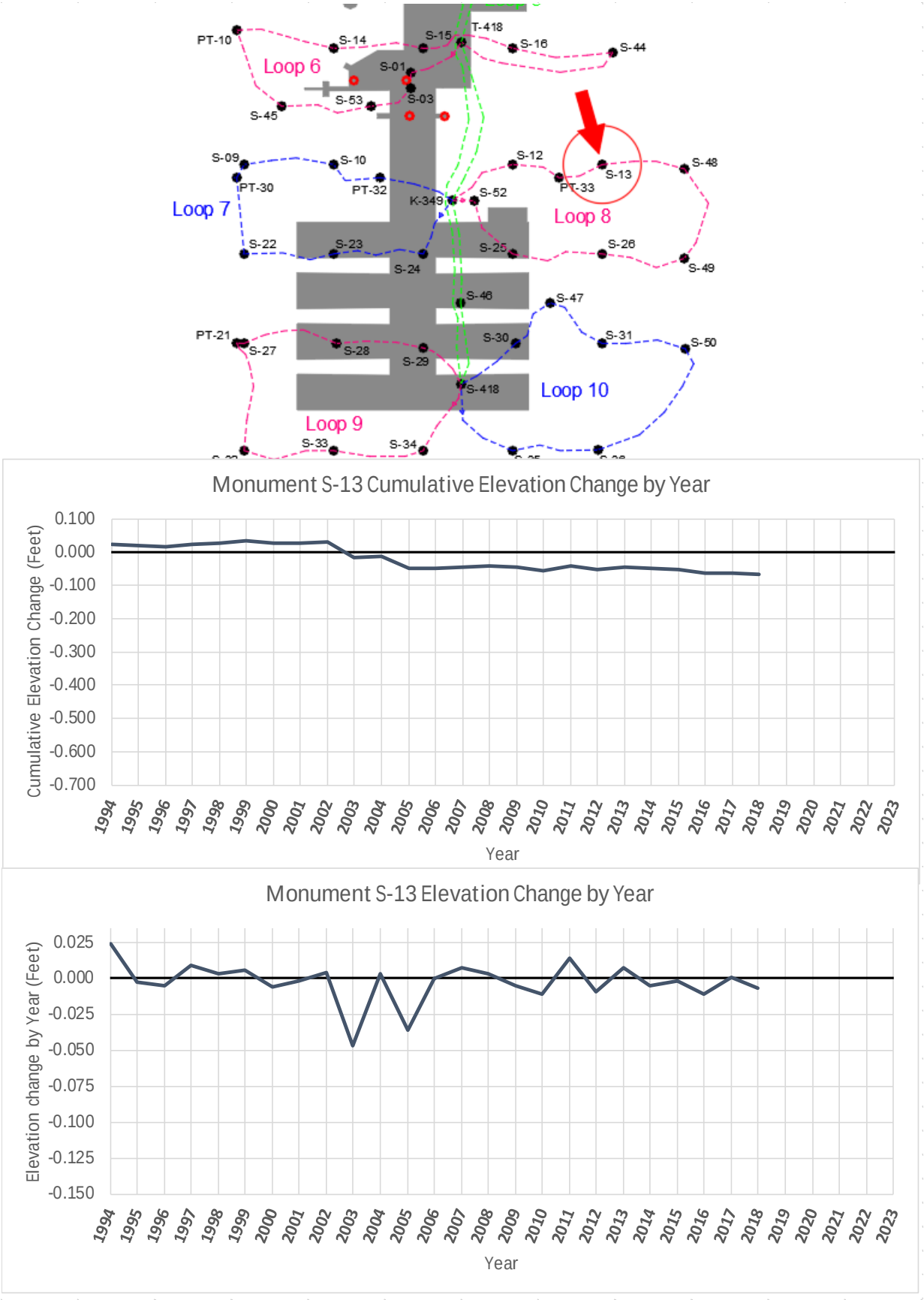


Figure 7. Monument S-13 Elevation Data Graphs

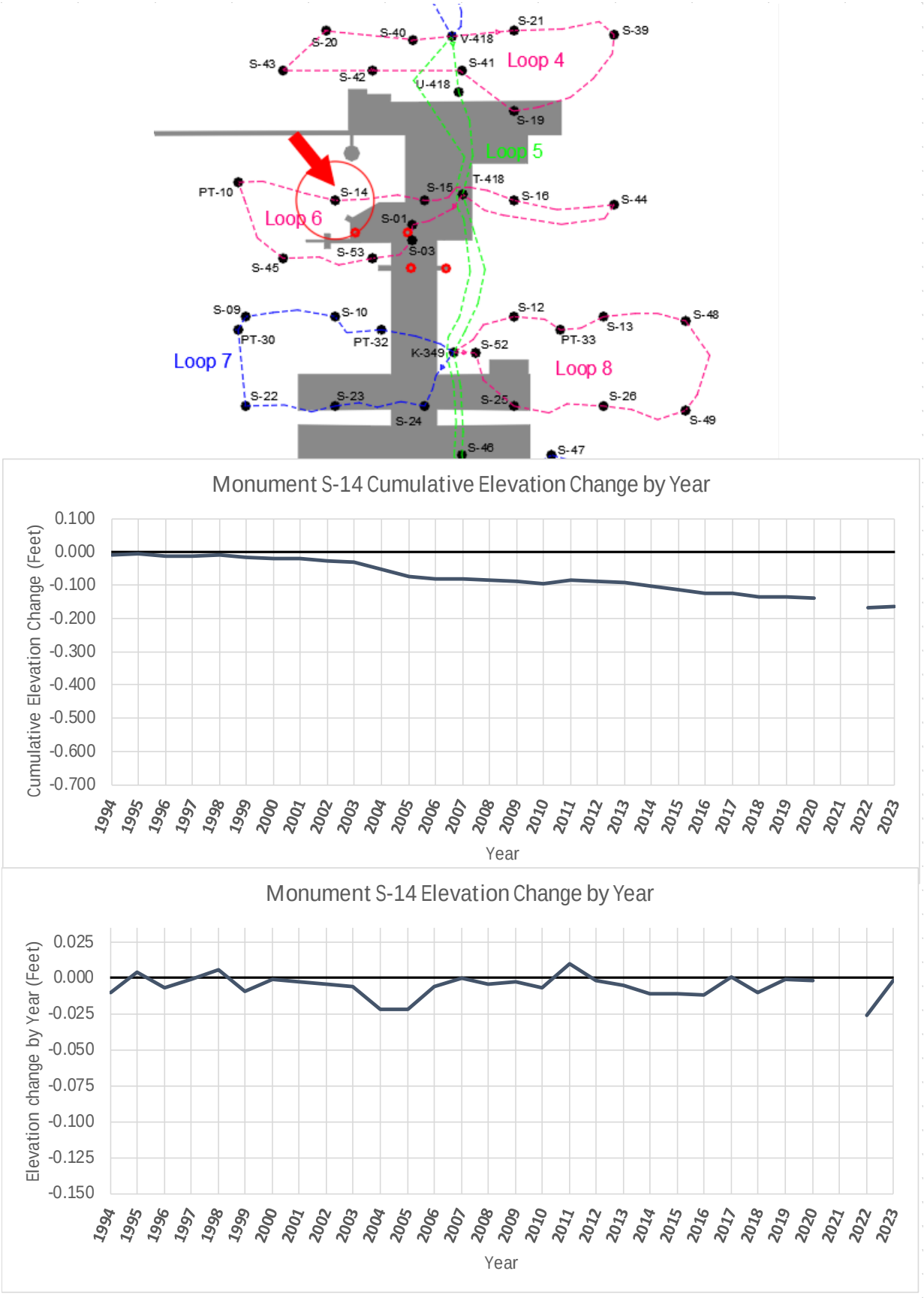


Figure 8. Monument S-14 Elevation Data Graphs

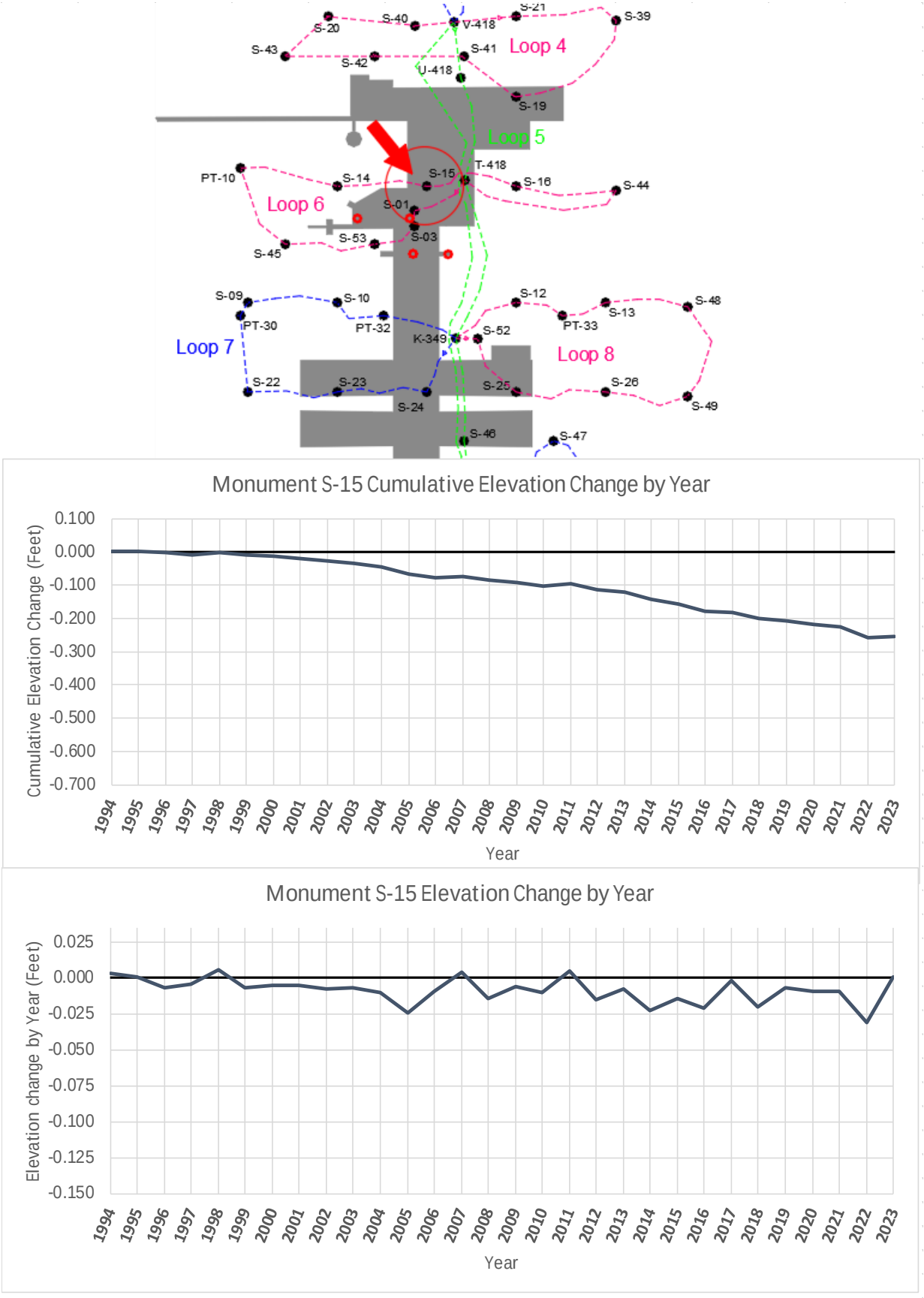


Figure 9. Monument S-15 Elevation Data Graphs

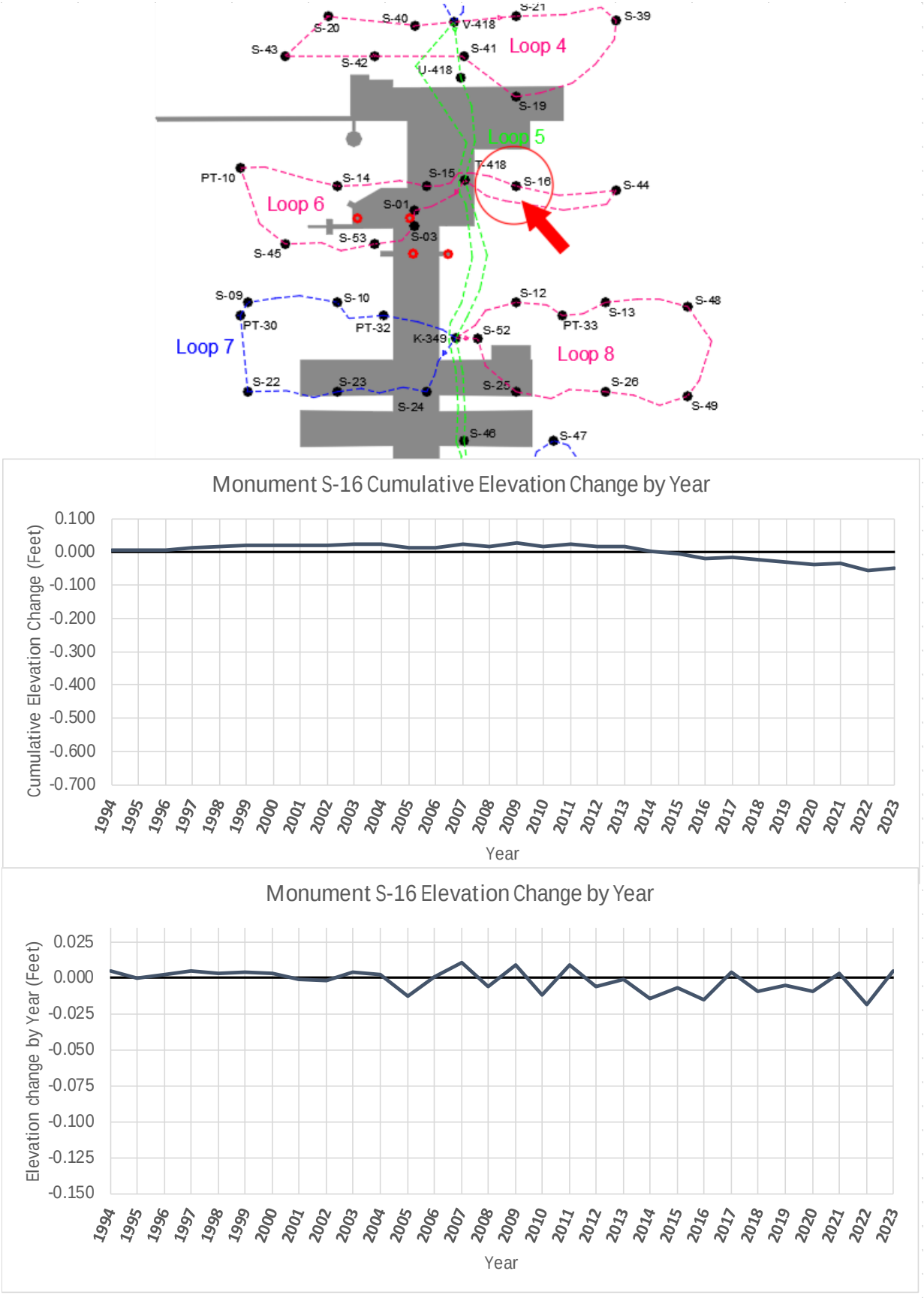


Figure 10. Monument S-16 Elevation Data Graphs

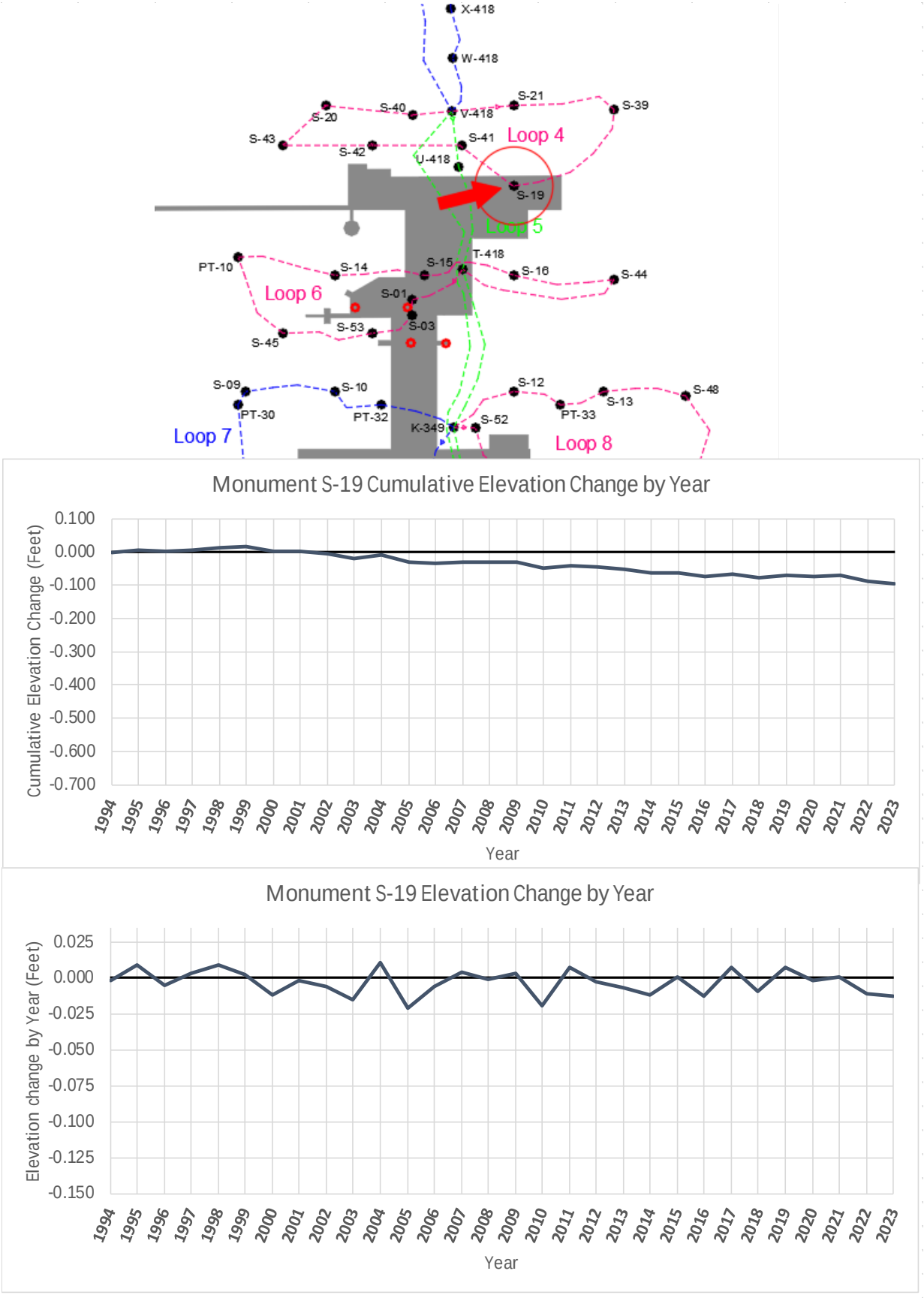


Figure 11. Monument S-19 Elevation Data Graphs

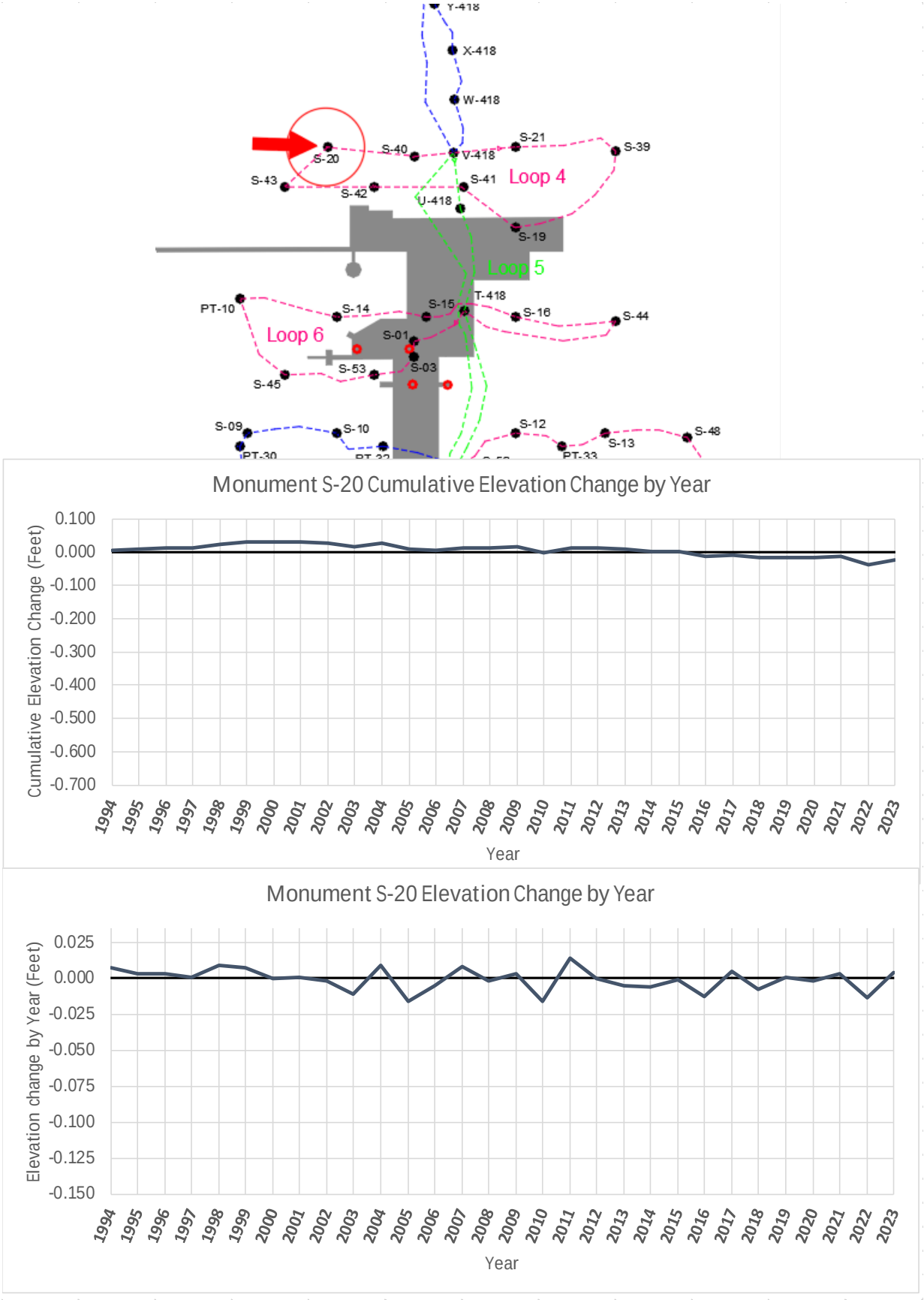


Figure 12. Monument S-20 Elevation Data Graphs

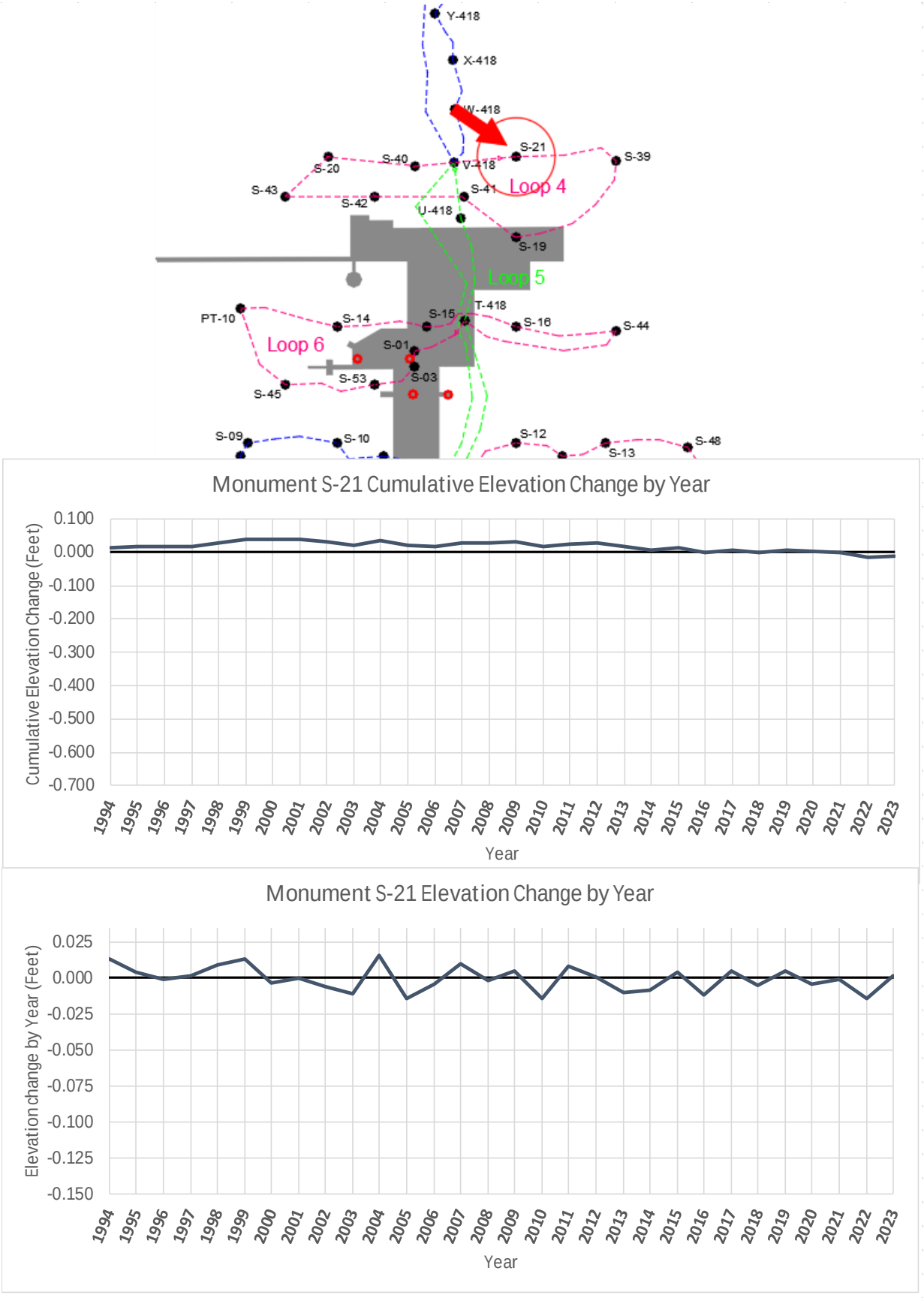


Figure 13. Monument S-21 Elevation Data Graphs

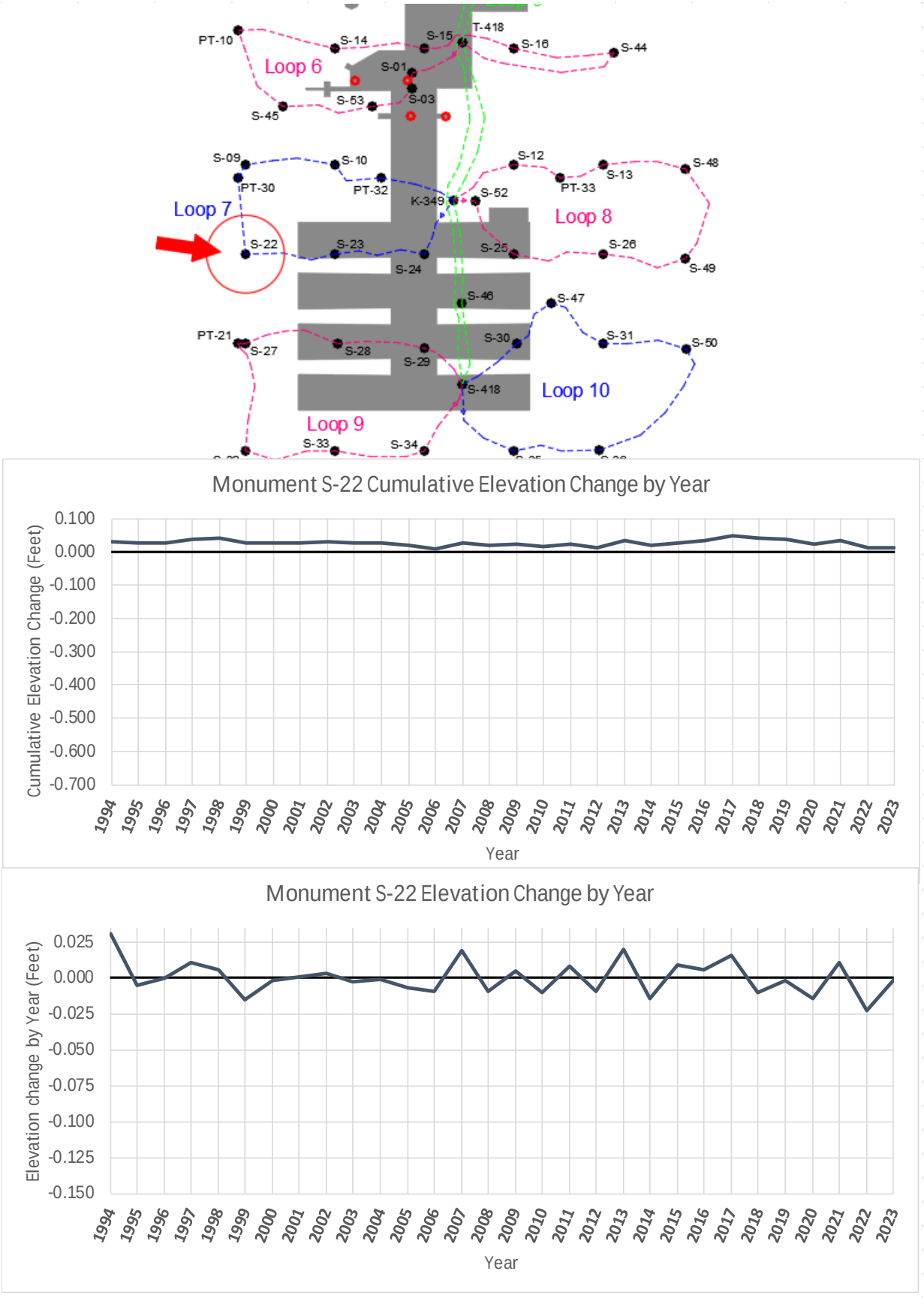


Figure 14. Monument S-22 Elevation Data Graphs

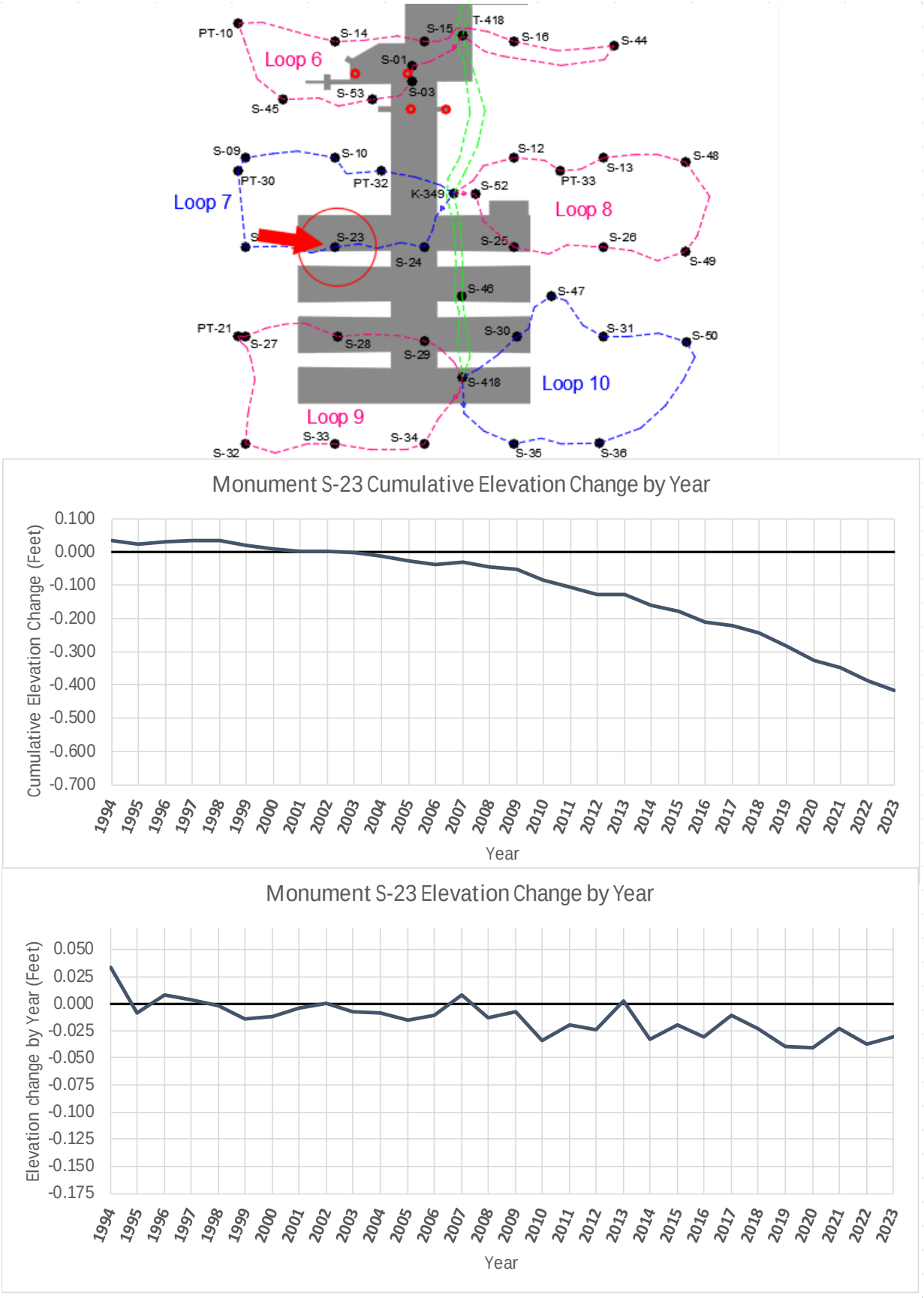


Figure 15. Monument S-23 Elevation Data Graphs

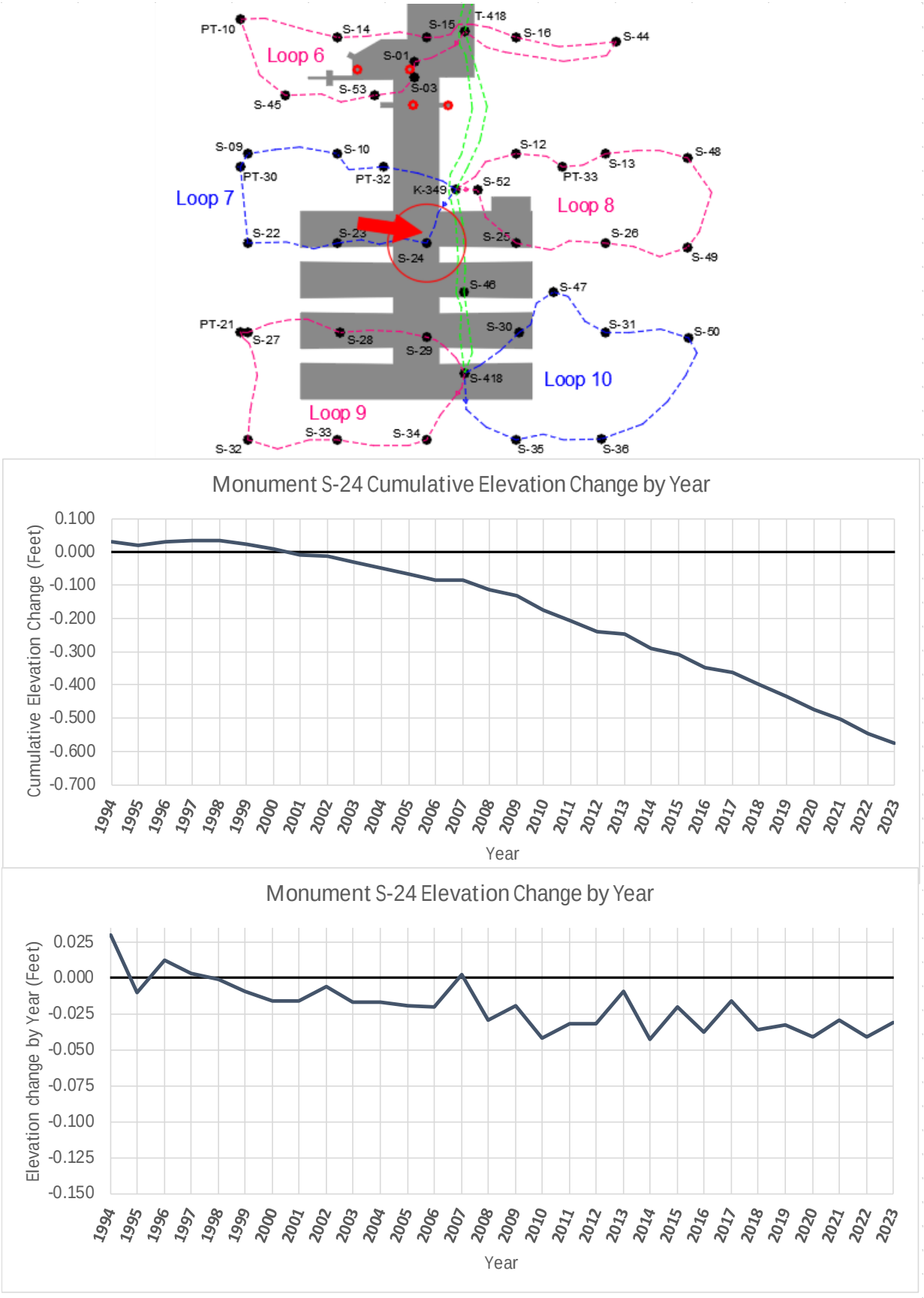


Figure 16. Monument S-24 Elevation Data Graphs

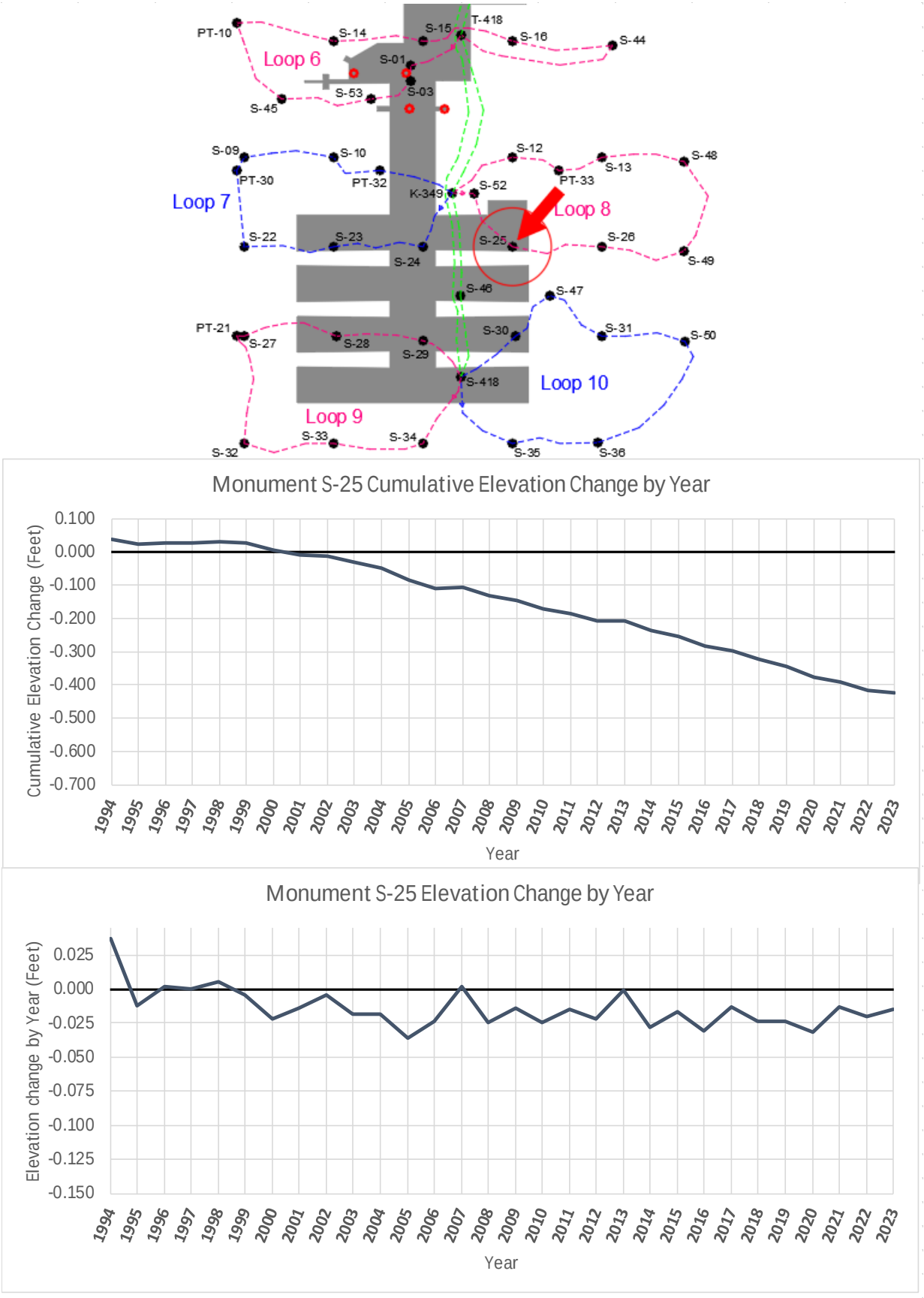


Figure 17. Monument S-25 Elevation Data Graphs

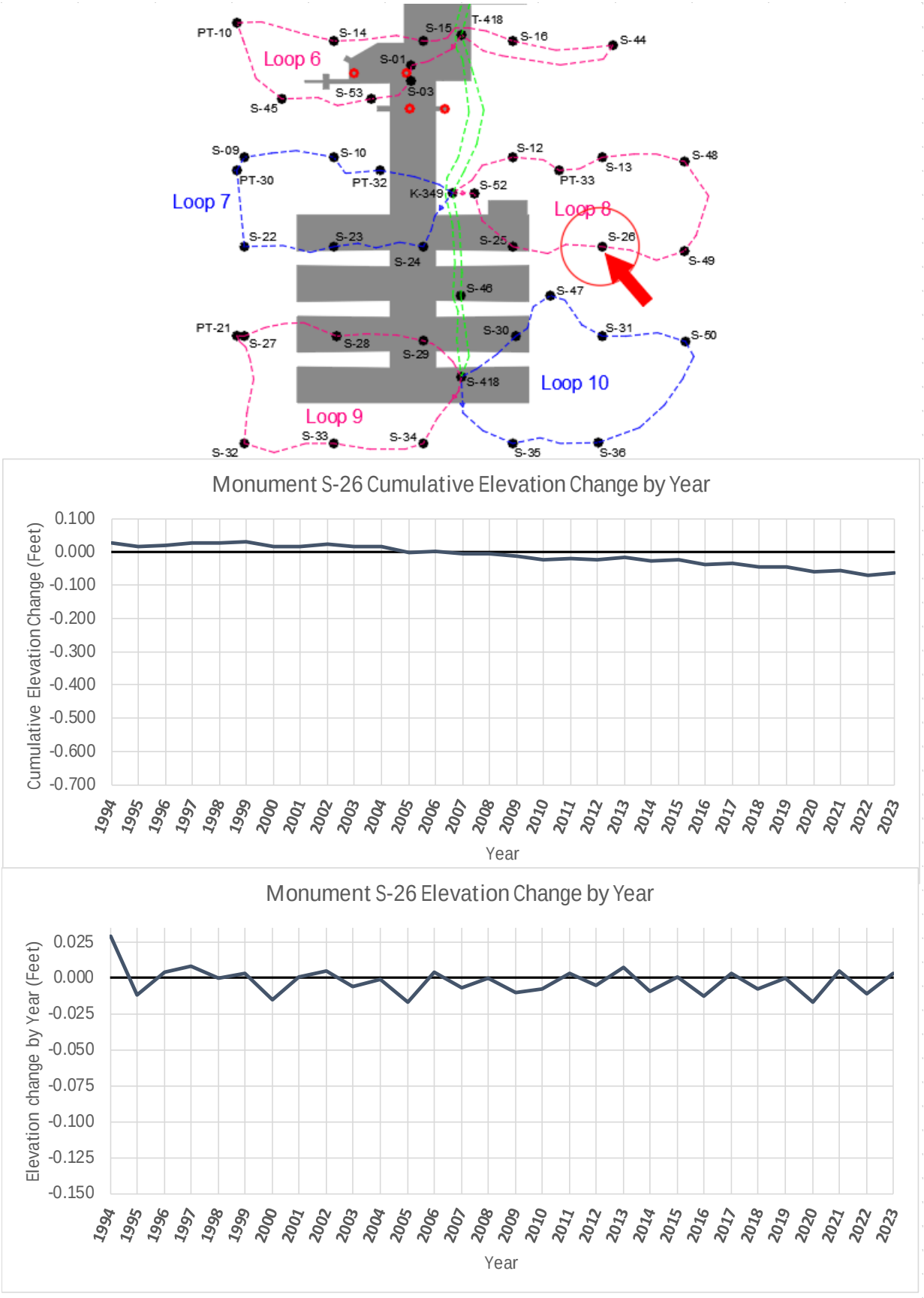


Figure 18. Monument S-26 Elevation Data Graphs

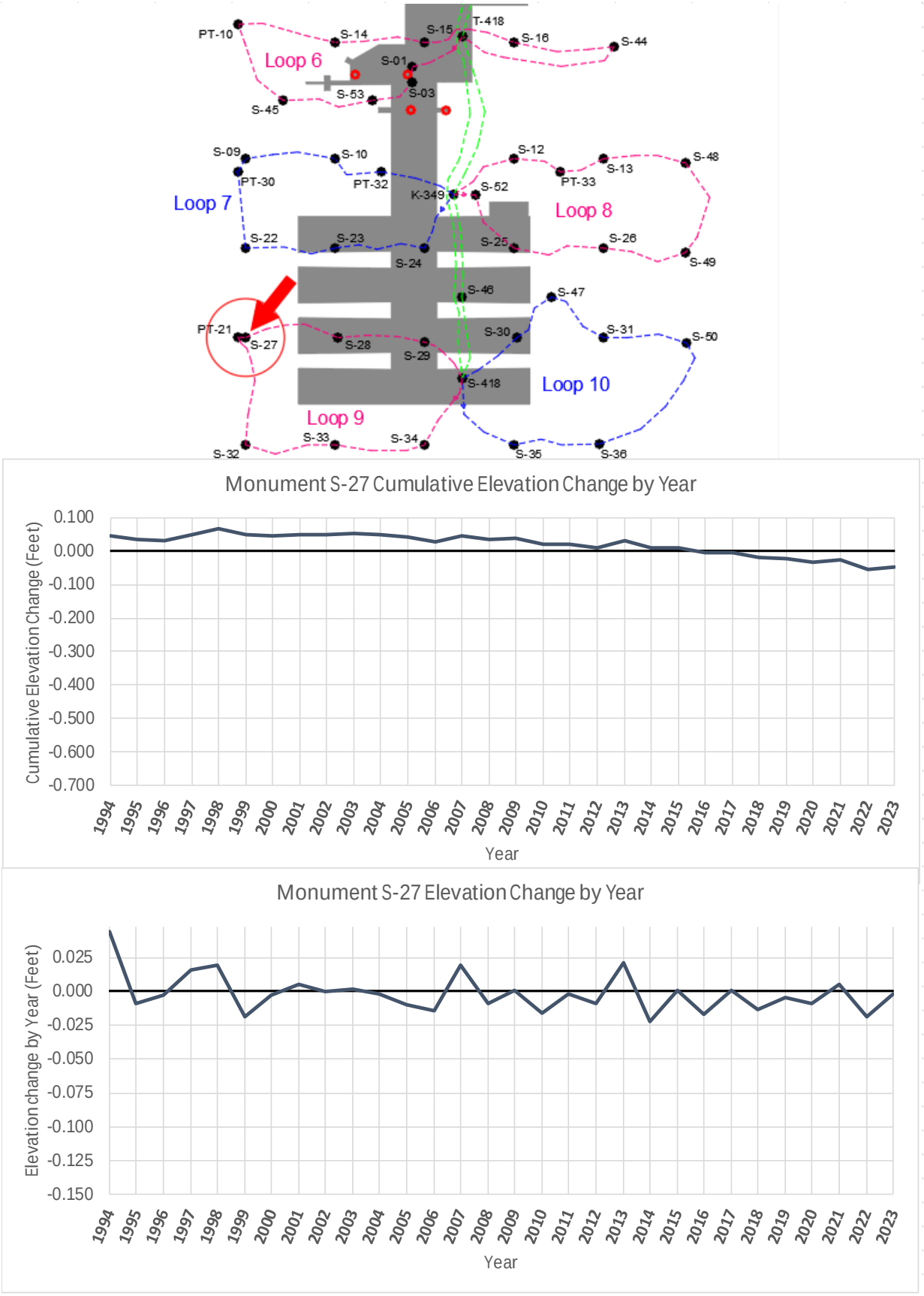


Figure 19. Monument S-27 Elevation Data Graphs

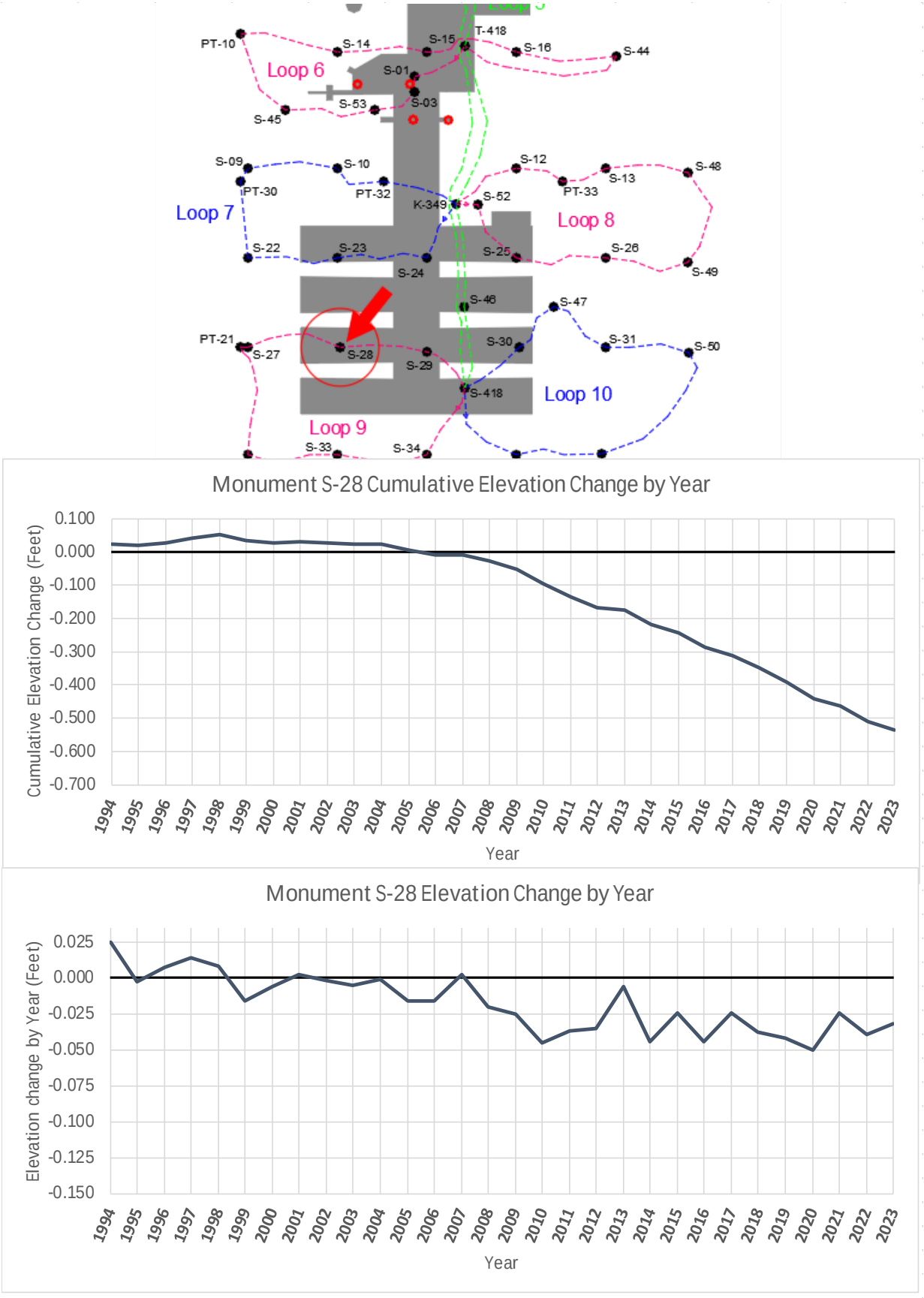


Figure 20. Monument S-28 Elevation Data Graphs

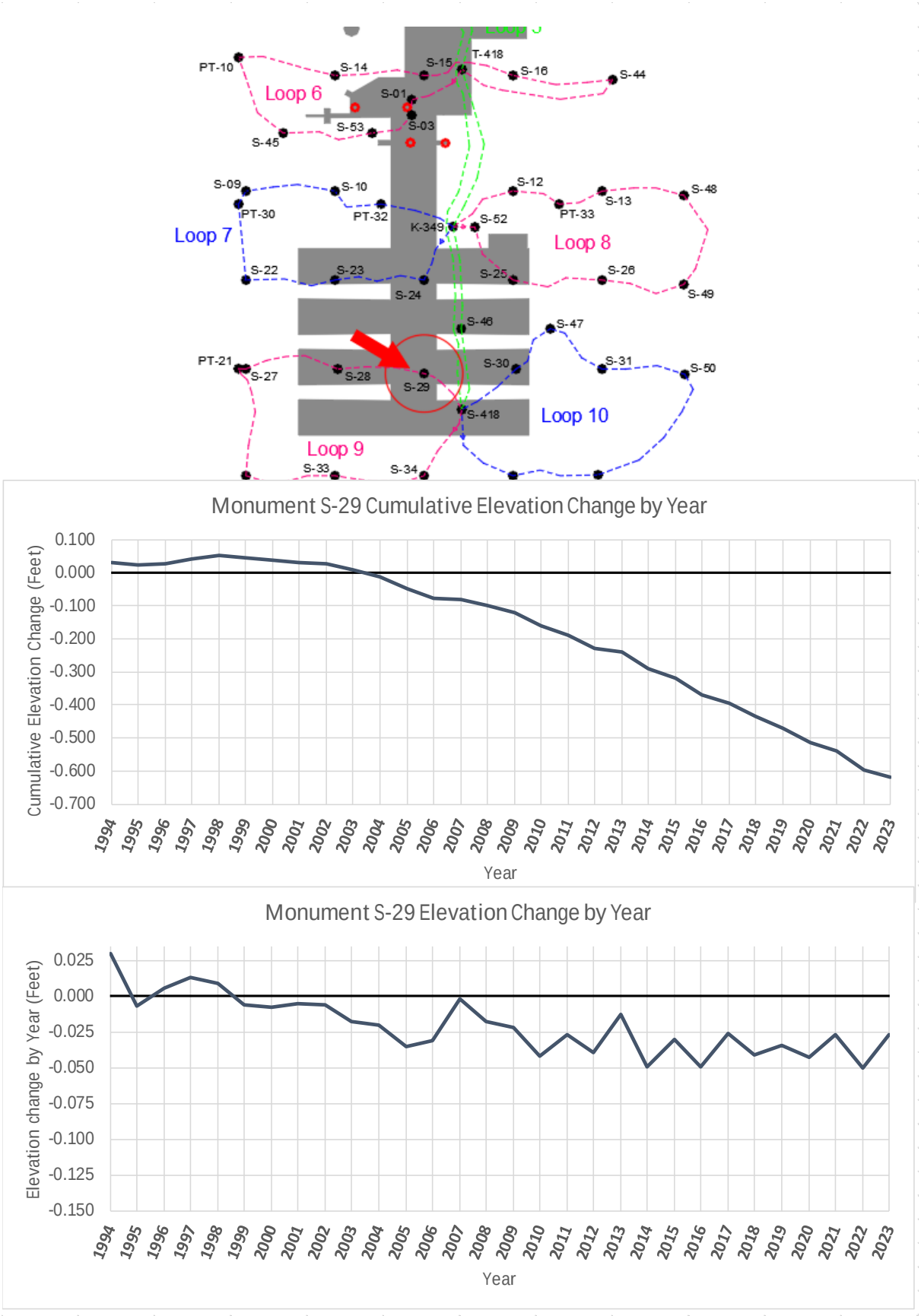


Figure 21. Monument S-29 Elevation Data Graphs

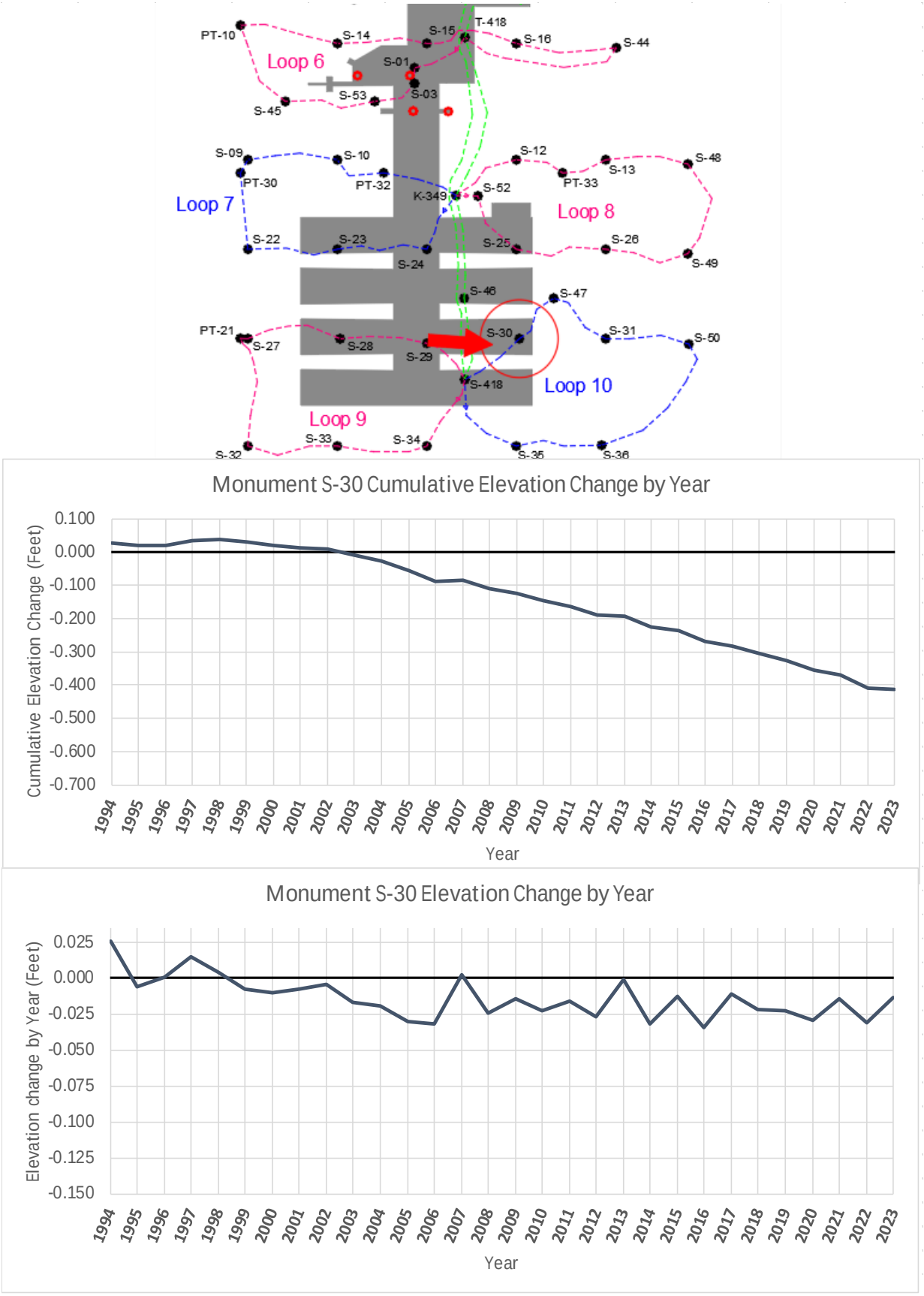


Figure 22. Monument S-30 Elevation Data Graphs

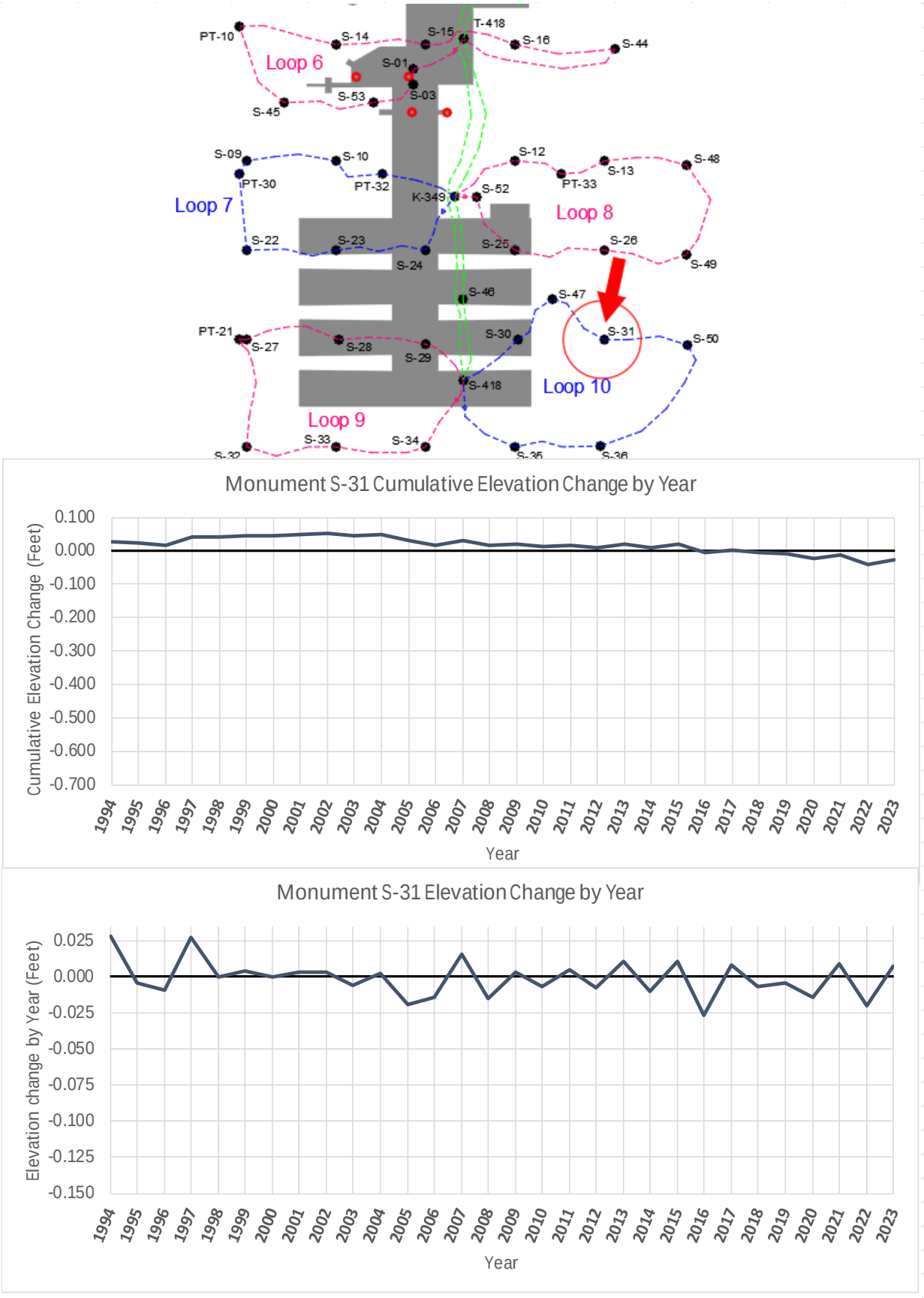


Figure 23. Monument S-31 Elevation Data Graphs

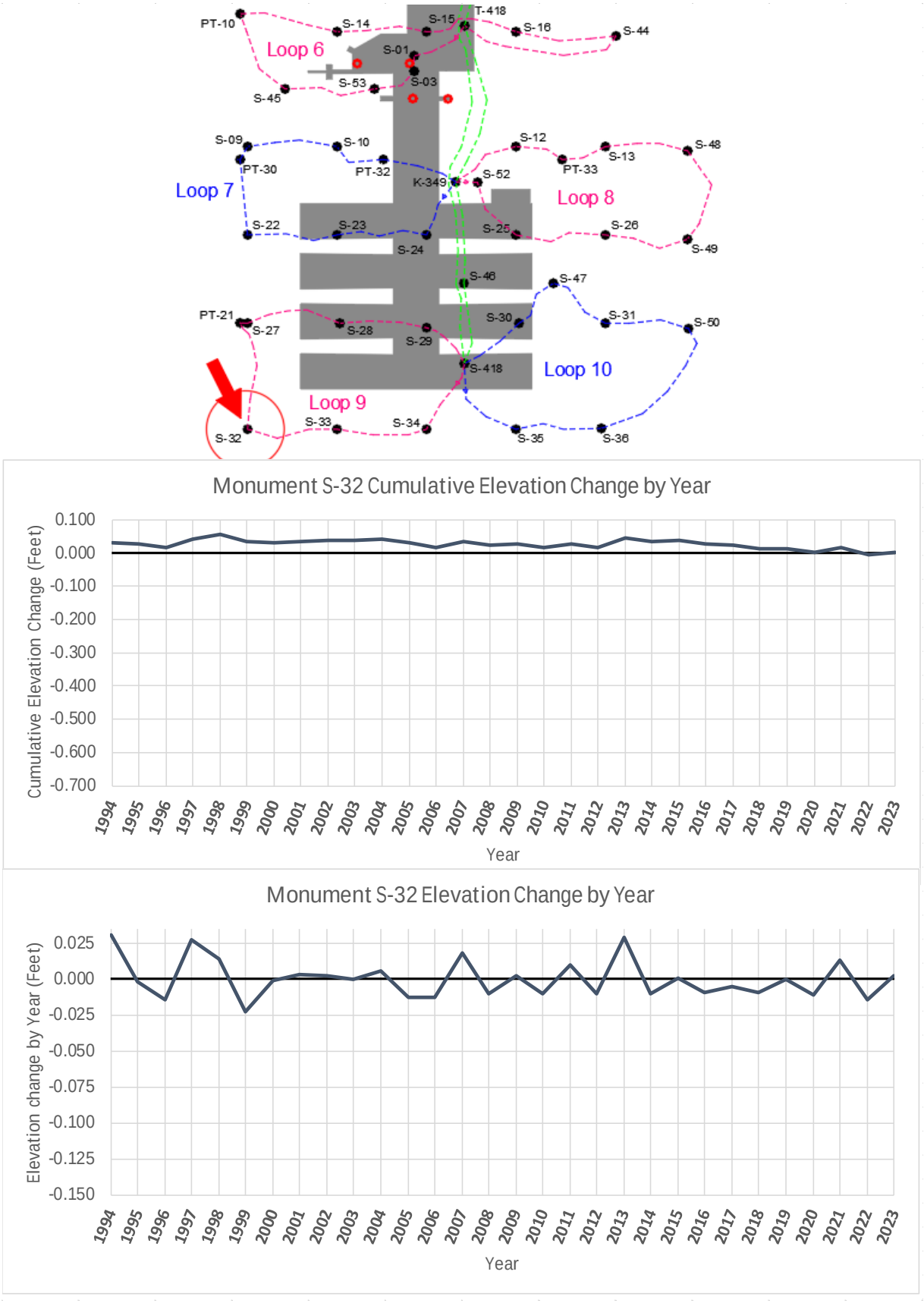


Figure 24. Monument S-32 Elevation Data Graphs

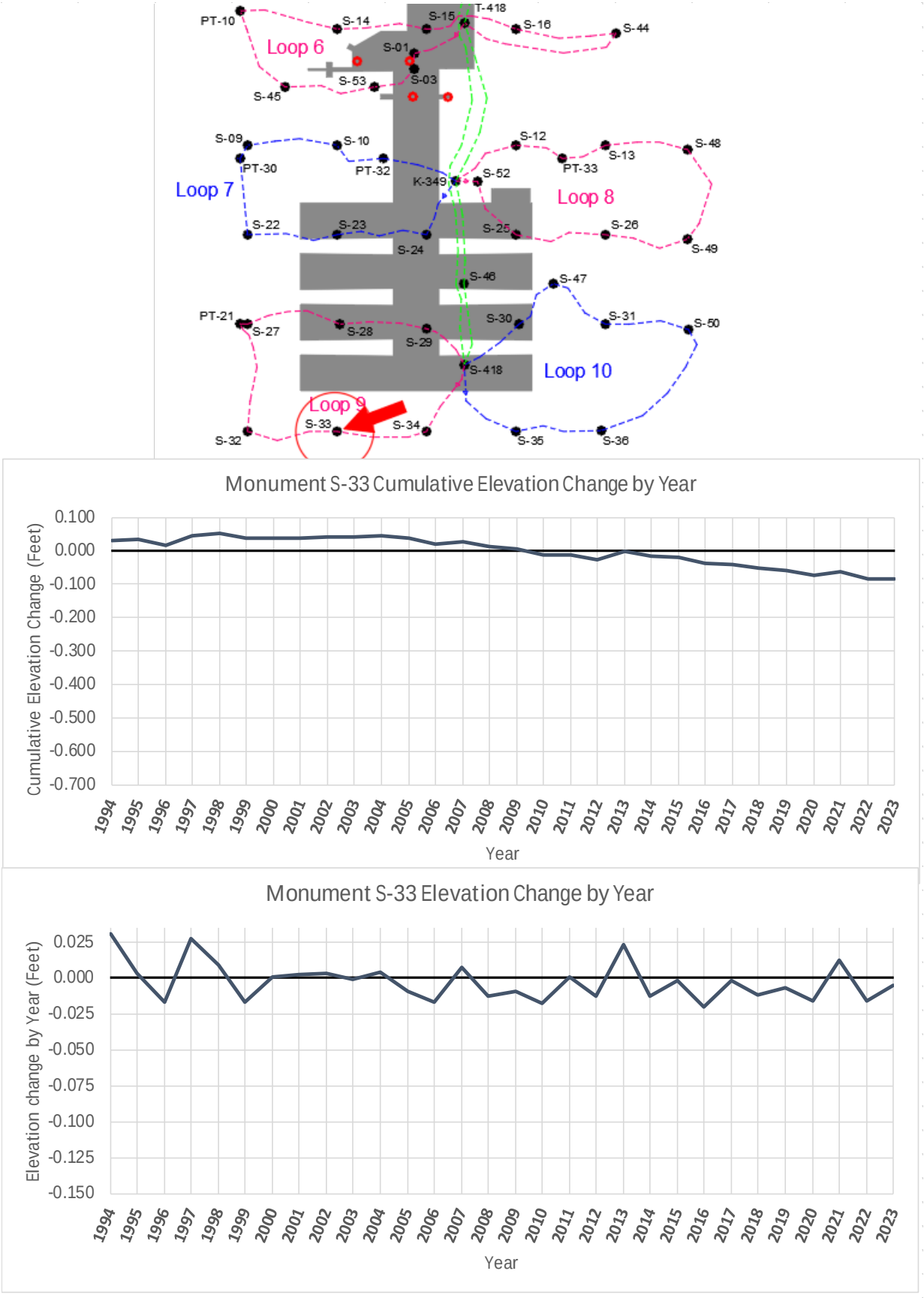


Figure 25. Monument S-33 Elevation Data Graphs

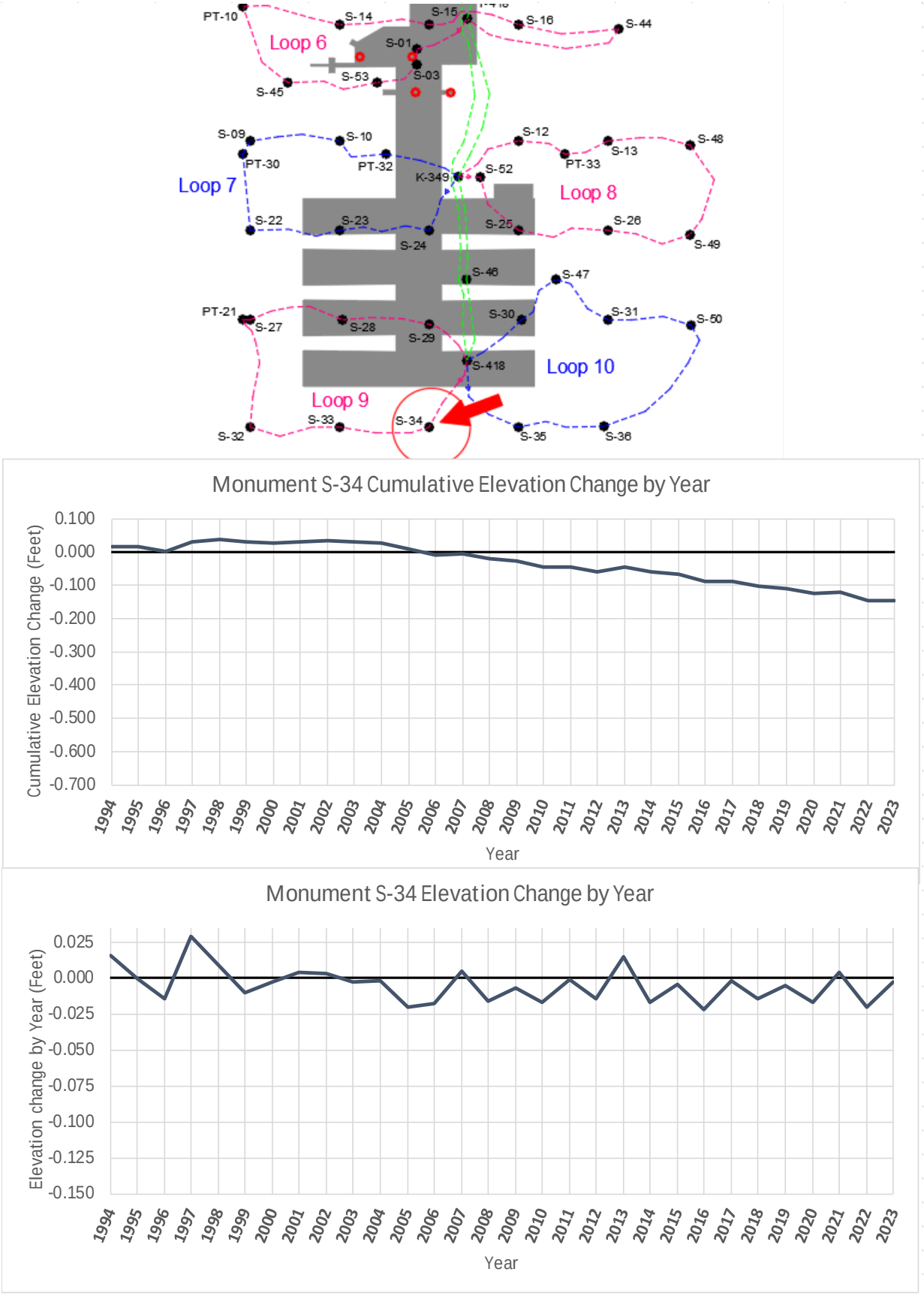


Figure 26. Monument S-34 Elevation Data Graphs

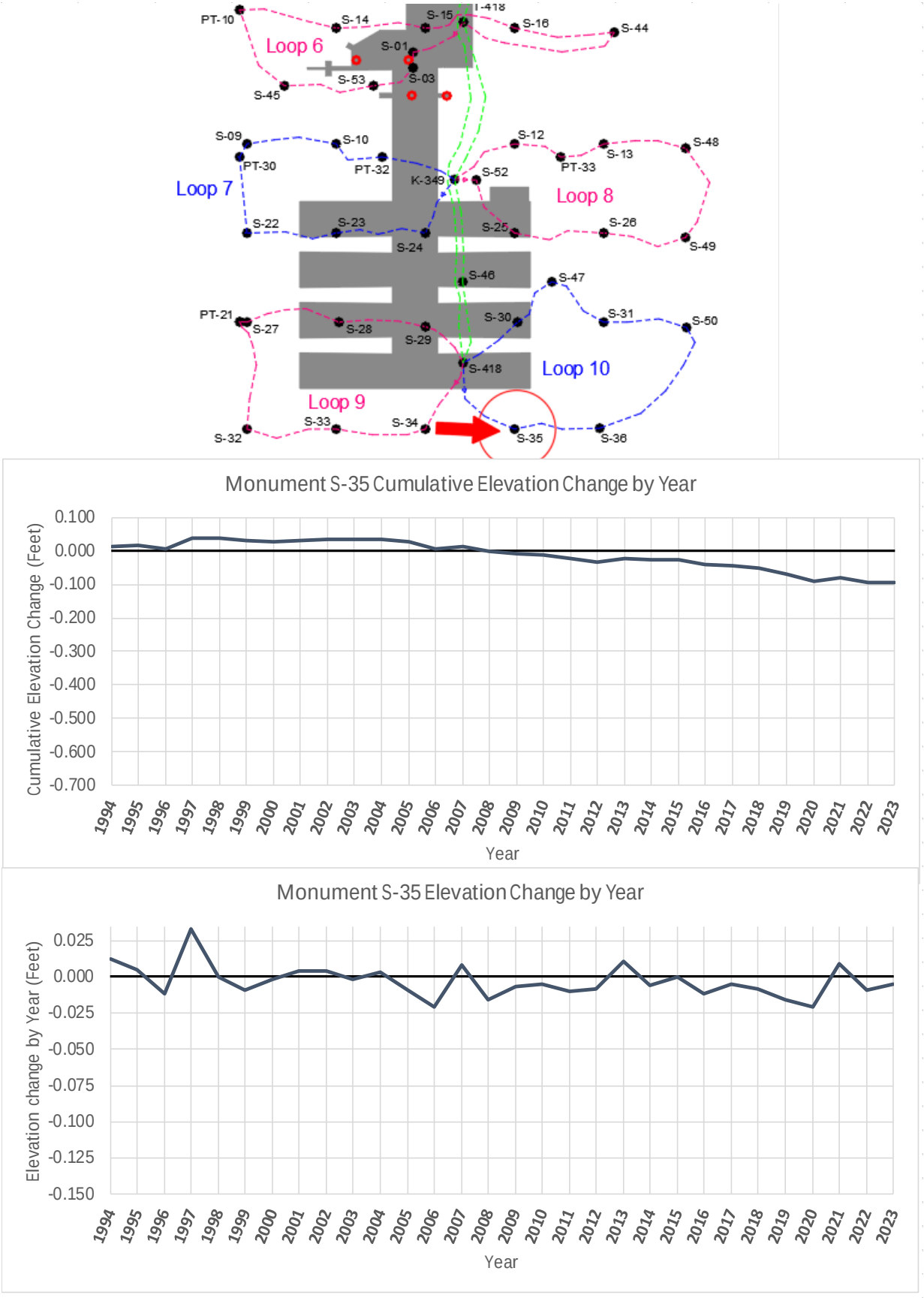


Figure 27. Monument S-35 Elevation Data Graphs

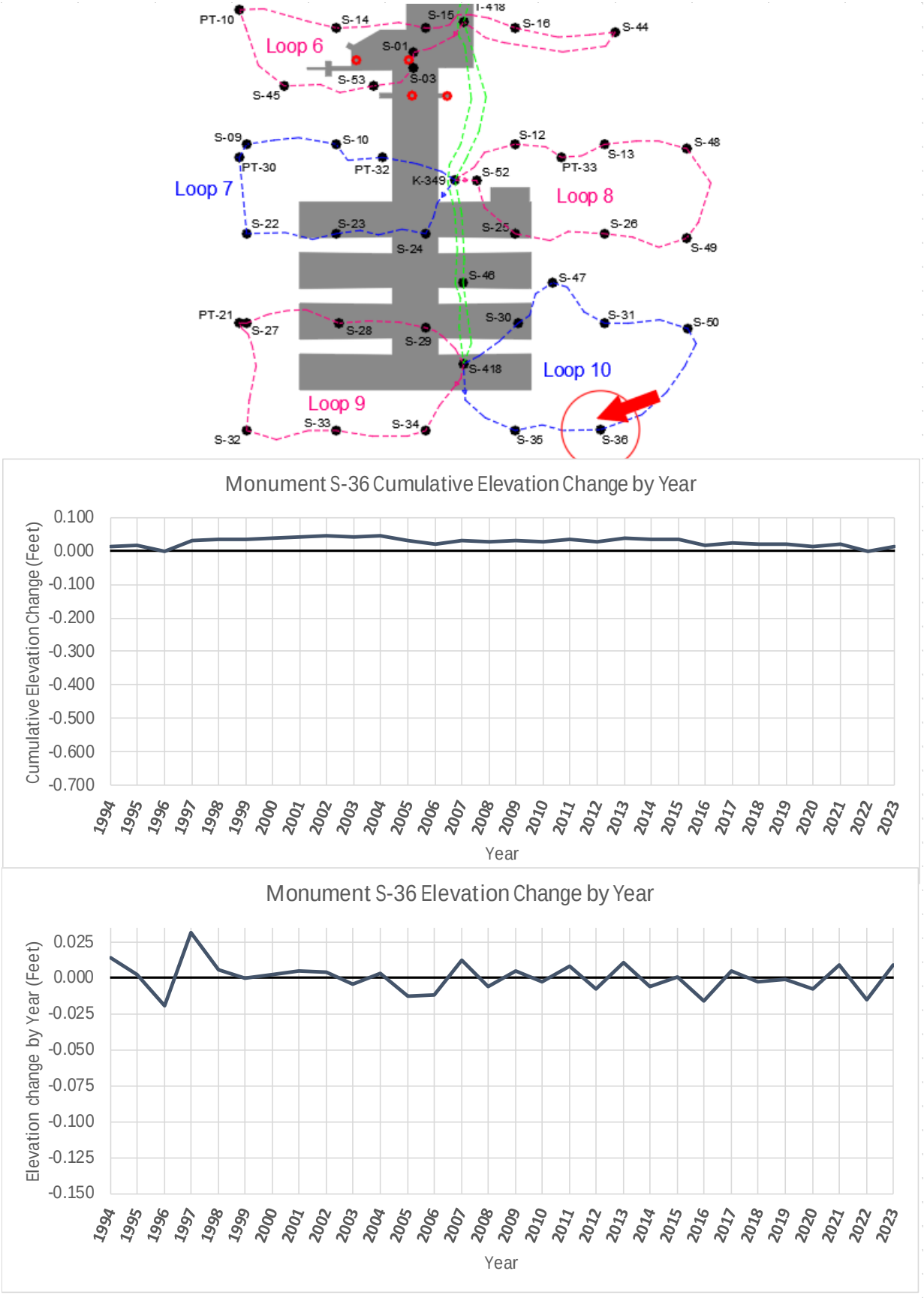


Figure 28. Monument S-36 Elevation Data Graphs

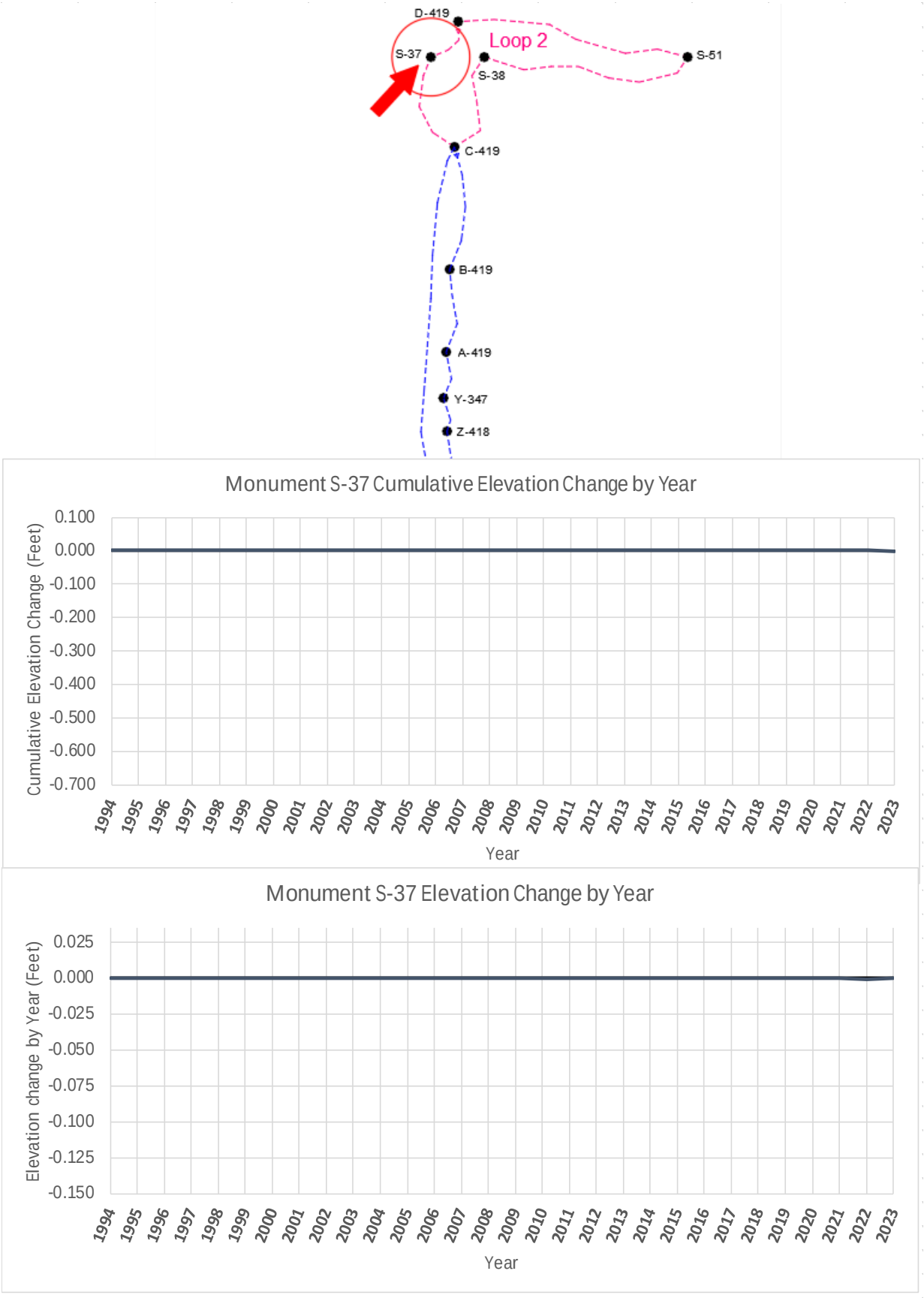


Figure 29. Monument S-37 Elevation Data Graphs

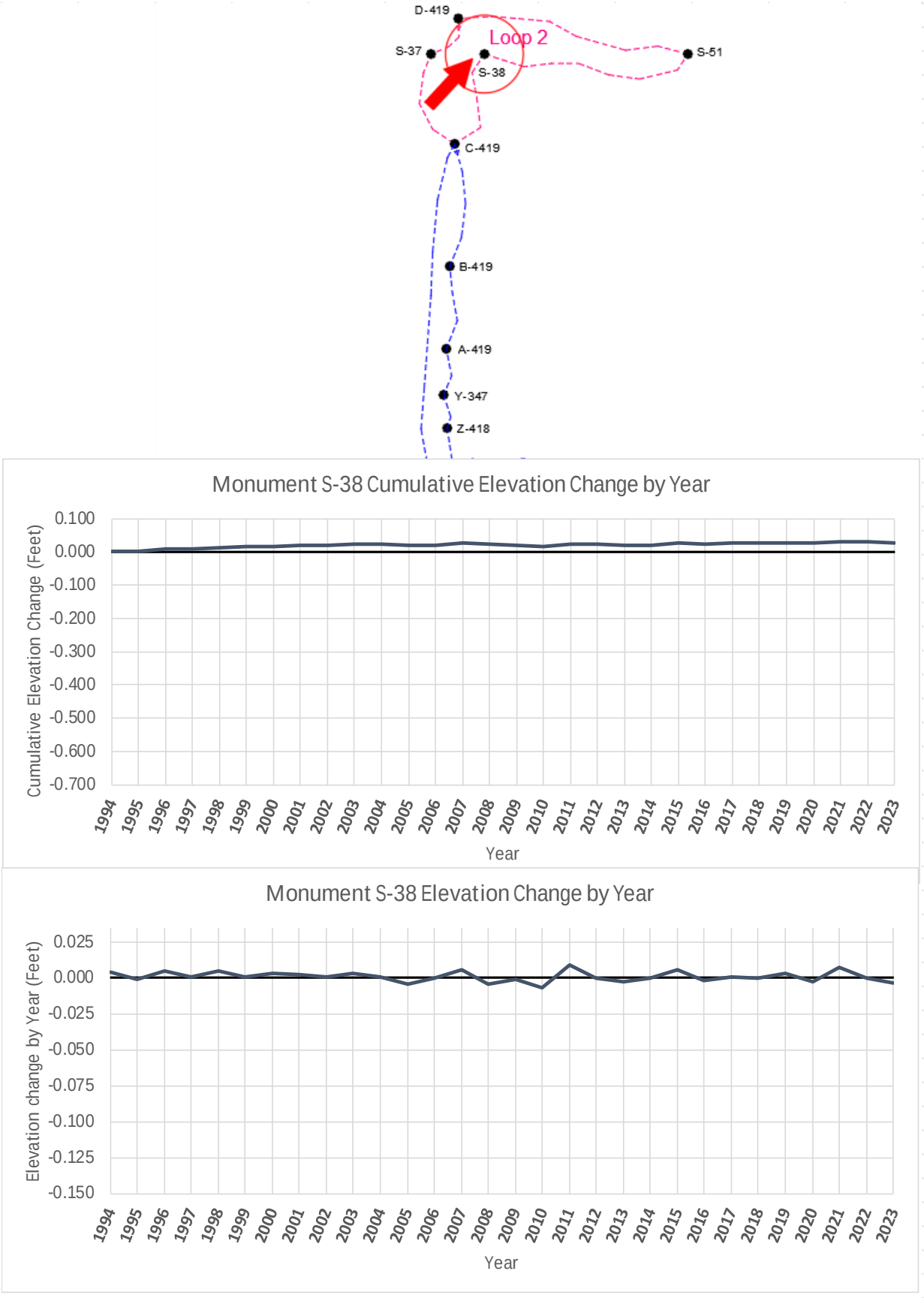


Figure 30. Monument S-38 Elevation Data Graphs

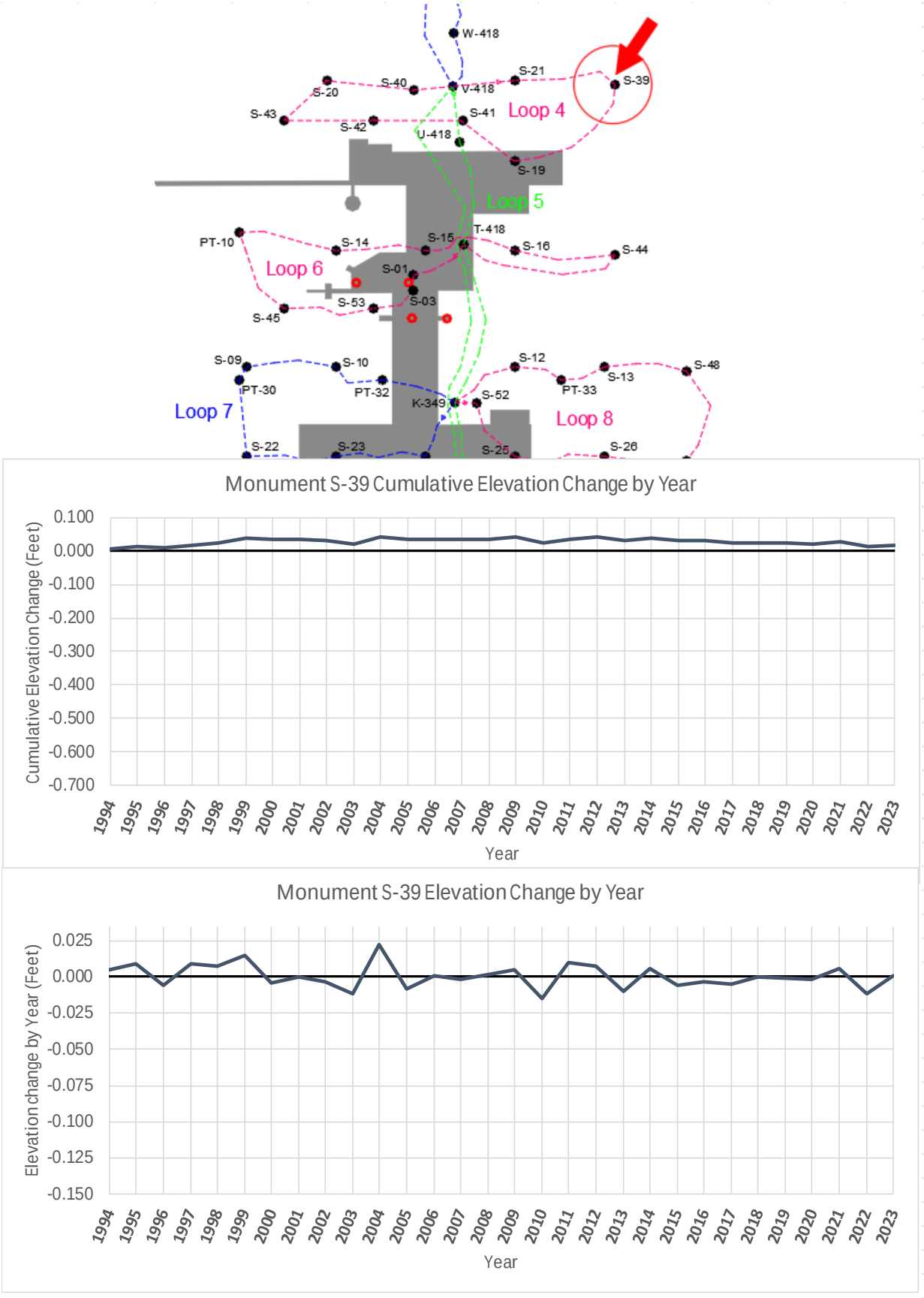


Figure 31. Monument S-39 Elevation Data Graphs

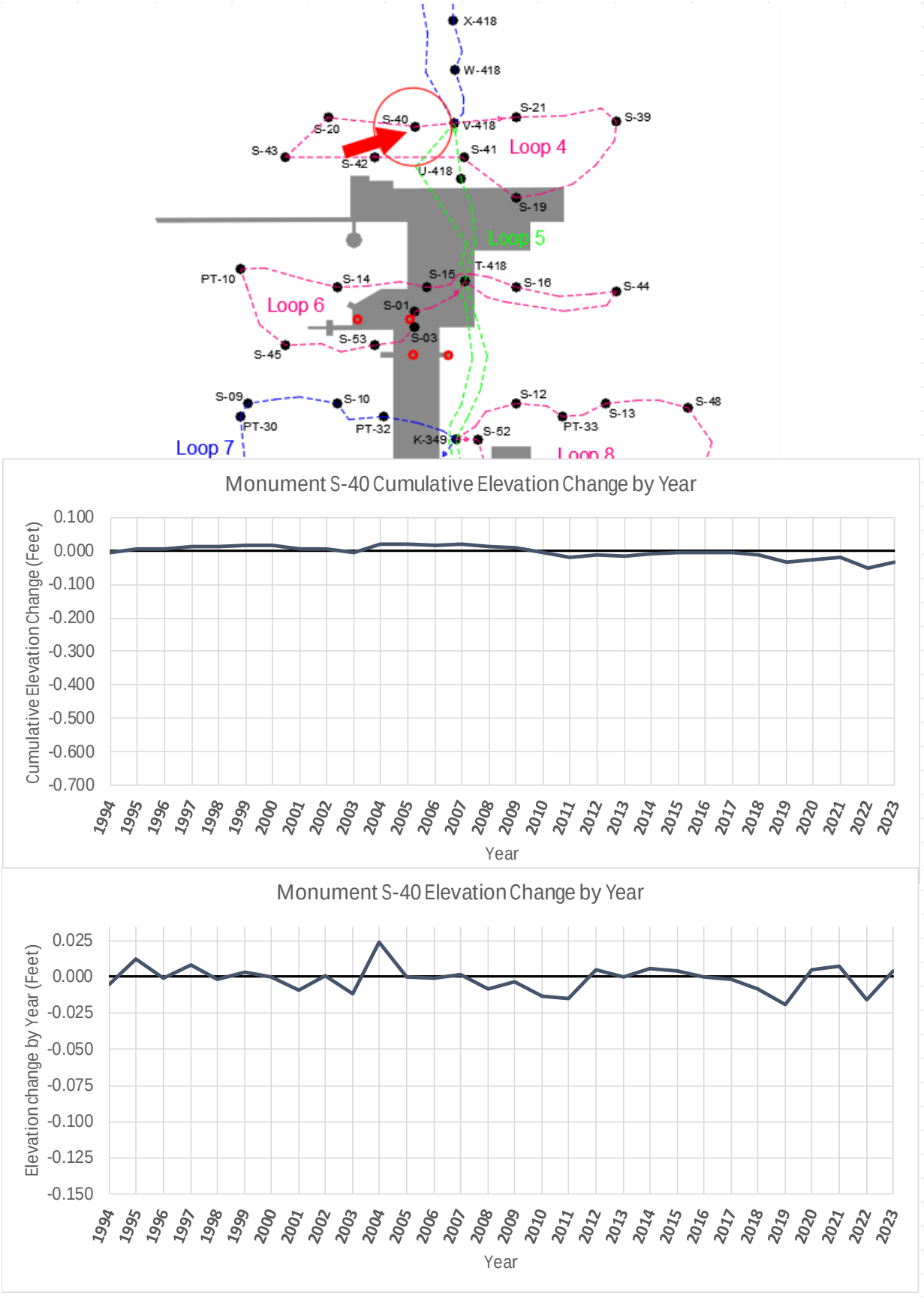


Figure 32. Monument S-40 Elevation Data Graphs

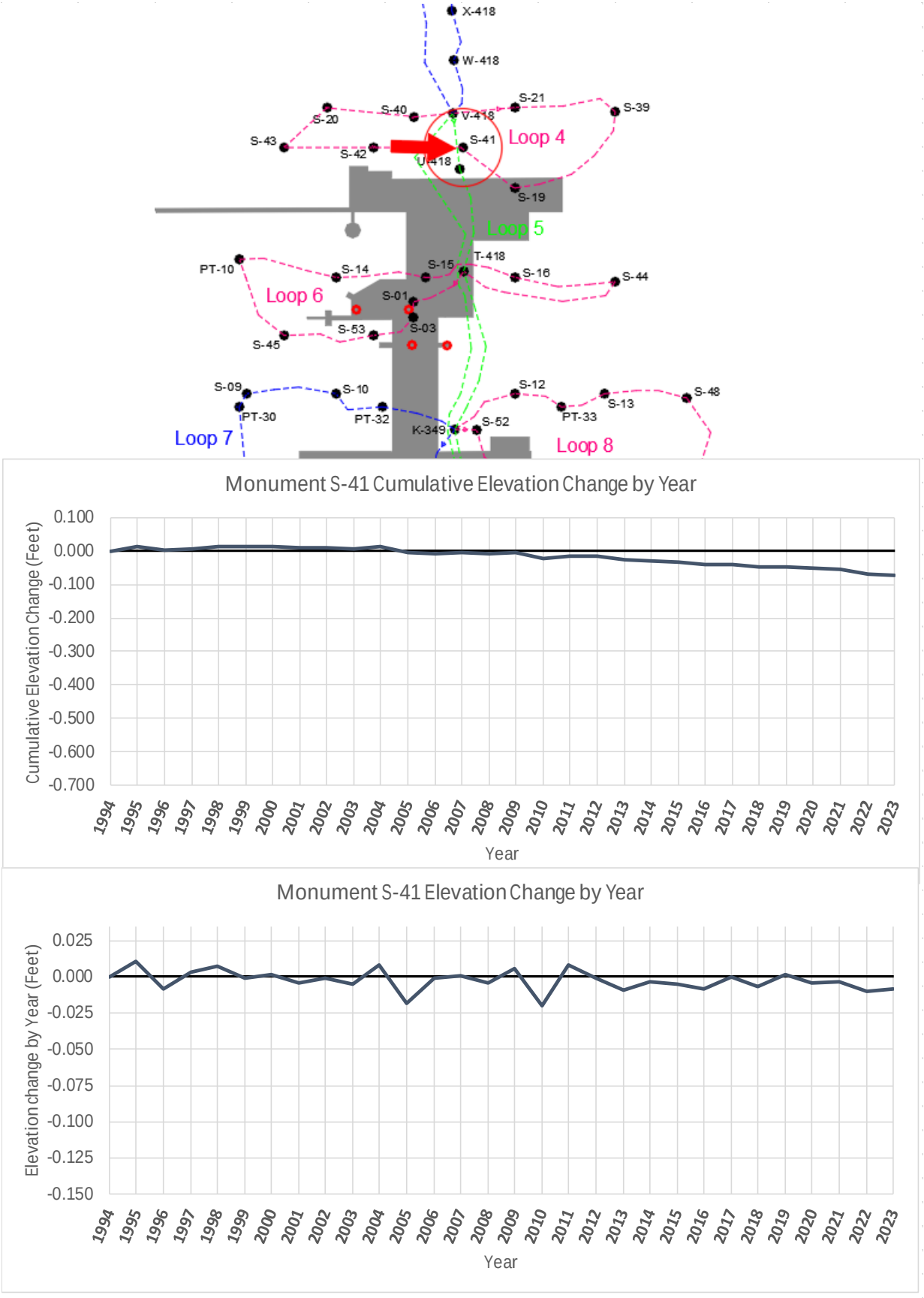


Figure 33. Monument S-41 Elevation Data Graphs

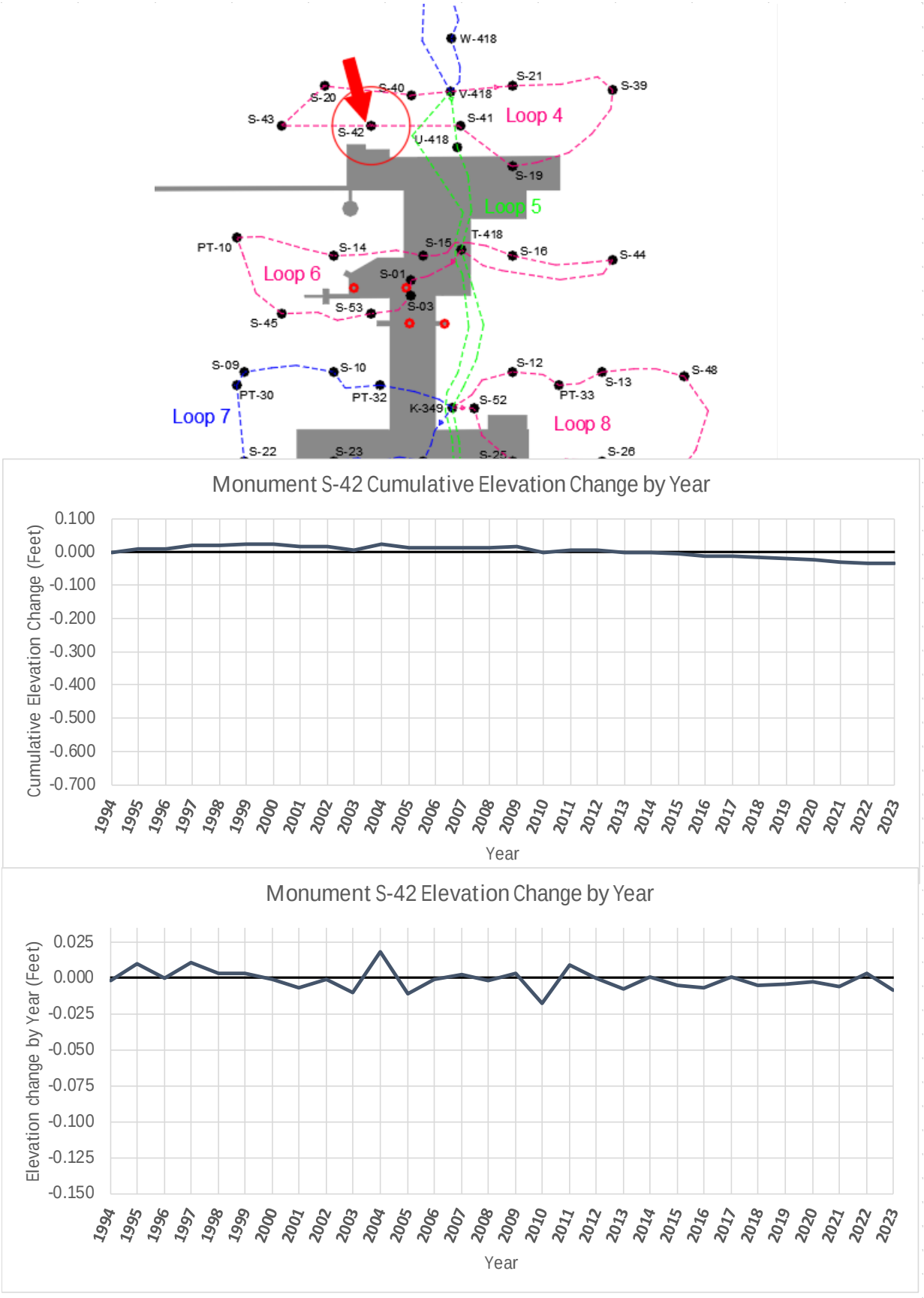


Figure 34. Monument S-42 Elevation Data Graphs

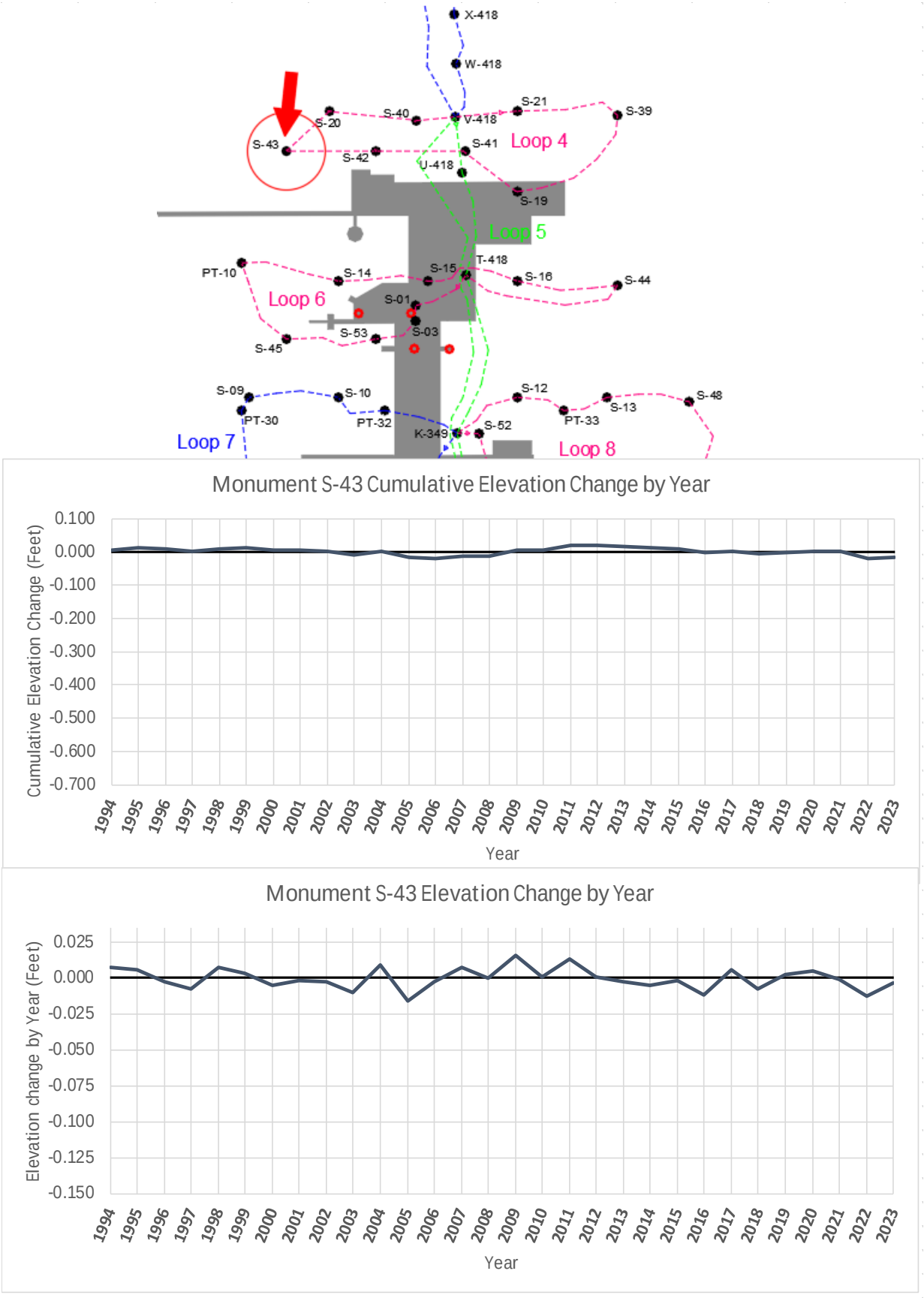


Figure 35. Monument S-43 Elevation Data Graphs

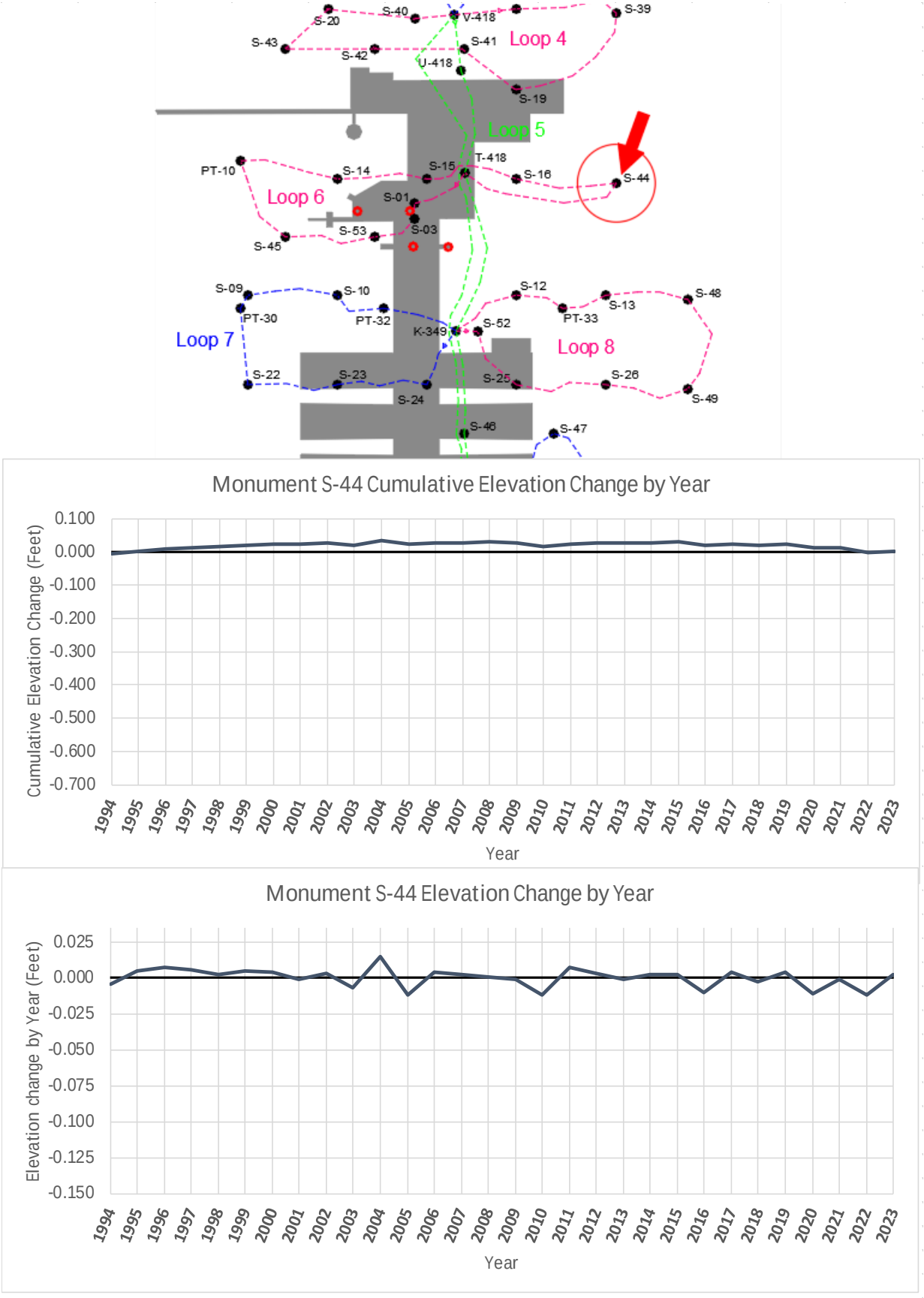


Figure 36. Monument S-44 Elevation Data Graphs

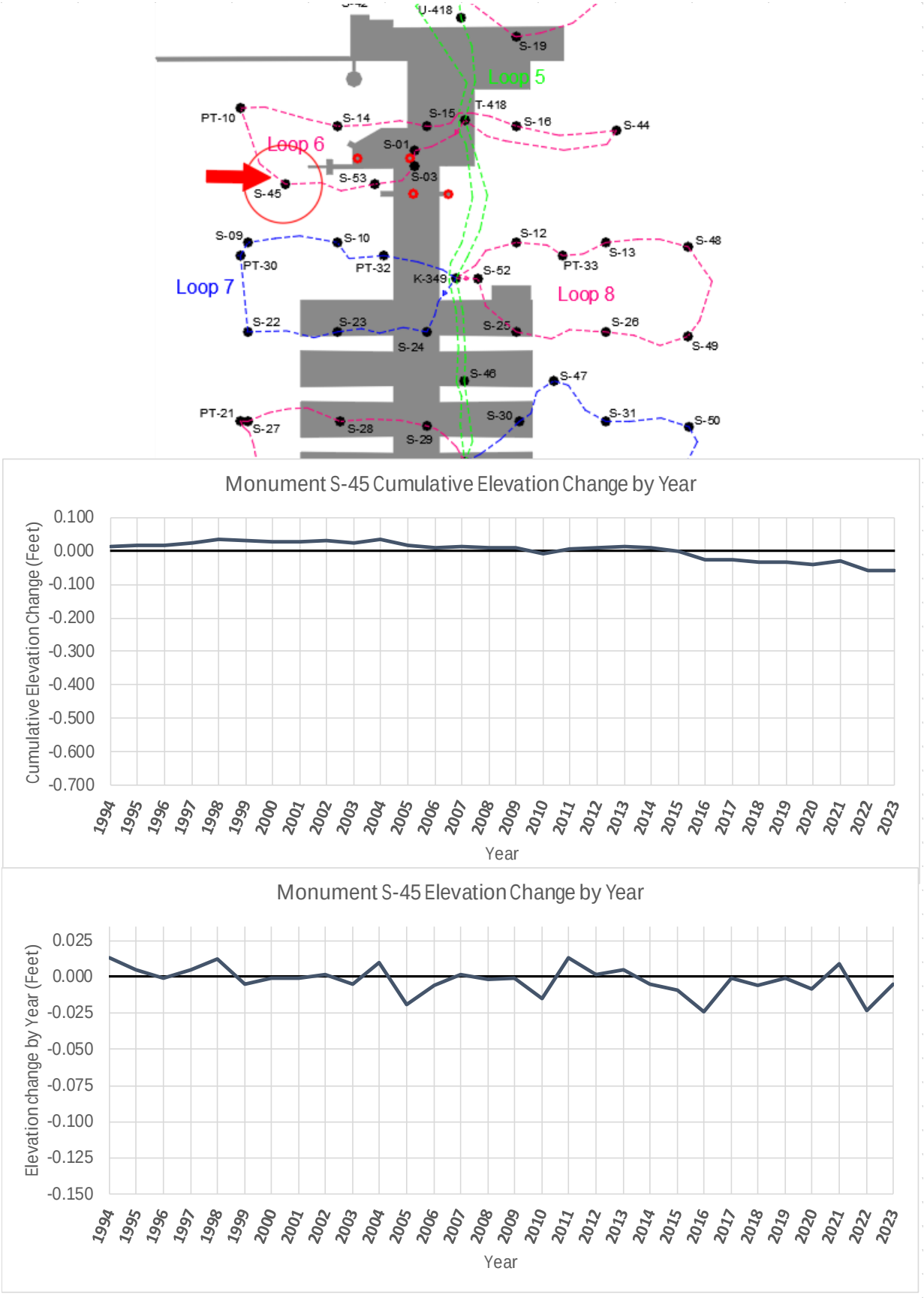


Figure 37. Monument S-45 Elevation Data Graphs

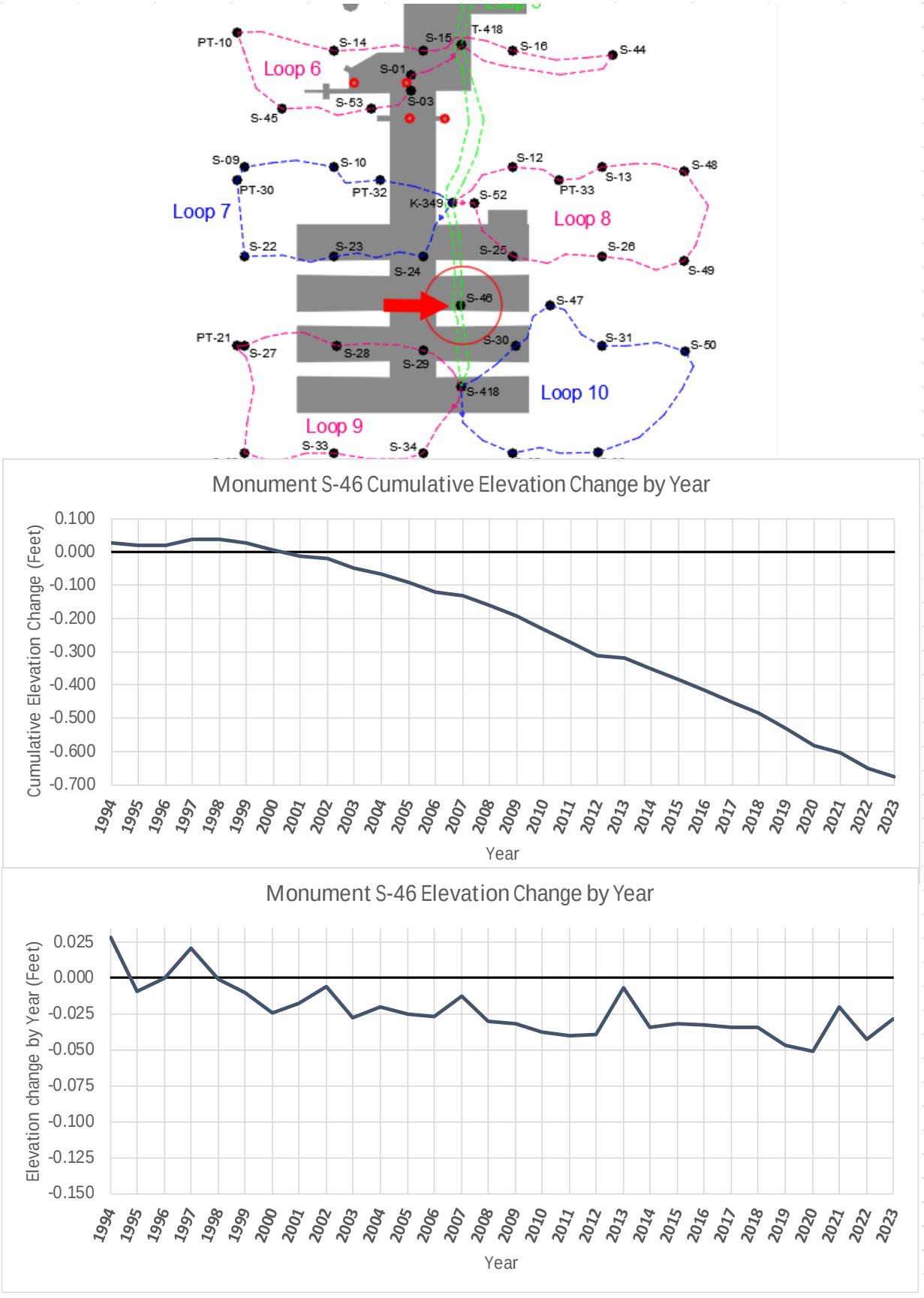


Figure 38. Monument S-46 Elevation Data Graphs

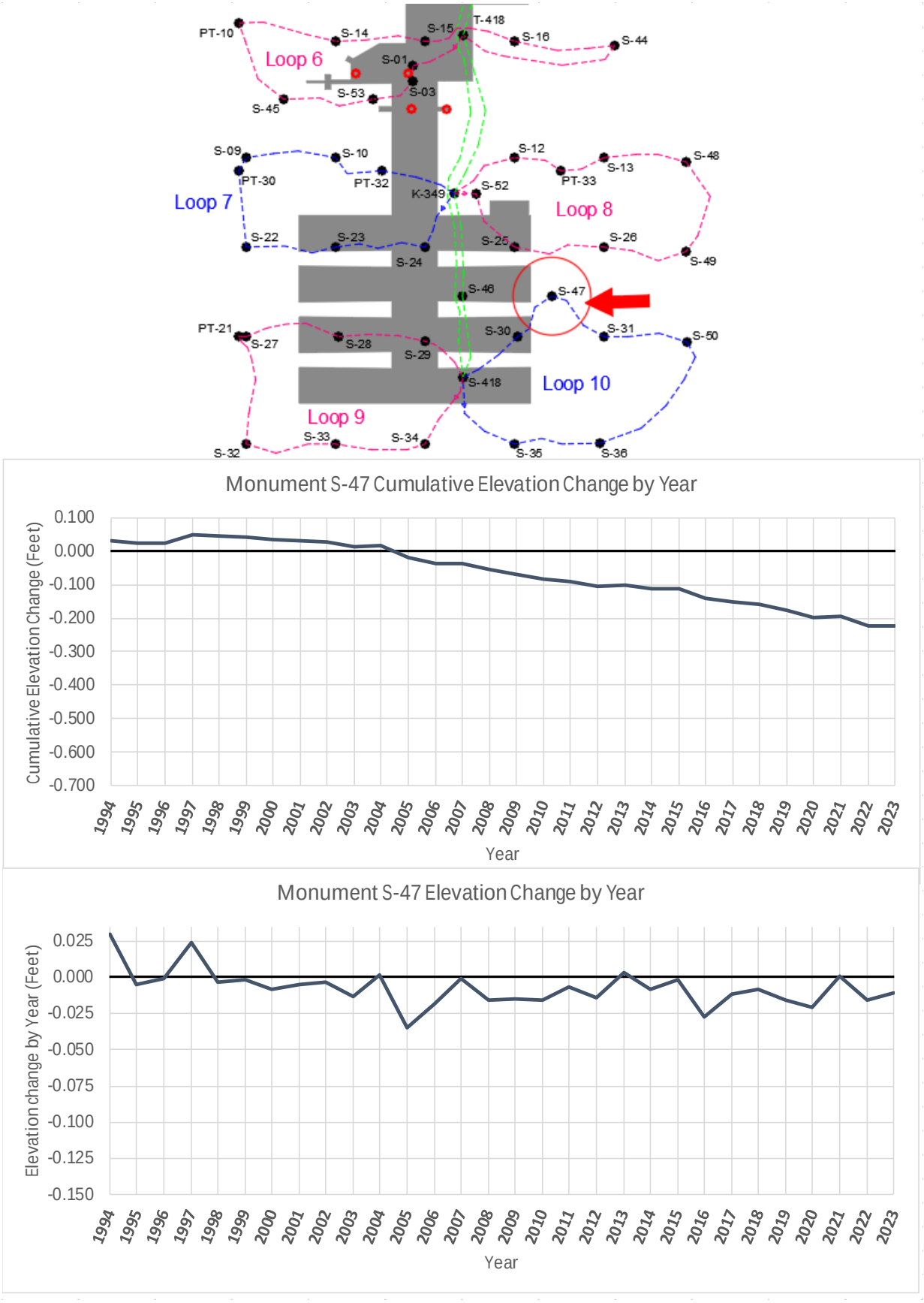


Figure 39. Monument S-47 Elevation Data Graphs

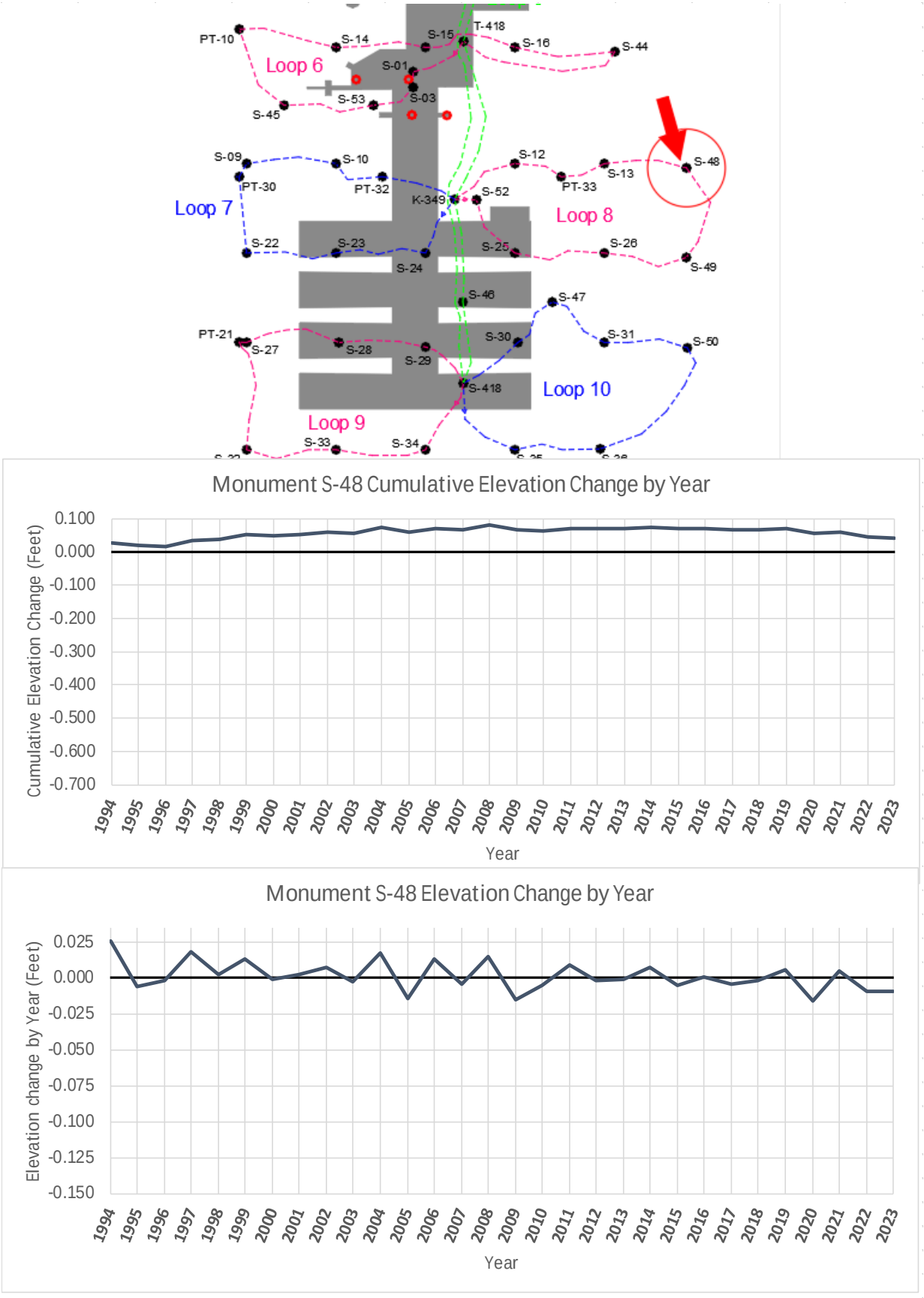


Figure 40. Monument S-48 Elevation Data Graphs

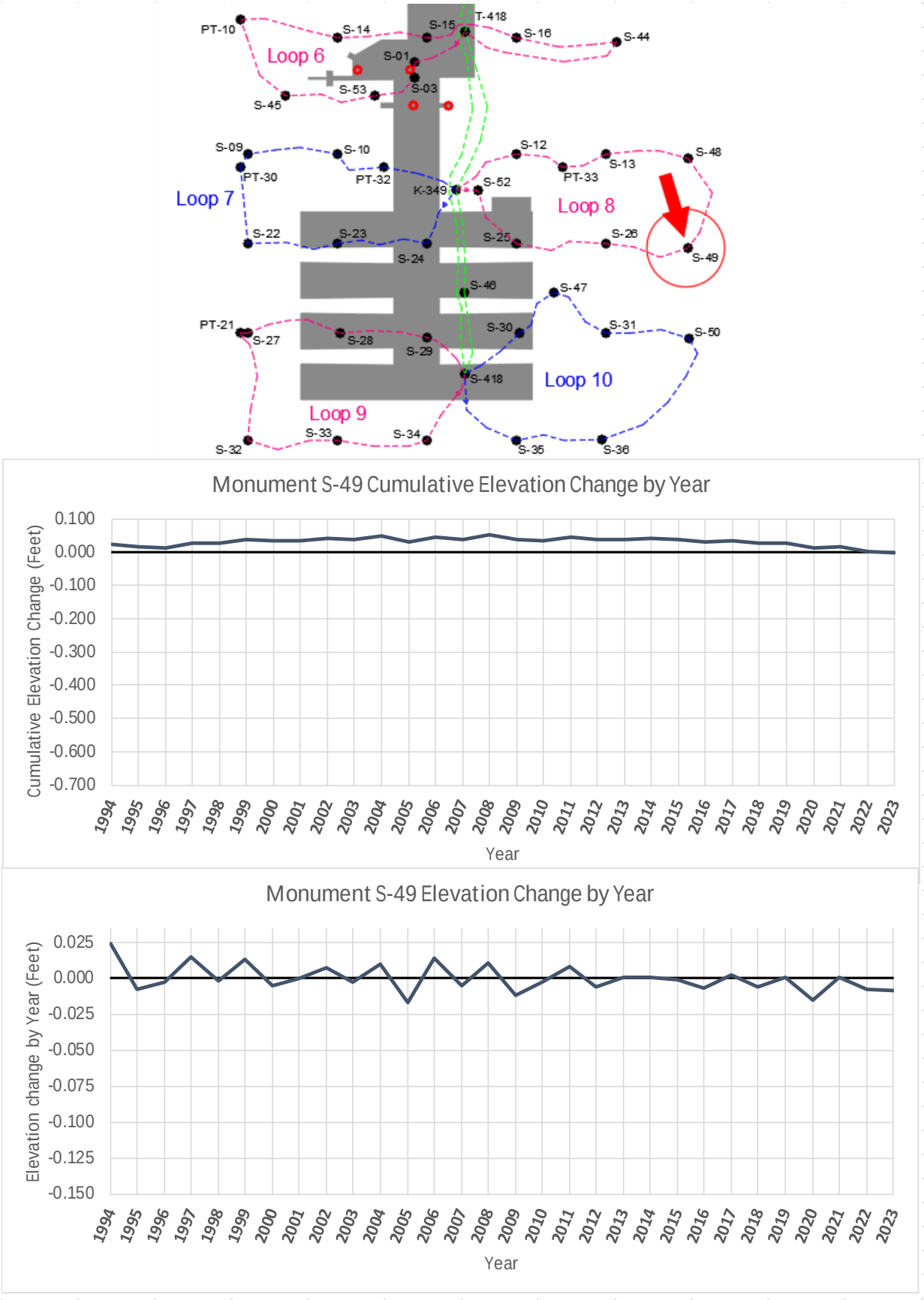


Figure 41. Monument S-49 Elevation Data Graphs

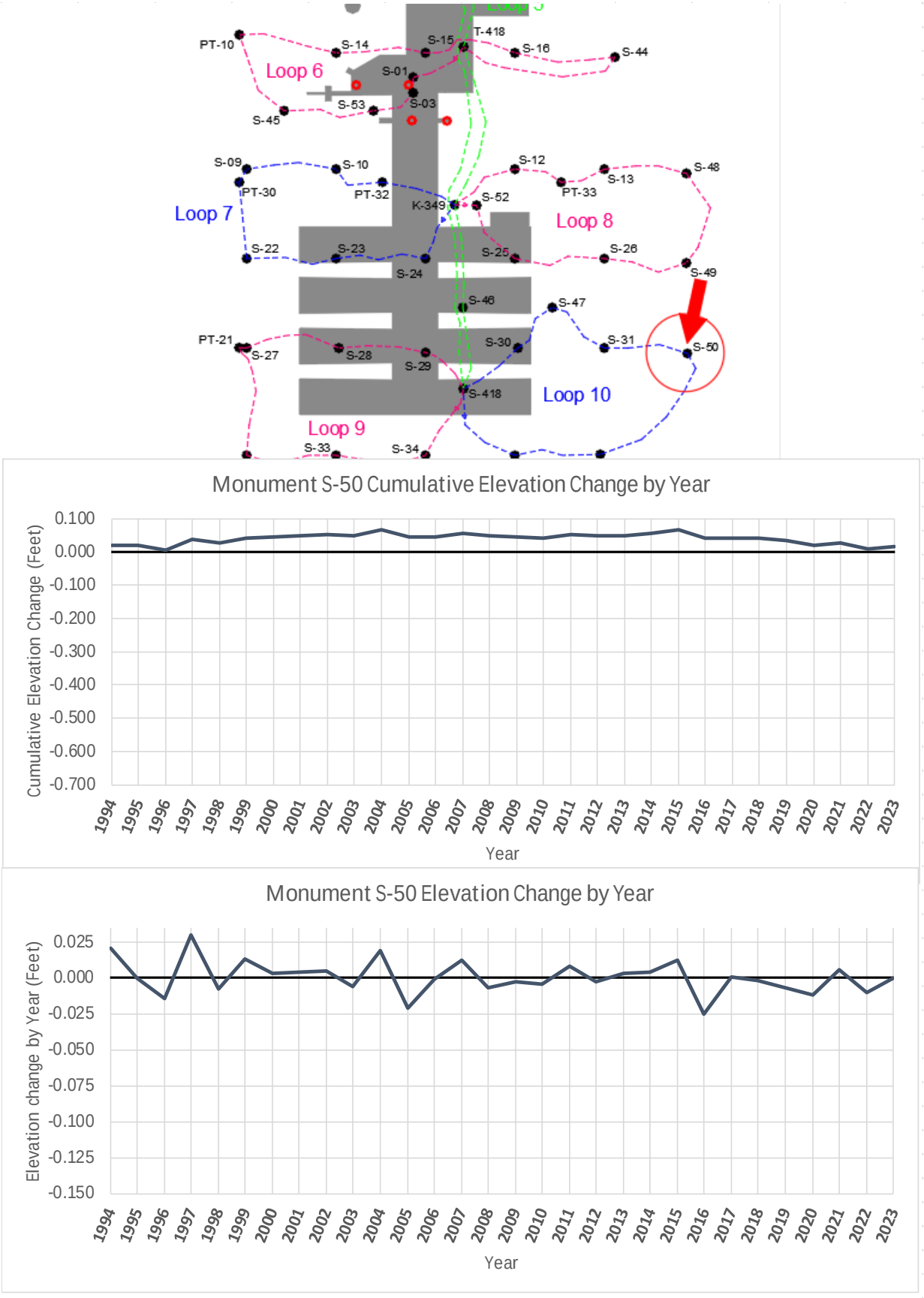


Figure 42. Monument S-50 Elevation Data Graphs

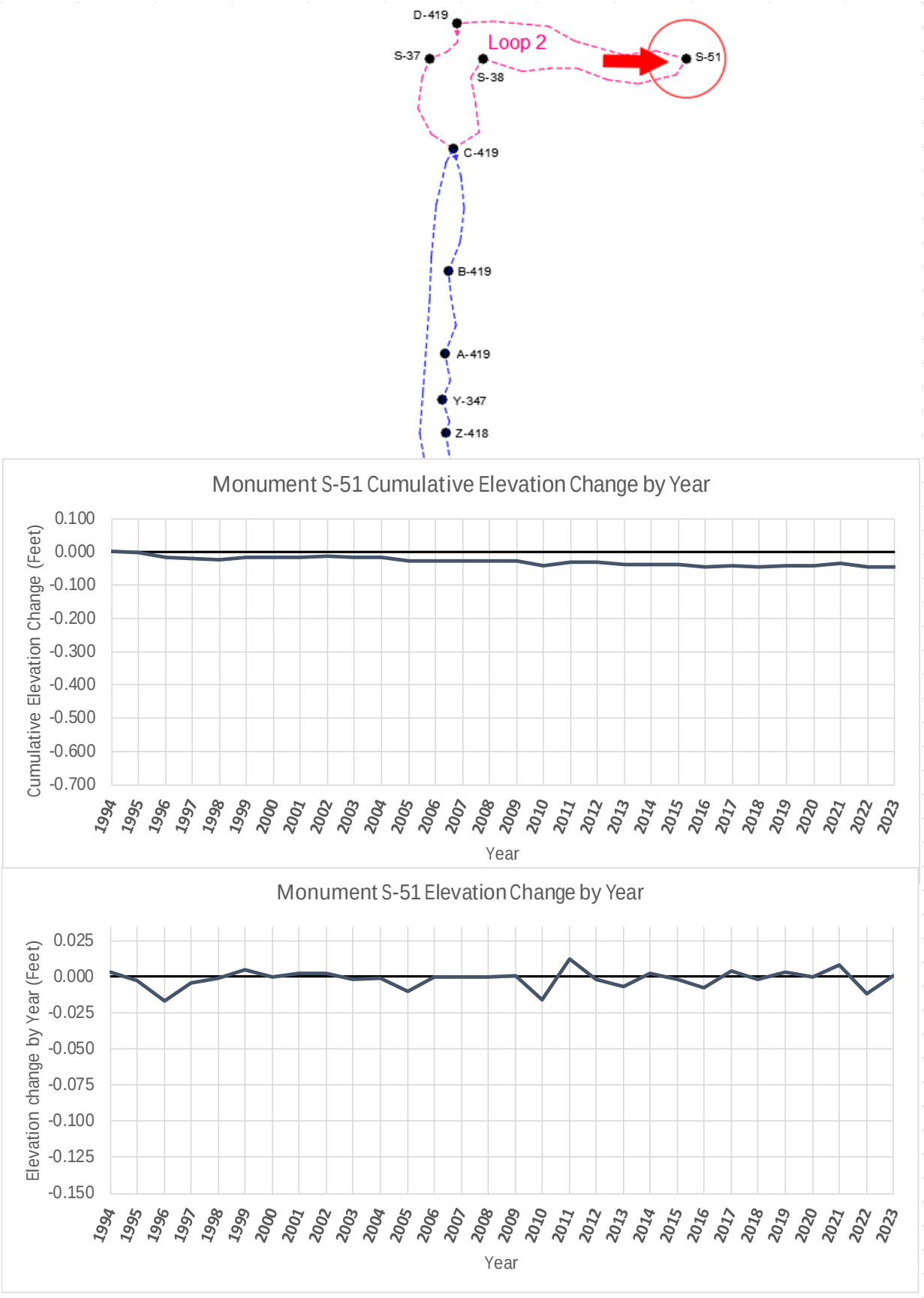


Figure 43. Monument S-51 Elevation Data Graphs

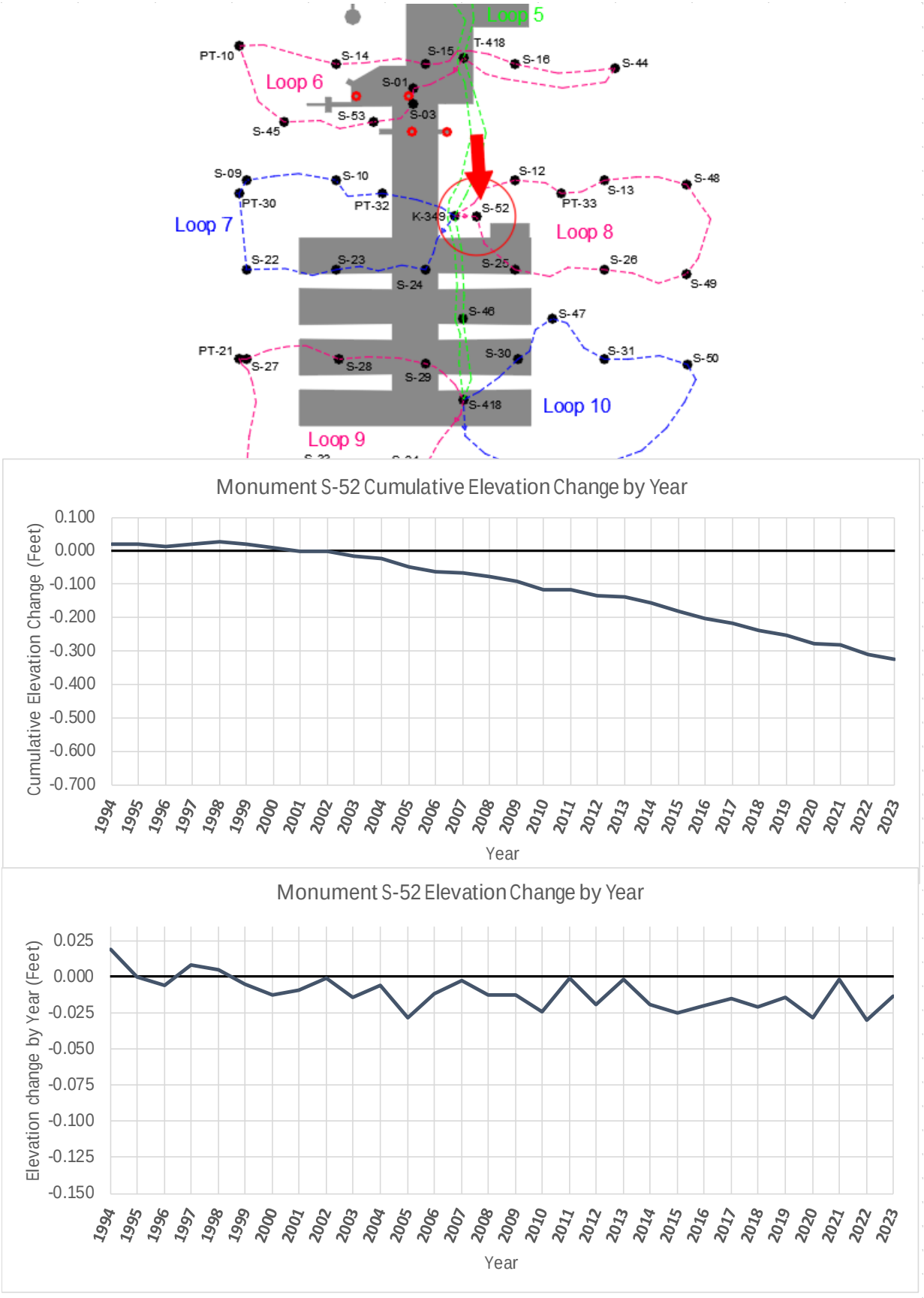


Figure 44. Monument S-52 Elevation Data Graphs

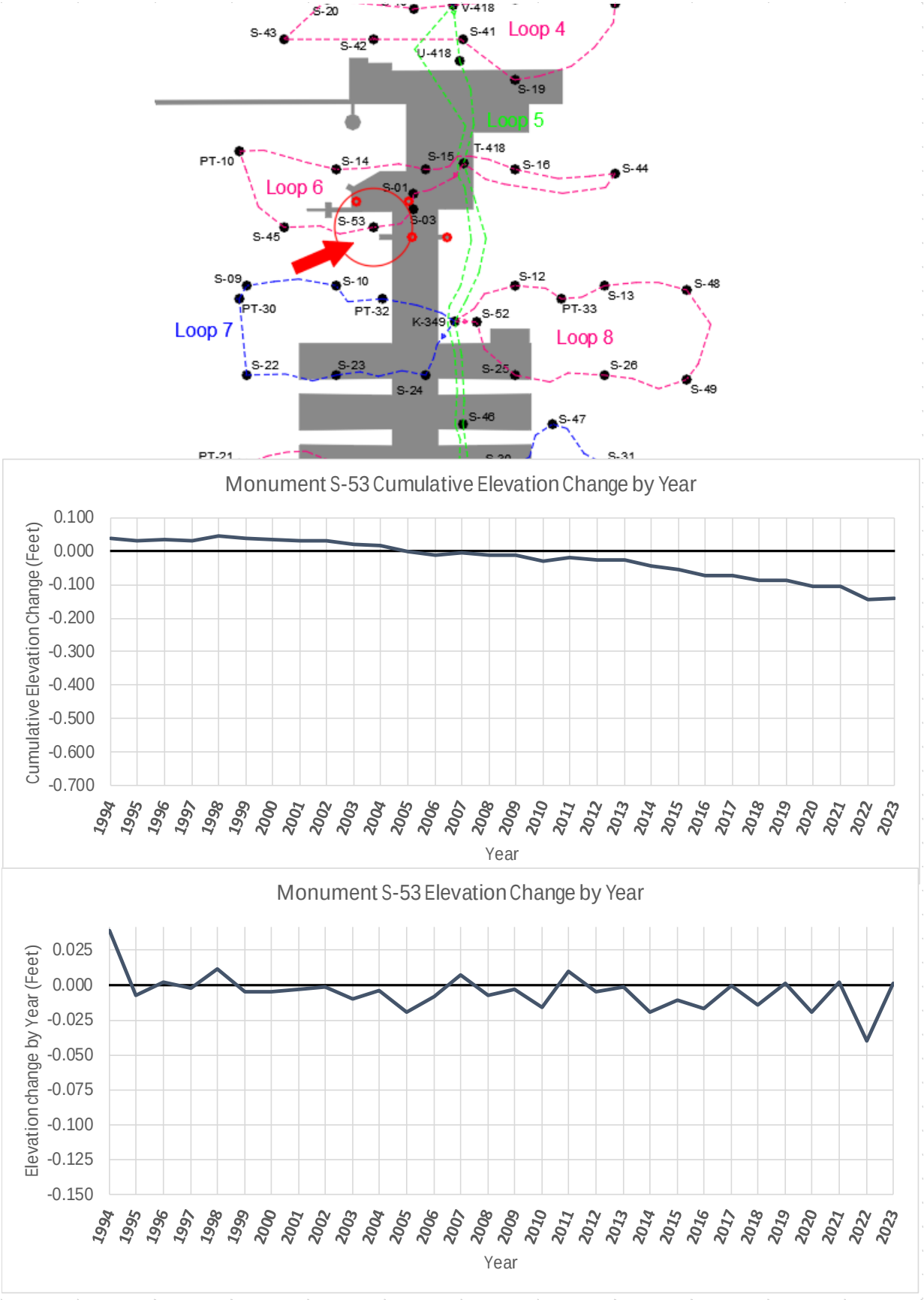
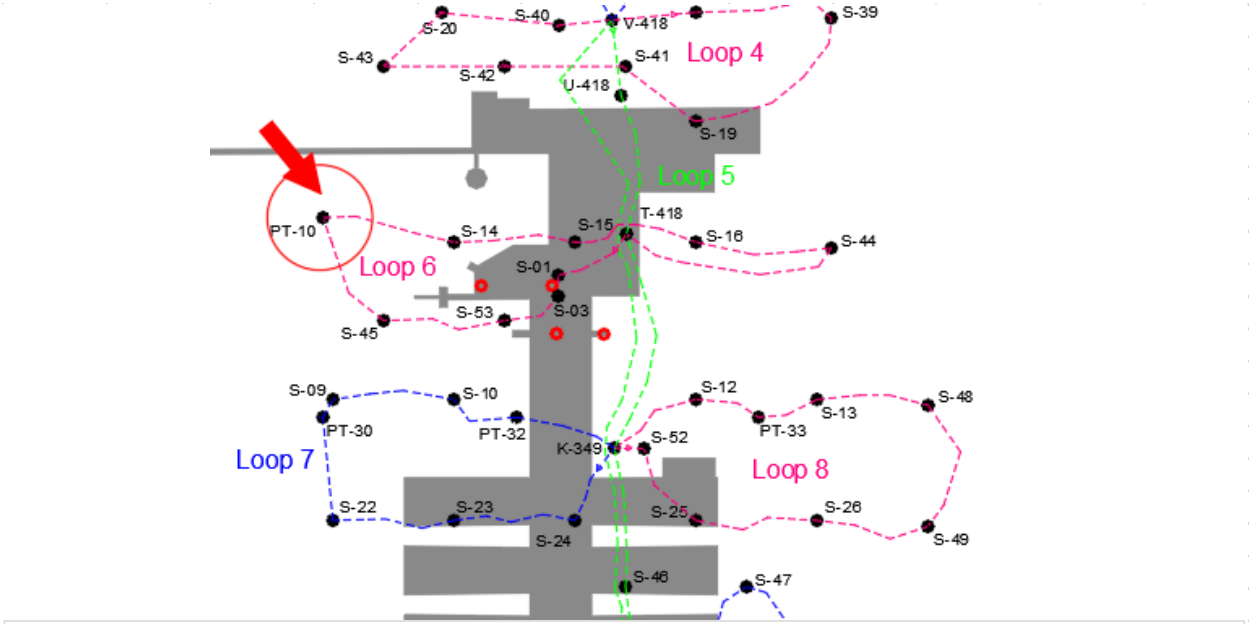
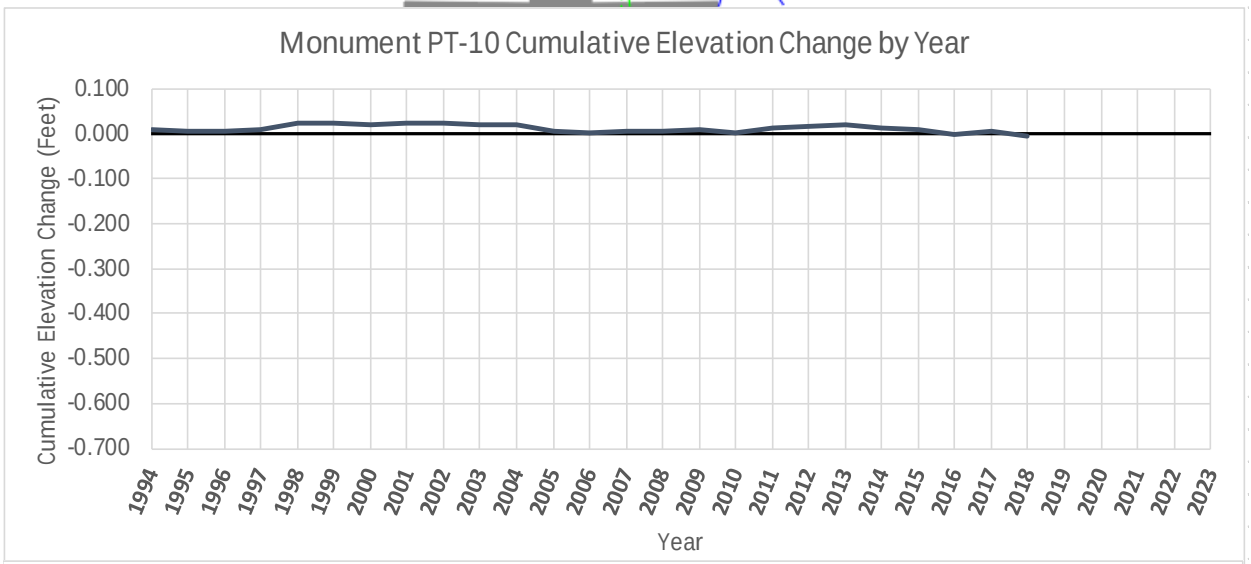


Figure 45. Monument S-53 Elevation Data Graphs





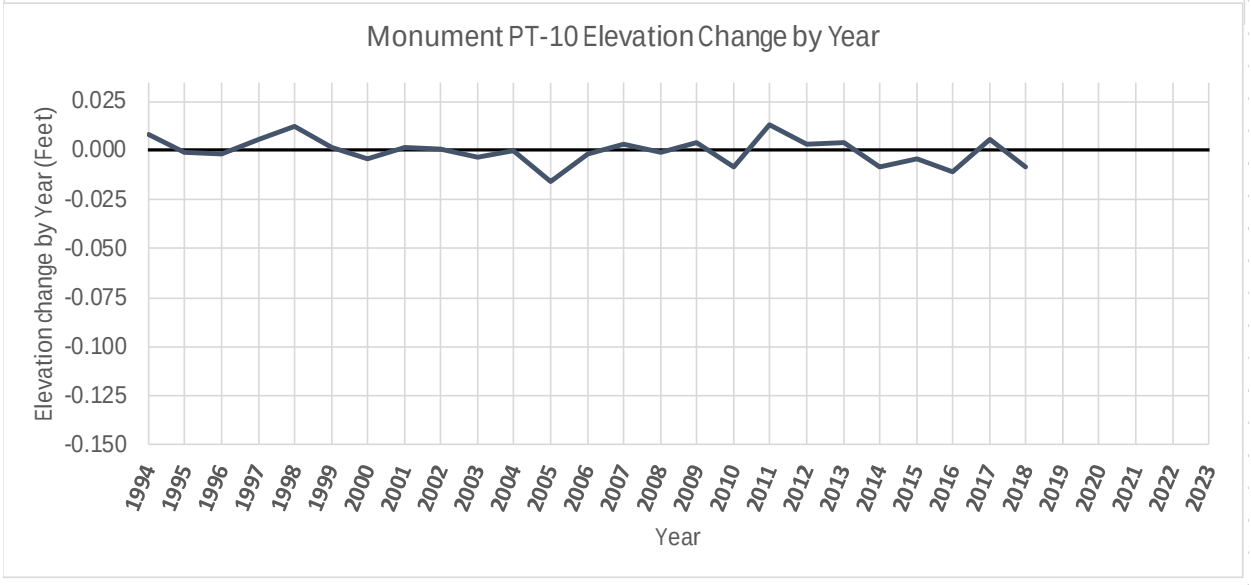


Figure 46. Monument PT-10 Elevation Data Graphs

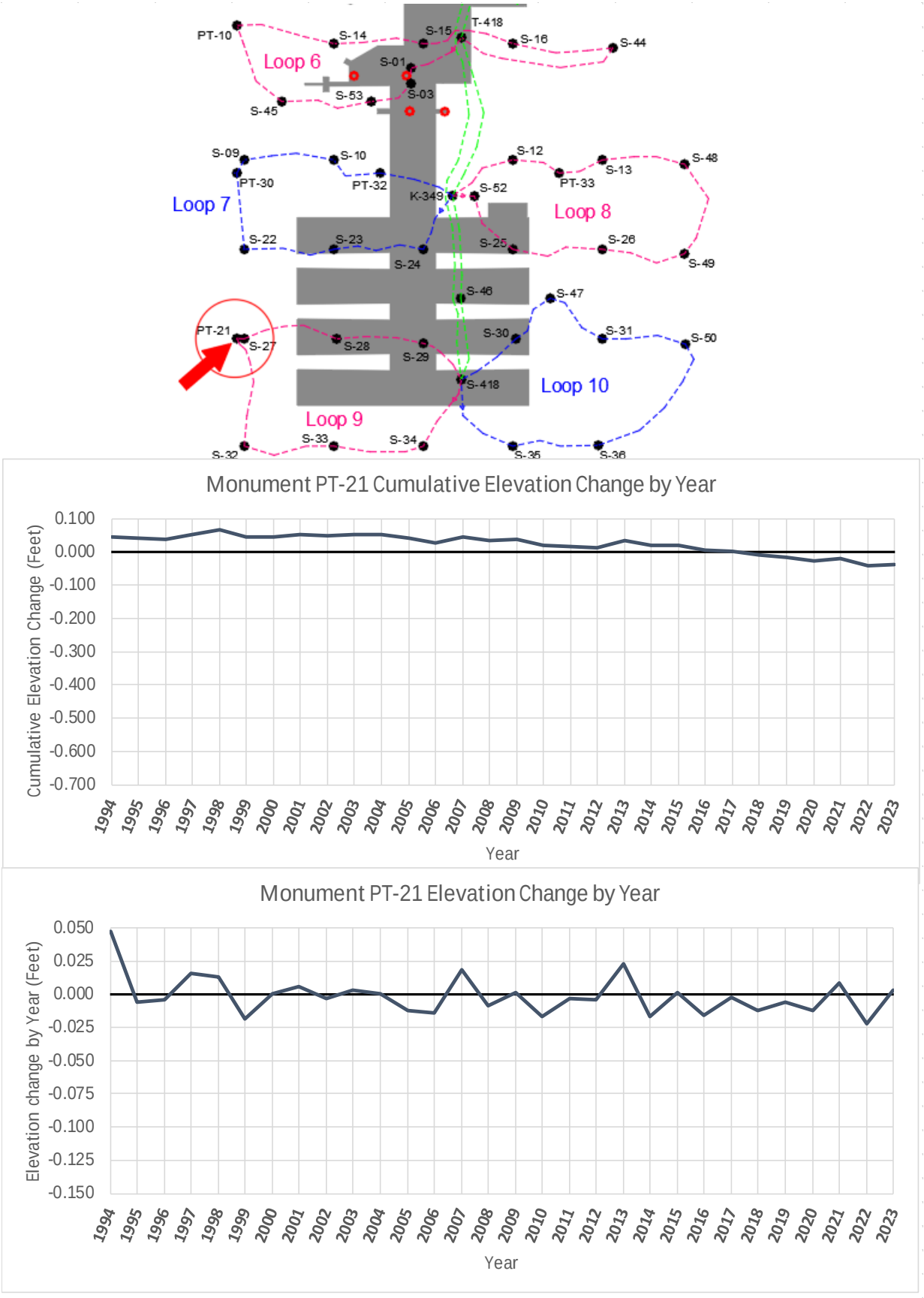


Figure 47. Monument PT-21 Elevation Data Graphs

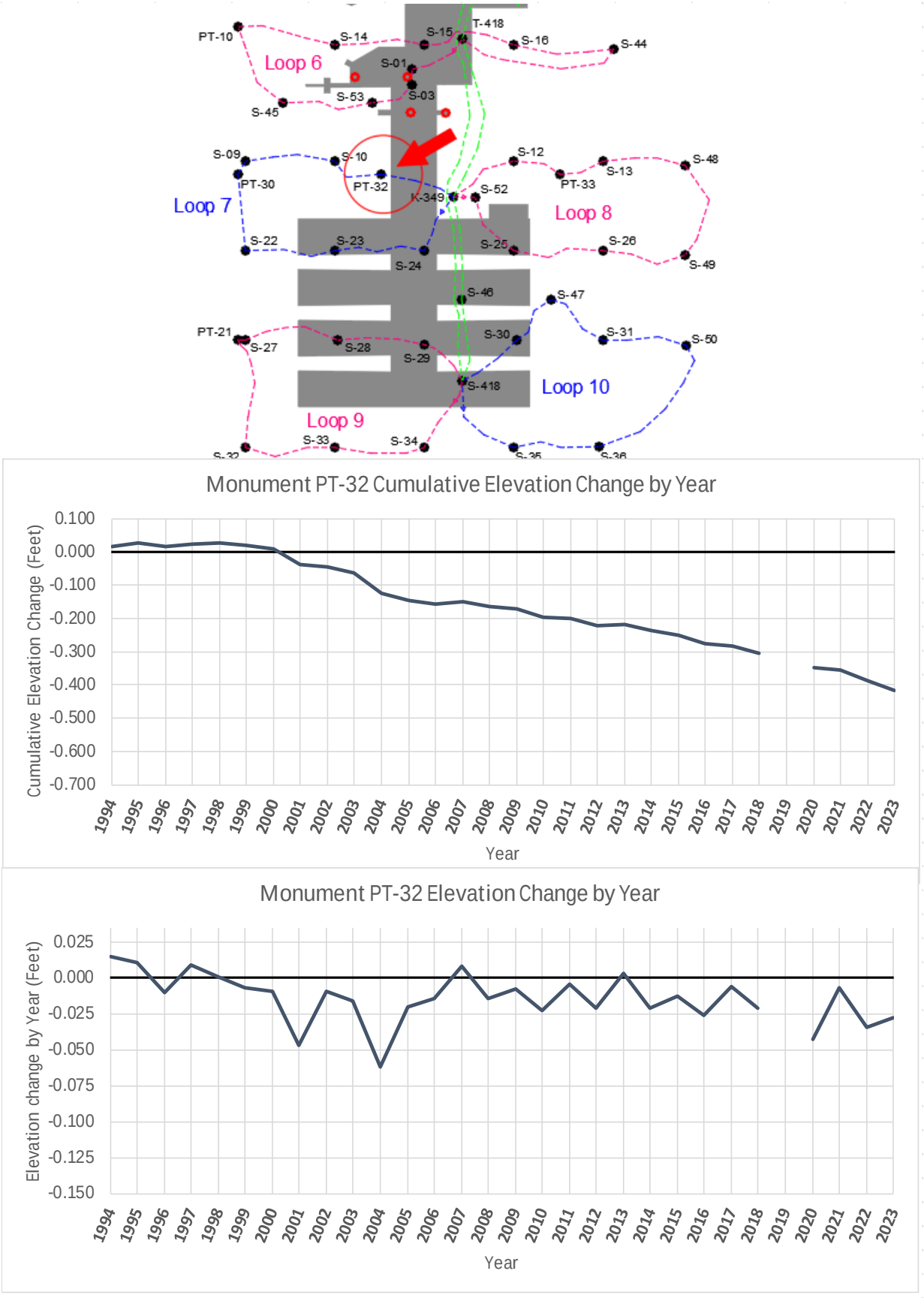


Figure 48. Monument PT-32 Elevation Data Graphs

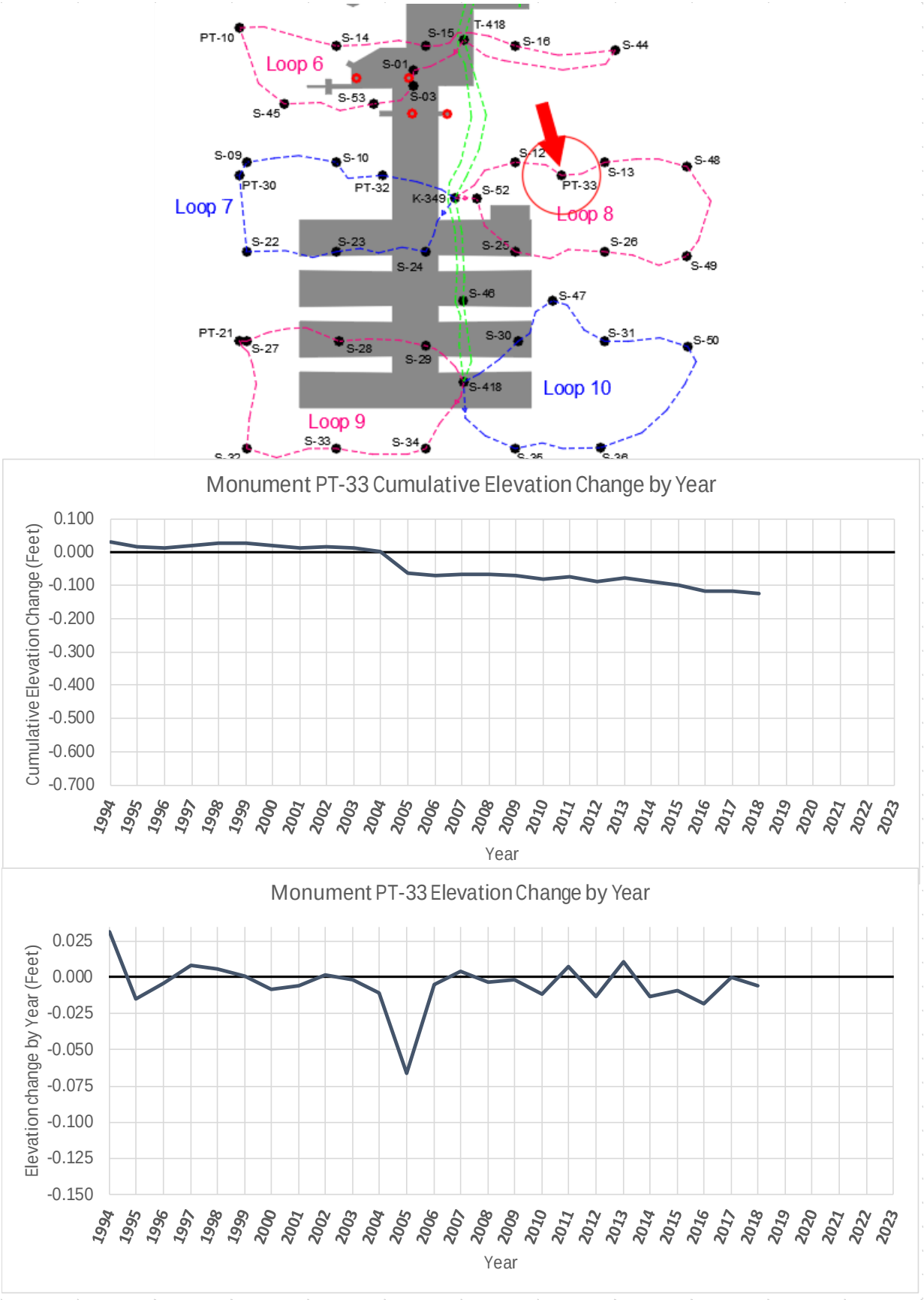


Figure 49. Monument PT-33 Elevation Data Graphs

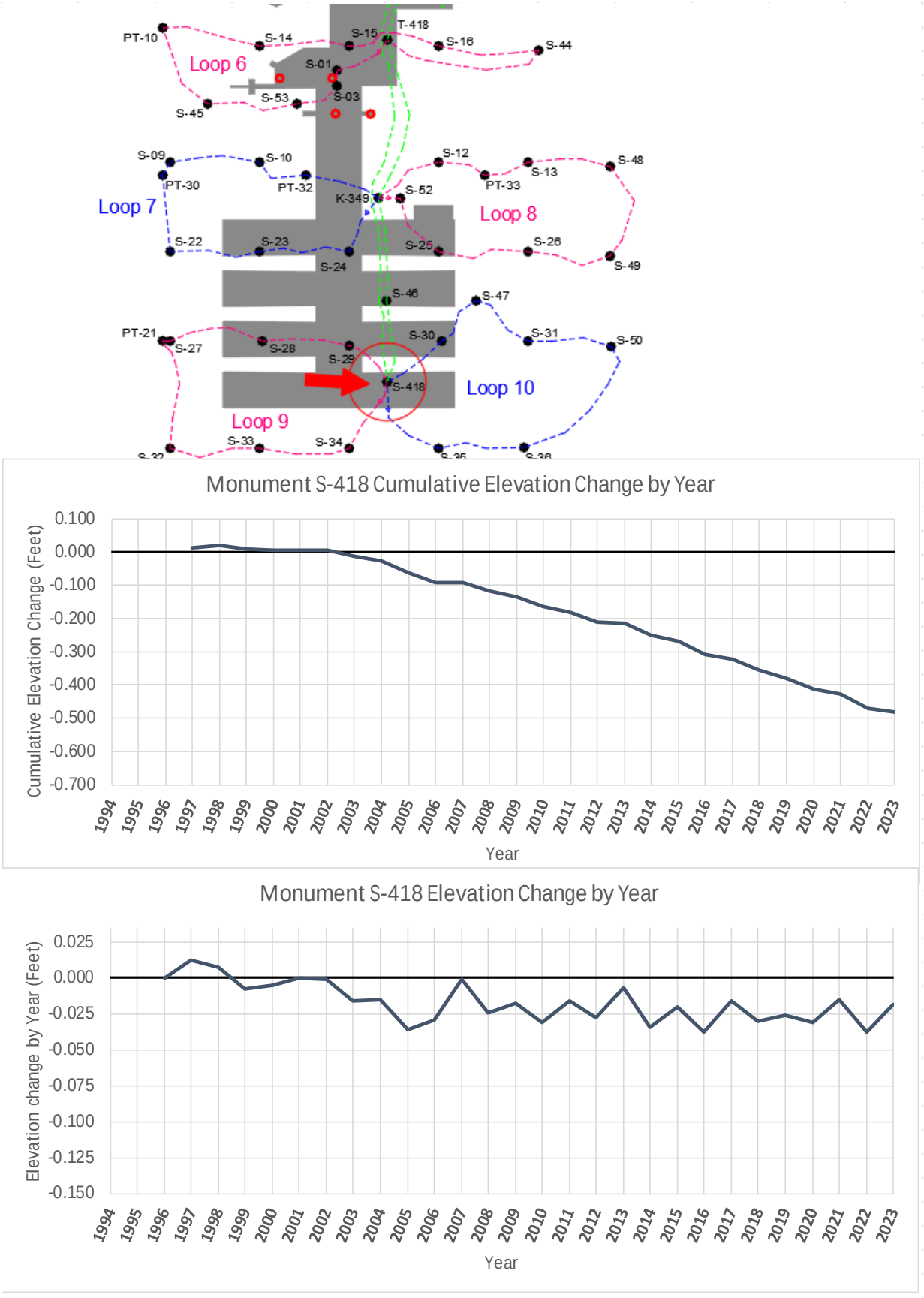


Figure 50. M S-418 Elevation Data Graphs

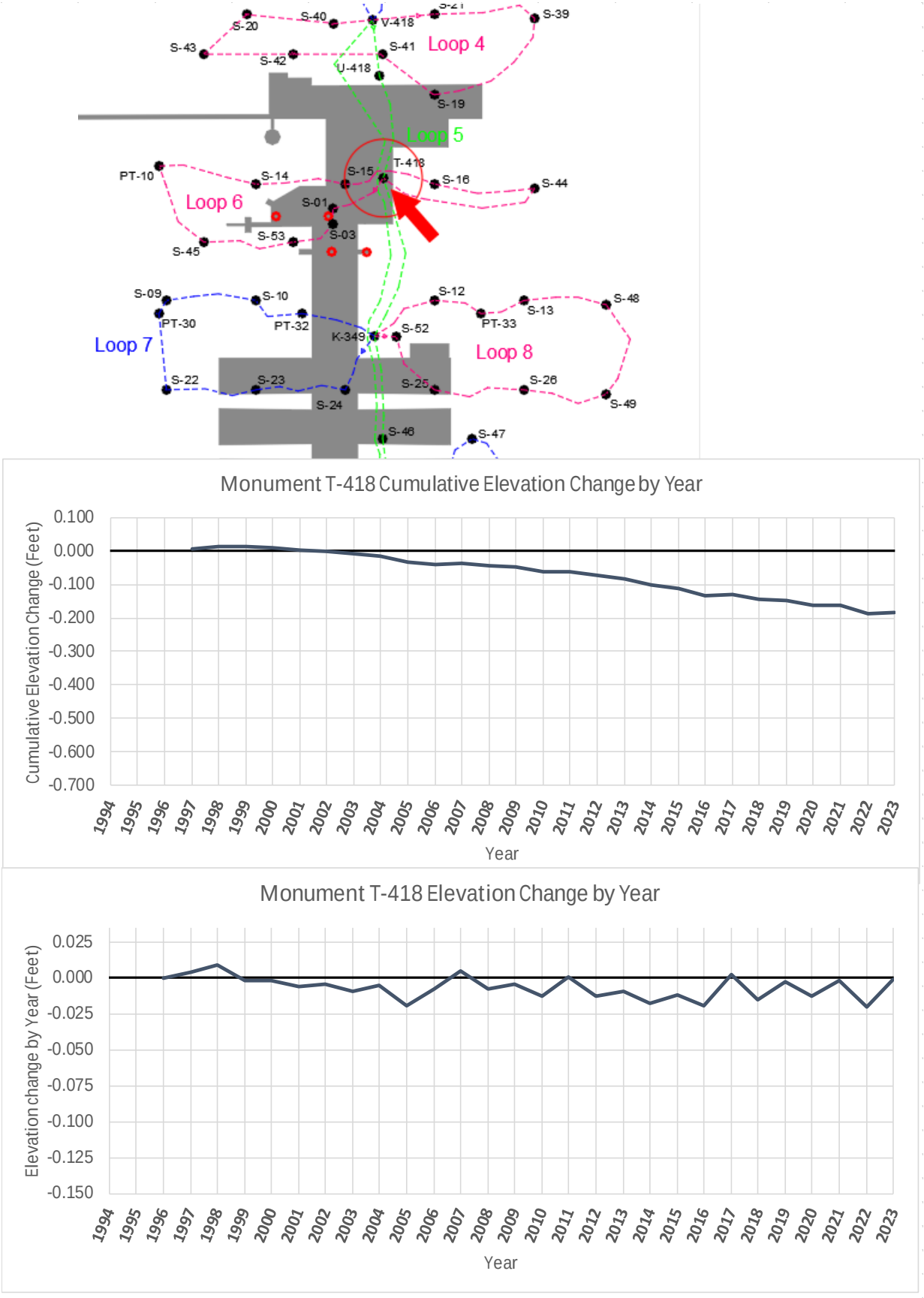


Figure 51. Monument T-418 Elevation Data Graphs

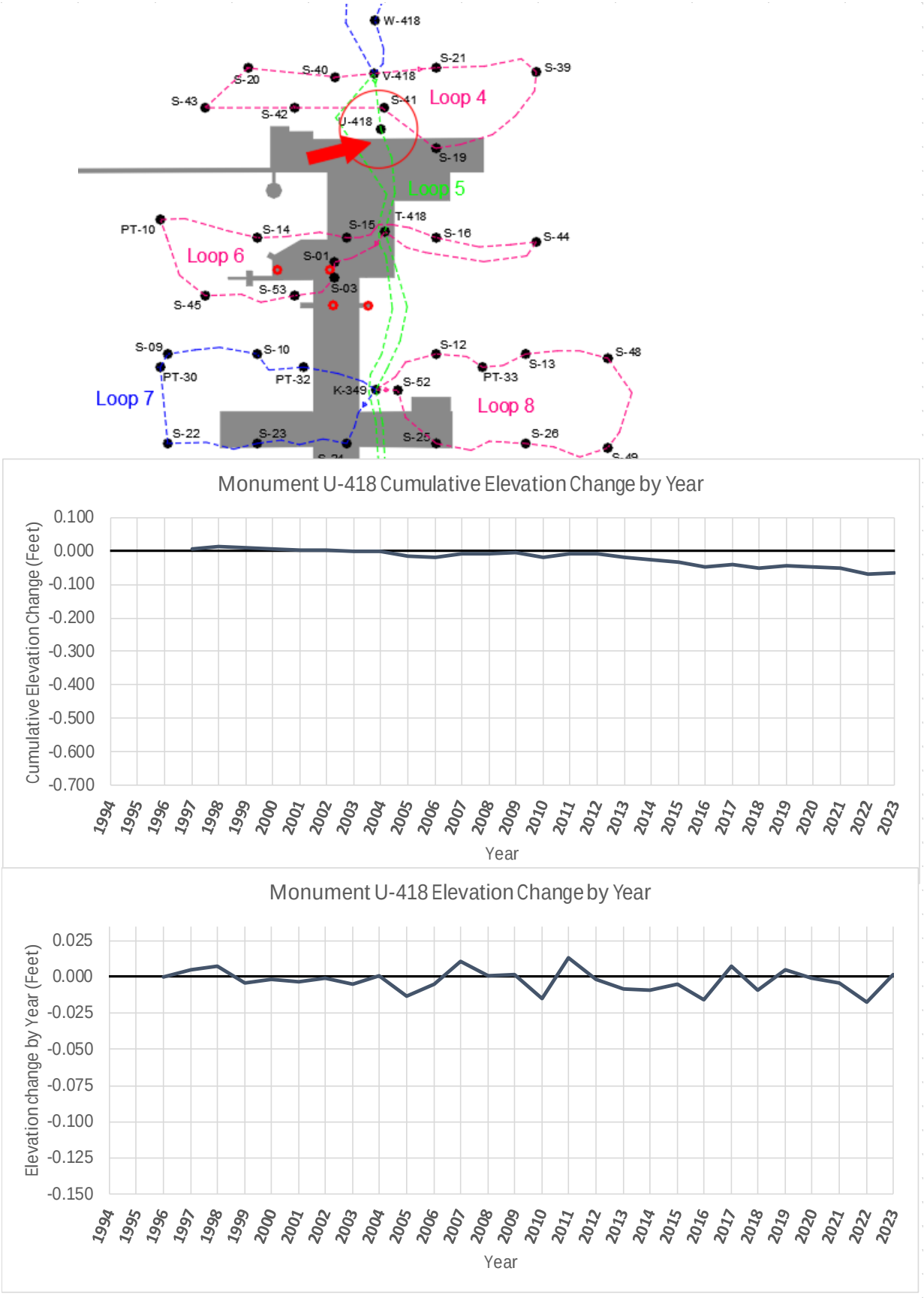


Figure 52. Monument U-418 Elevation Data Graphs

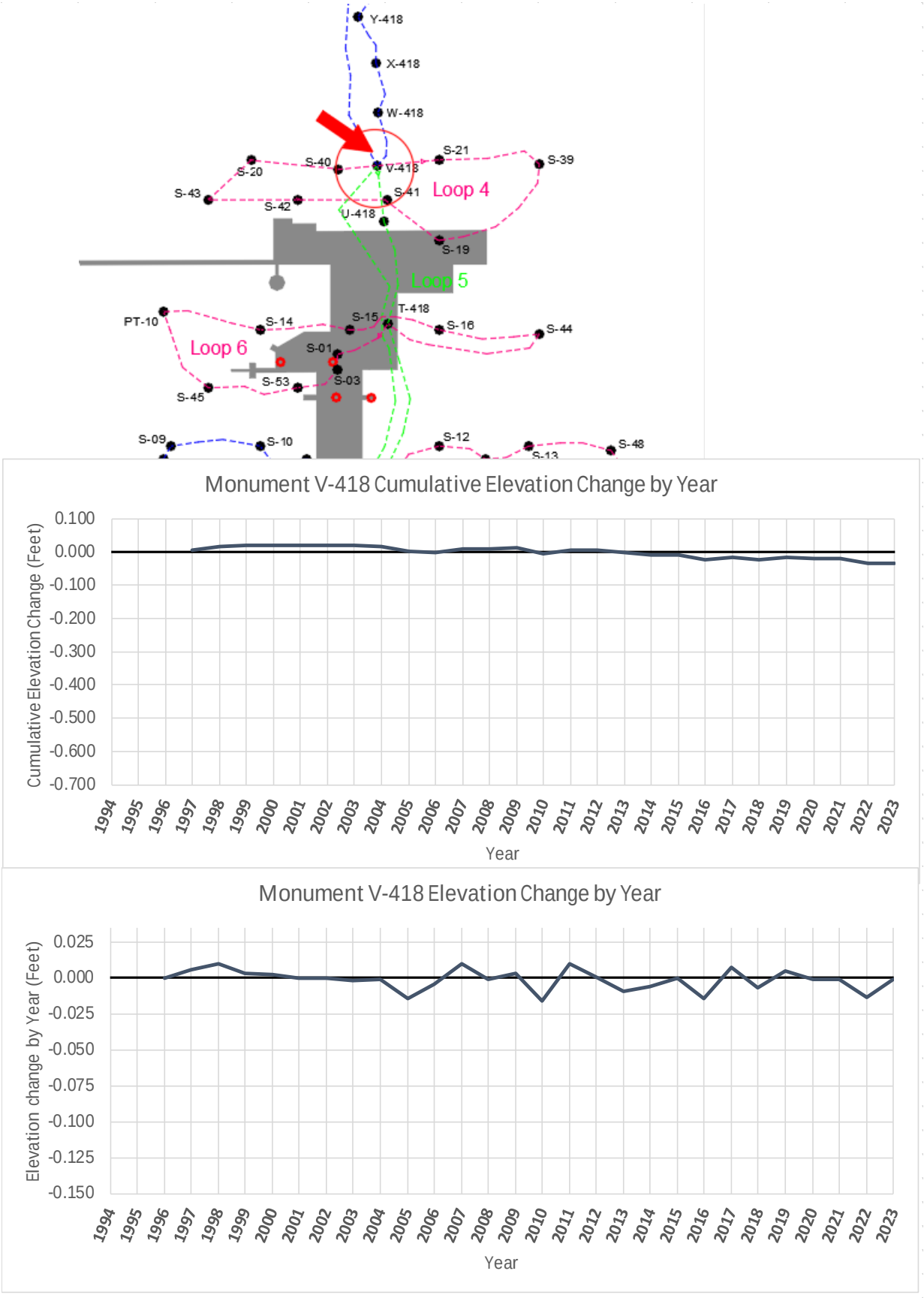


Figure 53. Monument V-418 Elevation Data Graphs

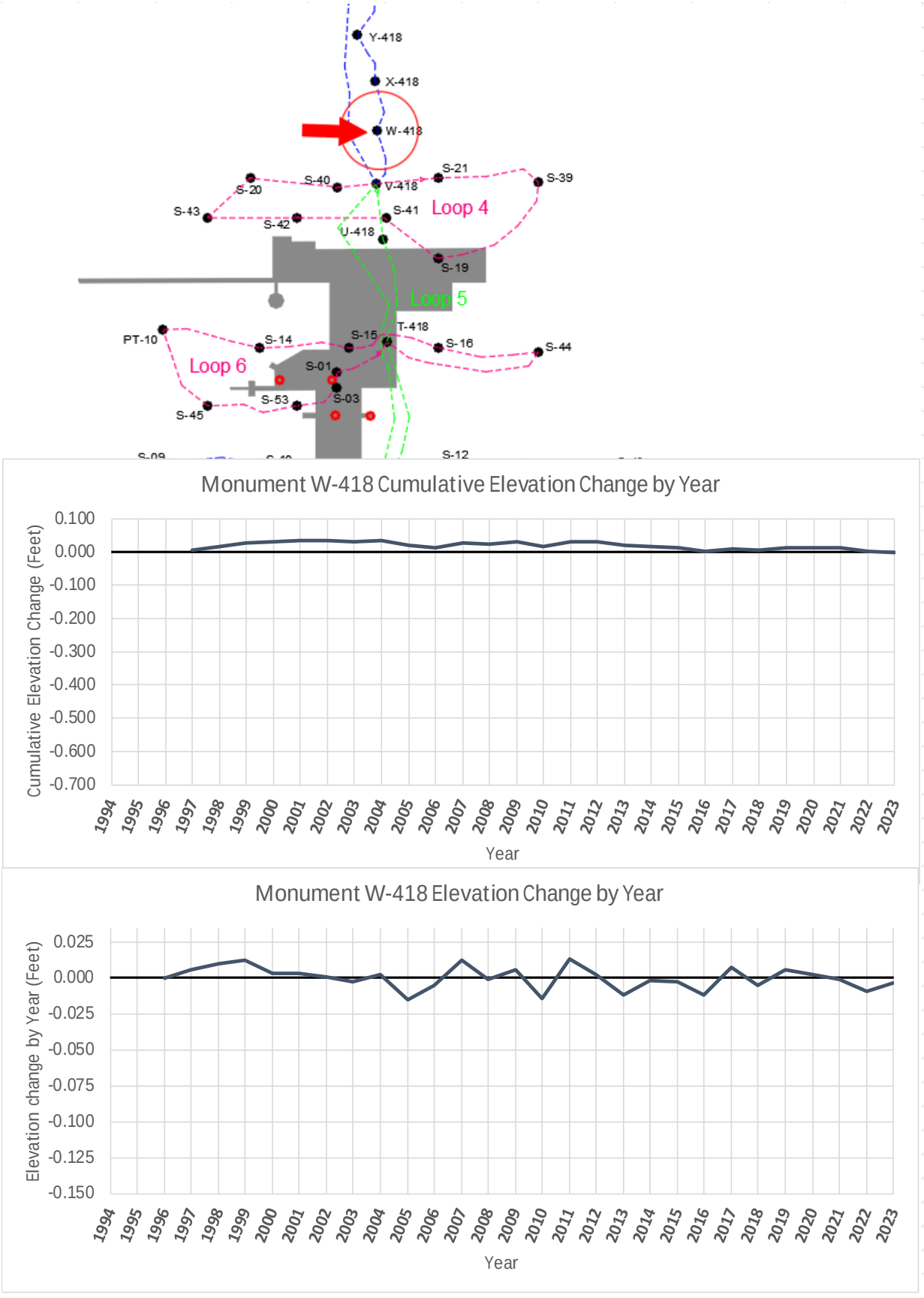


Figure 54. Monument W-418 Elevation Data Graphs

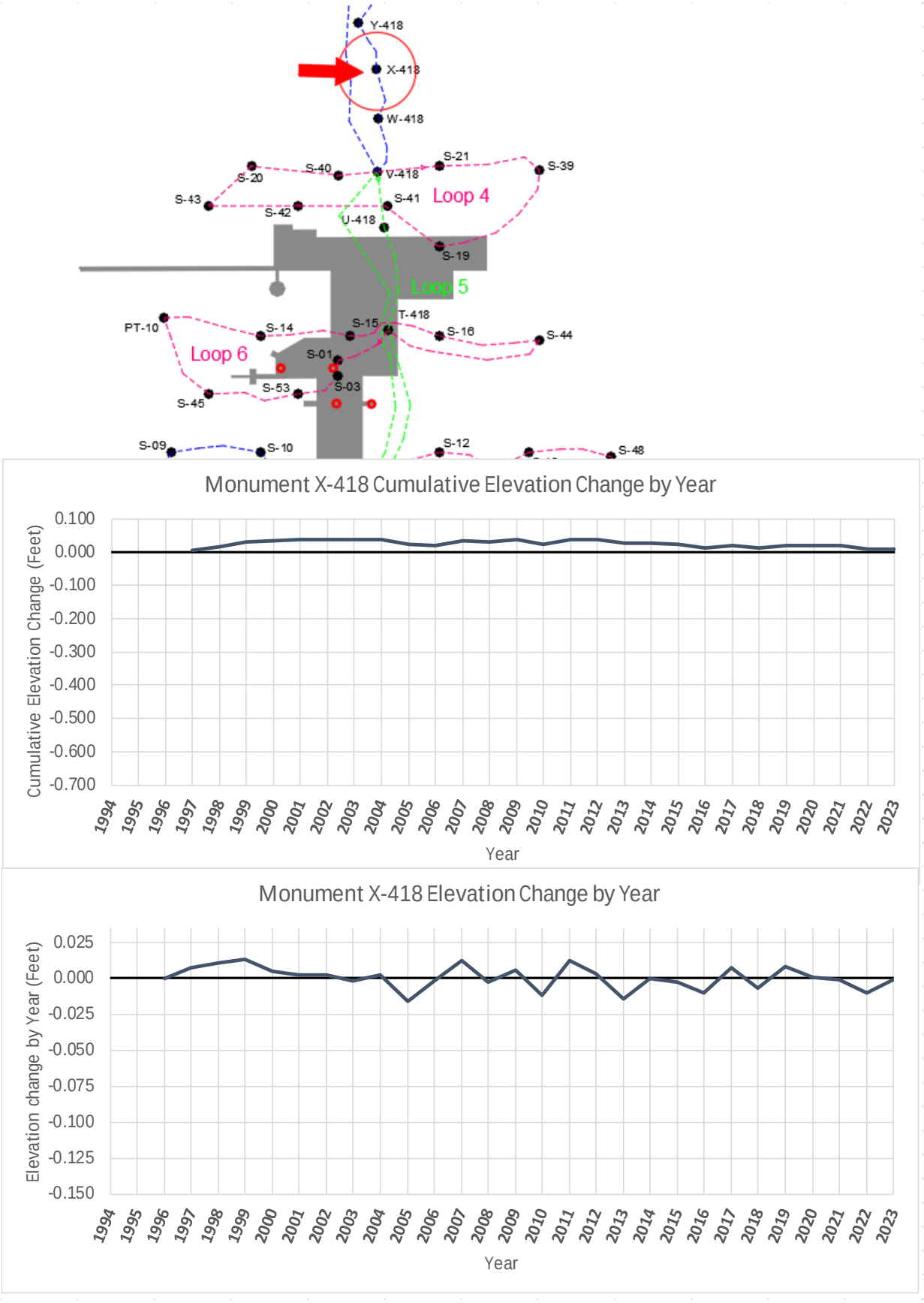


Figure 55. Monument X-418 Elevation Data Graphs

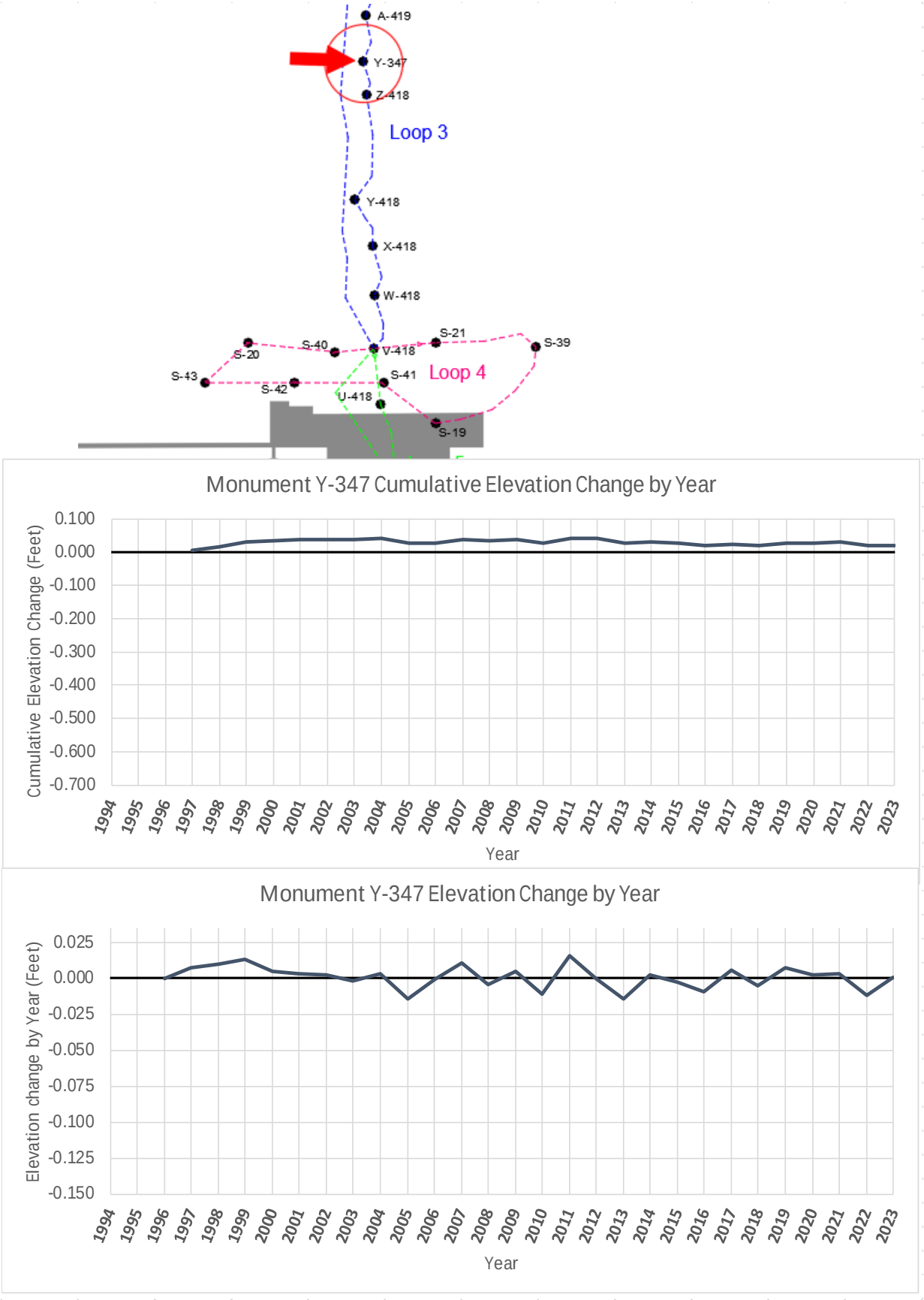


Figure 56. Monument Y-347 Elevation Data Graphs

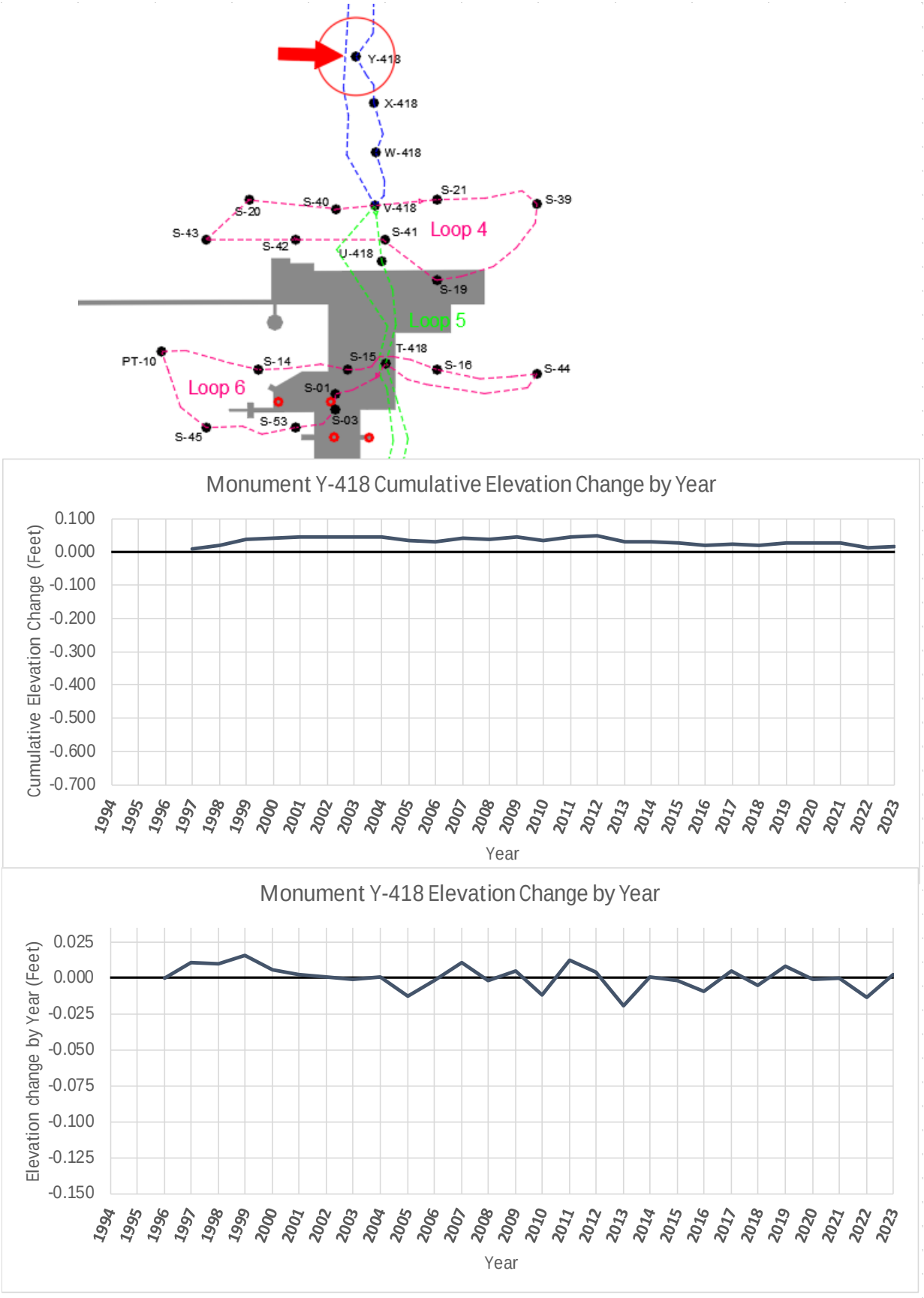


Figure 57. Monument Y-418 Elevation Data Graphs

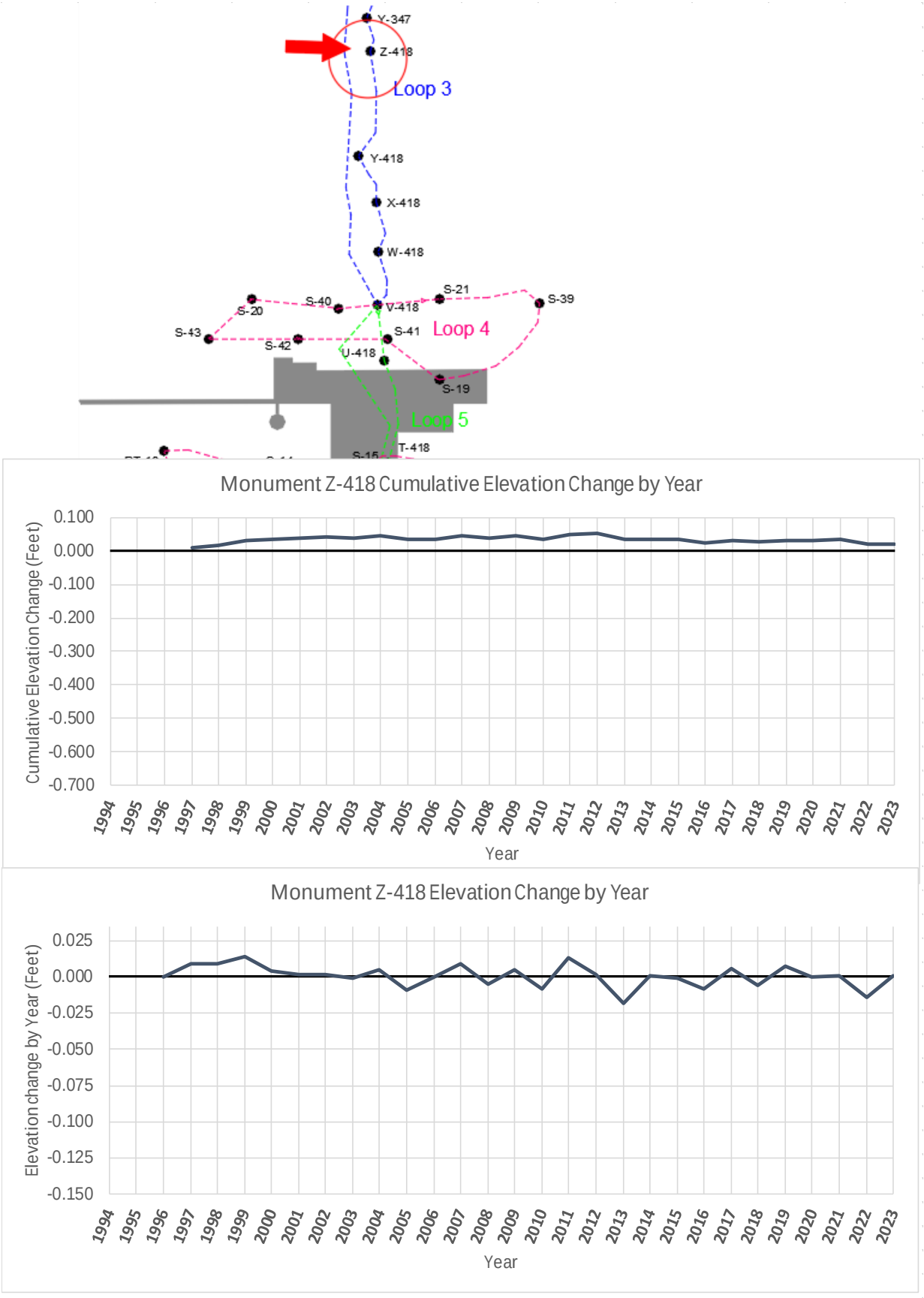


Figure 58. Monument Z-418 Elevation Data Graphs

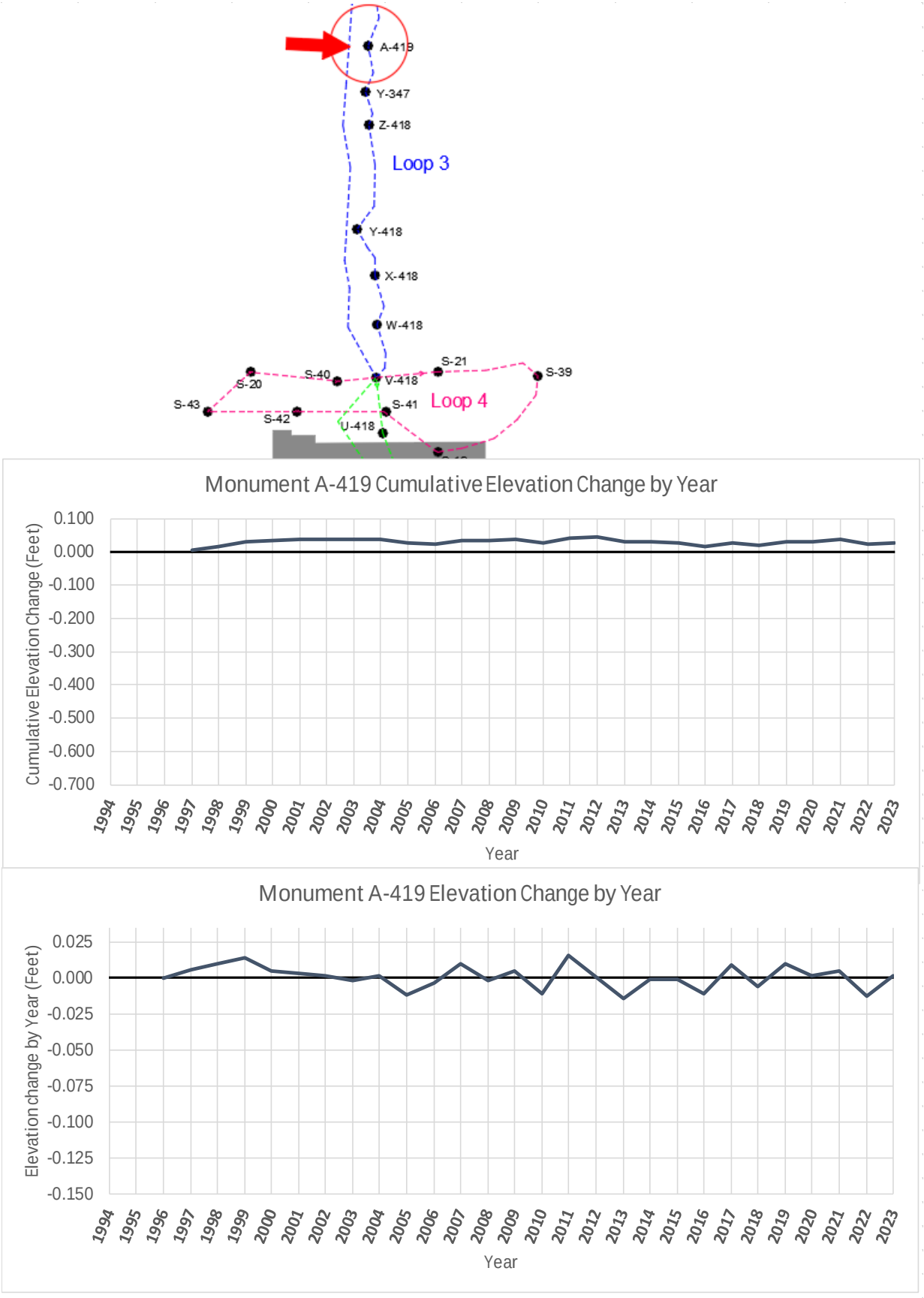


Figure 59. Monument A-419 Elevation Data Graphs

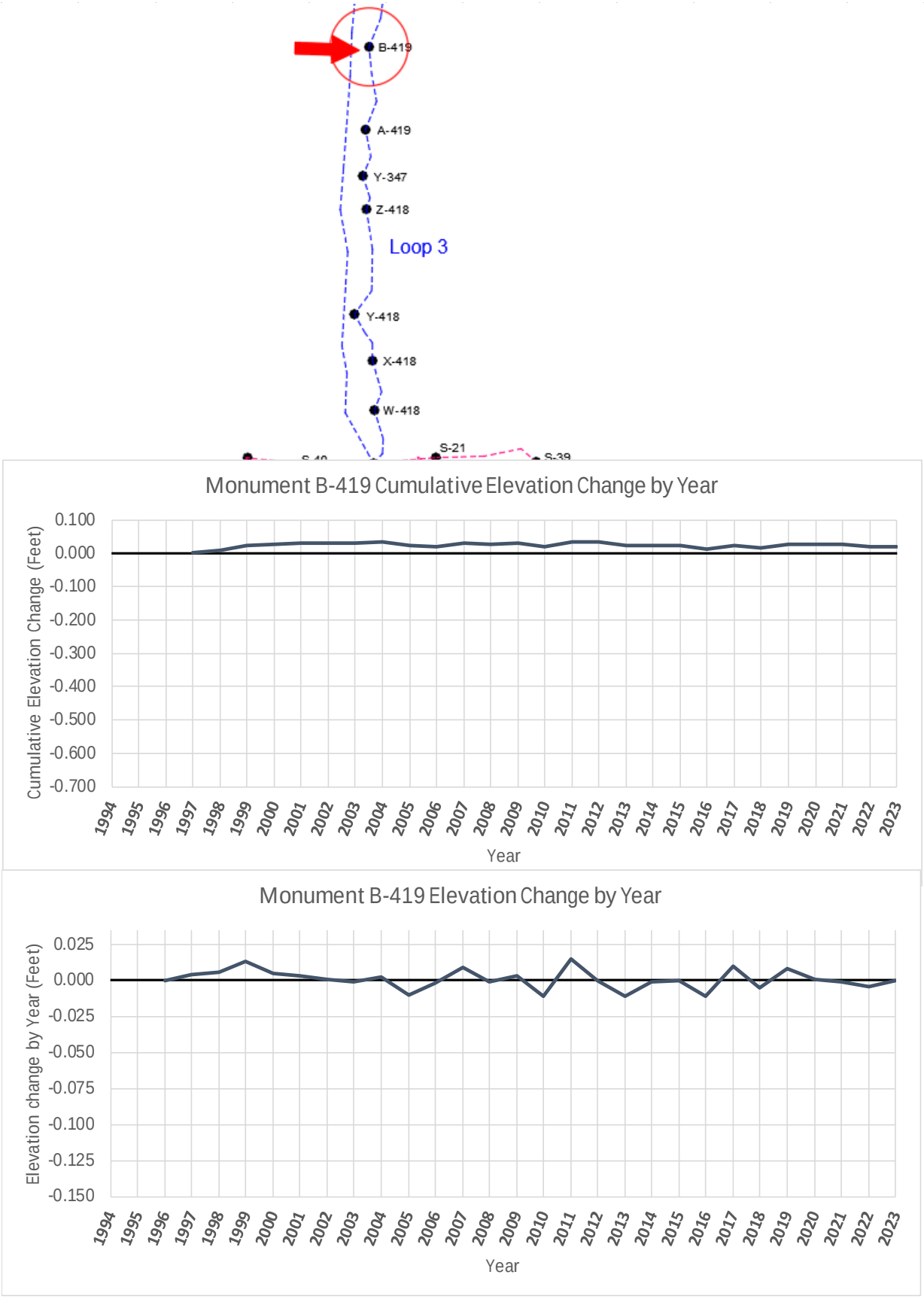


Figure 60. Monument B-419 Elevation Data Graphs

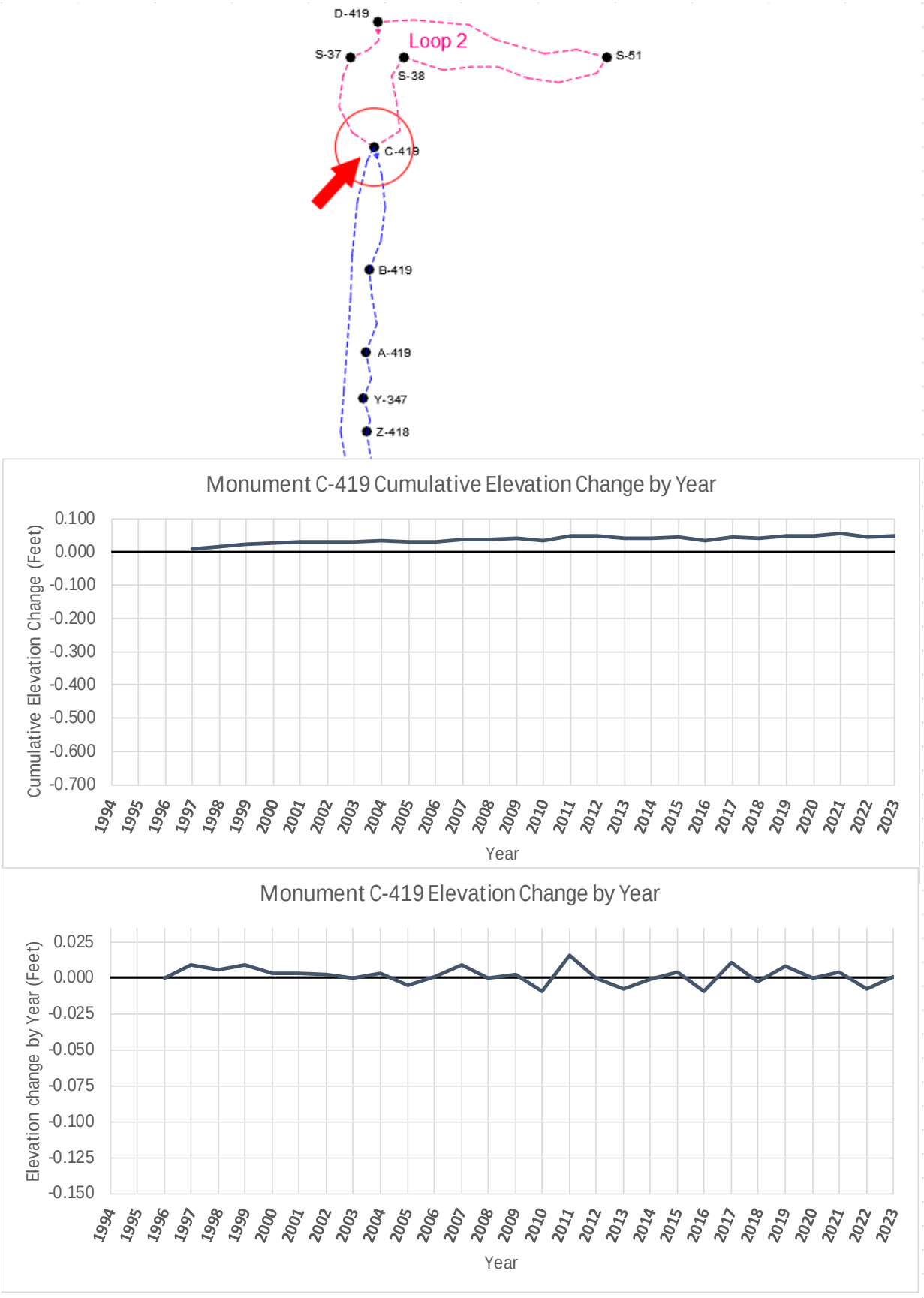


Figure 61. Monument C-419 Elevation Data Graphs

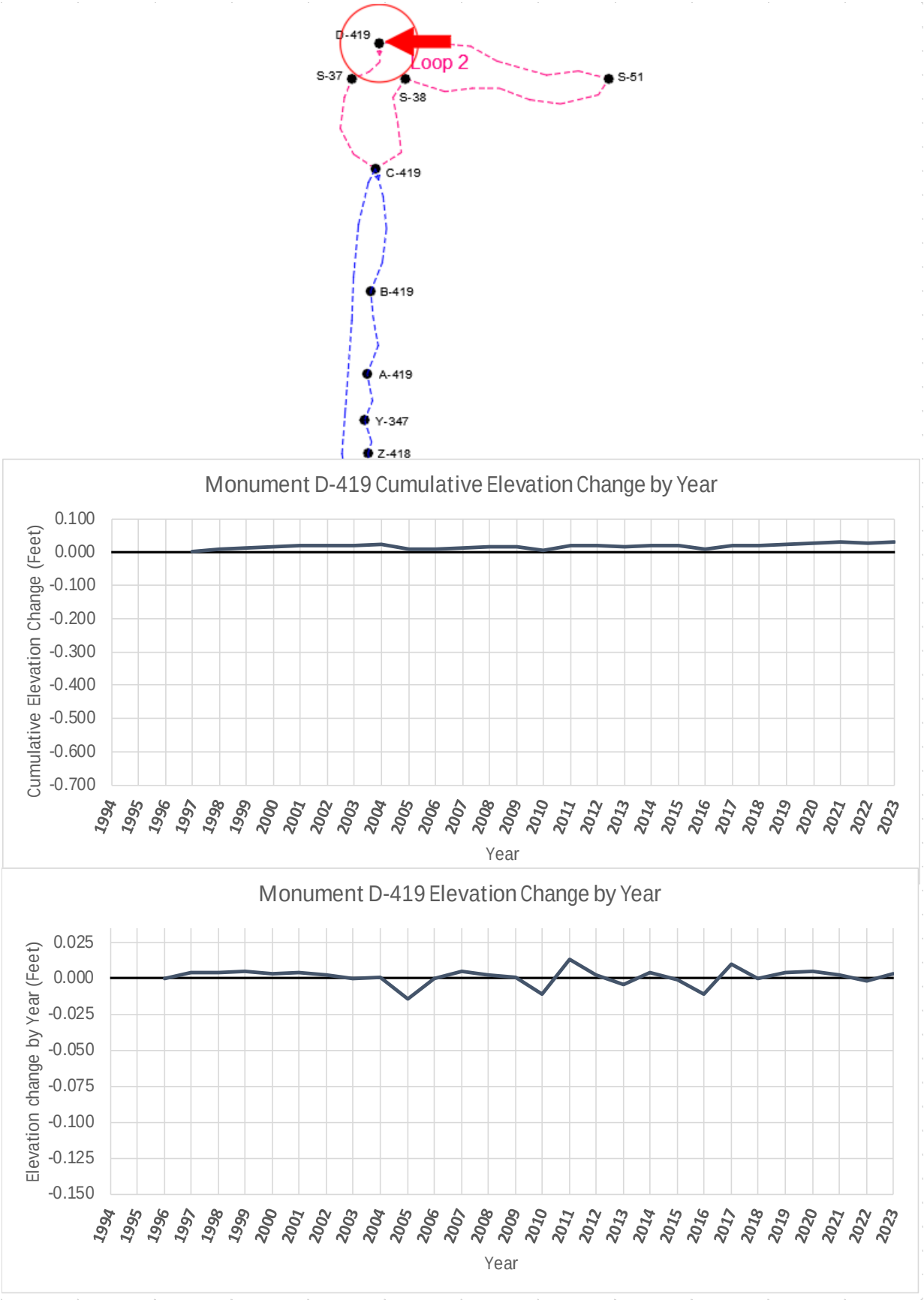


Figure 62. Monument D-419 Elevation Data Graphs

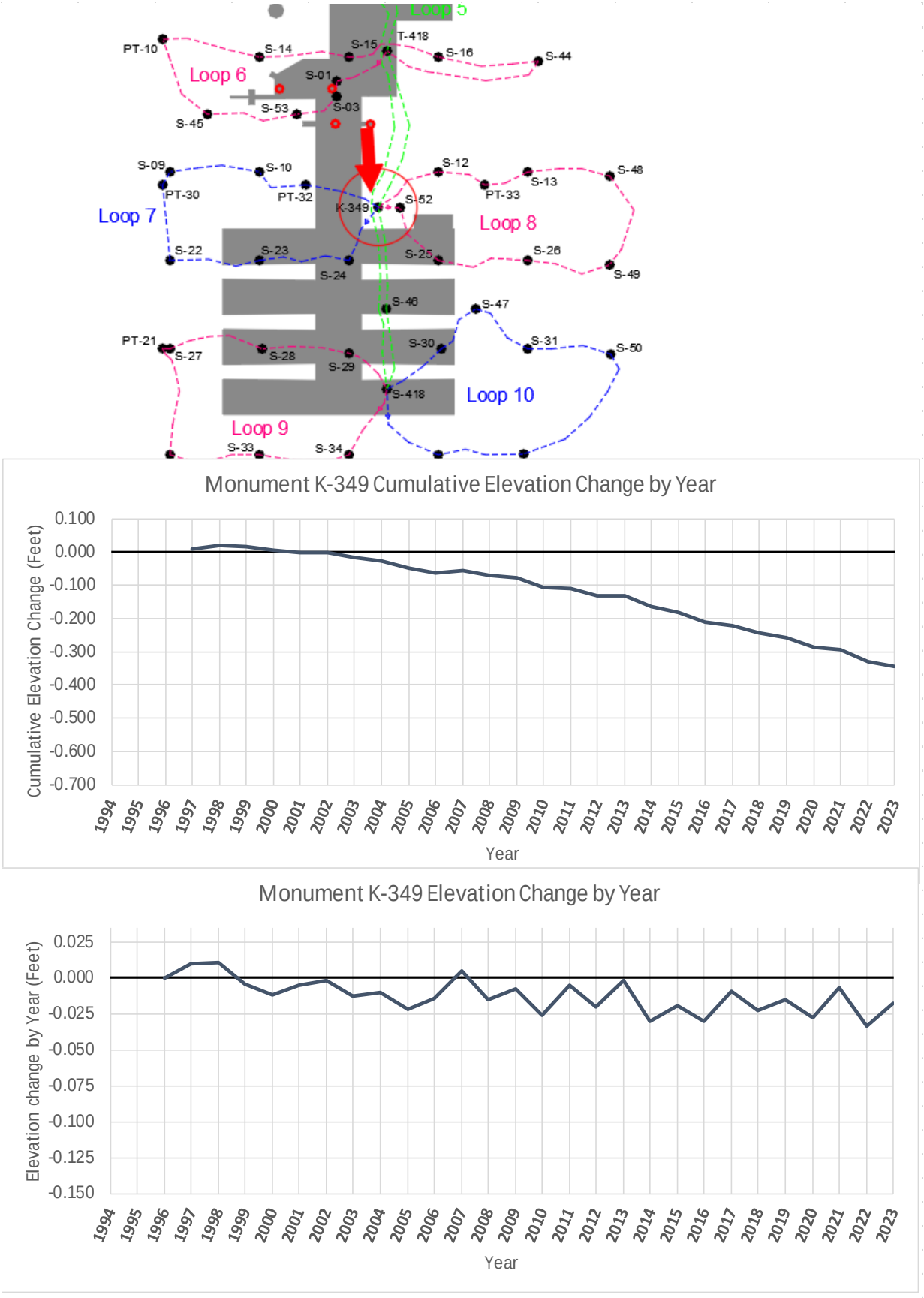


Figure 63. Monument K-349 Elevation Data Graphs

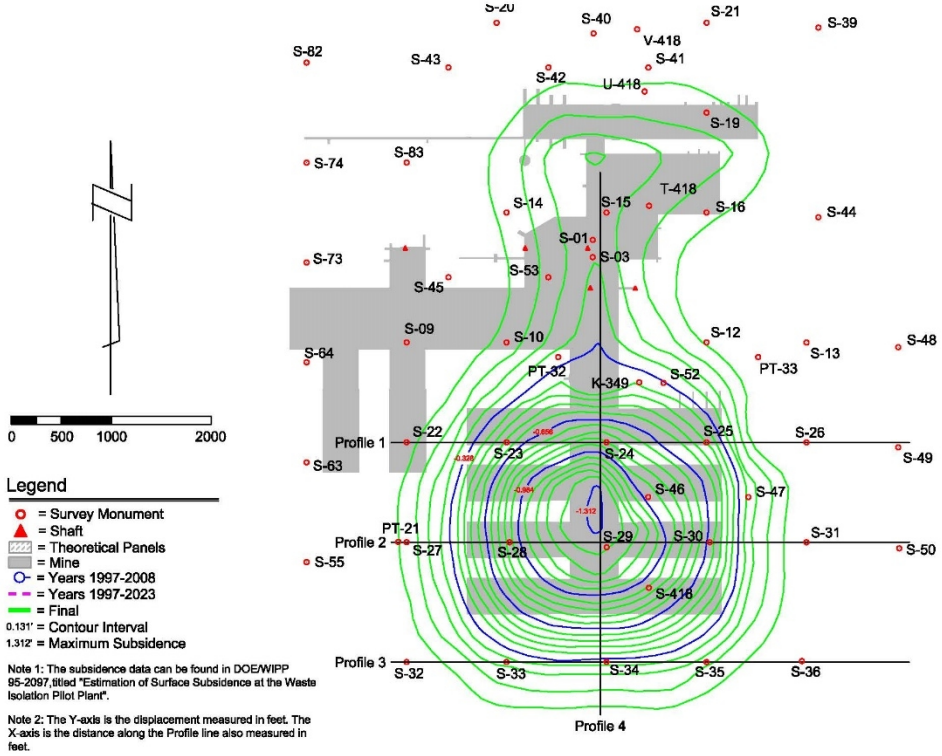


Figure 64a. WIPP Subsidence with Monument locations (Top-down View) (Backfill Engineering Analysis Report, IT Corporation, August 1994; Estimation of Surface Subsidence at the Waste Isolation Pilot Plant, DOE/WIPP-95-2097, 1995)

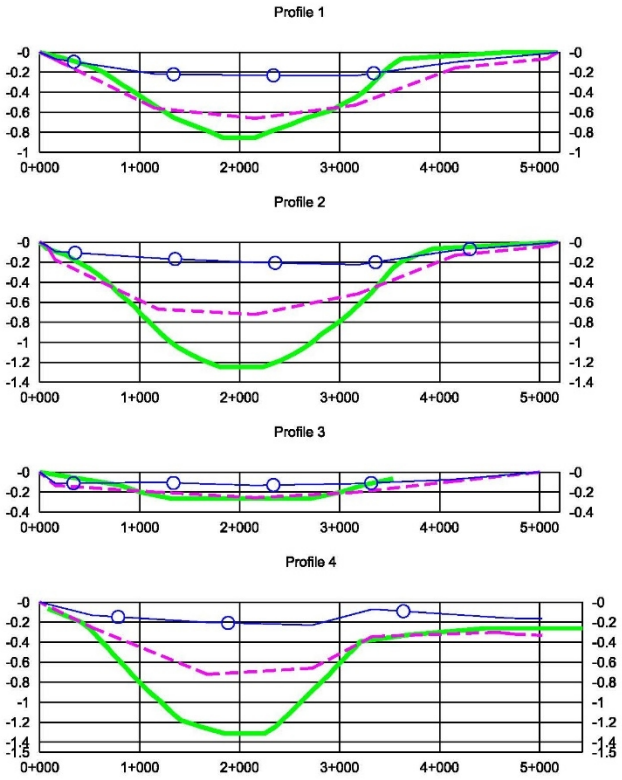


Figure 64b. Cross-sections of profiles 1-4 (Backfill Engineering Analysis Report, IT Corporation, August 1994; Estimation of Surface Subsidence at the Waste Isolation Pilot Plant, DOE/WIPP-95-2097, 1995)

In these cross -sectional profiles, the blue lines represent the subsidence over the years of 1997 to 2008. The dashed magenta line represents the subsidence over the years 1997 to 2023. Finally, the green line represents the predicted final subsidence