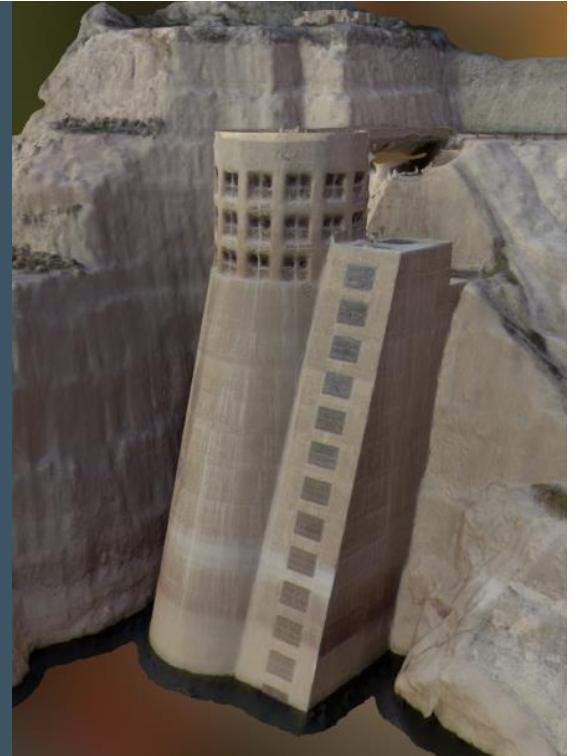




Seven Oaks Dam Monitoring Report 2020

OC Survey
Geodetic Unit



Seven Oaks Dam, San Bernardino California

Final Report for October 2020 Survey

History

The Seven Oaks Dam (SOD) was constructed by the United States Army Corps of Engineers (USACE), Los Angeles District and was completed November 15, 1999. The dam is located on the Santa Ana River in the upper Santa Ana Canyon about 8 miles northeast of the City of Redlands. This dam is planned to operate in tandem with Prado Dam, which is located on the Santa Ana River approximately 40 miles downstream. Together, these dams will provide flood protection to Orange County.

The SOD is an earth and rock fill dam with a crest elevation of 2610 feet NGVD29. The maximum height above the streambed is 550 feet. The crest length is 2980 feet. The intake tower is 225.5 feet high with a tower deck elevation of 2302 feet NGVD29.

A significant factor of SOD is that it is located near the San Andreas Rift zone. Here the San Andreas Fault interacts with other faults (most notably the San Jacinto fault zone and the Pinto Mountain fault) and thereby becomes somewhat fractured. Ancient and inactive strands of the San Andreas Fault can be found in this area. Although this area has been inactive for some time, there is concern that a significant earthquake could damage and affect SOD.

Monitoring Plan

Please see the “Seven Oaks Dam – Survey Monitoring Procedures and Guidelines-October 2020” document for details pertaining to monitoring the dam.

Horizontal Control Datum

The horizontal control datum to be used for this project is the “CCS83, Zone VI, 1998.5 Epoch” as described in the “Final Survey Report” prepared by Towill Inc. This epoch was calculated by transforming all record horizontal coordinates from the NGS/CORS stations used in the initial base and control survey using the NGS HTDP program.

NAD27 project coordinates are also calculated. The transformation from NAD83 to NAD27 is done using the following conversion from the “Final Survey Report” prepared by Towill Inc.,

NAD83 North: 2350217.575 = NAD27 North: 709771.99 (Difference = 1640445.585)

NAD83 East: 6304283.766 = NAD27 East: 1742874.80 (Difference = 4561408.966)

No rotation, no scale change.

It should be noted that on page 6 of the Towill Inc. “Final Survey Report”, the NAD27 North 7079771.99, should be North 709771.99. This was a typographical error and was found while verifying the transformation.

Vertical Control Datum

The vertical control datum to be used for this project is the “NGVD29” as described in the “Final Survey Report” prepared by Towill Inc. This datum is based on control pillar GPS# 5009, SO2001-363 which has an elevation written on the monument plate, being 2608.130 feet. This elevation best fit the record settlement monument elevation. All other monument elevations were calculated from this origin through the direct level differences.

Survey Accuracies

The accuracies stated here are based on the published manufacture equipment accuracies and the survey methodology used. These accuracies are *estimates* and should be used cautiously.

Elevations using the Leica 3003 precise level	+/- 0.01’
Horizontal positions using GPS receivers	+/- 0.03’
Horizontal positions using Leica TCA 1103 total station	+/- 0.02’

Survey Results

All monitoring points were surveyed as described in the “Seven Oaks Dam – Survey Monitoring Procedures and Guidelines - October 2020” document. All results from all previous annual surveys including the October 2020 survey are shown relative to the initial January 2001 survey.

Dam Monitoring Points - Vertical

The dam shows continual settling movement (vertical), although slowing down in the last few years, with the greatest emphasis being at the center and decreasing to the outside. The largest vertical difference being -0.61’ (SM151) at the center (upstream) top of dam and decreasing to -0.11’ (SM143) and -0.09’ (SM160) at the outside edge of the dam.

Dam Monitoring Points – Horizontal

The horizontal positions were measured using GPS methodology. There are a number of monitoring points located on the easterly and westerly sides of the dam that are showing slight horizontal movement roughly towards the center of the dam and are worth noting. This movement correlates with the settling of the dam and has been apparent in almost all of the previous surveys, but the amounts are very small. Below is a list of monitoring points with a displacement $\geq 0.10'$.

Bench Level:

Downstream 2310' level	None
Downstream 2510' level	SM110, SM111, SM114, SM115, SM117, SM119
Downstream 2560' level	SM122, SM124
Downstream Top of Dam	SM127, SM128, SM131, SM137, SM140
Upstream Top of Dam	SM146, SM148, SM154, SM156
Upstream 2530' level	SM161, SM162, SM163, SM169, SM171
Upstream 2360' level	None

Outlet Structure Monitoring Points

The outlet structure appears relatively stable. All horizontal and vertical measurements agree with previous surveys to within $0.05'$ +/- . No significant movement has been detected.

Intake Structure Monitoring Points

The intake structure appears relatively stable. Station “SO2001-3” located at the bottom of the tower has proven to be a difficult monument to level due to its location. There was no monitoring of this monument (SO2001-3) because it was underwater during this year’s survey. The height of this station is more than likely less accurate than the station located at the top of the tower SO2001-4. The horizontal positions are very stable. No significant movement has been detected.

Inclinometer Monitoring Points - Vertical

The 6 inclinometer monitoring points show the same vertical movement as their surrounding dam monitoring points.

Inclinometer Monitoring Points - Horizontal

The horizontal positions were measured using GPS methodology. All SI monitoring points located on the east and west sides of the dam show the same amount and direction

County of Orange – OC Public Works – OC Survey Section – Geodetic Control Unit

of horizontal movement as the adjacent monitoring points being roughly towards the center of the dam.

Date of Surveys

Phase I & II – Horizontal positioning of monitoring points and control stations (GPS)

October 5, 7, 13, 20

Phase III – Differential leveling on all points

October 5, 6, 8, 13, 20

Phase VI – Horizontal positioning of tunnel settlement points (Conventional)

October 6

All measurements shown are in U.S. Survey feet unless otherwise stated.

Please see the “Overview” section, which details how the data was divided into sections and where the data can be found.

This report has been prepared by us or under our direction.



Art Andrew, P.L.S. 7042



January 5, 2021

Date:



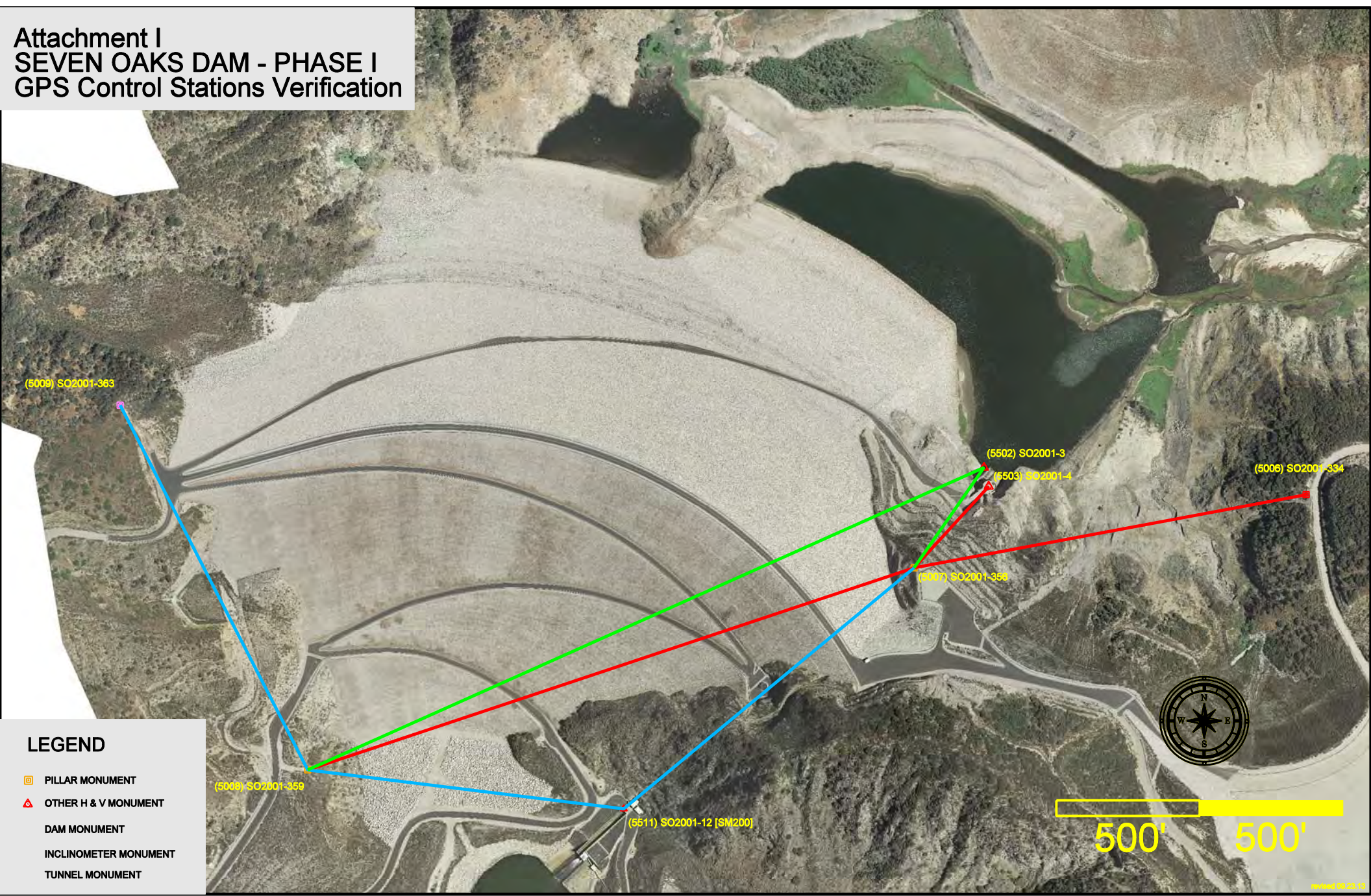
Elliott Medina, P.L.S. 9294



January 5, 2021

Date:

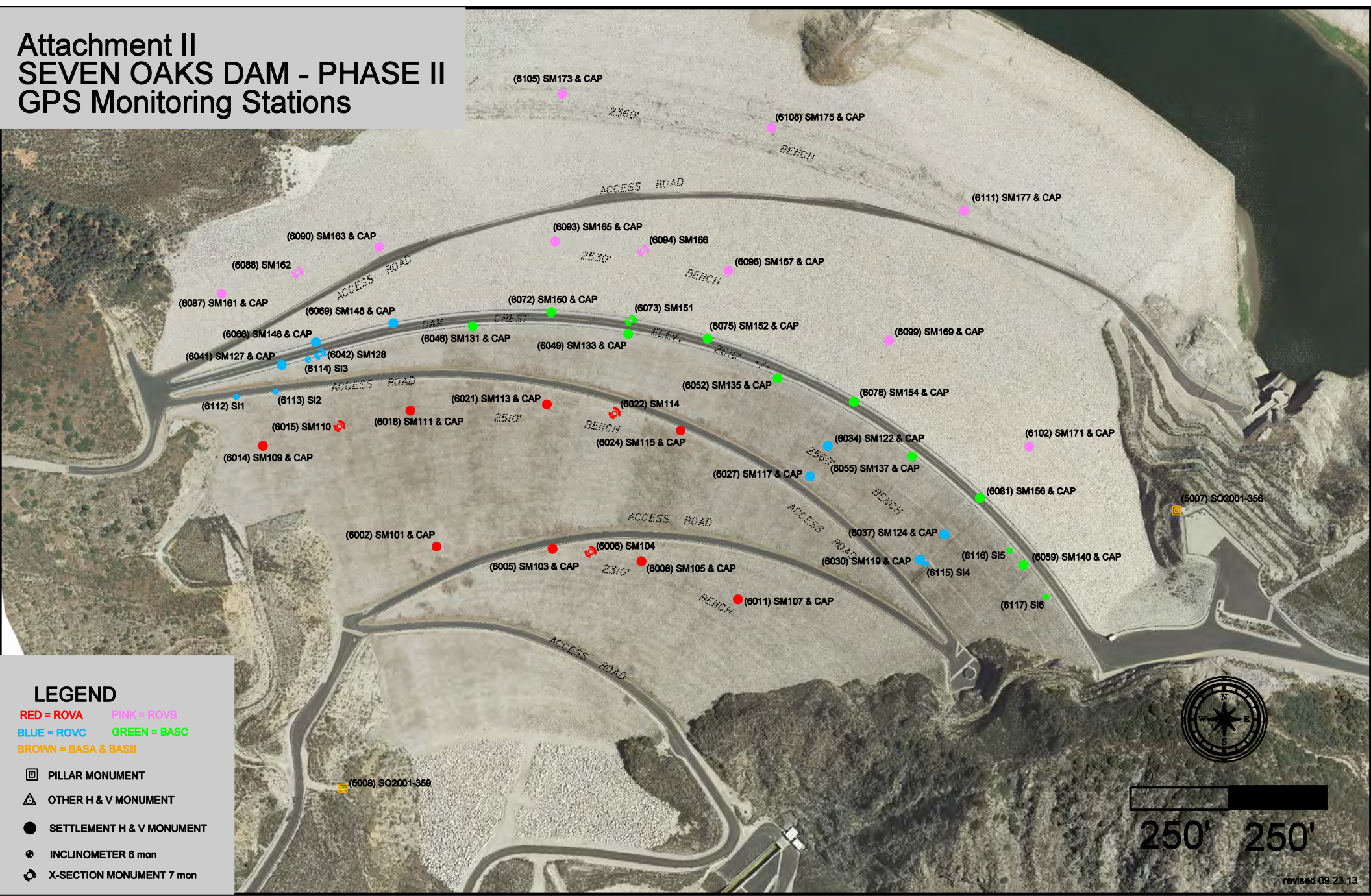
Attachment I
SEVEN OAKS DAM - PHASE I
GPS Control Stations Verification



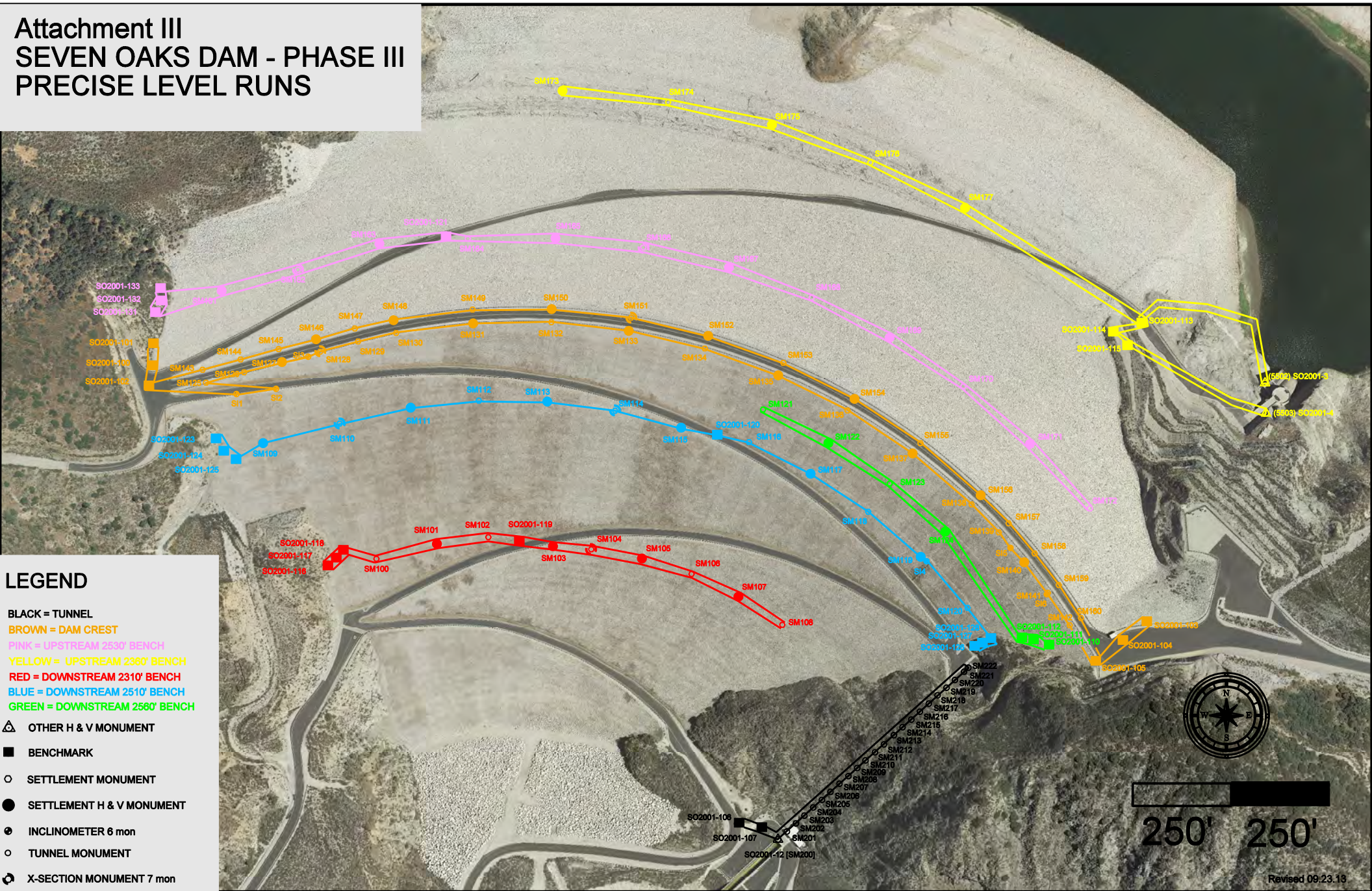
LEGEND

- PILLAR MONUMENT
- OTHER H & V MONUMENT
- DAM MONUMENT
- INCLINOMETER MONUMENT
- TUNNEL MONUMENT

Attachment II SEVEN OAKS DAM - PHASE II GPS Monitoring Stations



Attachment III
SEVEN OAKS DAM - PHASE III
PRECISE LEVEL RUNS



Attachment VI

PHASE IV

TUNNEL MONITORING - AZIMUTH SHOTS

- = FD PILLER MONUMENT
- ▲ - FD. 2-1/2" USCE BRASS DISK SET FLUSH IN CONC. STRUCTURE

SET PAINTED TARGET
@ END OF TUNNEL AS
SHOWN BELOW:



TARGET
[SM 222]

S02001-359 (GPS 5008)



277-01-20.2

47-59-37.0 (use for monitoring)
TUNNEL



N.T.S.

S02001-12
[SM 200]
(GPS 5511)

TUNNEL MONITORING PROCEDURES:

INST TCA-1103 @ SM 200

1. SET AZIMUTH BACKSIGHTING 5008 OF 277-01-20.2
2. CHECK AZIMUTH BY SIGHTING EAST & WEST TOWER LEGS (4 SETS)
3. TURN TO PAINTED TARGET ON TUNNEL WALL (4 SETS)
4. VERIFY AZIMUTH OF "47-59-37.0" TO PAINTED TARGET

INST TCA-1103 @ SM 200

1. BACKSIGHT PAINTED TARGET ON WALL
2. SET AZIMUTH "47-59-37.0" IN INSTRUMENT
3. MEASURE STATION & OUTS TO ALL MONITORING POINTS (2 SETS)

178-27-04.5

178-01-02.0

TOWER
WEST LEG

TOWER
EAST LEG

ELECTRICAL
TRANSMISSION
TOWERS

(PAINTED AZIMUTH MARKS)
SCRIBED VERTICAL LINE IN STEEL TOWER
PAINTED TARGET AS SHOWN BELOW:



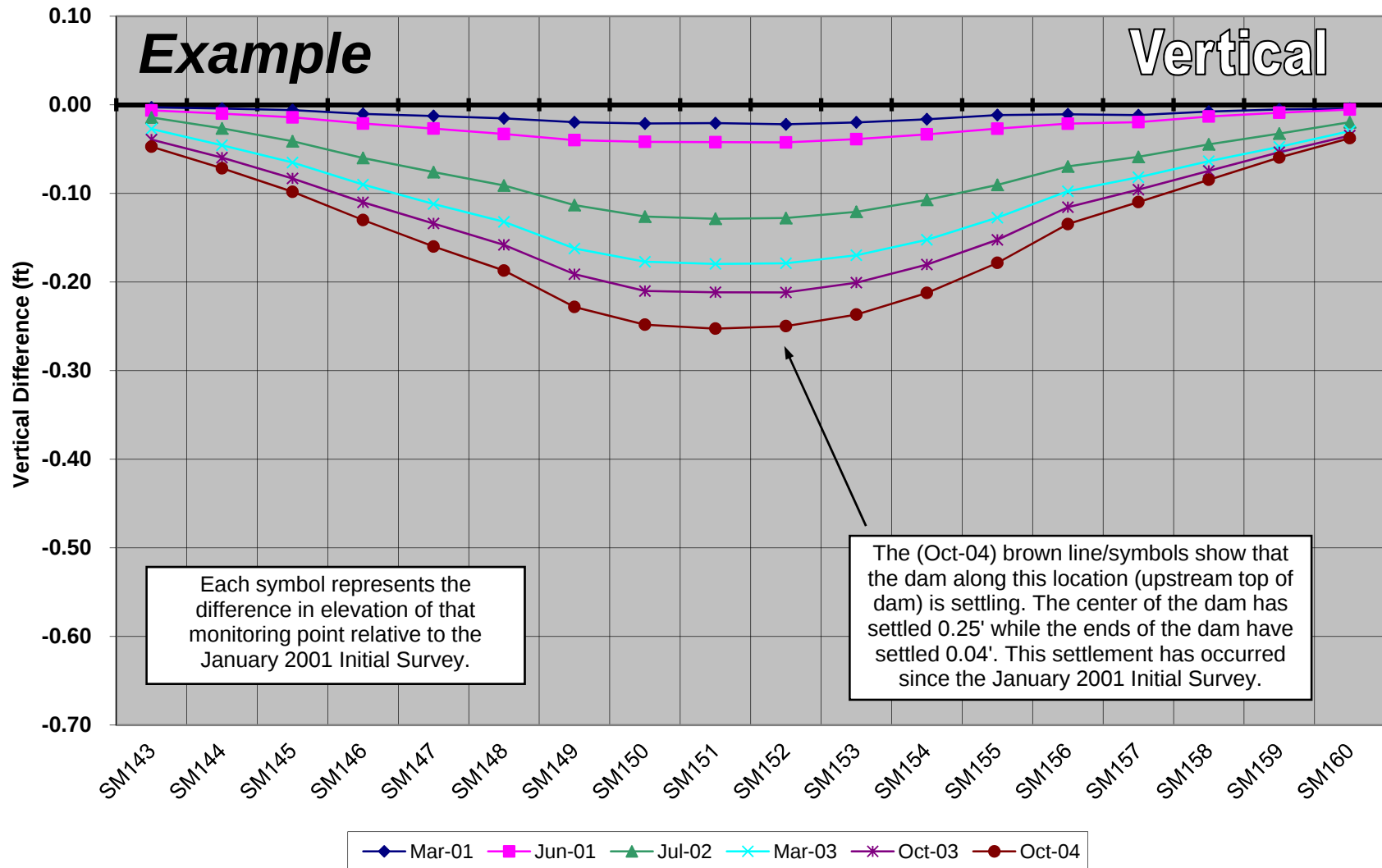
EXAMPLE GRAPHS

The following examples are designed to graphically show what might be seen if displacement at station 11+35 had occurred.

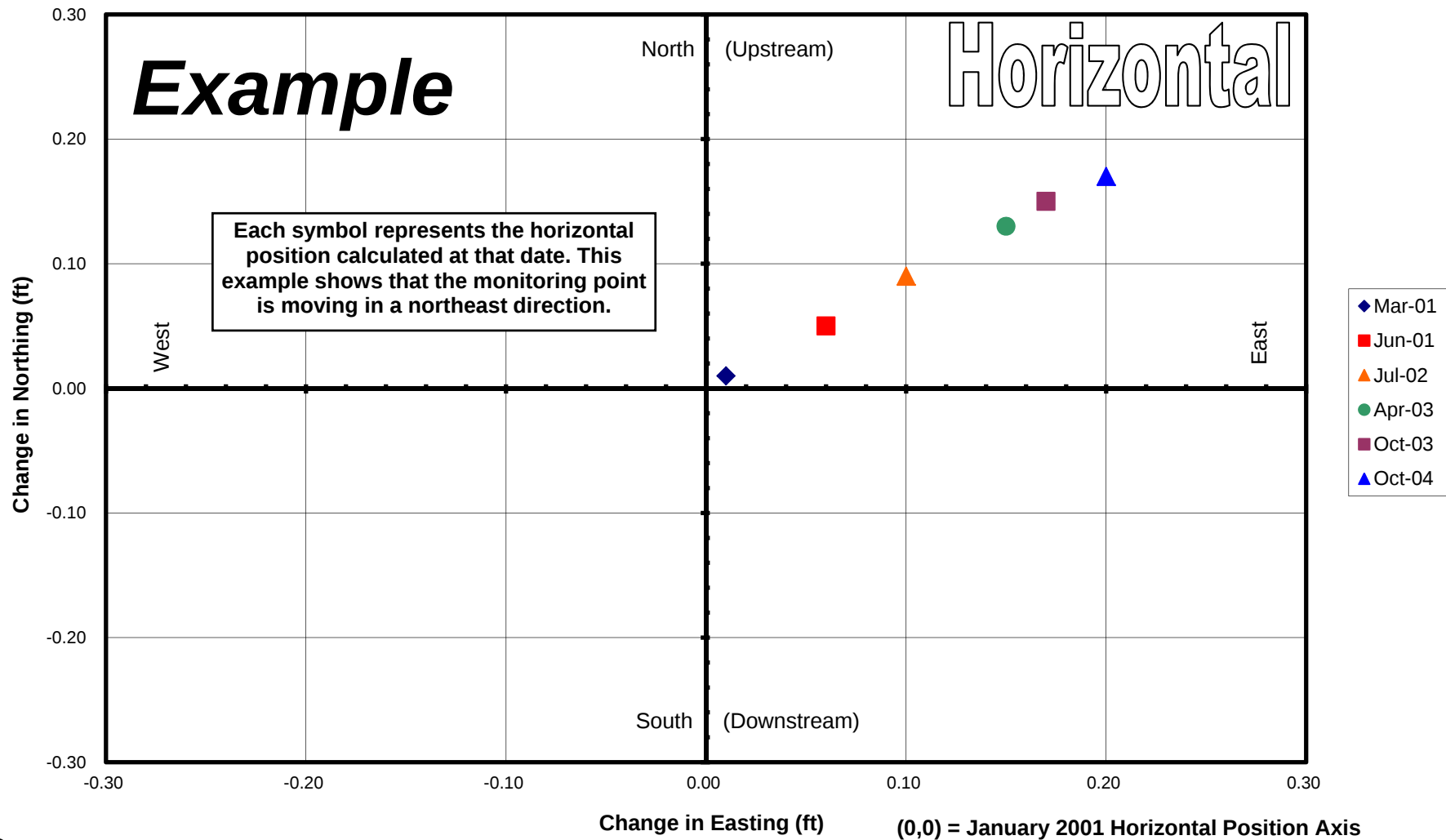
The “Vertical Movement” graph shows that station 11+35 has subsided about 0.28’ since 1995.

The “Horizontal Movement” graph shows a monitoring point’s movement of about 0.02’ per year in a Northeasterly direction.

Seven Oaks Dam Vertical Movement since January 2001 Initial Survey Profile View - Looking Upstream



EXAMPLE
Monitoring Point
Horizontal Movement since January 2001 Initial Survey



Seven Oaks Dam Monitoring Survey 2020

Dam Monitoring Points

Horizontal Datum = CCS83, Zone VI, 1998.5 Epoch and CCS27, Zone VI Project Coordinates

Vertical Datum = None

<u>GPS#</u>	<u>NAME</u>	<u>(NAD83) NORTH (ft)</u>	<u>(NAD83) EAST (ft)</u>	<u>(NAD27) NORTH (ft)</u>	<u>(NAD27) EAST (ft)</u>	<u>Description</u>
5007	SO2001-356	2350923.584	6306400.252	710477.999	1744991.286	Control Pillar
5008	SO2001-359	2350217.575	6304283.766	709771.990	1742874.800	Control Pillar
5006	SO2001-334	2351183.490	6307768.980	710737.905	1746360.014	Control Pillar
5009	SO2001-363	2351492.234	6303627.941	711046.649	1742218.975	Control Pillar
5503	SO2001-4	2351215.583	6306645.526	710769.998	1745236.560	Brass Disk
5511	SO2001-12 / SM200	2350081.783	6305386.411	709636.198	1743977.445	Brass Disk
	Downstream 2310 Level					
6002	SM101	2350831.917	6304519.925	710386.332	1743110.959	BOLT IN TOP CAP
6005	SM103	2350825.874	6304815.304	710380.289	1743406.338	TOP CAP NO BOLT
6006	SM104	2350818.331	6304912.382	710372.746	1743503.416	BOLT IN TOP CAP
6008	SM105	2350794.707	6305041.314	710349.122	1743632.348	BOLT IN TOP CAP
6011	SM107	2350698.360	6305286.140	710252.775	1743877.174	BOLT IN TOP CAP
	Downstream 2510 Level					
6014	SM109	2351088.950	6304079.769	710643.365	1742670.803	BOLT IN TOP CAP
6015	SM110	2351137.399	6304274.028	710691.814	1742865.062	BOLT IN TOP CAP
6018	SM111	2351177.510	6304453.755	710731.925	1743044.789	BOLT IN TOP CAP
6021	SM113	2351193.291	6304801.118	710747.706	1743392.152	BOLT IN TOP CAP
6022	SM114	2351170.228	6304972.947	710724.643	1743563.981	BOLT IN TOP CAP
6024	SM115	2351126.884	6305140.320	710681.299	1743731.354	BOLT IN TOP CAP
6027	SM117	2351011.173	6305469.204	710565.588	1744060.238	BOLT IN TOP CAP
6030	SM119	2350799.216	6305748.520	710353.631	1744339.554	BOLT IN TOP CAP
	Downstream 2560 level					
6034	SM122	2351088.934	6305514.585	710643.349	1744105.619	BOLT IN TOP CAP
6037	SM124	2350863.961	6305811.133	710418.376	1744402.167	BOLT IN TOP CAP

Seven Oaks Dam Monitoring Survey 2020

Dam Monitoring Points

Horizontal Datum = CCS83, Zone VI, 1998.5 Epoch and CCS27, Zone VI Project Coordinates

Vertical Datum = None

<u>GPS#</u>	<u>NAME</u>	<u>(NAD83) NORTH (ft)</u>	<u>(NAD83) EAST (ft)</u>	<u>(NAD27) NORTH (ft)</u>	<u>(NAD27) EAST (ft)</u>	<u>Description</u>
	Top of Dam-South side					
6041	SM127	2351293.762	6304128.057	710848.177	1742719.091	BOLT IN TOP CAP
6042	SM128	2351319.865	6304224.606	710874.280	1742815.640	BOLT IN TOP CAP
6046	SM131	2351392.829	6304613.529	710947.244	1743204.563	BOLT IN TOP CAP
6049	SM133	2351373.046	6305007.902	710927.461	1743598.936	BOLT IN TOP CAP
6052	SM135	2351260.242	6305386.207	710814.657	1743977.241	BOLT IN TOP CAP
6055	SM137	2351060.920	6305727.098	710615.335	1744318.132	BOLT IN TOP CAP
6059	SM140	2350786.346	6306011.030	710340.761	1744602.064	BOLT IN TOP CAP
	Top of Dam-North Side					
6066	SM146	2351352.717	6304215.613	710907.132	1742806.647	BOLT IN TOP CAP
6069	SM148	2351400.746	6304411.050	710955.161	1743002.084	BOLT IN TOP CAP
6072	SM150	2351428.740	6304813.056	710983.155	1743404.090	BOLT IN TOP CAP
6073	SM151	2351406.567	6305013.558	710960.982	1743604.592	BOLT IN TOP CAP
6075	SM152	2351360.610	6305210.077	710915.025	1743801.111	BOLT IN TOP CAP
6078	SM154	2351200.186	6305579.767	710754.601	1744170.801	BOLT IN TOP CAP
6081	SM156	2350956.666	6305900.920	710511.081	1744491.954	BOLT IN TOP CAP
	Upstream 2530 level					
6087	SM161	2351474.931	6303975.365	711029.346	1742566.399	BOLT IN TOP CAP
6088	SM162	2351527.942	6304168.074	711082.357	1742759.108	BOLT IN TOP CAP
6090	SM163	2351594.804	6304374.094	711149.219	1742965.128	BOLT IN TOP CAP
6093	SM165	2351608.899	6304822.527	711163.314	1743413.561	BOLT IN TOP CAP
6094	SM166	2351584.366	6305044.572	711138.781	1743635.606	BOLT IN TOP CAP
6096	SM167	2351533.546	6305261.749	711087.961	1743852.783	BOLT IN TOP CAP
6099	SM169	2351356.050	6305670.922	710910.465	1744261.956	BOLT IN TOP CAP

Seven Oaks Dam Monitoring Survey 2020

Dam Monitoring Points

Horizontal Datum = CCS83, Zone VI, 1998.5 Epoch and CCS27, Zone VI Project Coordinates

Vertical Datum = None

<u>GPS#</u>	<u>NAME</u>	<u>(NAD83) NORTH (ft)</u>	<u>(NAD83) EAST (ft)</u>	<u>(NAD27) NORTH (ft)</u>	<u>(NAD27) EAST (ft)</u>	<u>Description</u>
6102	SM171	2351086.555	6306026.405	710640.970	1744617.439	BOLT IN TOP CAP
	Upstream 2360 level					
6105	SM173	2351982.771	6304840.740	711537.186	1743431.774	BOLT IN TOP CAP
6108	SM175	2351892.249	6305368.703	711446.664	1743959.737	BOLT IN TOP CAP
6111	SM177	2351683.281	6305862.407	711237.696	1744453.441	BOLT IN TOP CAP
	Inclinometers					
6112	SI1	2351212.335	6304012.158	710766.750	1742603.192	PUNCH MARK IN RIM
6113	SI2	2351225.132	6304112.492	710779.547	1742703.526	PUNCH MARK IN RIM
6114	SI3	2351306.901	6304194.381	710861.316	1742785.415	PUNCH MARK IN RIM
6115	SI4	2350787.364	6305764.184	710341.779	1744355.218	PUNCH MARK IN RIM
6116	SI5	2350820.815	6305976.172	710375.230	1744567.206	PUNCH MARK IN RIM
6117	SI6	2350705.260	6306067.356	710259.675	1744658.390	PUNCH MARK IN RIM
The values are from the Control Trimble-Business Center Software adjustment constraining						
GPS #5007 fixed 3-dimensionally and #5008 fixed horizontally, per November 2020 San Bernardino Surveyor GPS Survey.						

Seven Oaks Dam Monitoring Survey 2020

Dam Monitoring Points

Vertical Datum = NGVD29

<u>Designation</u>	<u>Elevation (ft)</u>
SI-1	2595.910
SI-2	2588.250
SI-3	2611.213
SI-4	2510.542
SI-5	2611.328
SI-6	2611.038
SM-100	2307.281
SM-101	2306.701
SM-102	2306.718
SM-103	2306.976
SM-104	2306.495
SM-105	2306.470
SM-106	2306.511
SM-107	2306.542
SM-108	2306.834
SM-109	2507.267
SM-110	2506.889
SM-111	2506.606
SM-112	2506.466
SM-113	2506.440
SM-114	2506.462
SM-115	2506.549
SM-116	2506.044
SM-117	2506.076
SM-118	2506.352
SM-119	2506.637
SM-120	2507.080
SM-121	2556.381
SM-122	2556.579
SM-123	2556.480
SM-124	2556.896
SM-125	2609.664
SM-126	2609.576
SM-127	2609.724
SM-128	2609.964
SM-129	2610.063
SM-130	2610.570
SM-131	2611.227
SM-132	2611.269
SM-133	2611.187
SM-134	2611.208
SM-135	2611.166
SM-136	2611.121
SM-137	2610.807

Seven Oaks Dam Monitoring Survey 2020

Dam Monitoring Points

Vertical Datum = NGVD29

SM-138	2610.511
SM-139	2610.386
SM-140	2610.202
SM-141	2609.927
SM-142	2609.496
SM-143	2609.482
SM-144	2609.452
SM-145	2609.690
SM-146	2609.748
SM-147	2610.216
SM-148	2610.249
SM-149	2611.102
SM-150	2611.484
SM-151	2611.314
SM-152	2611.291
SM-153	2611.252
SM-154	2611.084
SM-155	2610.875
SM-156	2610.587
SM-157	2610.351
SM-158	2610.285
SM-159	2609.906
SM-160	2609.551
SM-161	2526.242
SM-162	2525.980
SM-163	2525.730
SM-164	2525.430
SM-165	2525.291
SM-166	2525.222
SM-167	2525.409
SM-168	2525.413
SM-169	2525.526
SM-170	2525.768
SM-171	2526.125
SM-172	2526.502
SM-173	2356.906
SM-174	2356.997
SM-175	2357.008
SM-176	2356.718
SM-177	2356.763
SM-200	2067.996
SM-201	2068.040
SM-202	2068.375
SM-203	2069.167
SM-204	2069.974

Seven Oaks Dam Monitoring Survey 2020

Dam Monitoring Points

Vertical Datum = NGVD29

SM-205	2070.740
SM-206	2071.521
SM-207	2072.283
SM-208	2073.066
SM-209	2073.826
SM-210	2074.650
SM-211	2075.420
SM-212	2076.213
SM-213	2077.124
SM-214	2077.871
SM-215	2078.700
SM-216	2079.451
SM-217	2080.234
SM-218	2081.489
SM-219	2083.046
SM-220	2084.288
SM-221	2085.063
SM-222	2093.477
SO2001-4	2302.230

Data Index (TAB)

Dn 2310'
Dn 2510'
Dn 2560'
Dn Top of Dam
Up Top of Dam
Up 2530'
Up 2360'

Inclinometer

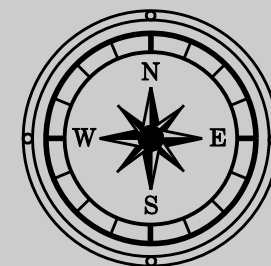
See these sections for each data set

Intake (TAB)

(5007) SO2001-356

70DM

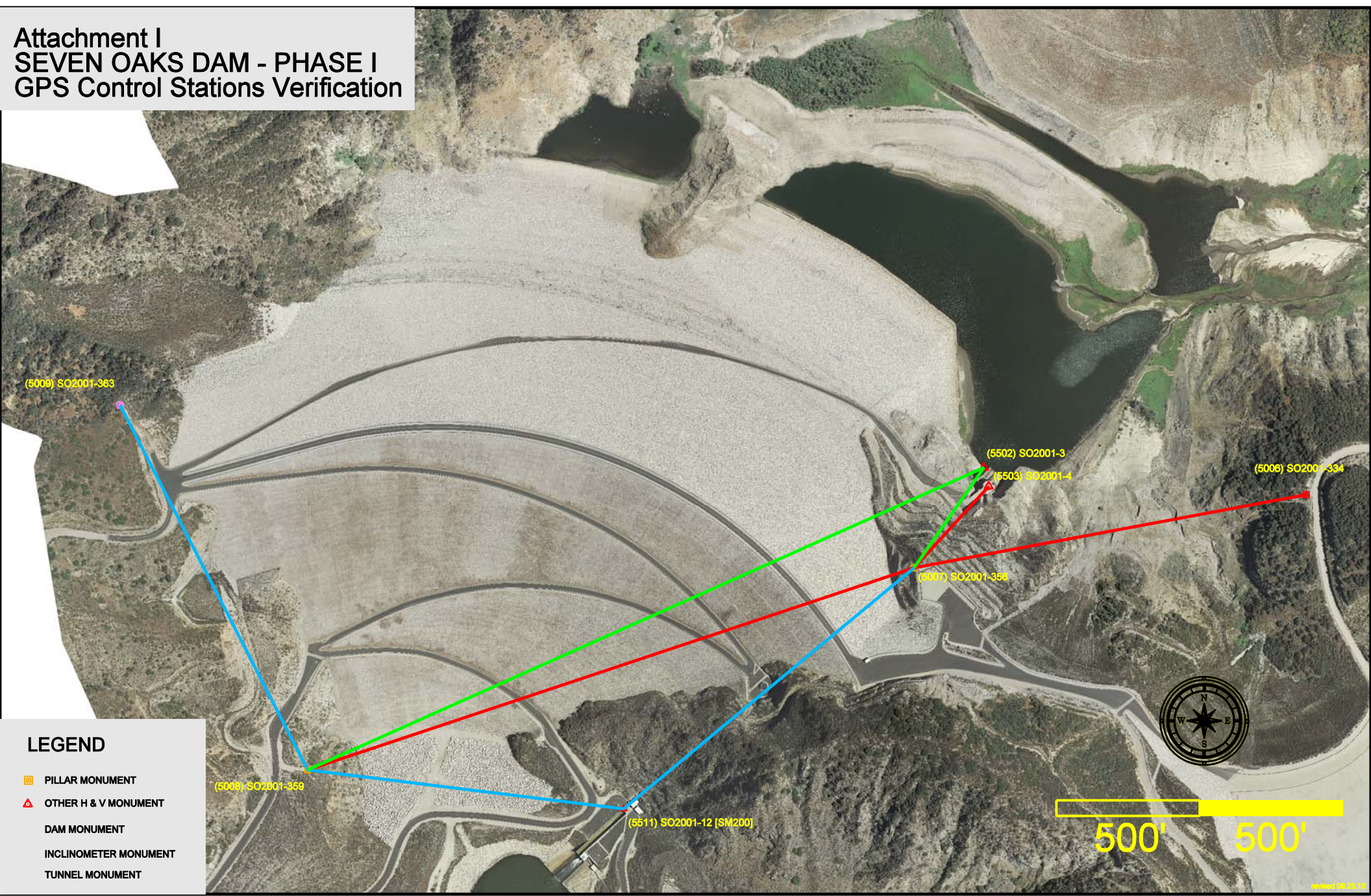
Outlet (TAB)



250' 250'

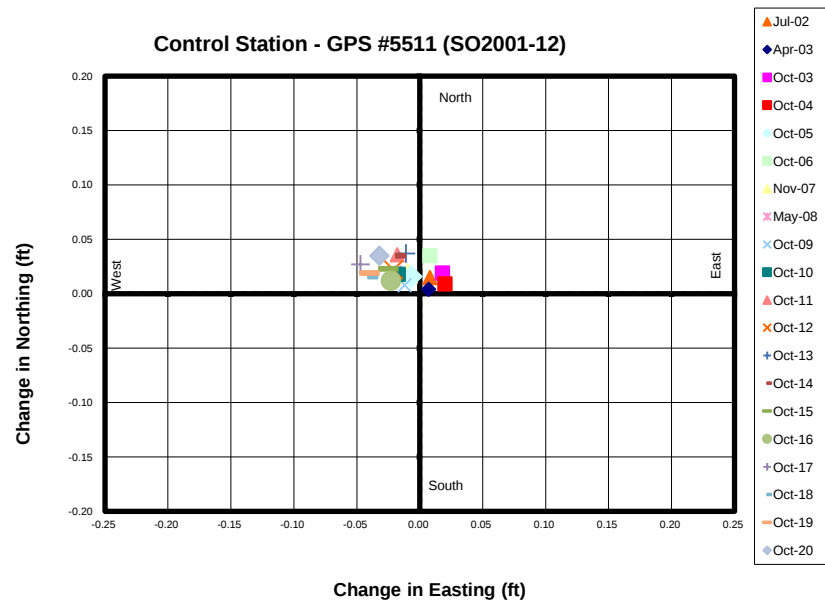
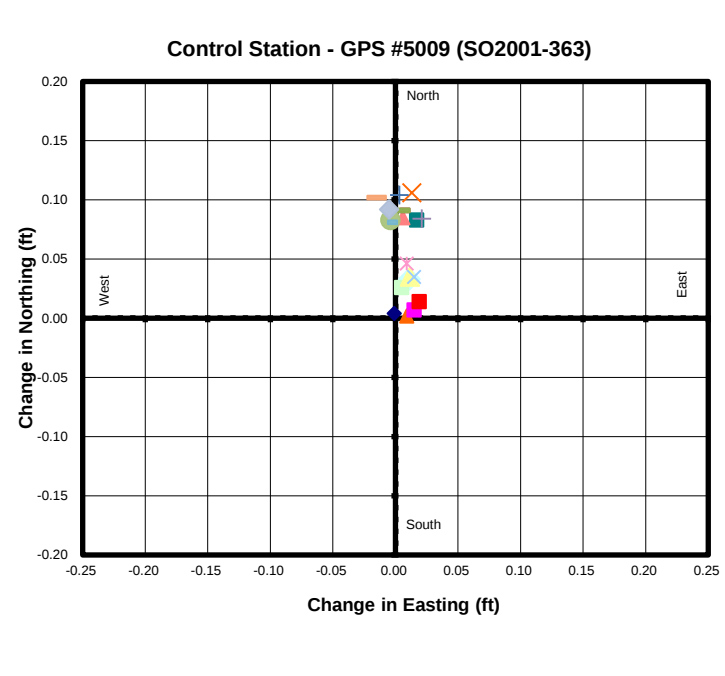
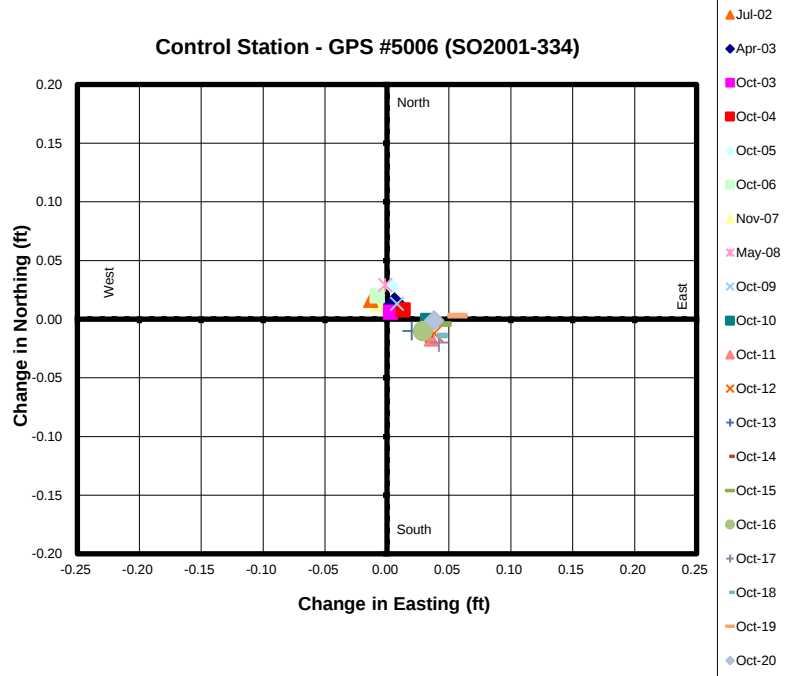
-  PILLAR MONUMENT
-  OTHER H & V MONUMENT
-  BENCHMARK
-  SETTLEMENT MONUMENT 77 mon
-  SETTLEMENT MONUMENT (SUBSET) 33 mon
-  INCLINOMETER 6 mon
-  CORS SITE
-  TUNNEL MONUMENT 22 mon
-  X-SECTION MONUMENT 7 mon

Attachment I
SEVEN OAKS DAM - PHASE I
GPS Control Stations Verification



Seven Oaks Dam - Control Station Verification (Horizontal)

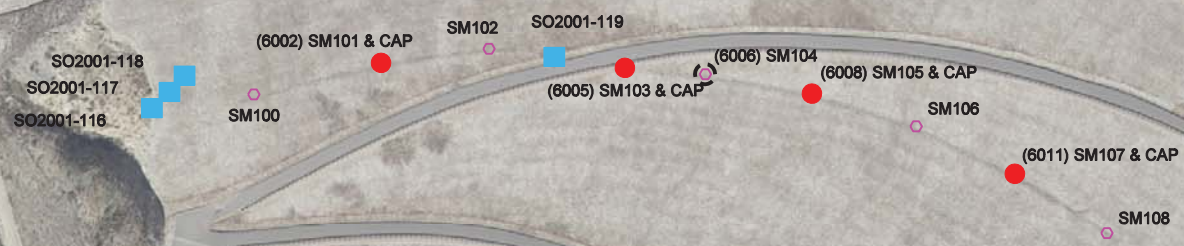
Horizontal Movement since January 2001 Survey



(0,0) = January 2001 Horizontal Position

Seven Oaks Dam Monitoring Survey

Downstream 2310' Level - Monitoring Points



LEGEND

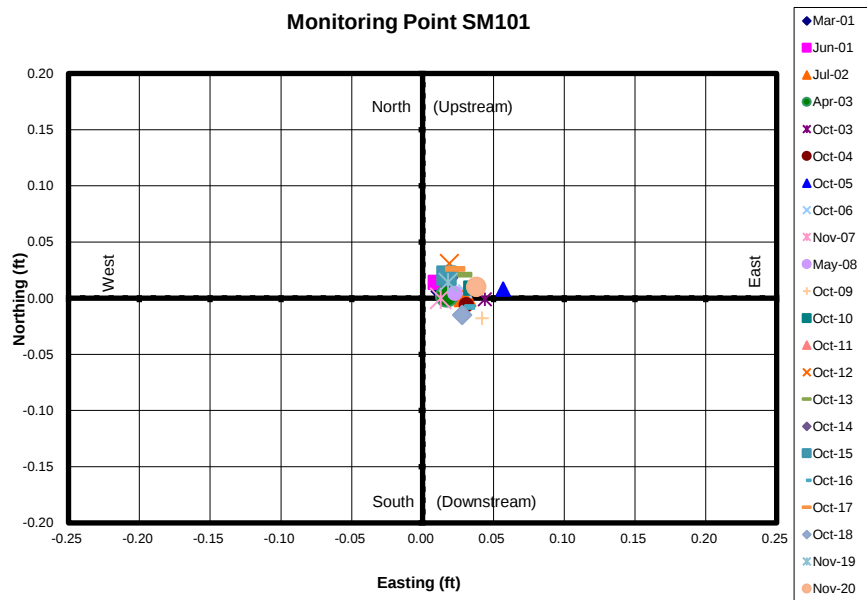
-  PILLAR MONUMENT
-  OTHER H & V MONUMENT
-  BENCHMARK
-  SETTLEMENT MONUMENT 77 mon
-  SETTLEMENT MONUMENT (SUBSET) 33 mon
-  INCLINOMETER 6 mon
-  CORS SITE
-  TUNNEL MONUMENT 22 mon
-  X-SECTION MONUMENT 7 mon



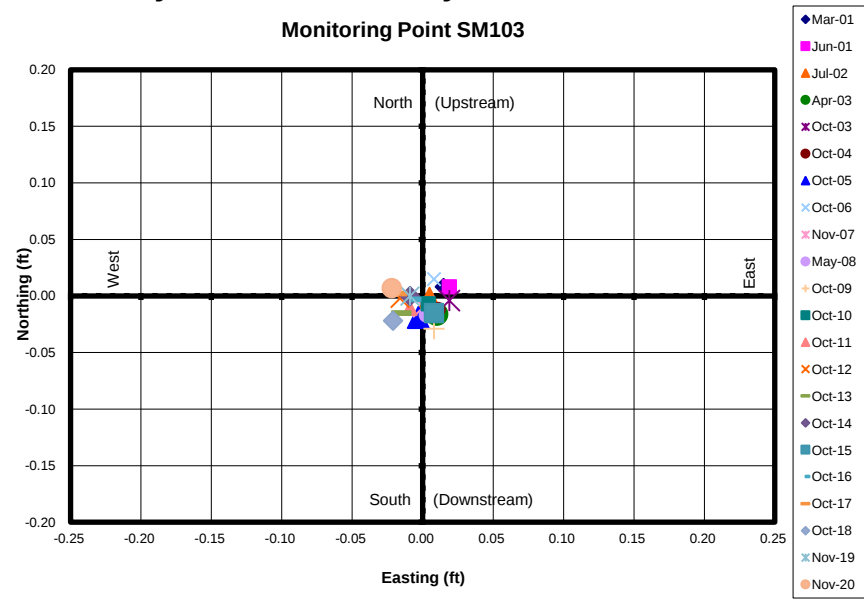
Seven Oaks Dam - Downstream 2310' Level (Horizontal)

Horizontal Movement since January 2001 Initial Survey

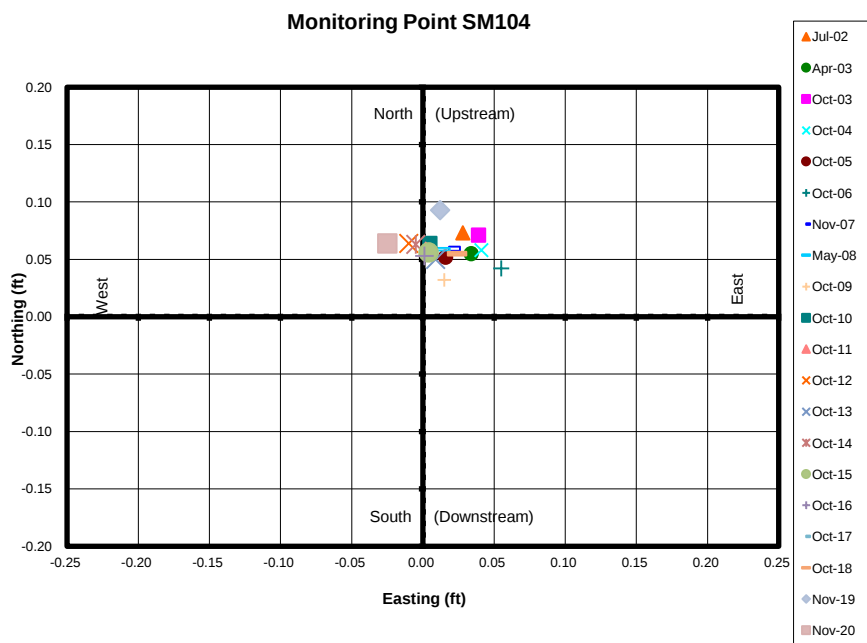
Monitoring Point SM101



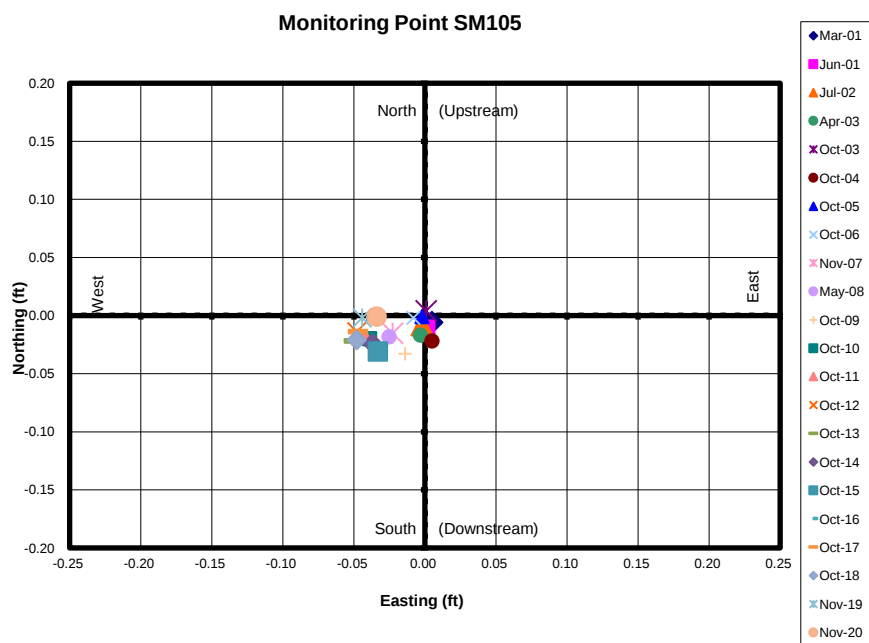
Monitoring Point SM103



Monitoring Point SM104

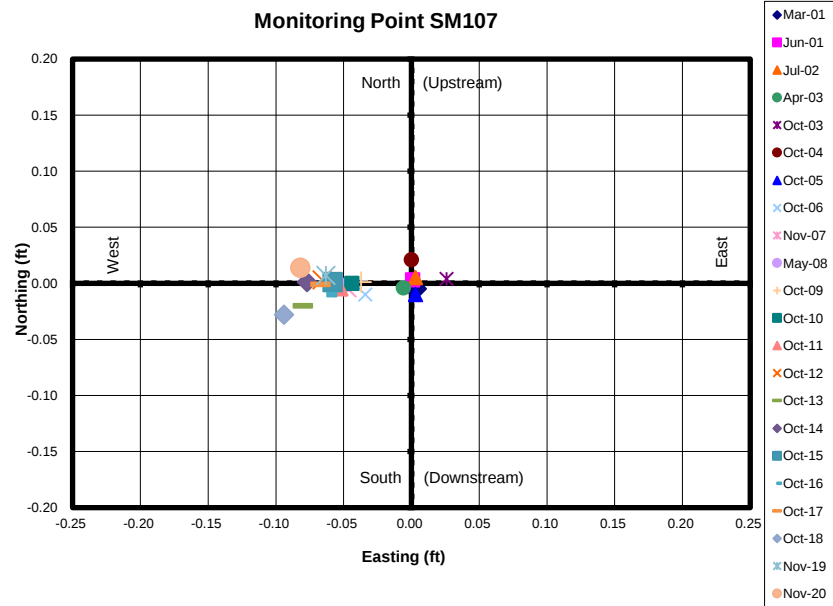


Monitoring Point SM105



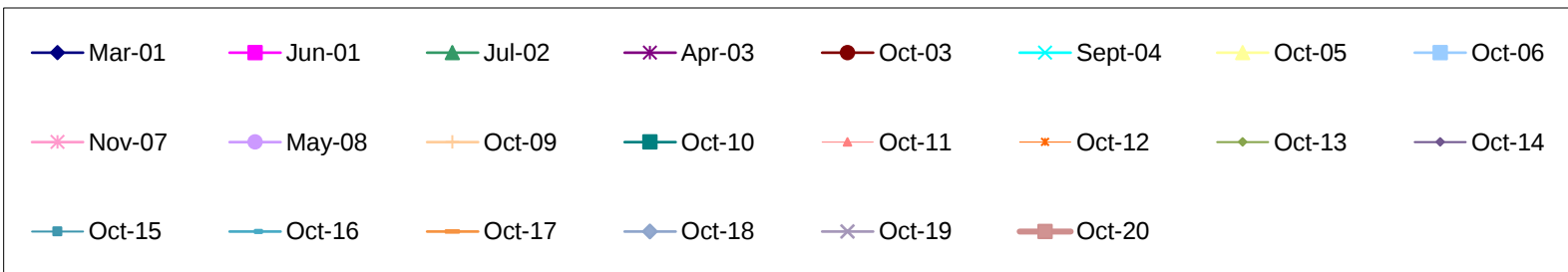
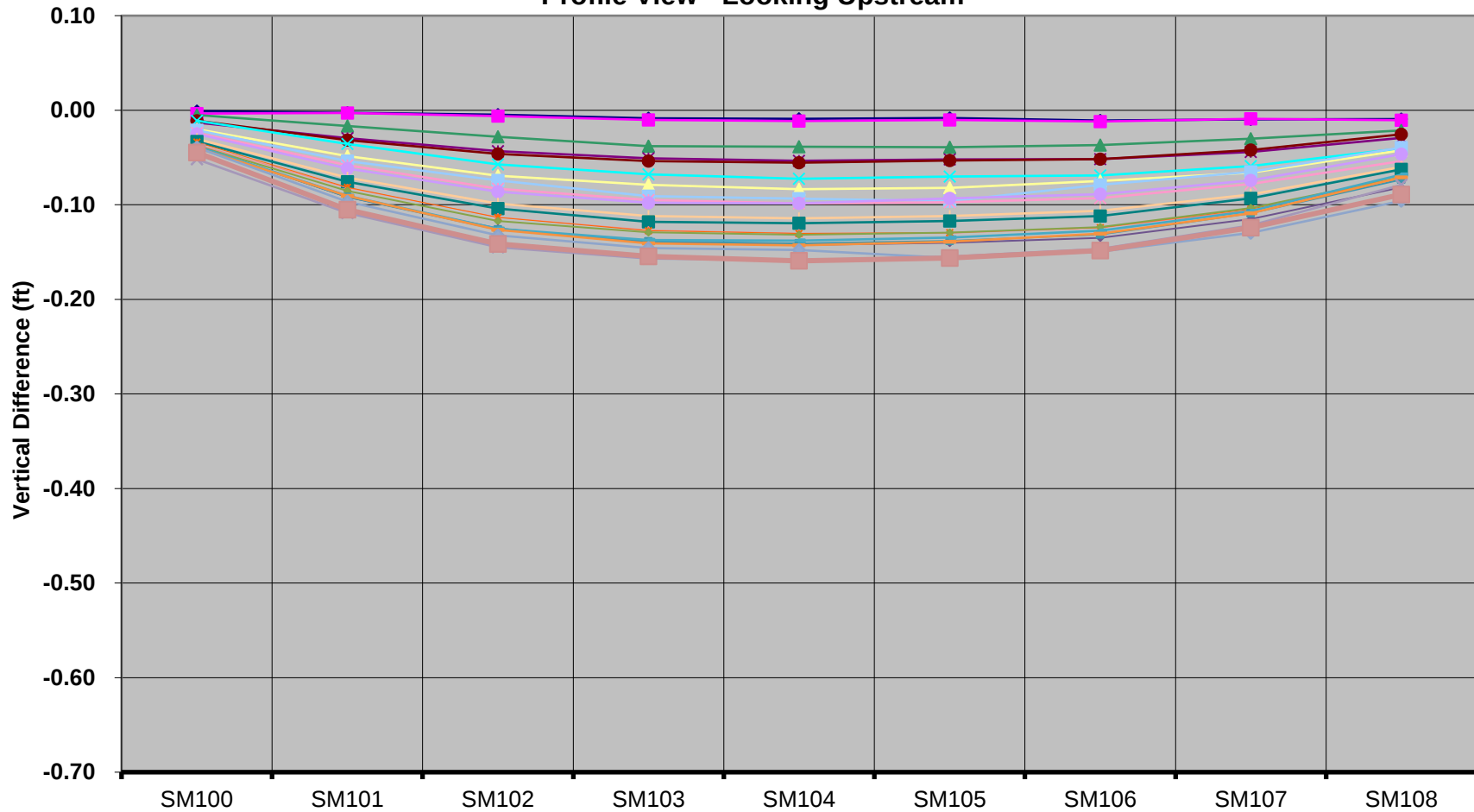
(0,0) = January 2001 Horizontal Position

Seven Oaks Dam - Downstream 2310' Level (Horizontal) Horizontal Movement since January 2001 Initial Survey



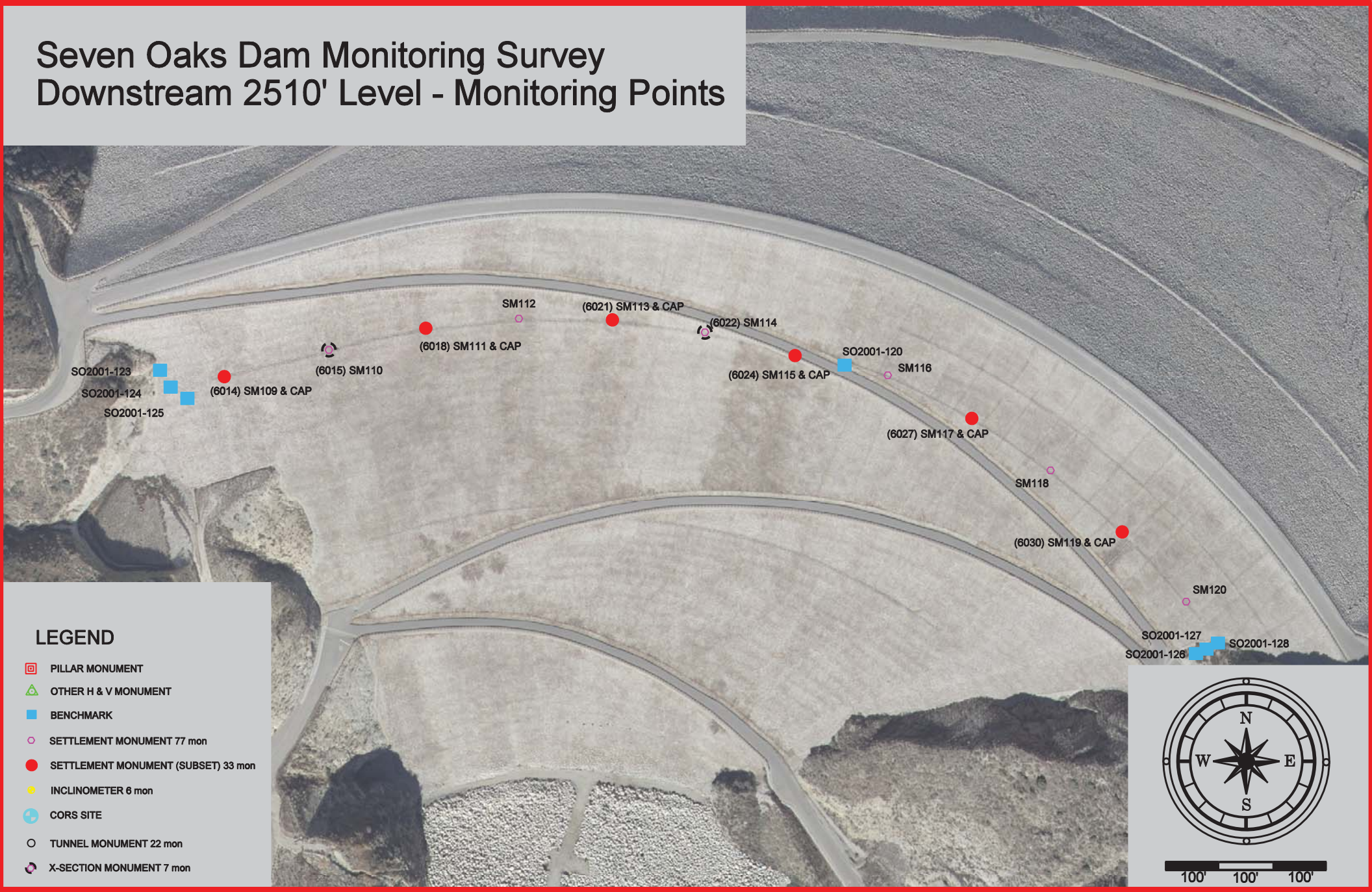
(0,0) = January 2001 Horizontal Position

Seven Oaks Dam - Downstream 2310' Level Vertical Movement since January 2001 Survey Profile View - Looking Upstream



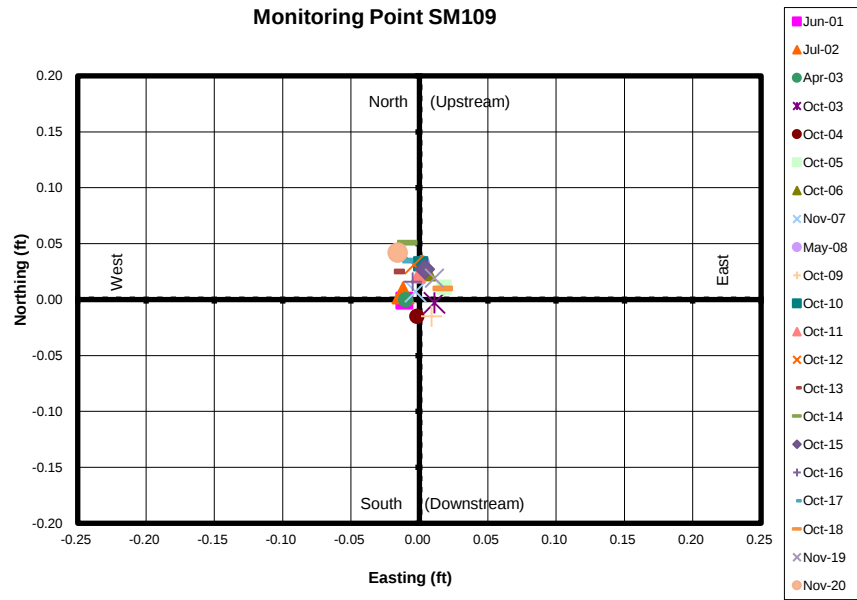
Seven Oaks Dam Monitoring Survey

Downstream 2510' Level - Monitoring Points

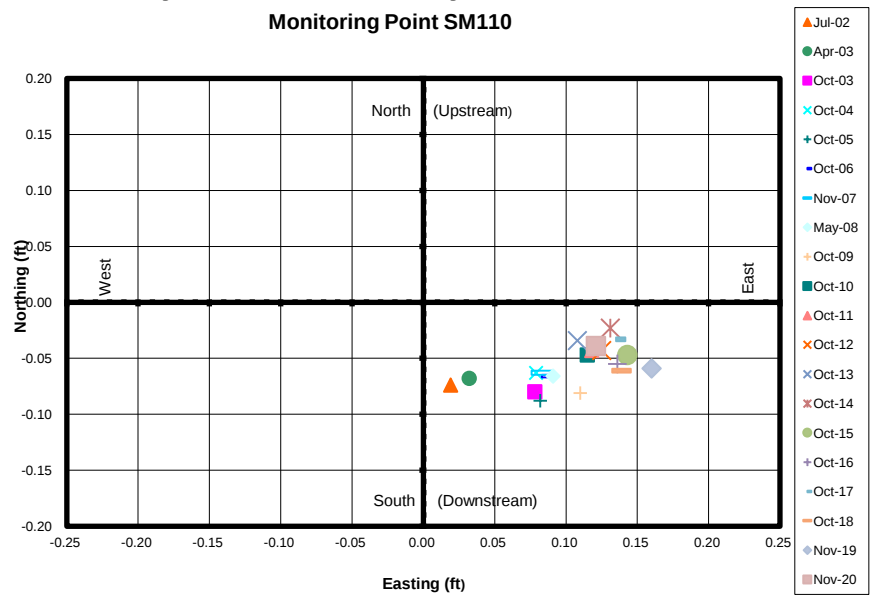


Seven Oaks Dam - Downstream 2510' Level (Horizontal) Horizontal Movement since January 2001 Initial Survey

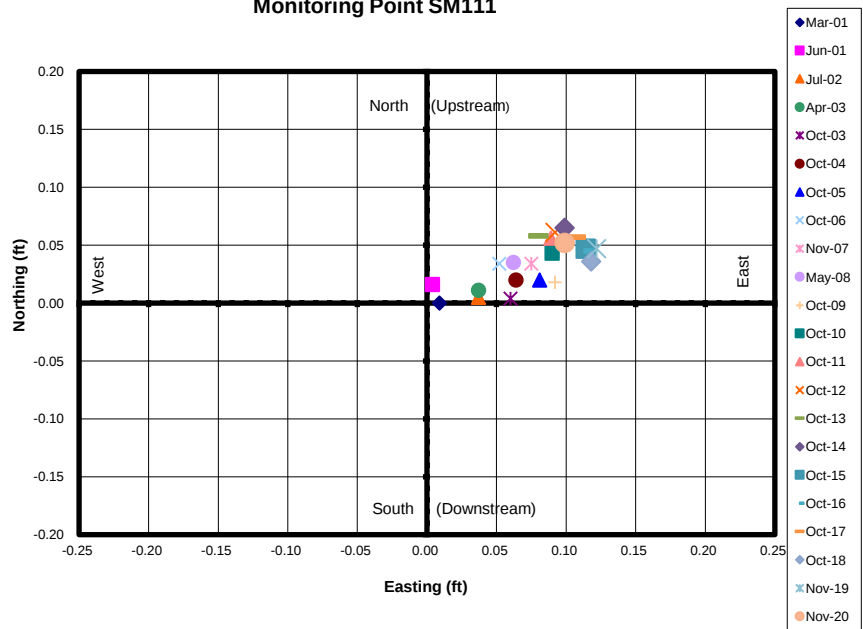
Monitoring Point SM109



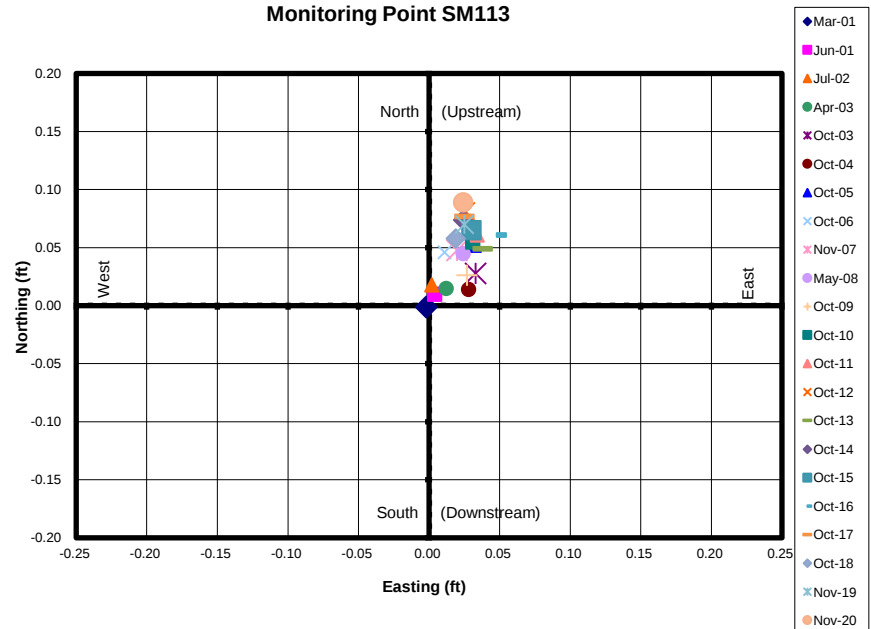
Monitoring Point SM110



Monitoring Point SM111

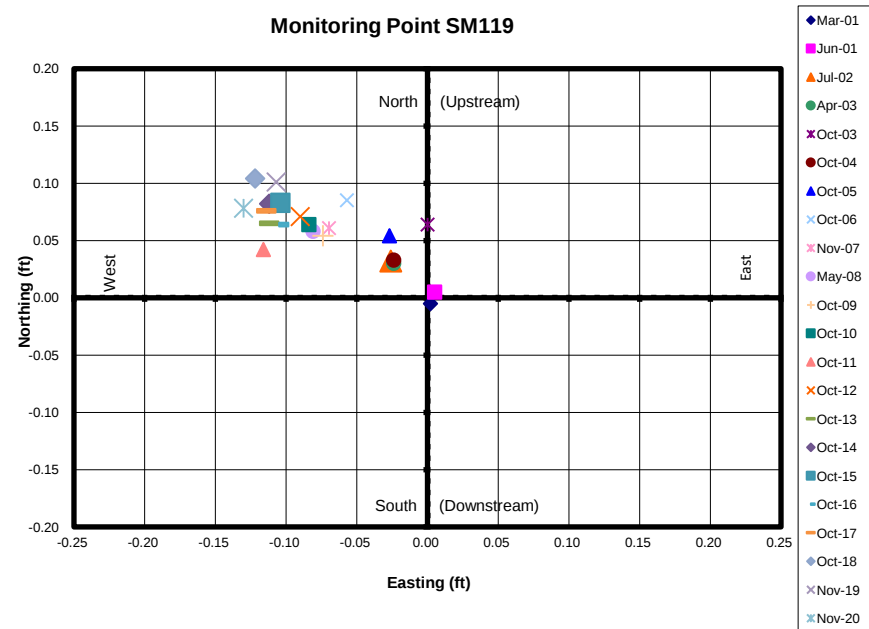
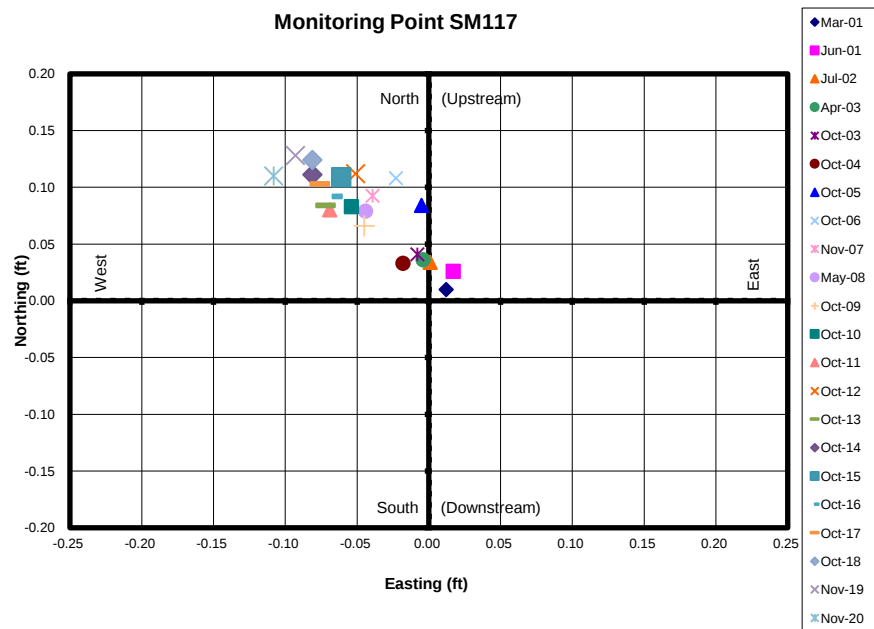
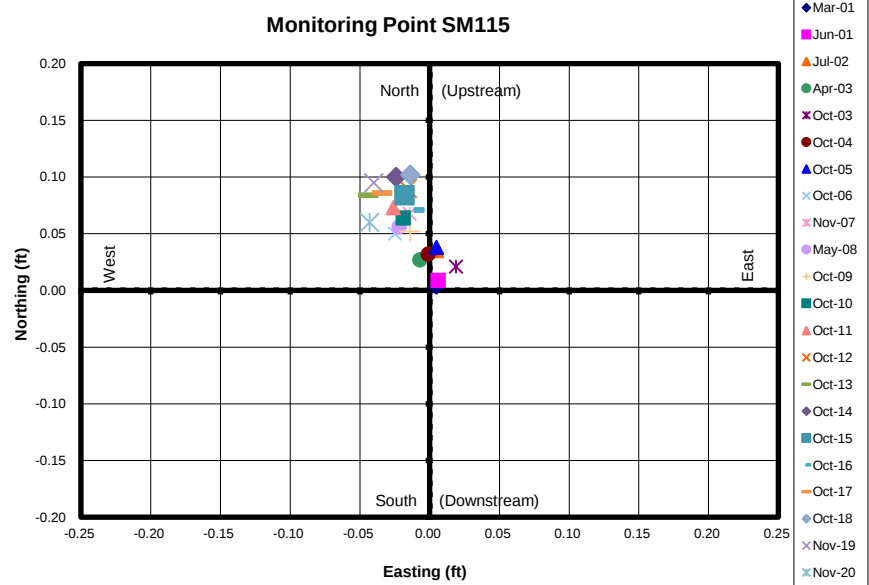
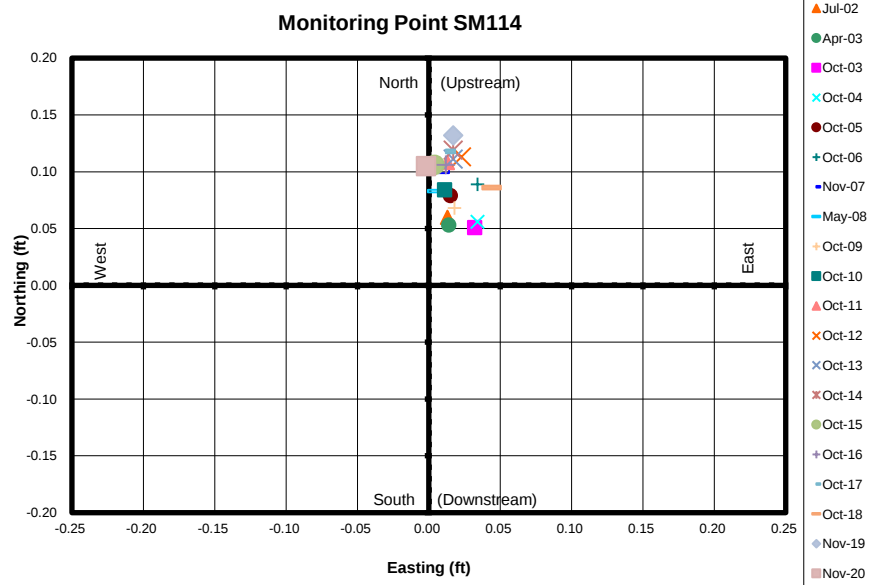


Monitoring Point SM113



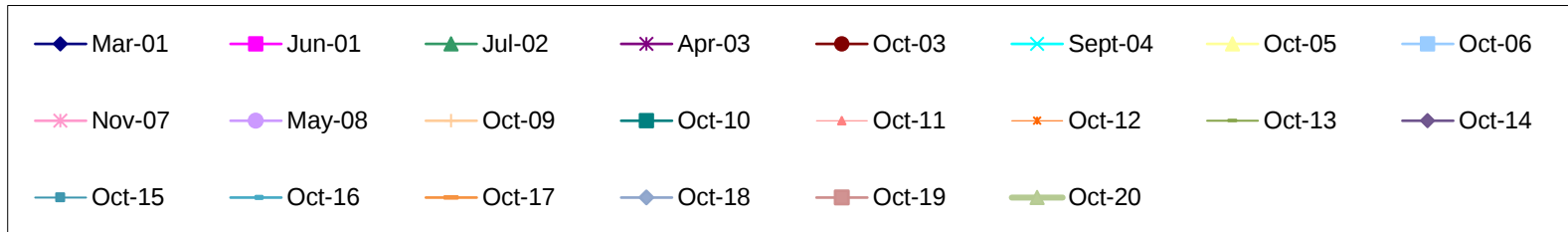
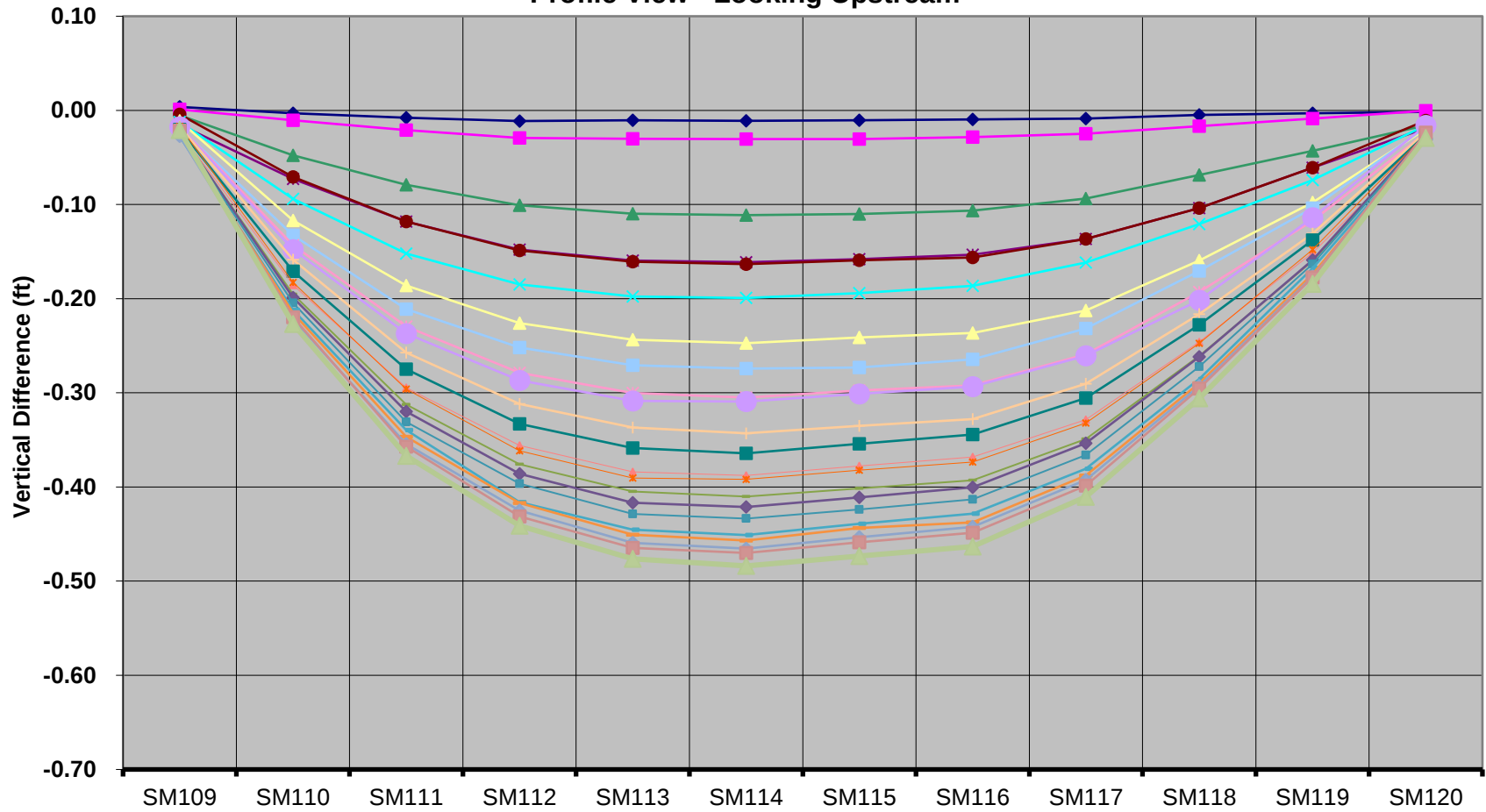
(0,0) = January 2001 Horizontal Position

Seven Oaks Dam - Downstream 2510' Level (Horizontal) Horizontal Movement since January 2001 Initial Survey



(0,0) = January 2001 Horizontal Position

Seven Oaks Dam - Downstream 2510' Level
Vertical Movement since January 2001 Survey
Profile View - Looking Upstream



Seven Oaks Dam Monitoring Survey

Downstream 2560' Level - Monitoring Points

LEGEND

PILLAR MONUMENT

OTHER H & V MONUMENT

BENCHMARK

SETTLEMENT MONUMENT 77 mon

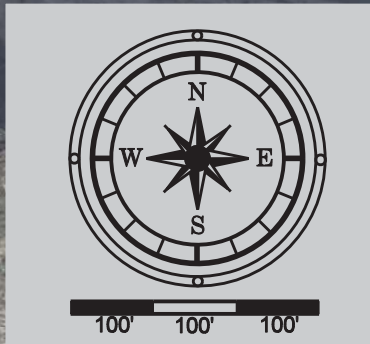
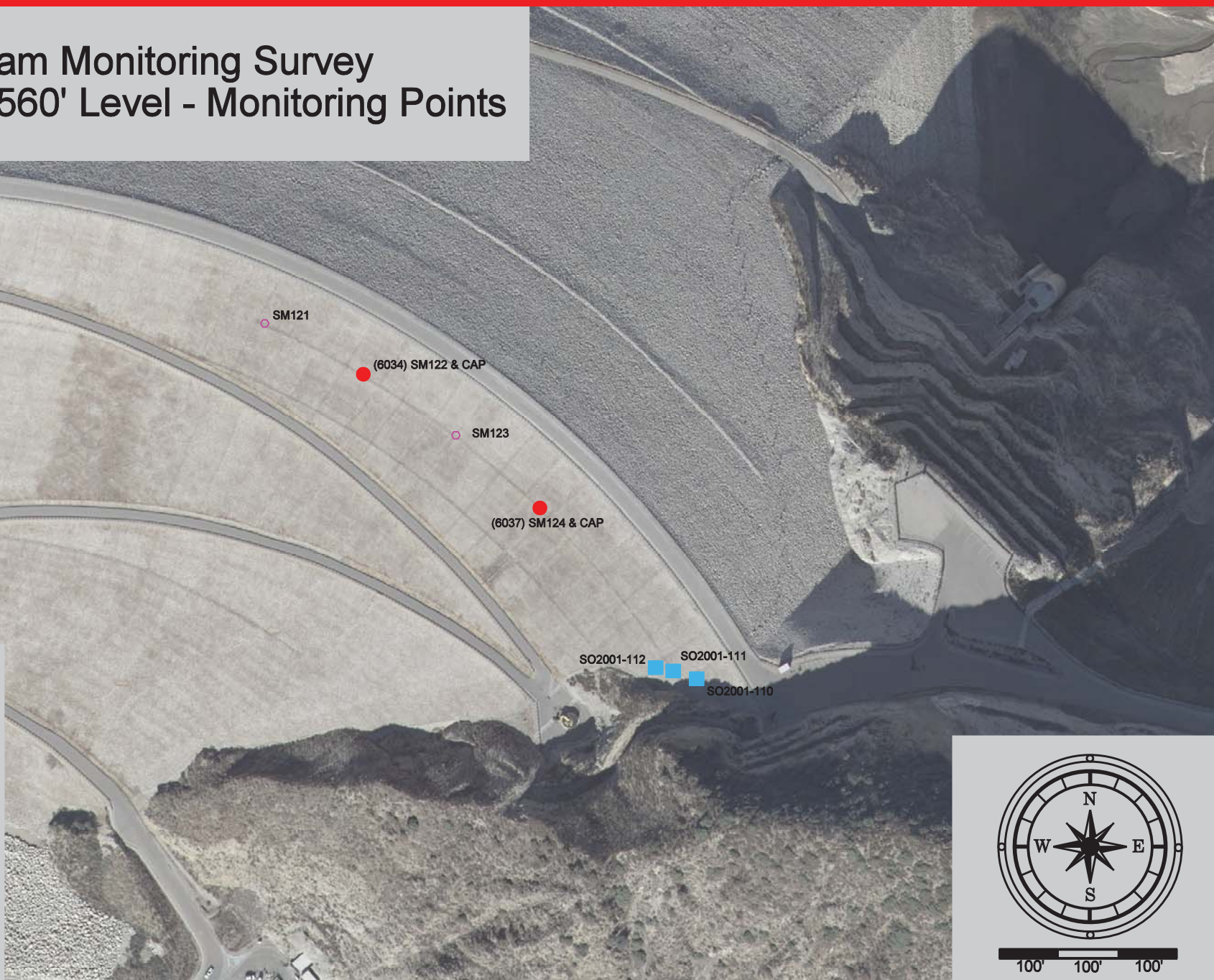
SETTLEMENT MONUMENT (SUBSET) 33 mon

INCLINOMETER 6 mon

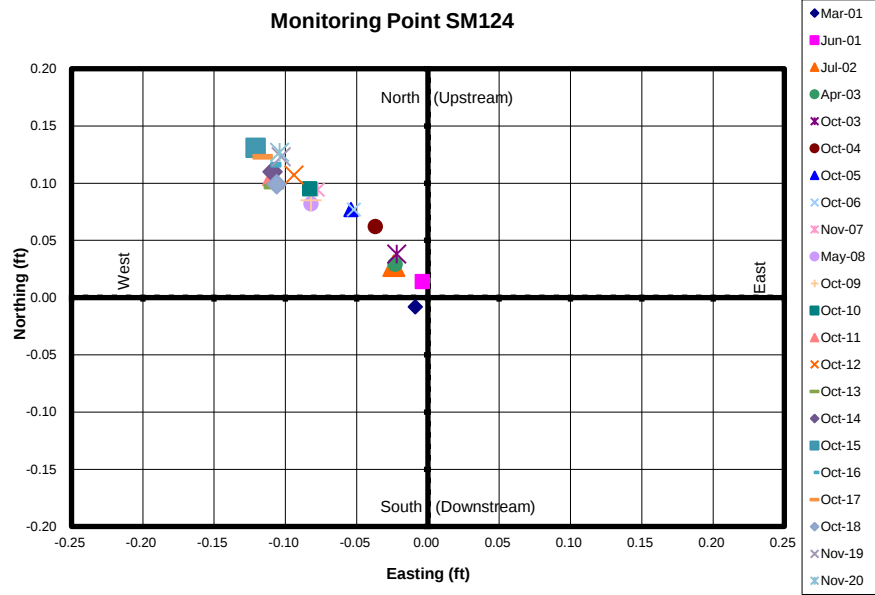
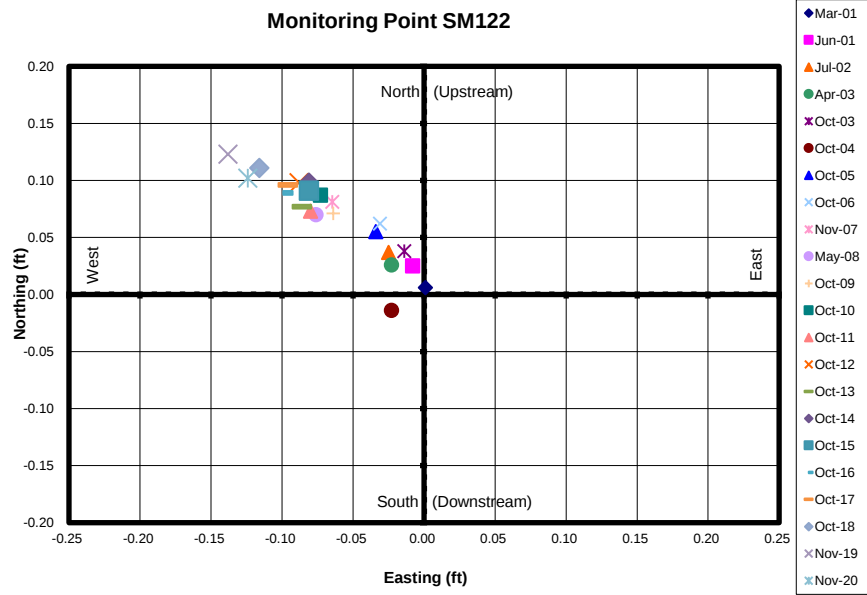
CORS SITE

TUNNEL MONUMENT 22 mon

X-SECTION MONUMENT 7 mon

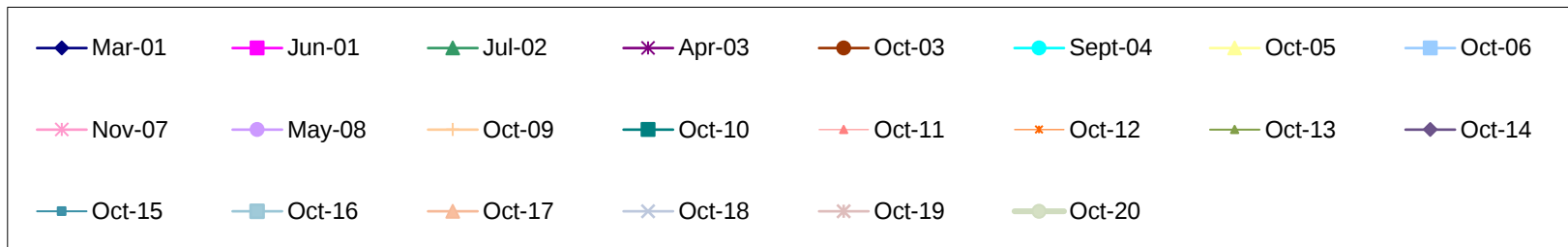
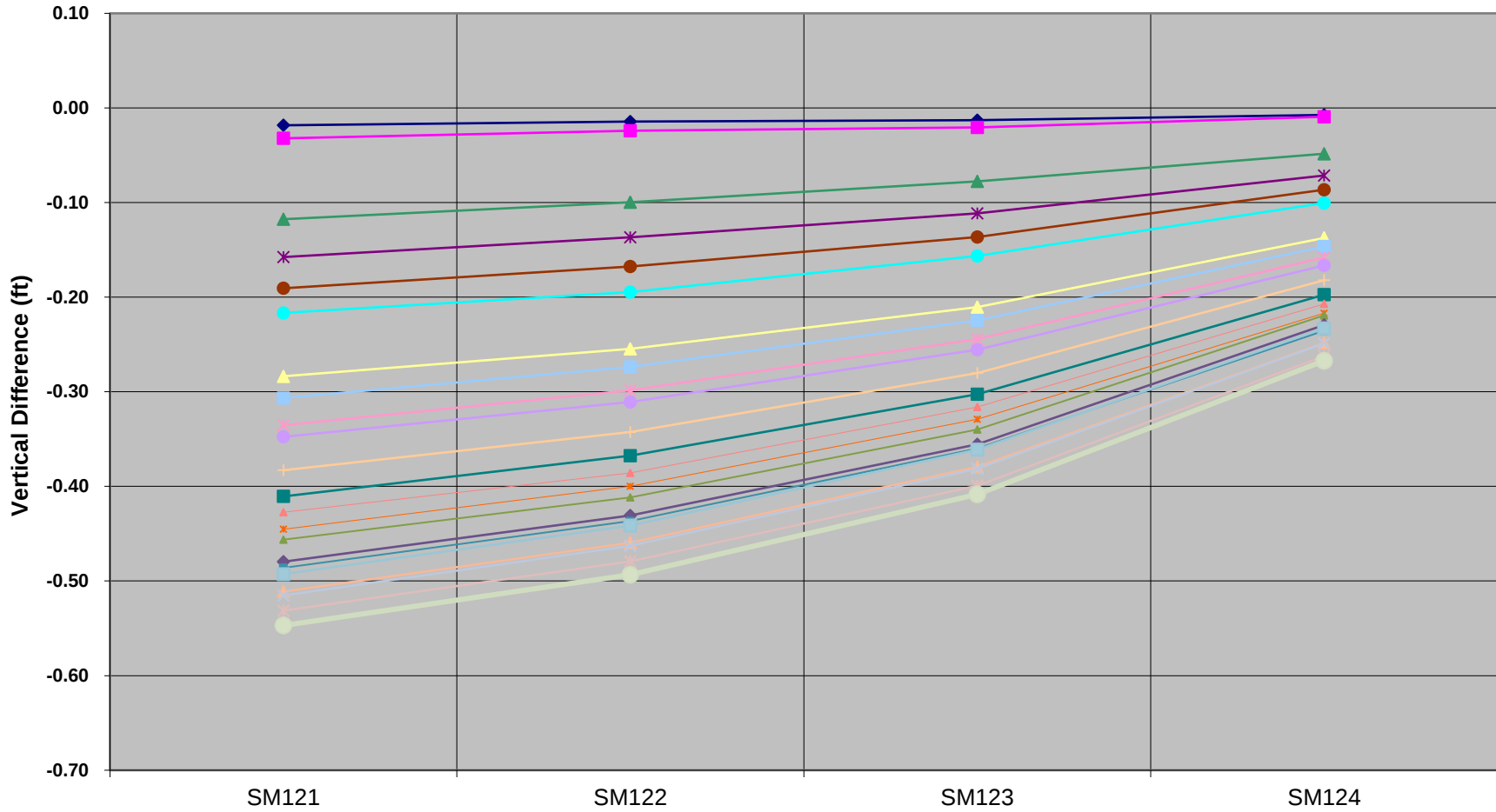


Seven Oaks Dam - Downstream 2560' Level (Horizontal) **Horizontal Movement since January 2001 Survey**



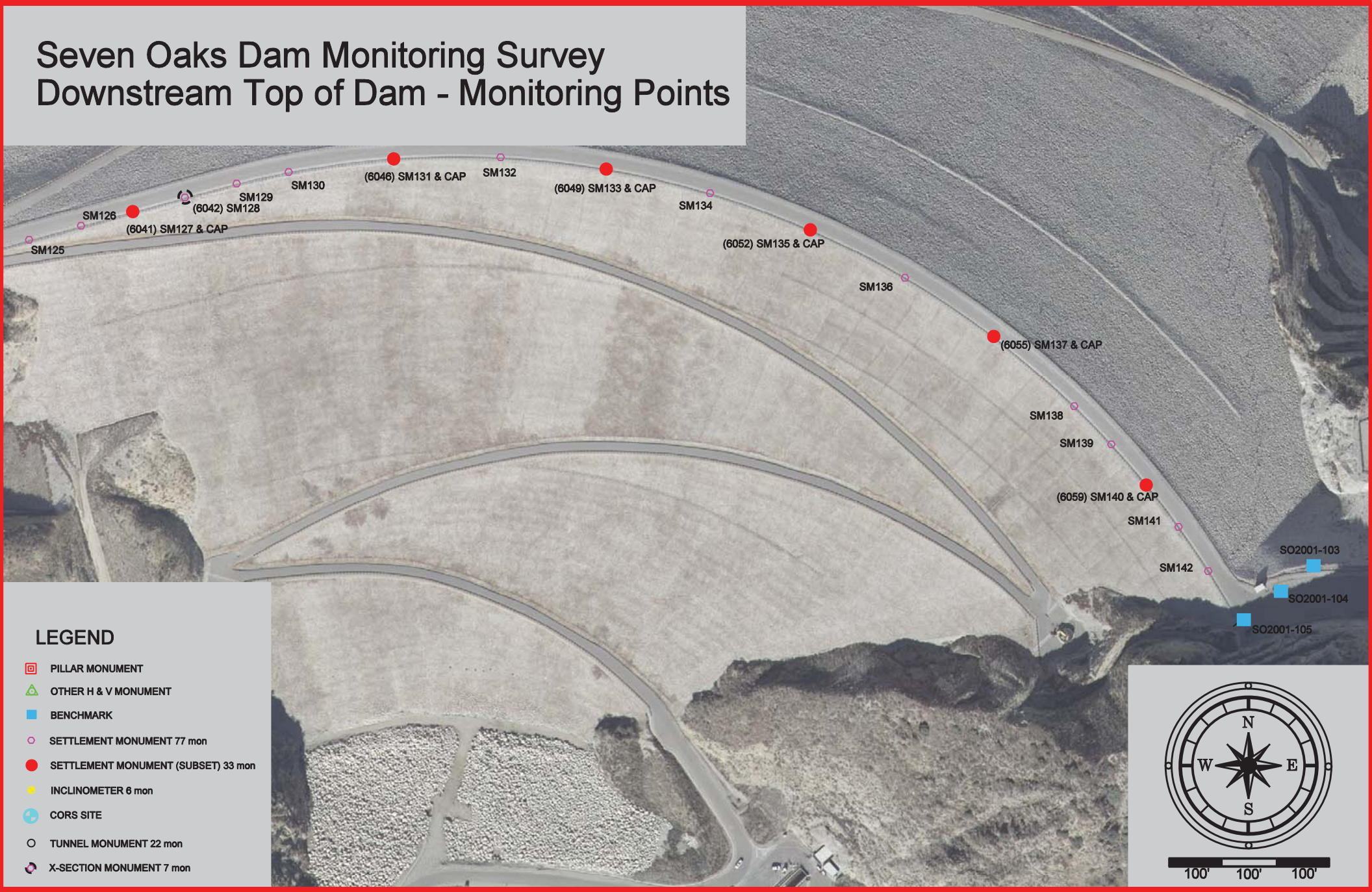
(0,0) = January 2001 Horizontal Position

Seven Oaks Dam - Downstream 2560' Level
Vertical Movement since January 2001 Survey
Profile View - Looking Upstream



Seven Oaks Dam Monitoring Survey

Downstream Top of Dam - Monitoring Points



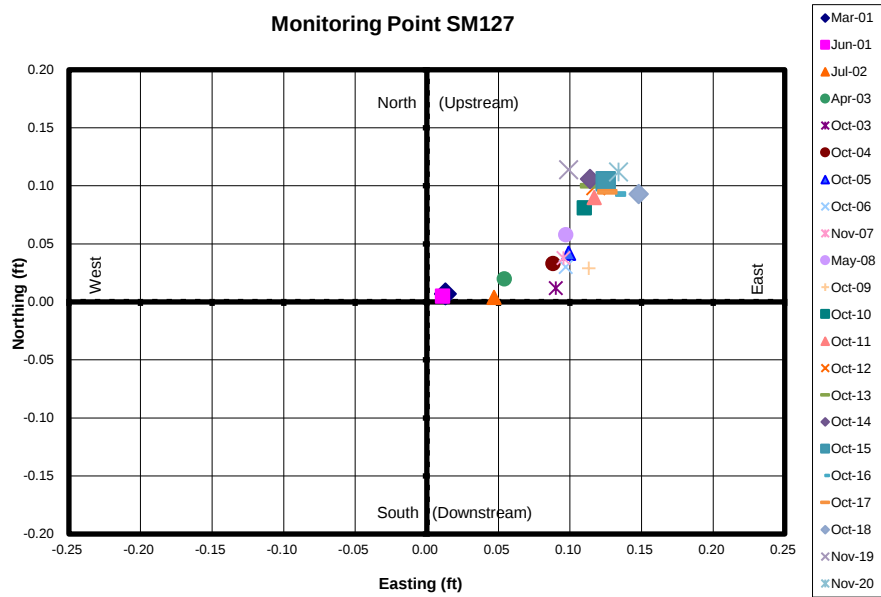
- LEGEND**
- PILLAR MONUMENT
 - OTHER H & V MONUMENT
 - BENCHMARK
 - SETTLEMENT MONUMENT 77 mon
 - SETTLEMENT MONUMENT (SUBSET) 33 mon
 - INCLINOMETER 6 mon
 - CORS SITE
 - TUNNEL MONUMENT 22 mon
 - X-SECTION MONUMENT 7 mon



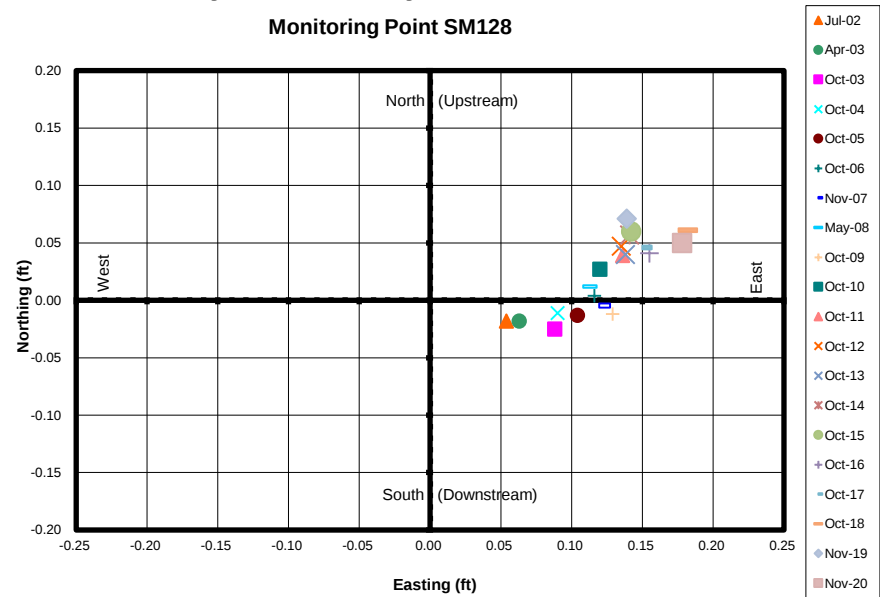
Seven Oaks Dam - Downstream Top of Dam (Horizontal)

Horizontal Movement since January 2001 Survey

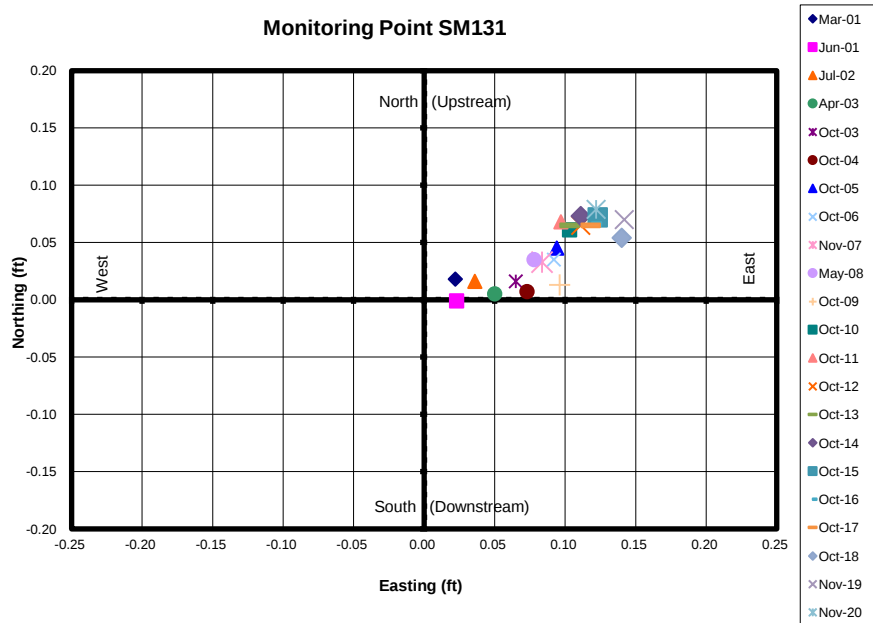
Monitoring Point SM127



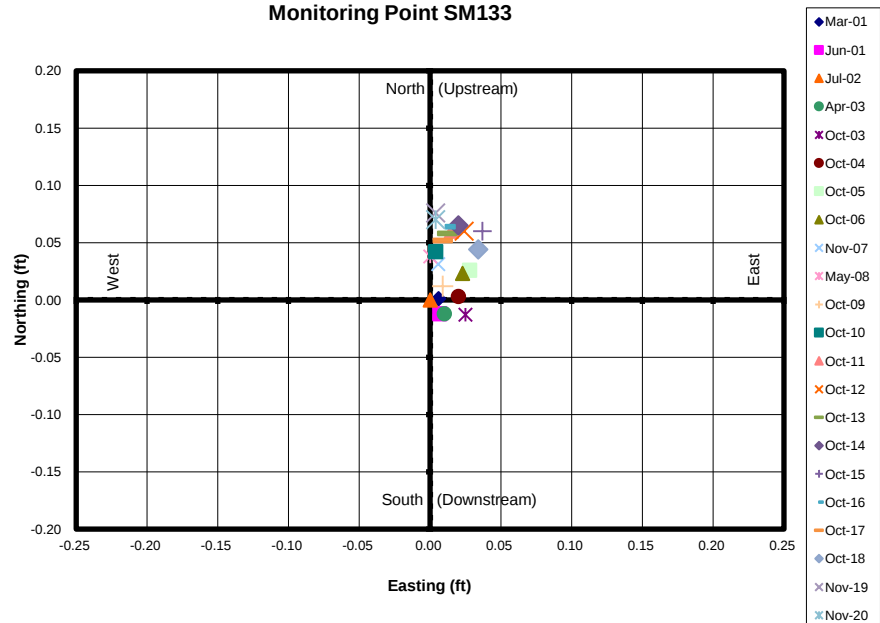
Monitoring Point SM128



Monitoring Point SM131



Monitoring Point SM133

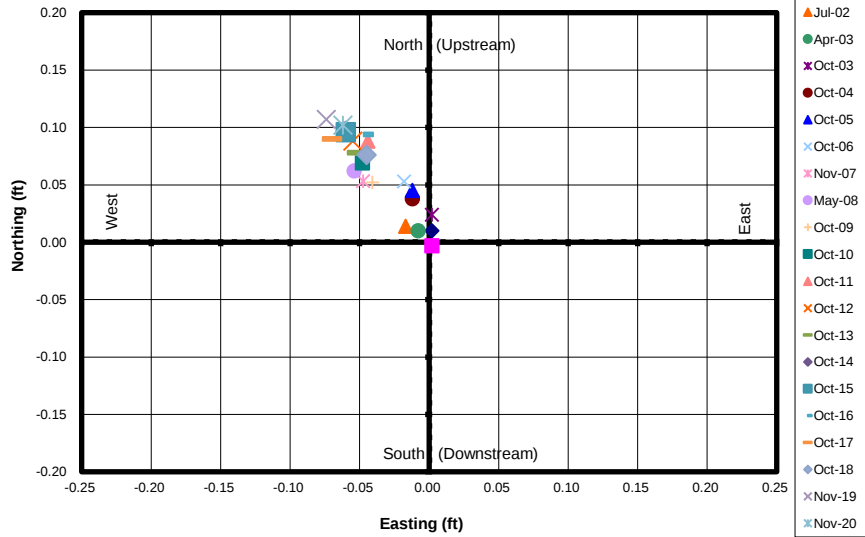


(0,0) = January 2001 Horizontal Position

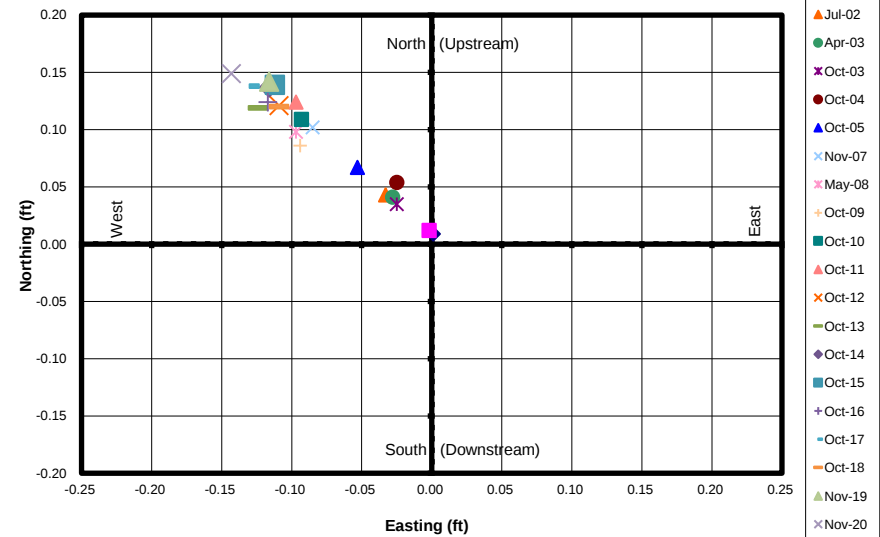
Seven Oaks Dam - Downstream Top of Dam (Horizontal)

Horizontal Movement since January 2001 Survey

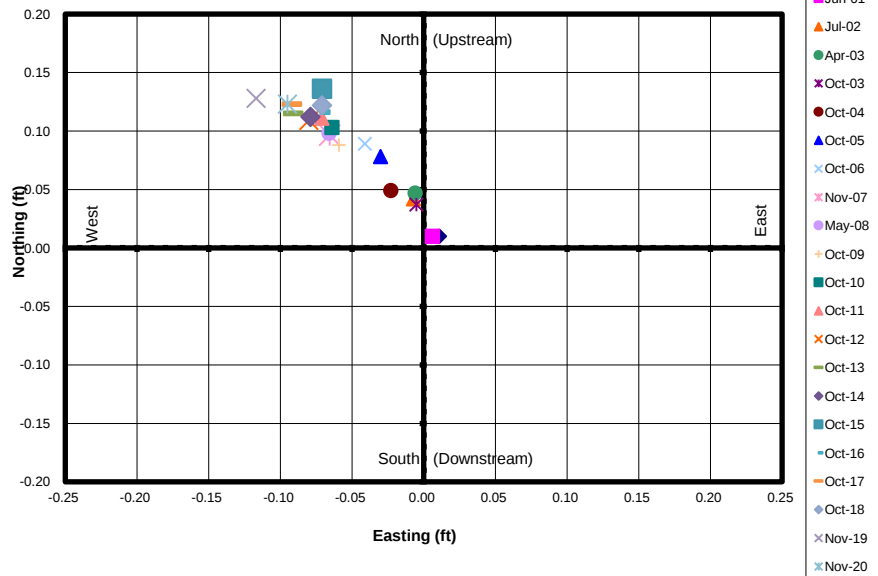
Monitoring Point SM135



Monitoring Point SM137

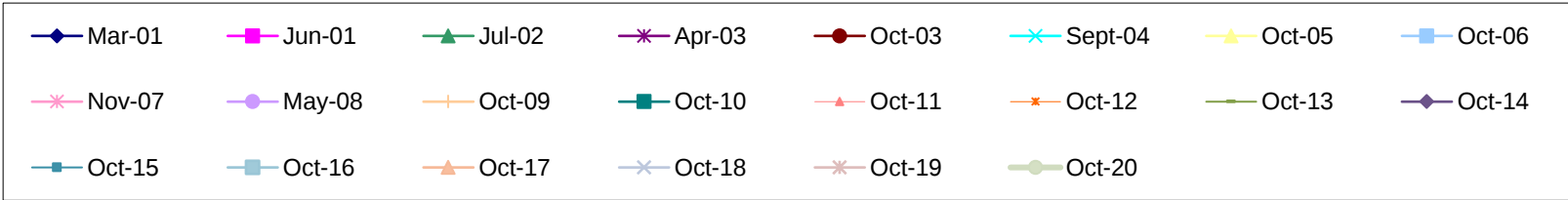


Monitoring Point SM140



(0,0) = January 2001 Horizontal Position

Profile View - Looking Upstream



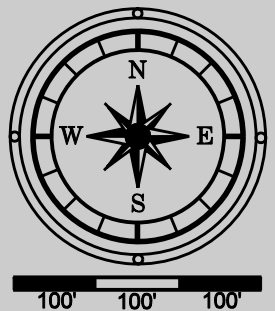
Seven Oaks Dam Monitoring Survey

Upstream Top of Dam - Monitoring Points

SO2001-101
SO2001-100
SO2001-102

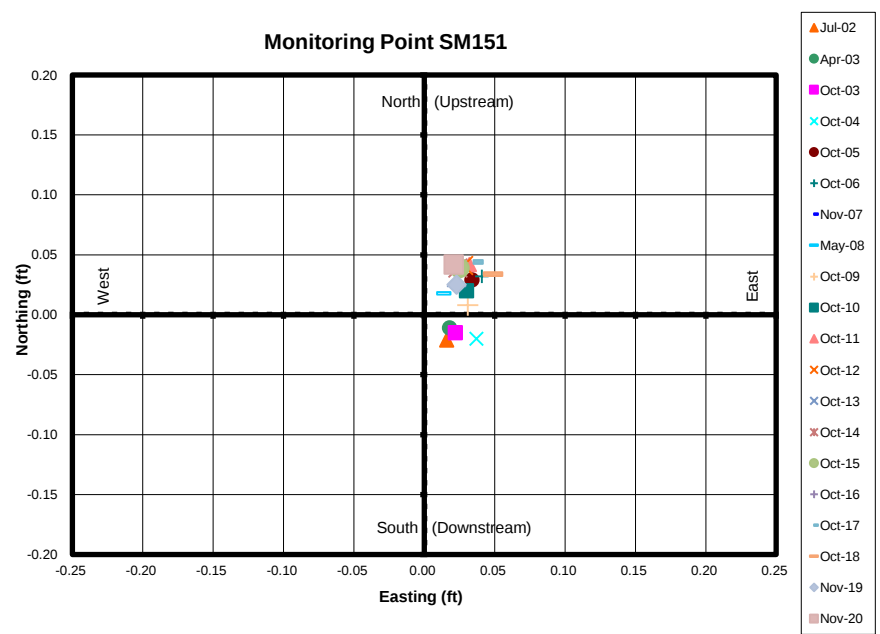
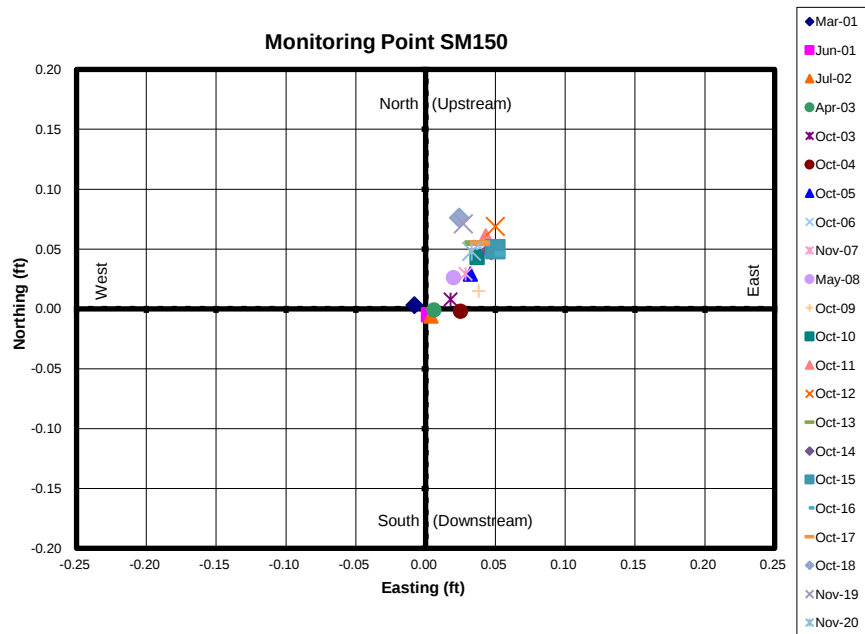
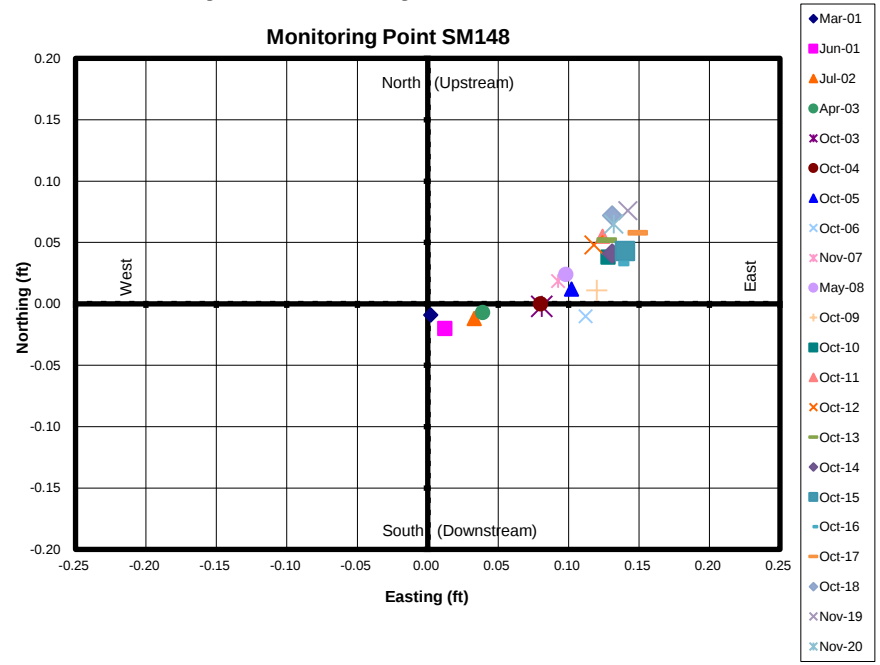
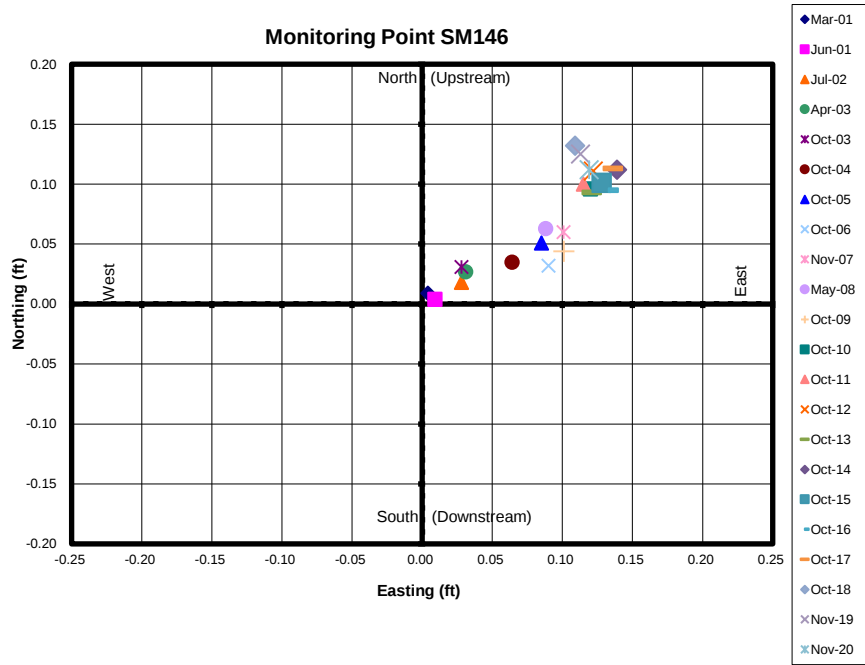


- LEGEND**
- PILLAR MONUMENT
 - OTHER H & V MONUMENT
 - BENCHMARK
 - SETTLEMENT MONUMENT 77 mon
 - SETTLEMENT MONUMENT (SUBSET) 33 mon
 - INCLINOMETER 6 mon
 - CORS SITE
 - TUNNEL MONUMENT 22 mon
 - X-SECTION MONUMENT 7 mon



Seven Oaks Dam - Upstream Top of Dam (Horizontal)

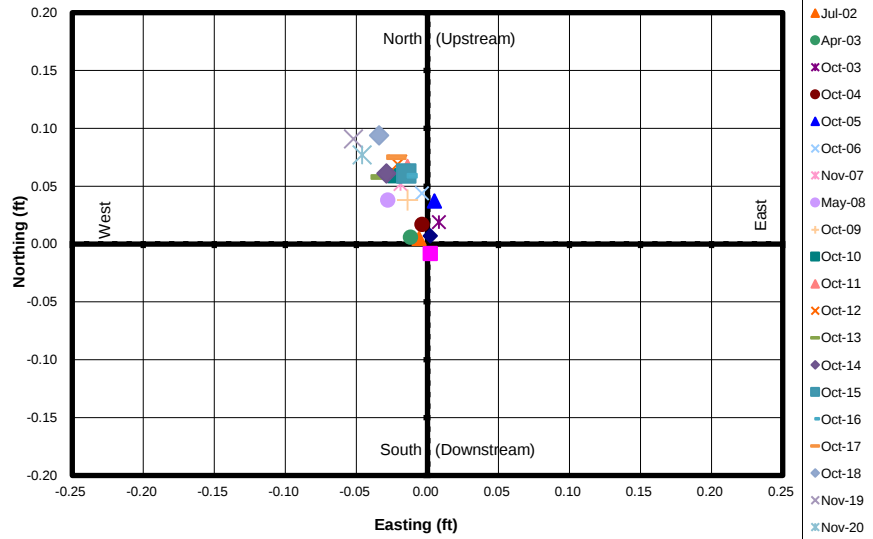
Horizontal Movement since January 2001 Survey



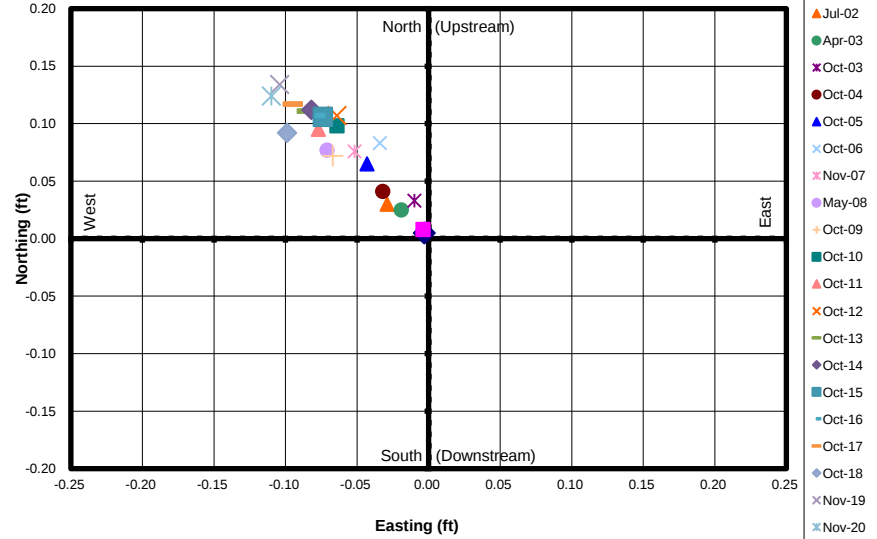
(0,0) = January 2001 Horizontal Position

Seven Oaks Dam - Upstream Top of Dam (Horizontal) Horizontal Movement since January 2001 Survey

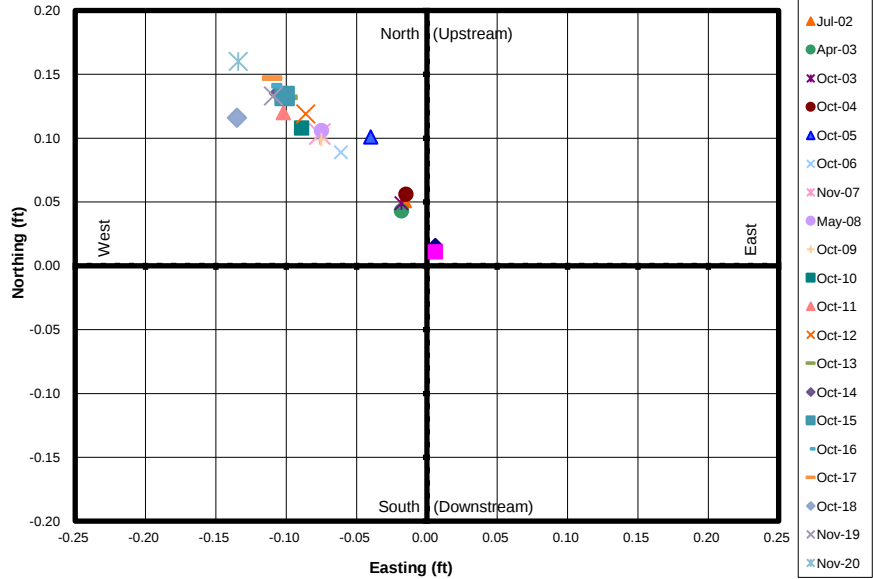
Monitoring Point SM152



Monitoring Point SM154

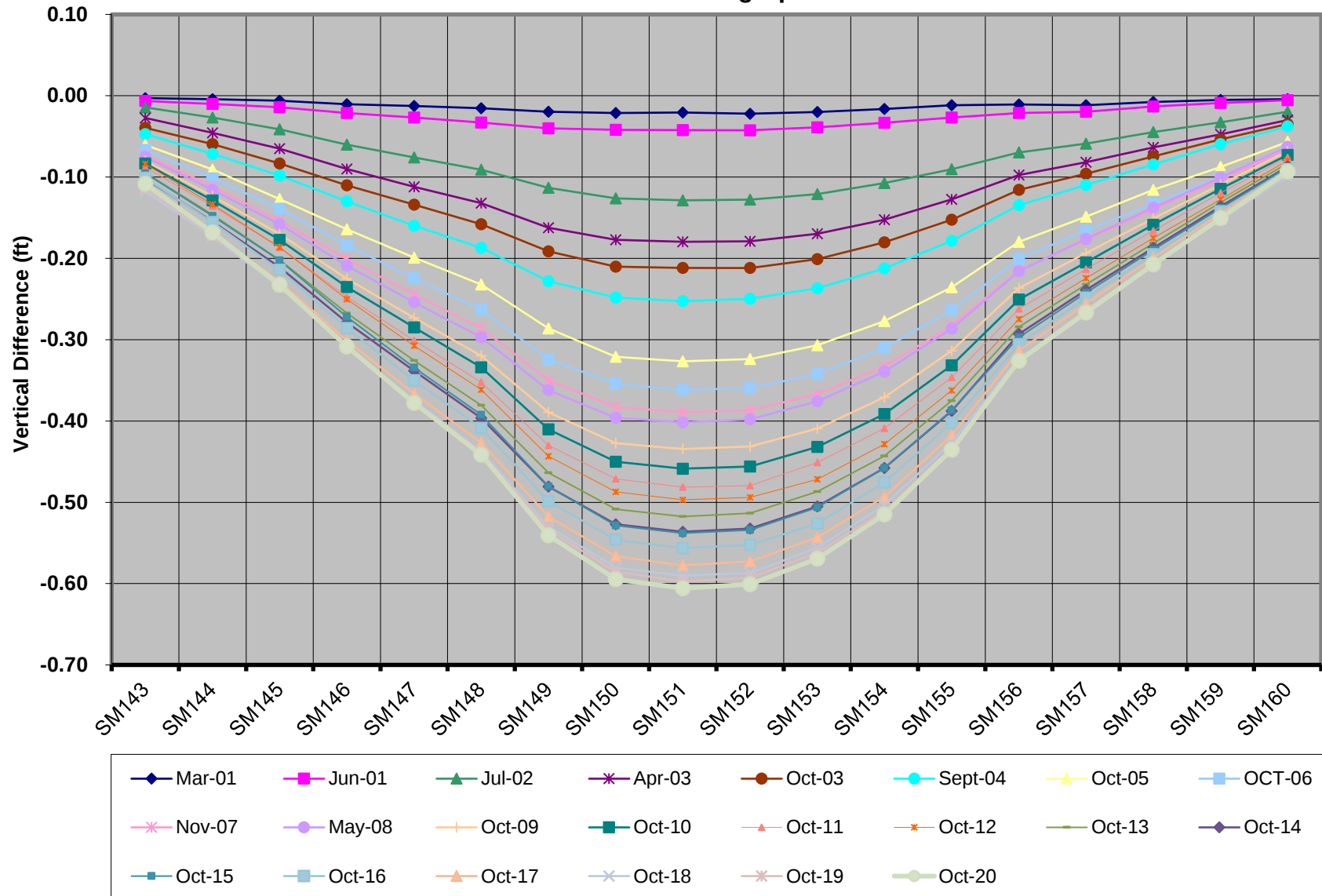


Monitoring Point SM156



(0,0) = January 2001 Horizontal Position

Seven Oaks Dam - Upstream Top of Dam
Vertical Movement since January 2001 Survey
Profile View - Looking Upstream



Seven Oaks Dam Monitoring Survey

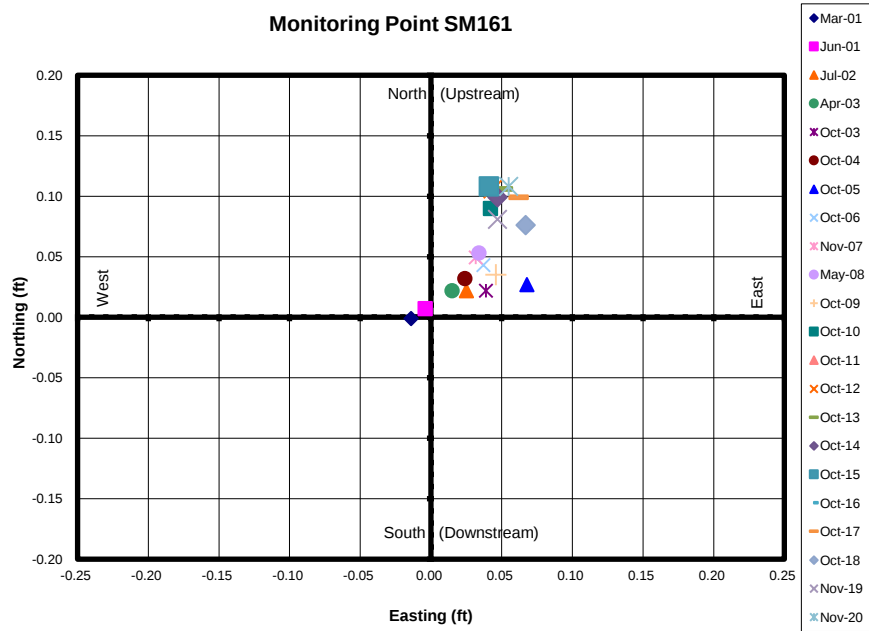
Upstream 2530' Level - Monitoring Points



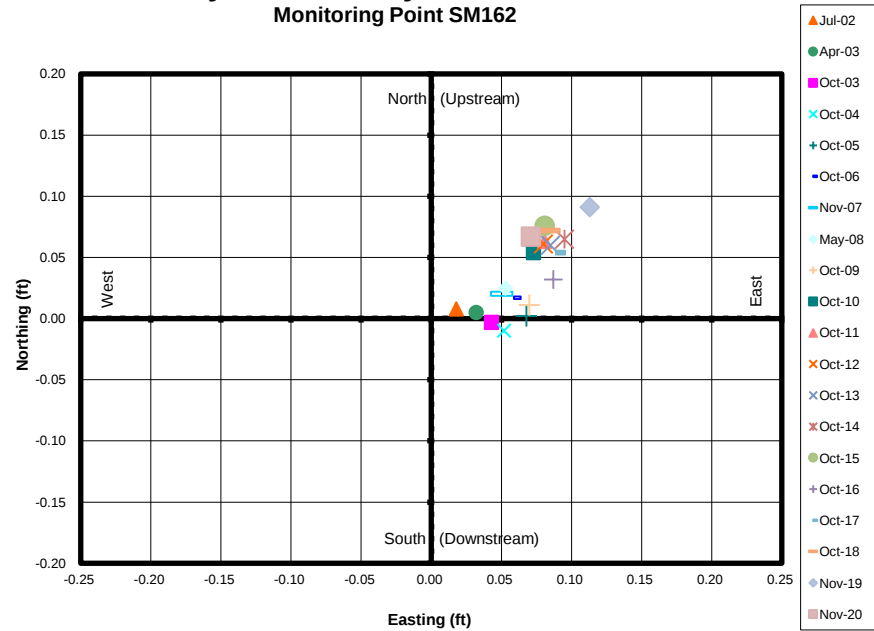
Seven Oaks Dam - Upstream 2530' level (Horizontal)

Horizontal Movement since January 2001 Survey

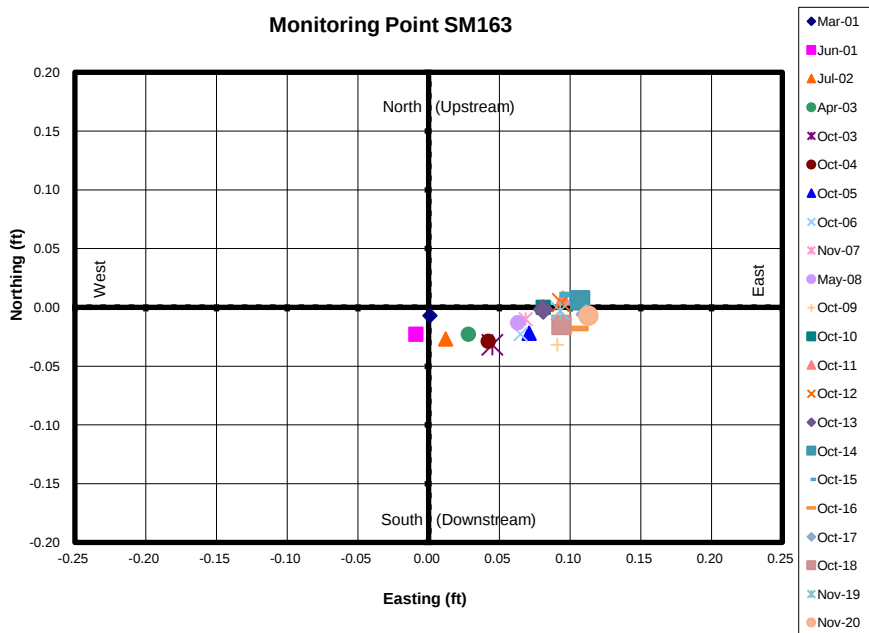
Monitoring Point SM161



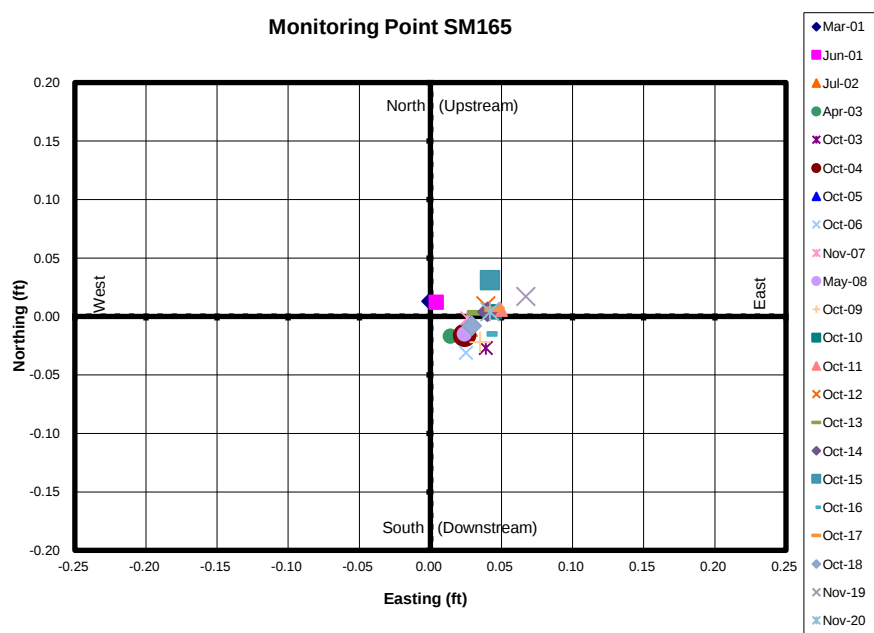
Monitoring Point SM162



Monitoring Point SM163



Monitoring Point SM165

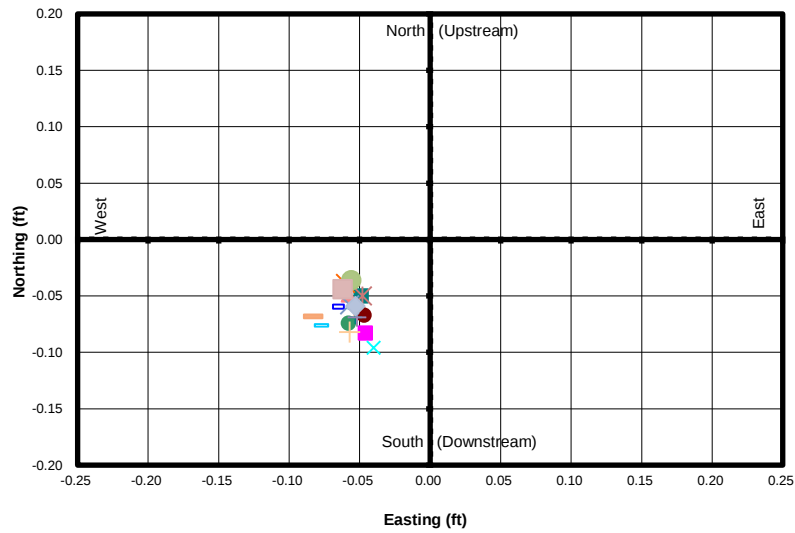


(0,0) = January 2001 Horizontal Position

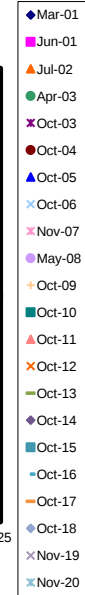
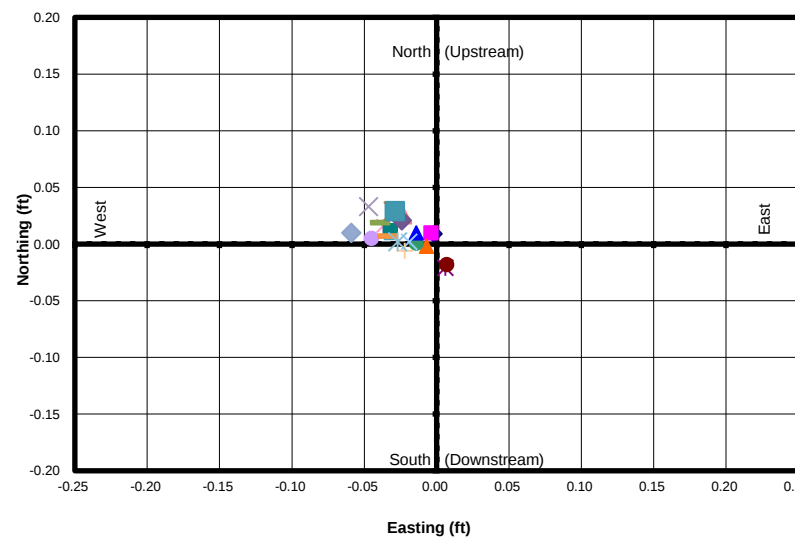
Seven Oaks Dam - Upstream 2530' level (Horizontal)

Horizontal Movement since January 2001 Survey

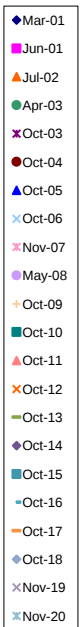
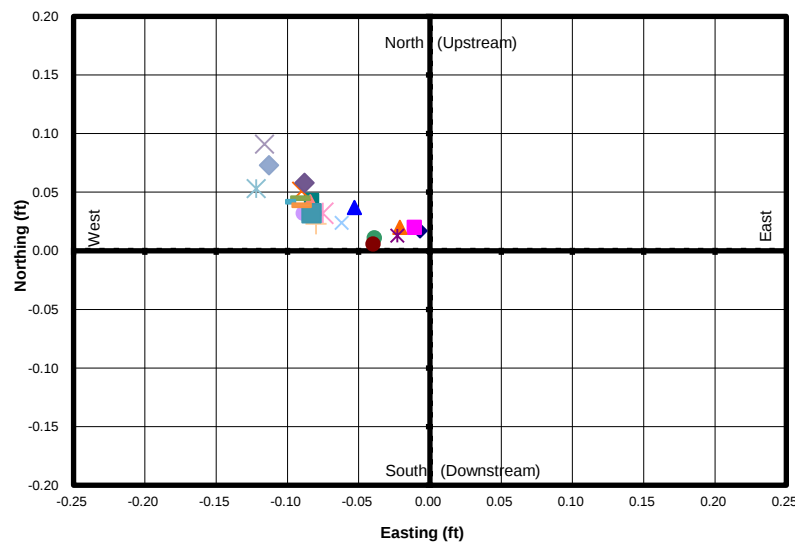
Monitoring Point SM166



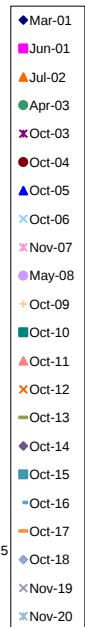
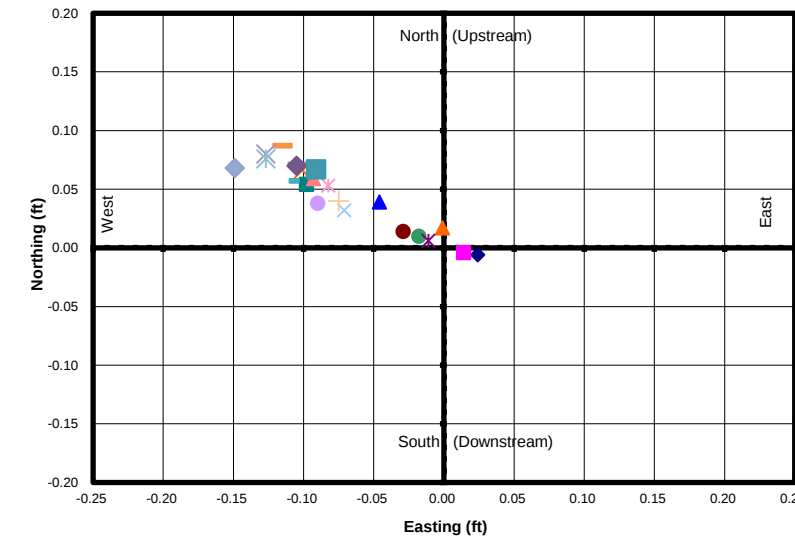
Monitoring Point SM167



Monitoring Point SM169

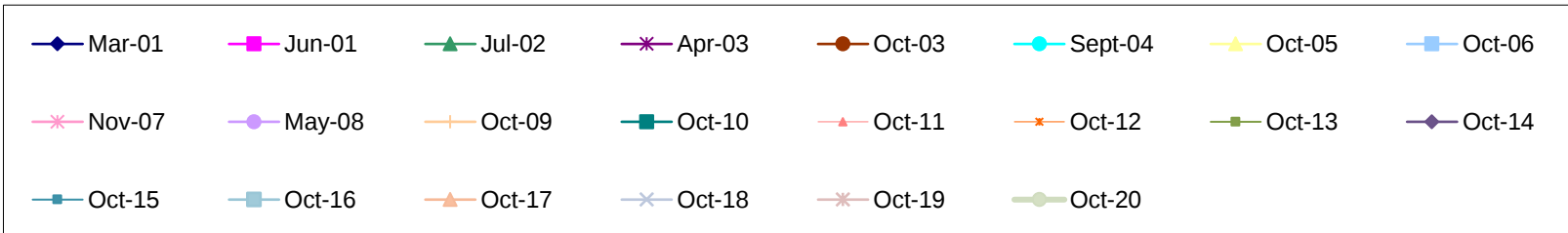
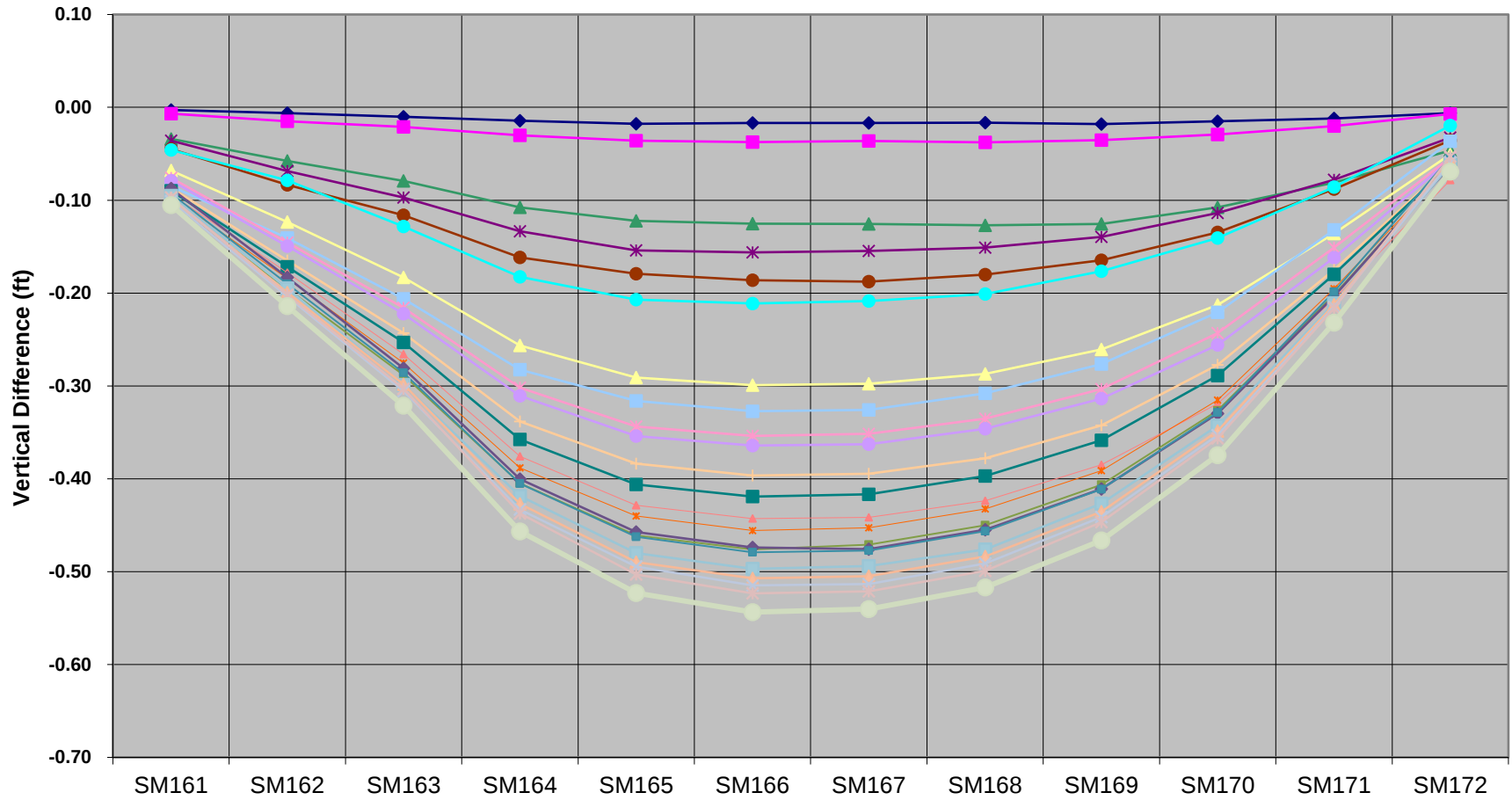


Monitoring Point SM171



(0,0) = January 2001 Horizontal Position

Seven Oaks Dam - Upstream 2530' Level Vertical Movement since January 2001 Survey Profile View - Looking Upstream



Seven Oaks Dam Monitoring Survey

Upstream 2360' Level - Monitoring Points

(6105) SM173 & CAP

SM174

(6108) SM175 & CAP

SM176

(6111) SM177 & CAP

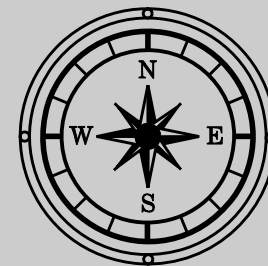
SO2001-113

SO2001-114

SO2001-115

LEGEND

-  PILLAR MONUMENT
-  OTHER H & V MONUMENT
-  BENCHMARK
-  SETTLEMENT MONUMENT 77 mon
-  SETTLEMENT MONUMENT (SUBSET) 33 mon
-  INCLINOMETER 6 mon
-  CORS SITE
-  TUNNEL MONUMENT 22 mon
-  X-SECTION MONUMENT 7 mon

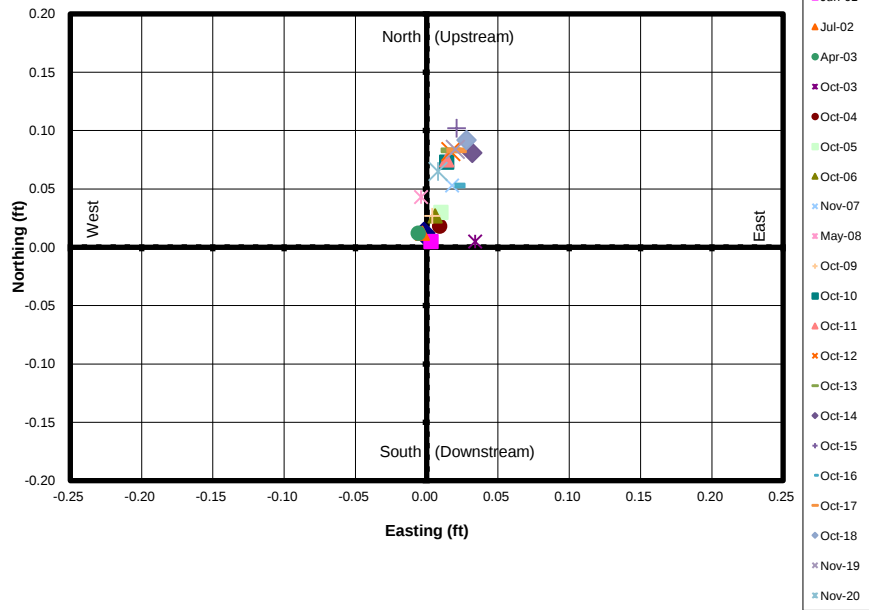


100' 100' 100'

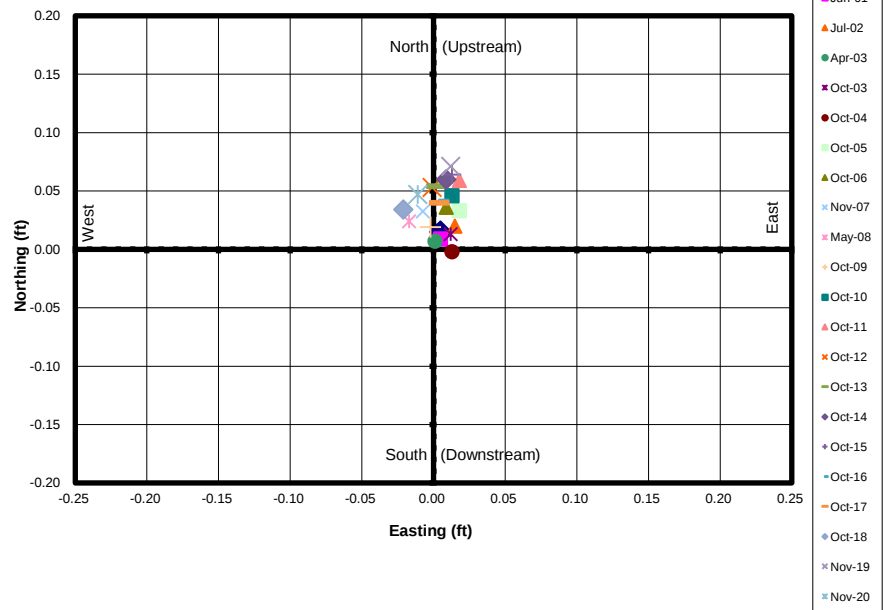
Seven Oaks Dam - Upstream 2360' level (Horizontal)

Horizontal Movement since January 2001 Survey

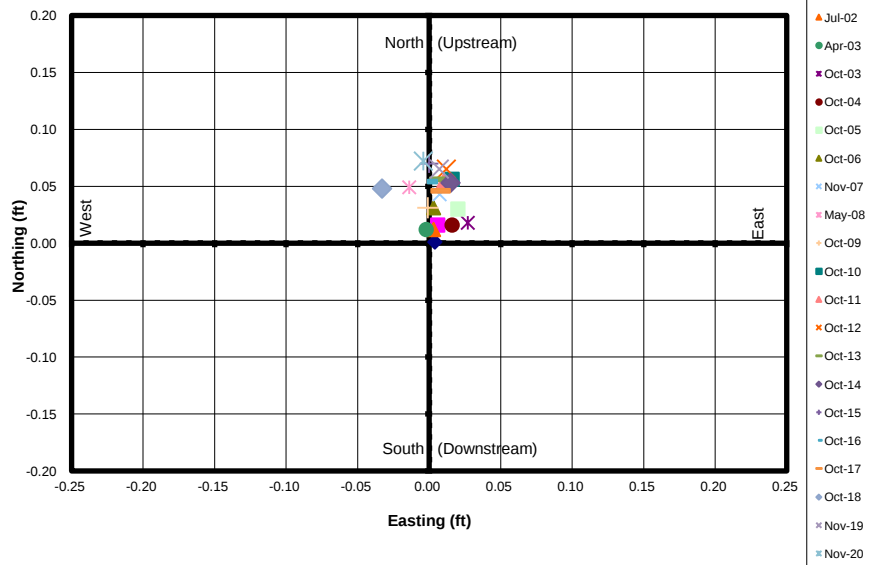
Monitoring Point SM173



Monitoring Point SM175

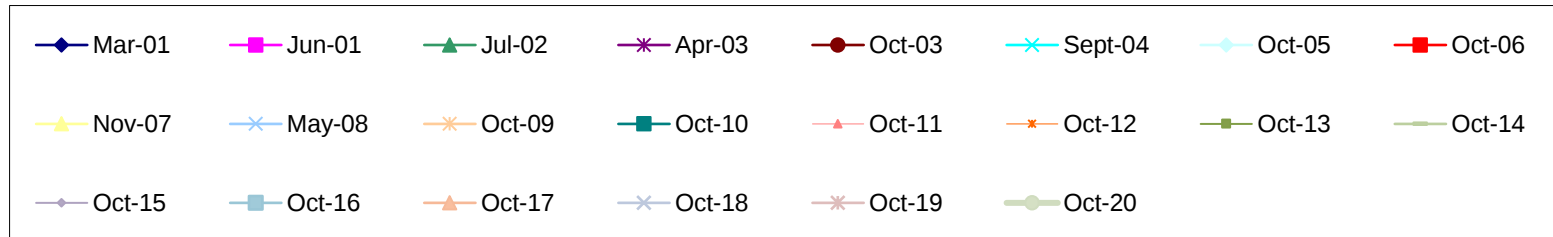
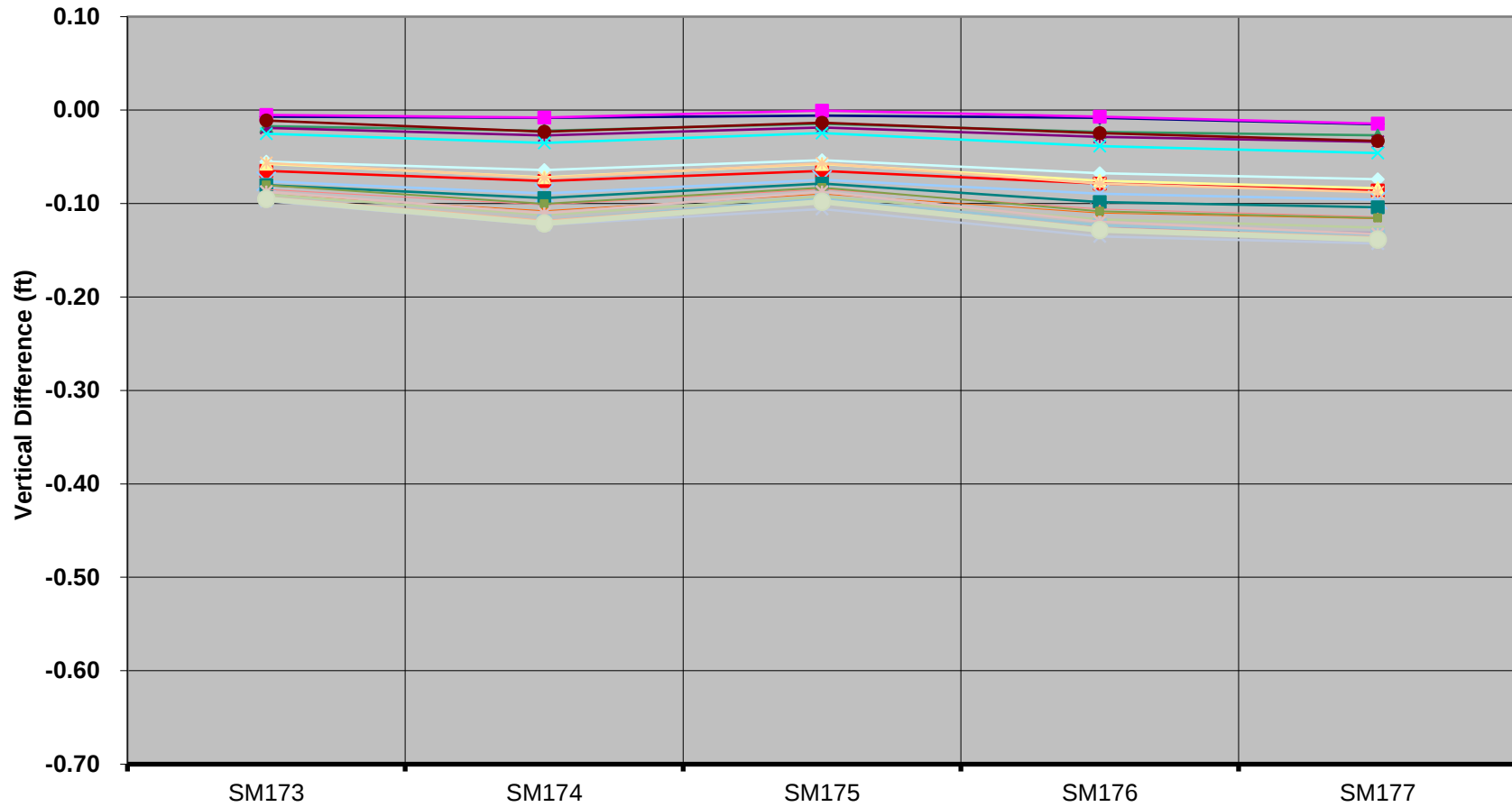


Monitoring Point SM177



(0,0) = January 2001 Horizontal Position

Seven Oaks Dam - Upstream 2360' Level
Vertical Movement since January 2001 Survey
Profile View - Looking Upstream



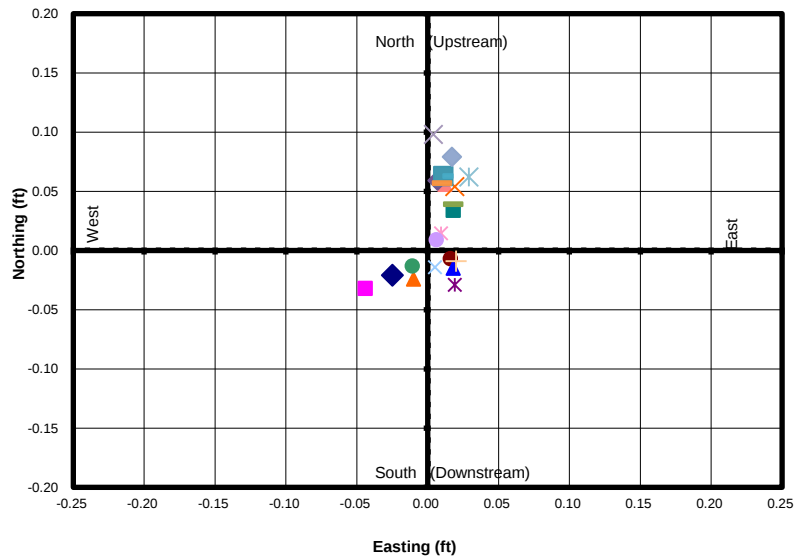
Seven Oaks Dam Monitoring Survey

Inclinometer Locations - Monitoring Points

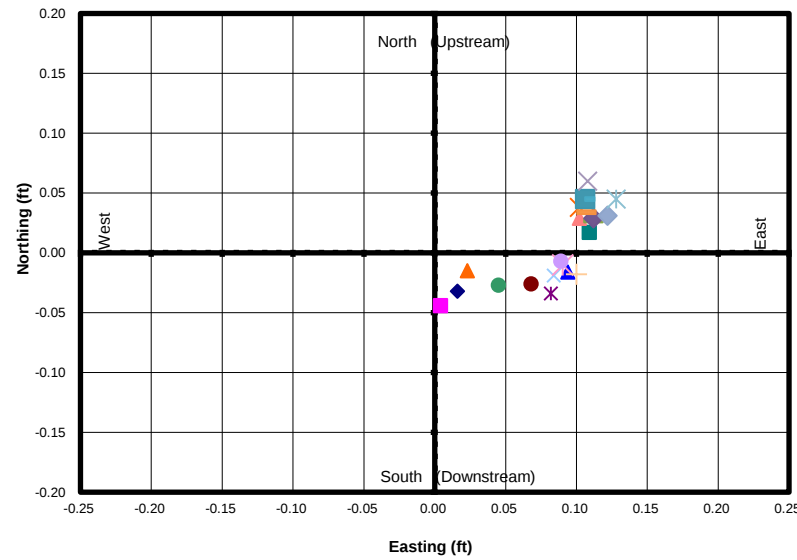


Seven Oaks Dam - Inclinerometers (Horizontal) Horizontal Movement since January 2001 Survey

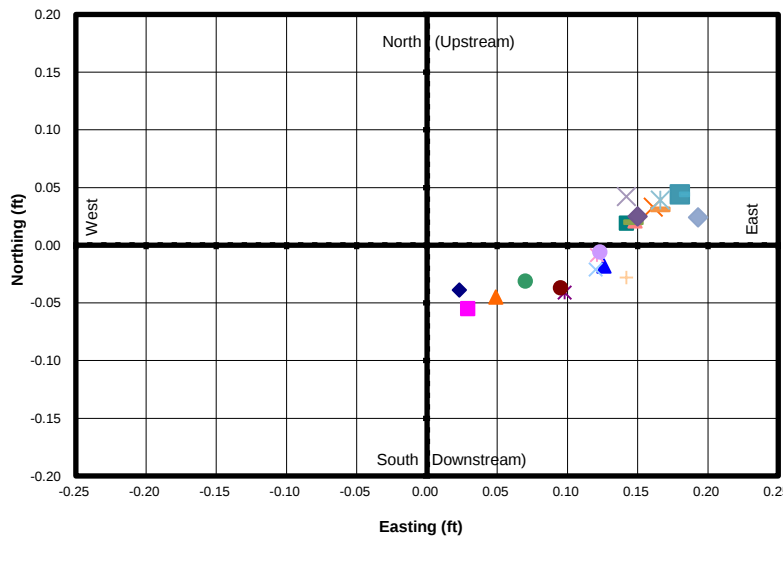
Inclinometer Monitoring Point SI-1



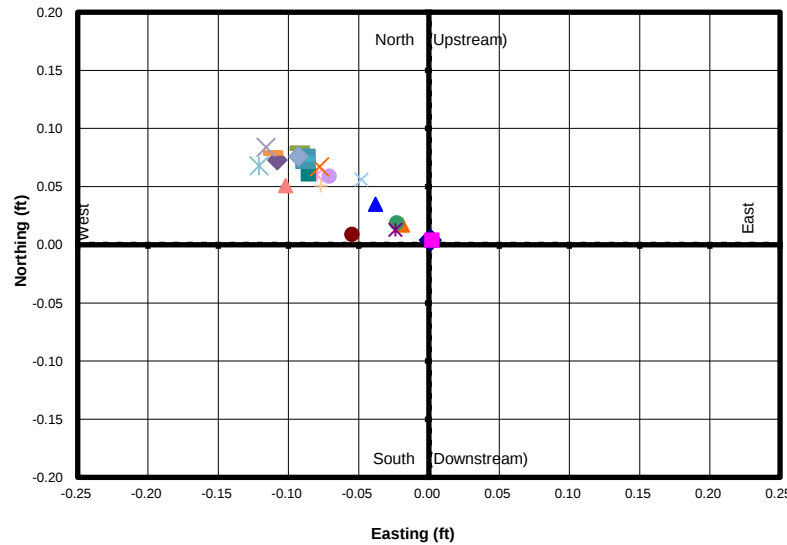
Inclinometer Monitoring Point SI-2



Inclinometer Monitoring Point SI-3



Inclinometer Monitoring Point SI-4

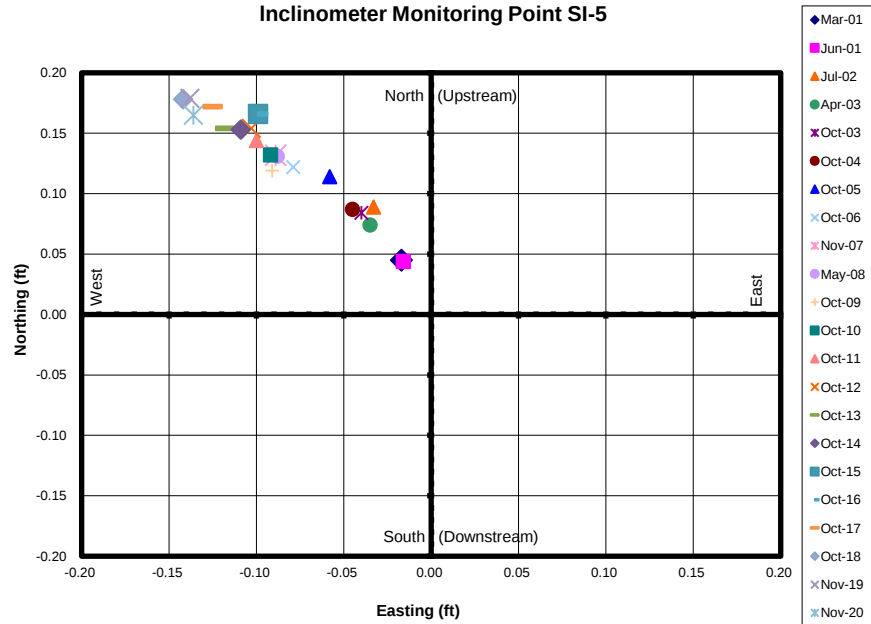


(0,0) = January 2001 Horizontal Position

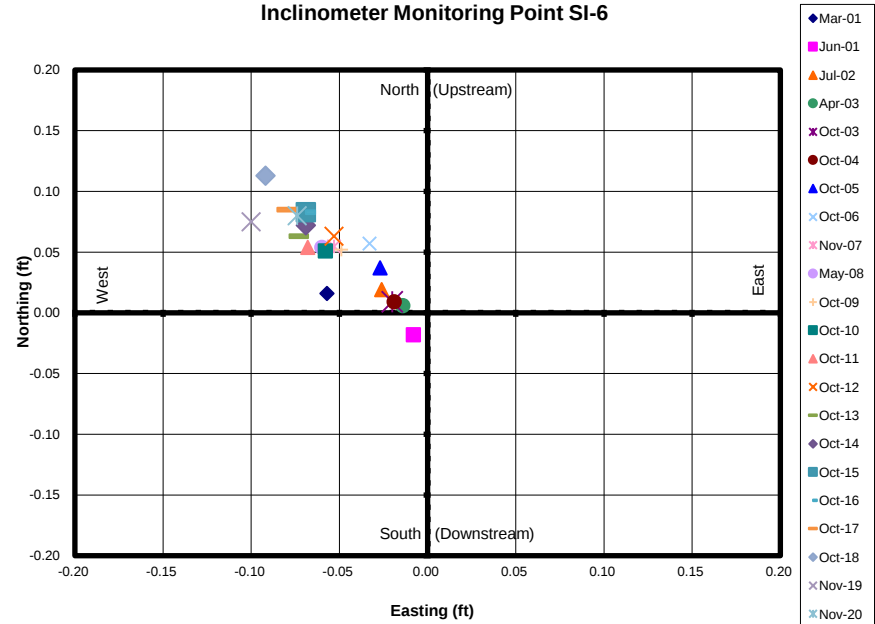
Seven Oaks Dam - Inclinerometers (Horizontal)

Horizontal Movement since January 2001 Survey

Inclinometer Monitoring Point SI-5

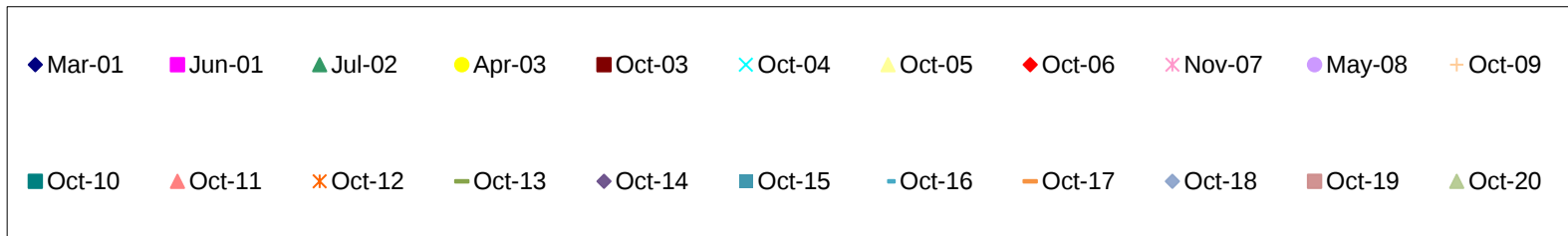
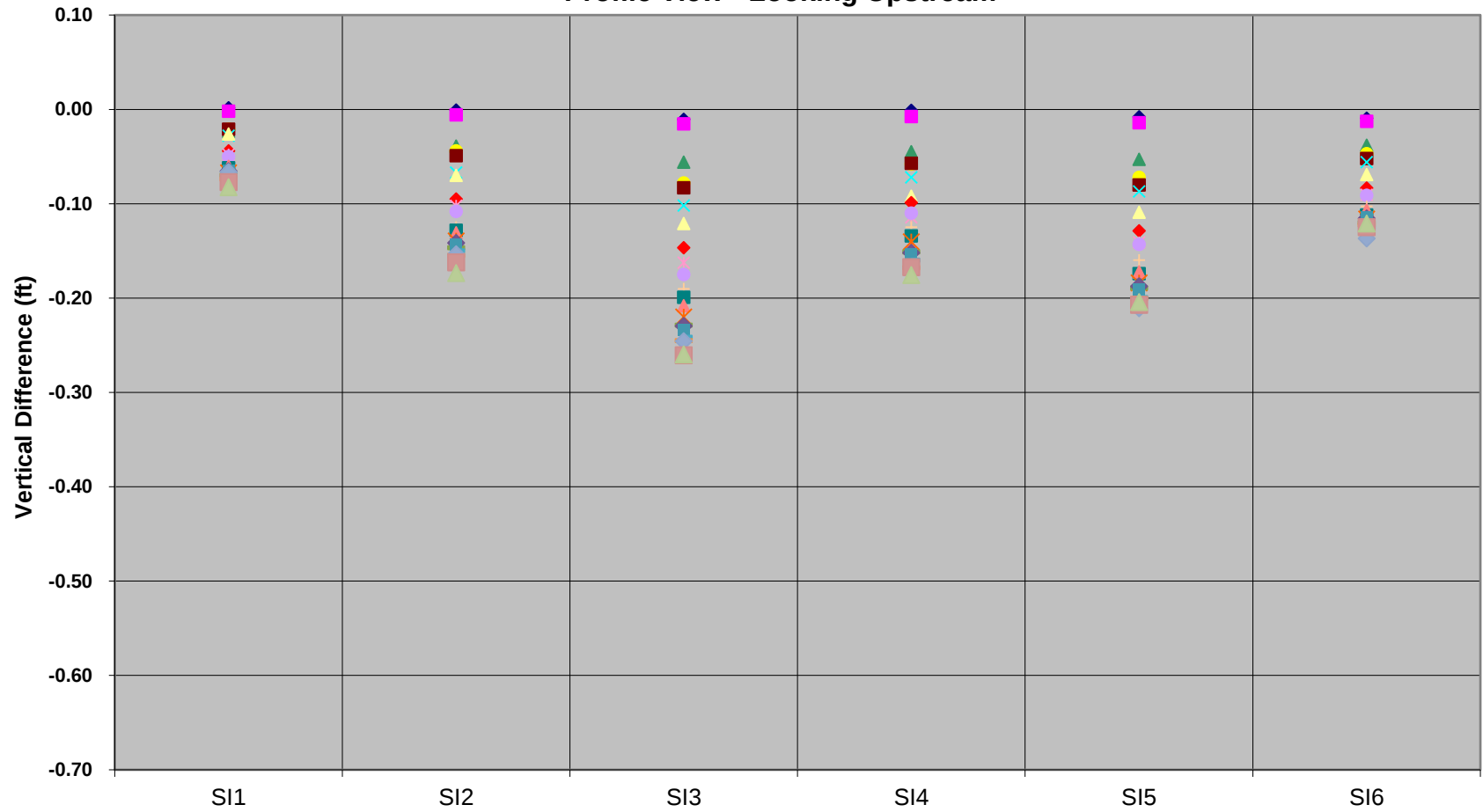


Inclinometer Monitoring Point SI-6



(0,0) = January 2001 Horizontal Position

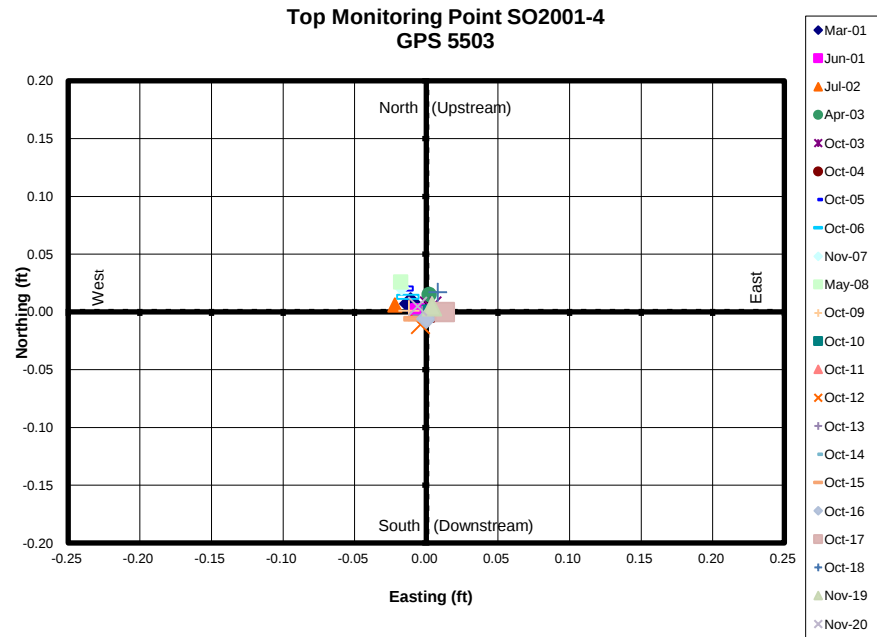
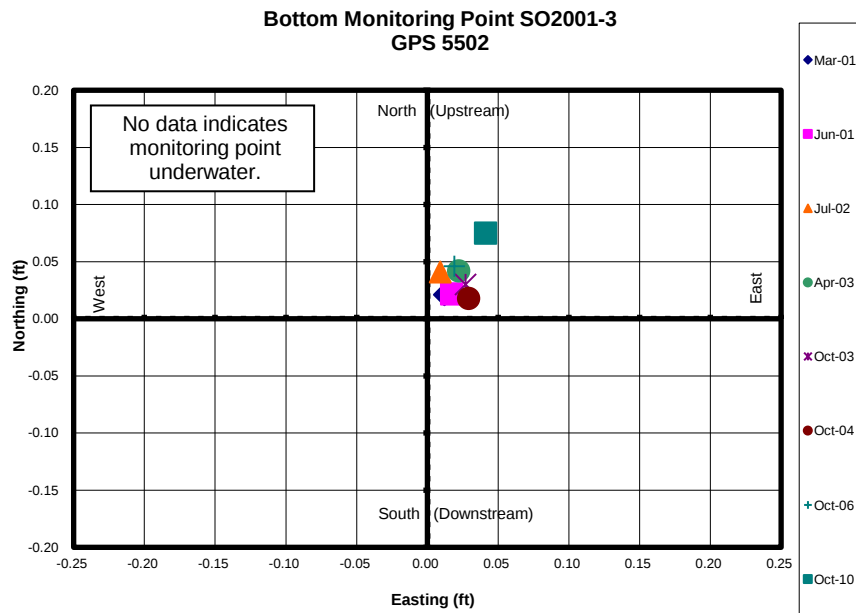
Seven Oaks Dam - Inclinator Vertical Movement since January 2001 Survey Profile View - Looking Upstream



Seven Oaks Dam Monitoring Survey Intake Tower - Monitoring Points



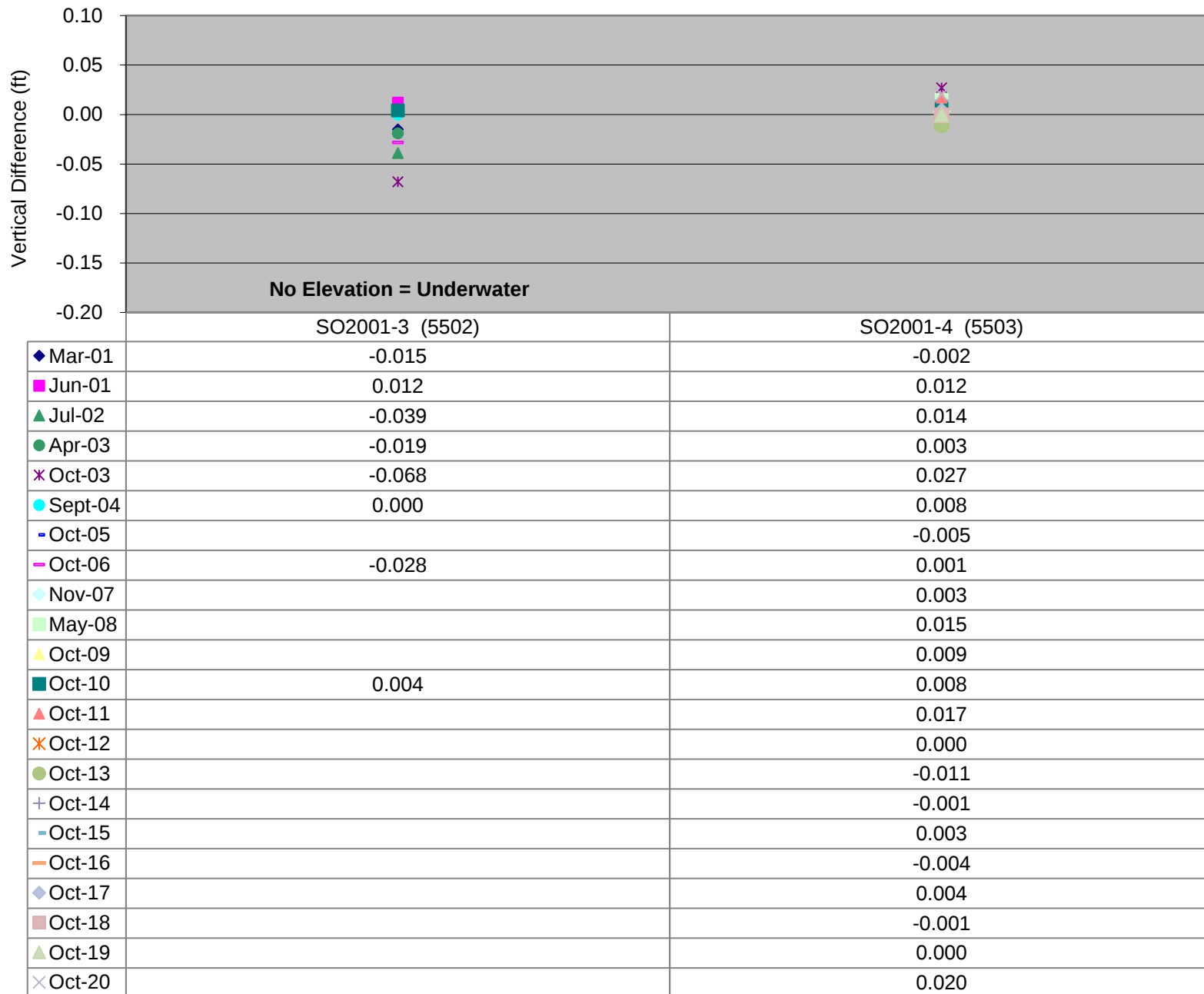
Seven Oaks Dam - Intake Tower Structure (Horizontal) Horizontal Movement since January 2001 Initial Survey



(0,0) = January 2001 Horizontal Position

Seven Oaks Dam - Intake Structure

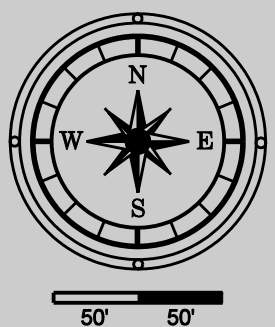
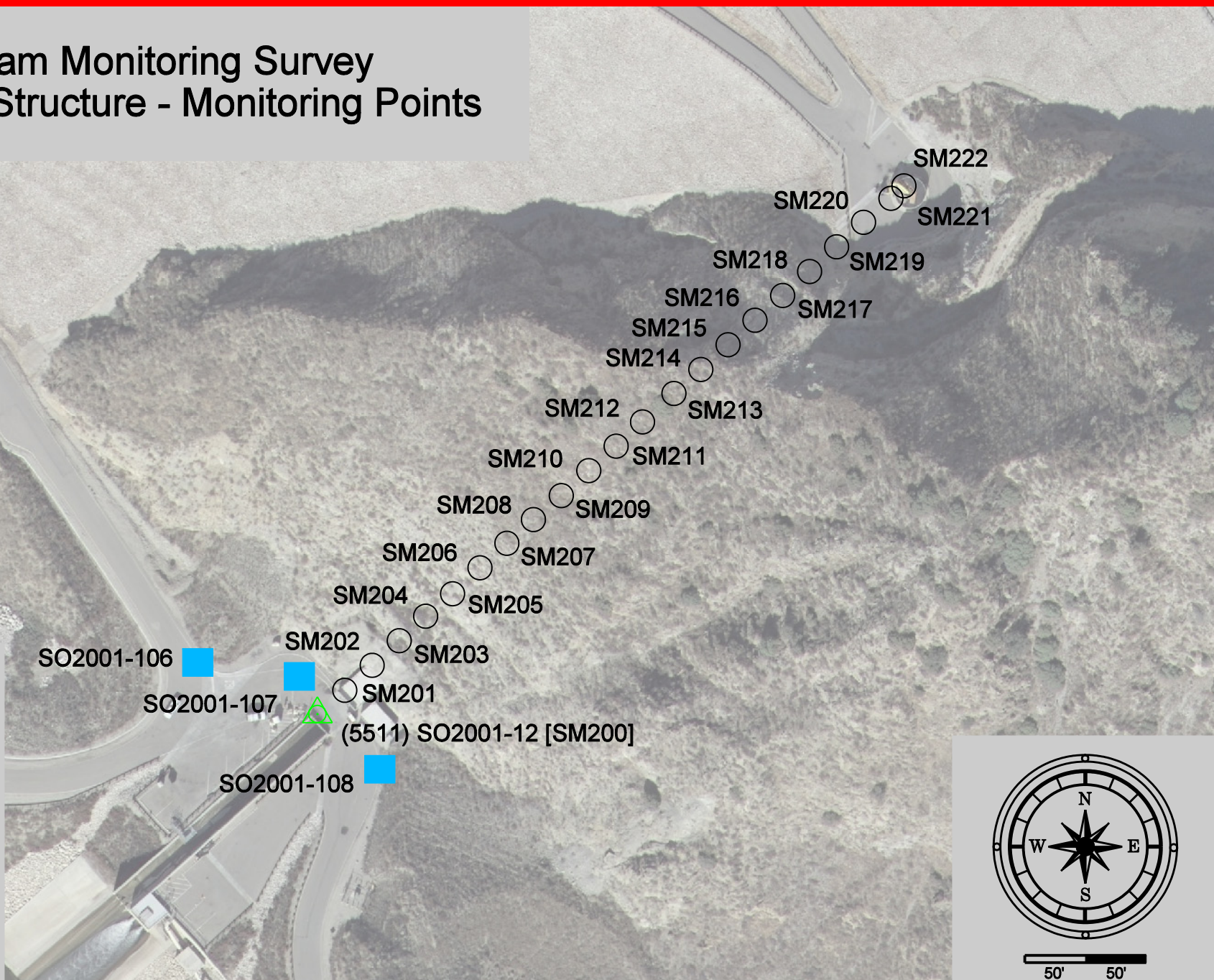
Vertical Movement since January 2001 Survey



Seven Oaks Dam Monitoring Survey

Outlet Tunnel Structure - Monitoring Points

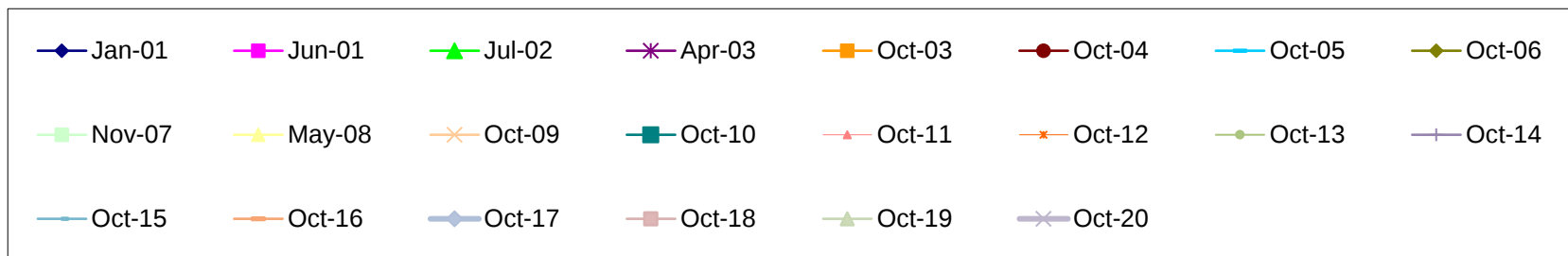
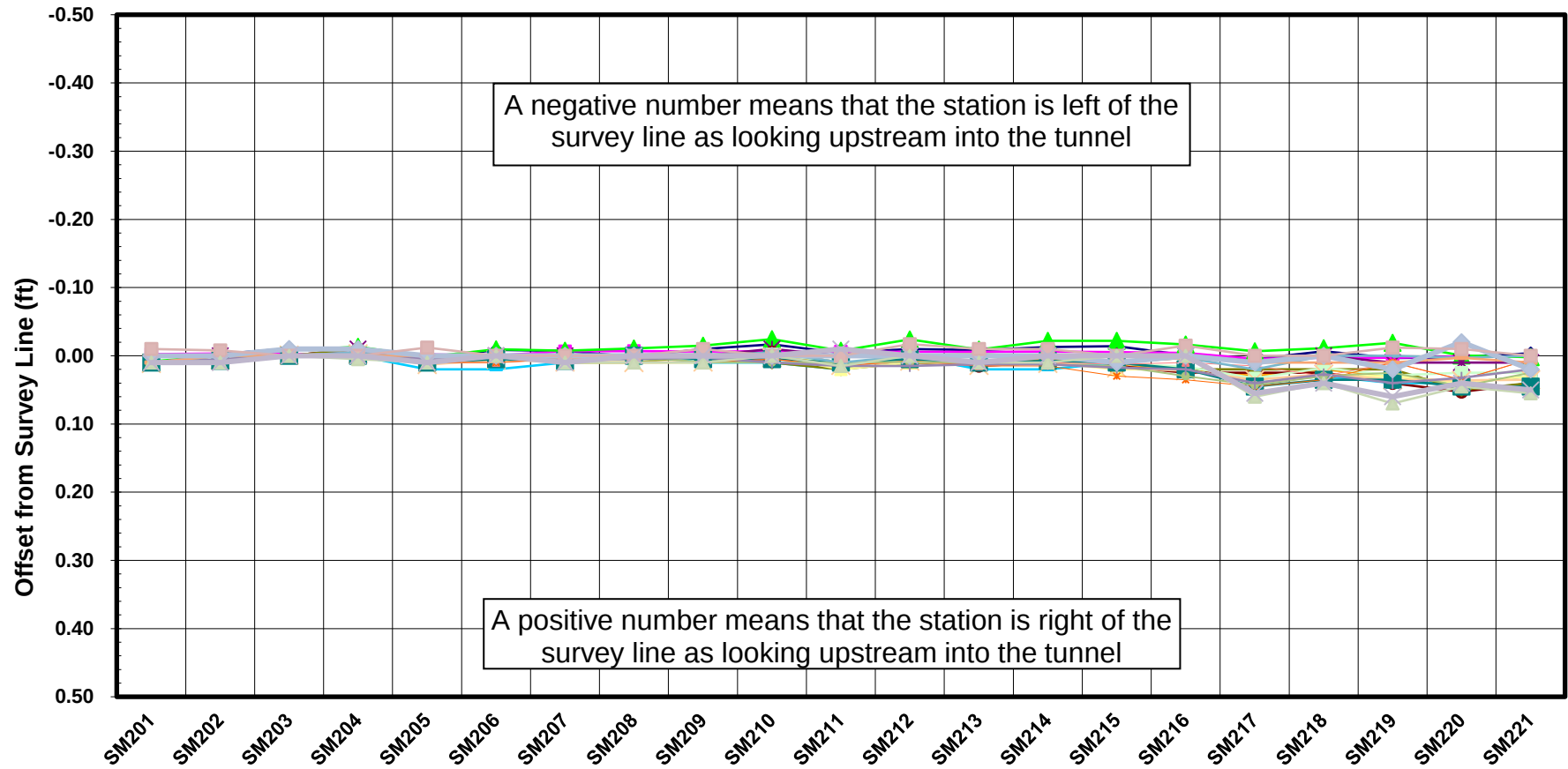
- LEGEND**
- PILLAR MONUMENT
 - OTHER H & V MONUMENT
 - BENCHMARK
 - SETTLEMENT MONUMENT 77 mon
 - SETTLEMENT MONUMENT (SUBSET) 33 mon
 - INCLINOMETER 6 mon
 - CORS SITE
 - TUNNEL MONUMENT 22 mon
 - X-SECTION MONUMENT 7 mon



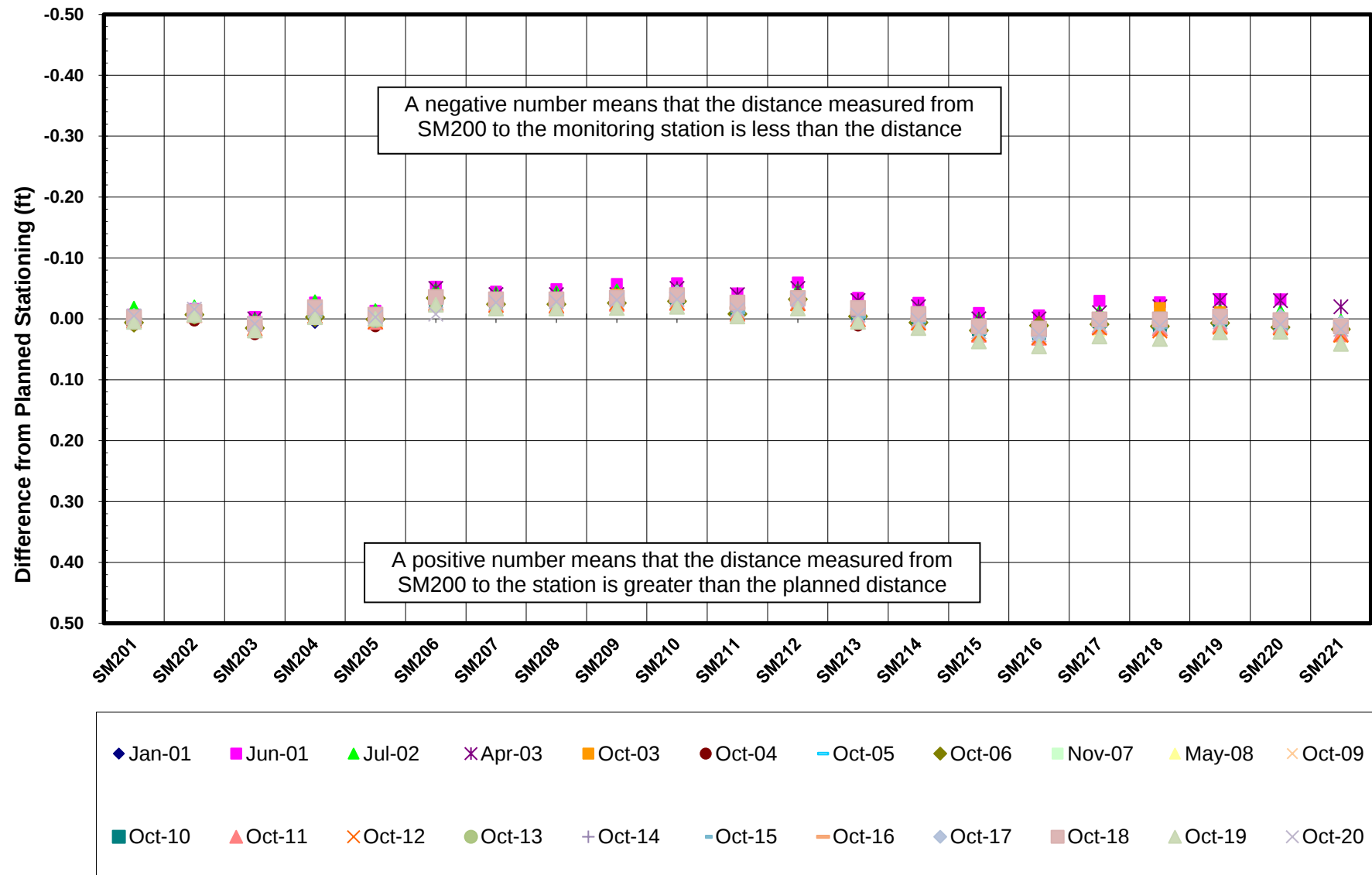
Seven Oaks Dam - Outlet Tunnel Structure

Horizontal Movement Since January 2001

Tunnel Alignment - Outs from Survey Line



Seven Oaks Dam - Outlet Tunnel Structure
Horizontal Movement Since January 2001
Tunnel Alignment - Difference from original distance



Seven Oaks Dam - Outlet Tunnel Structure Vertical Movement since January 2001 Survey Profile View - Looking from Right Side

