



Subsidence and
Deformation
Monitoring Studies
2016

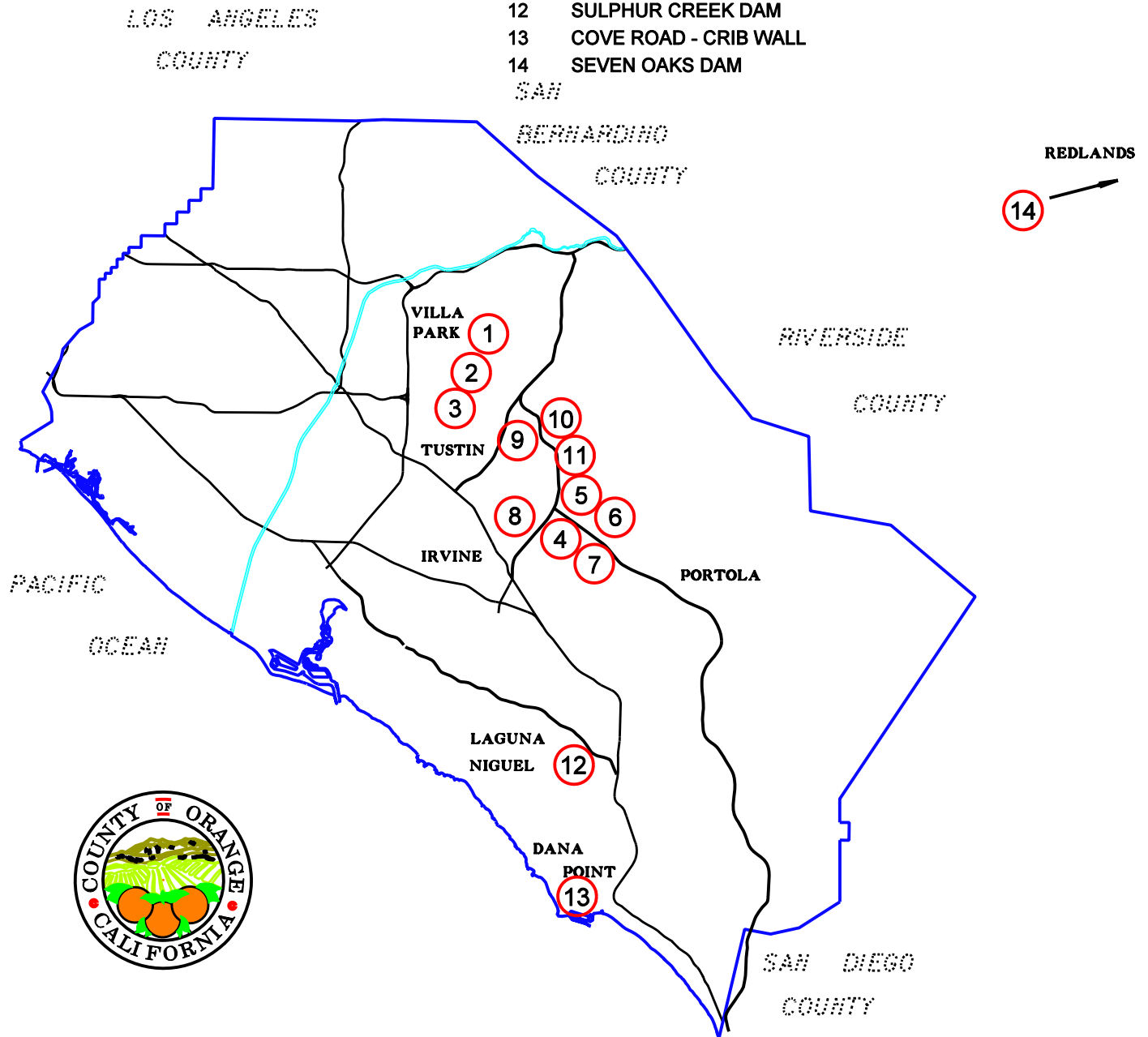


OC Survey
Geodetic Unit



Study Locations

#	STUDY
1	VILLA PARK DAM
2	PETERS CANYON DAM
3	LOWER PETERS CANYON DAM
4	MARSHBURN RETARDING BASIN
5	BEE CANYON RETARDING BASIN
6	ROUND CANYON RETARDING BASIN
7	AGUA CHINON RETARDING BASIN
8	TRABUCO RETARDING BASIN
9	ORCHARD ESTATES RETARDING BASIN
10	HICKS CANYON RETARDING BASIN
11	EAST HICKS CANYON RETARDING BASIN
12	SULPHUR CREEK DAM
13	COVE ROAD - CRIB WALL
14	SEVEN OAKS DAM



○ = SUBSIDENCE STUDY LOCATION & STUDY NUMBER

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REPORTS **STUDY #**

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Round Canyon Retarding Basin 6

Agua Chinon Retarding Basin 7

Trabuco Retarding Basin 8

Orchard Estates Retarding Basin 9

Hicks Canyon Retarding Basin 10

East Hicks Canyon Retarding Basin 11

Sulphur Creek Dam 12

Cove Road – Crib Wall 13

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This publication is a historical compilation of subsidence and deformation studies that are currently being performed.

Dam Monitoring Survey Reports

Purpose:

The State of California Division of Safety of Dams (DSOD) retains the responsibility of supervision of dams and reservoirs. DSOD requests periodic monitoring of dams to determine if they are stable. Monitoring may be requested at different intervals due to special circumstances such as earthquakes. OC Public Works Operations and Maintenance Division select which dams require monitoring and the elapsed time period for such surveys. Current dams being monitored with their interim are listed below:

#	Facility #	Dam	<u>2013</u>	<u>2014</u>	<u>2015</u>	<u>2016</u>	<u>2017</u>	<u>2018</u>	<u>2019</u>	<u>2020</u>
1	E08D01	Villa Park Dam	✓	✓	✓	✓	✓	✓	✓	✓
2	F06B03	Peters Canyon Dam	✓	✓	✓	✓	✓	✓	✓	✓
3	F06D02	Lower Peters Canyon Dam			✓			✓		
4	F16B01	Marshburn Retarding Basin	✓			✓			✓	
5	F16B02	Bee Canyon Retarding Basin	✓			✓			✓	
6	F16B03	Round Canyon Retarding Basin	✓			✓			✓	
7	F18B01	Agua Chinon Retarding Basin			✓			✓		
8	F25B01	Trabuco Retarding Basin	✓			✓			✓	
9	F26B02	Orchard Estates Retarding Basin	✓			✓			✓	
10	F27B01	Hicks Canyon Retarding Basin	✓			✓			✓	
11	F27B02	East Hicks Retarding Basin	✓			✓			✓	
12	J03D01	Sulphur Creek Dam	✓	✓	✓	✓	✓	✓	✓	✓
13		Cove Road – Crib Wall		✓		✓		✓		✓
14	E01D01	Seven Oaks Dam	✓	✓	✓	✓	✓	✓	✓	✓

Monitoring Procedures:

PHASE I

Utilizing Global Navigation Satellite System (GNSS) Static survey techniques, measure at least two of the dam monitoring control stations to at least two Continuous Global Positioning System (CGPS) stations or two OCS horizontal control stations which are located outside of the dam area. GNSS data is post-processed and a minimally constrained adjustment is done constraining the same singular control station for each survey year. Positions are compared from each survey year. This data is used to check the stability, horizontally and vertically, of the two dam monitoring stations. This information is not included in the report unless significant movement is found but can be obtained at OC Survey Section, Geodetic Control Unit.

PHASE II

Utilizing Precise leveling techniques following 2nd Order - Class II specifications, measure the vertical differences between all dam monitoring stations relative to at least two OCS Vertical control stations located outside the dam area. This data is used to monitor any subsidence and/or uplift on the dam monitoring stations.

PHASE III

Utilizing terrestrial or GNSS surveying techniques, measure station and offsets for each dam monitoring stations from the dam monitoring control stations. This data is used to monitor the horizontal movement on the dam monitoring stations.

COMMENTS:

Each annual survey is done using the same techniques with the same survey equipment if possible. Each survey report has a brief "Report Summary" that contains comments on each survey. Detailed information pertaining to monument descriptions and survey information are not included in the reports, but can be obtained at OC Survey Section, Geodetic Control Unit.

No evaluation of Subsidence or Deformation is determined by these reports. The intent of these reports are to provide survey data to assist the reader in the determination of the stability of these structures.

Four chart examples have been included explaining how to read and interpret each chart. These reports and data represent surveys made by me and/or under my direction.



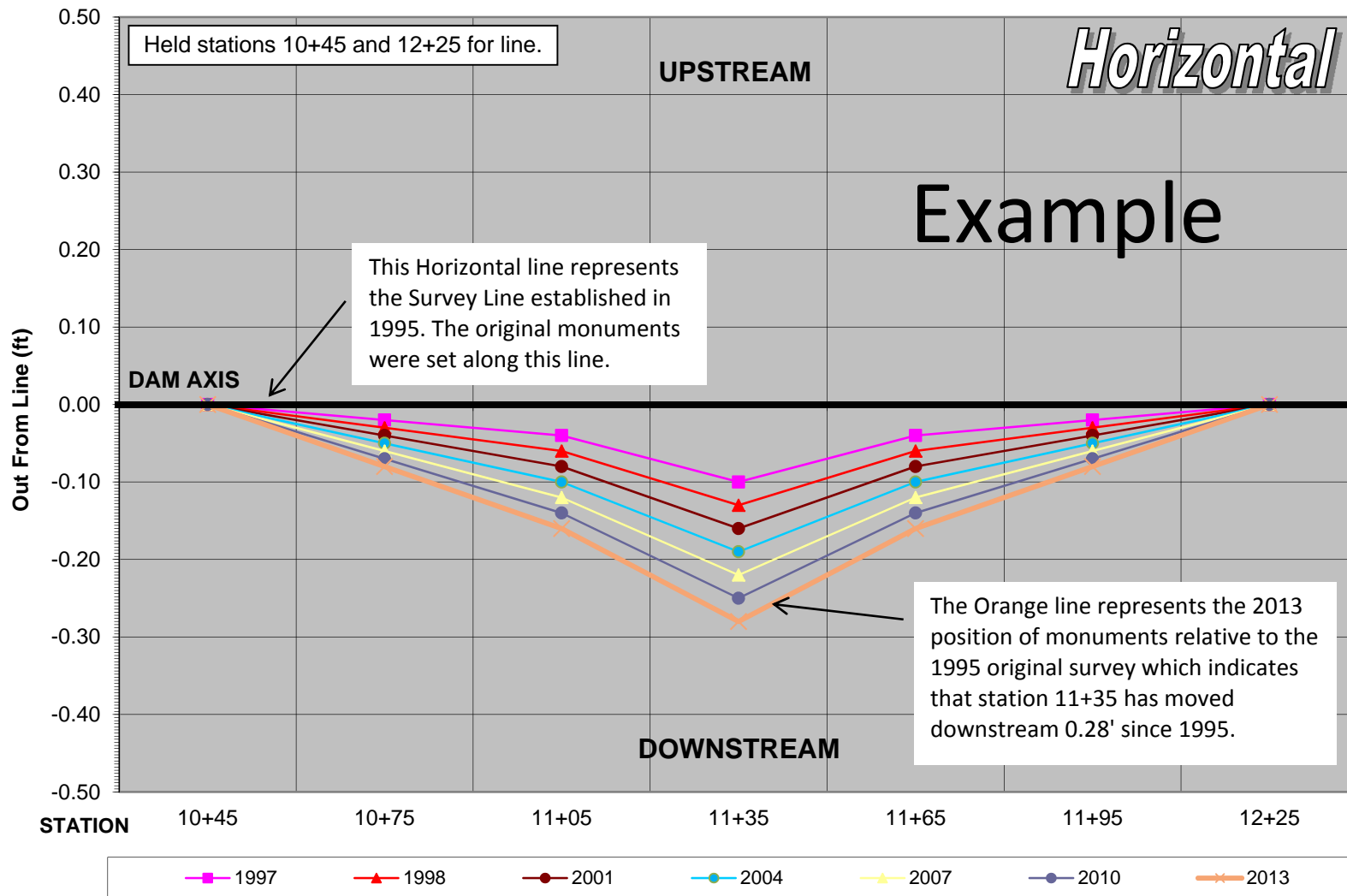
Arthur Ringland Andrew III, P.L.S. #7042



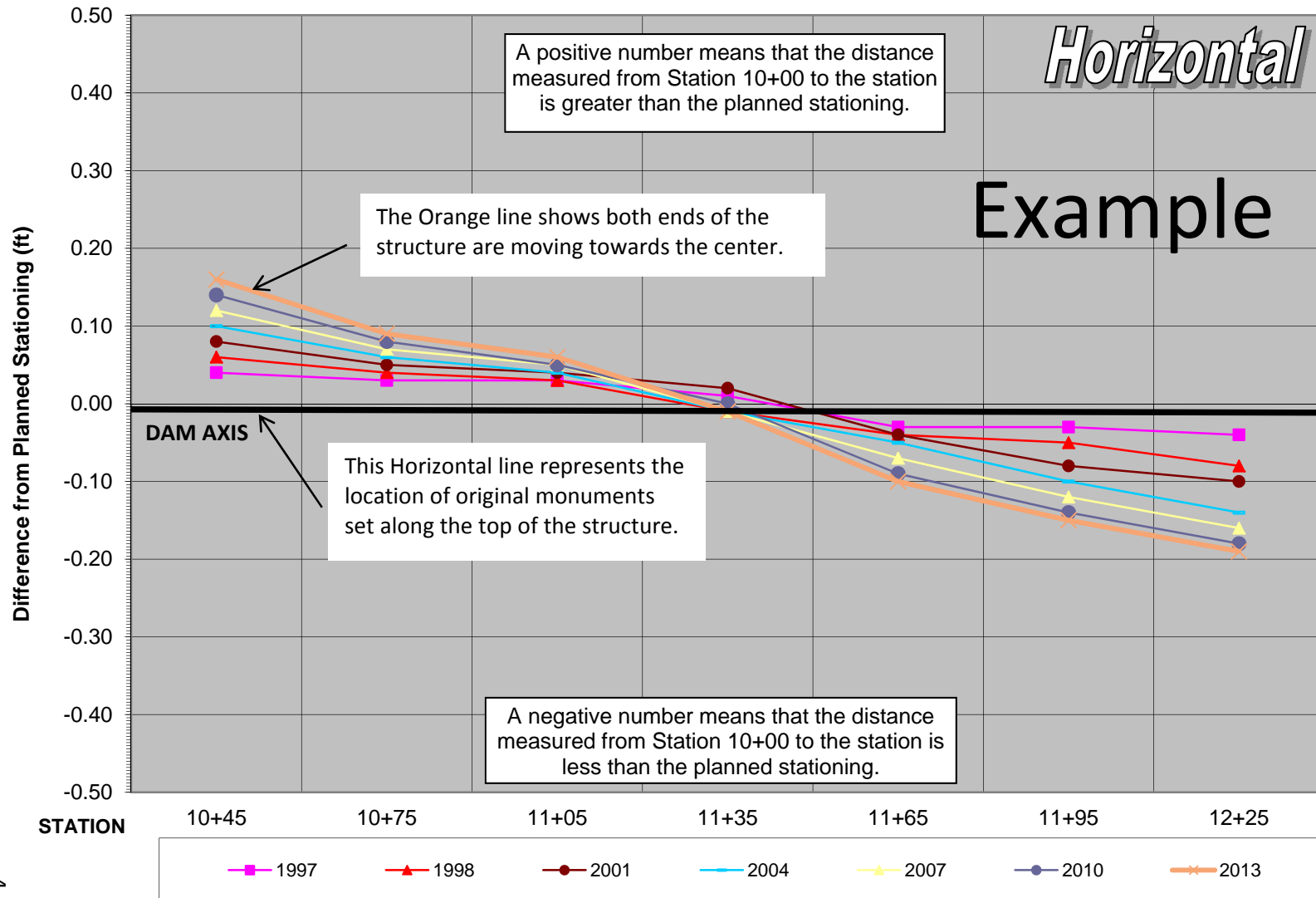
December 30, 2016

Date:

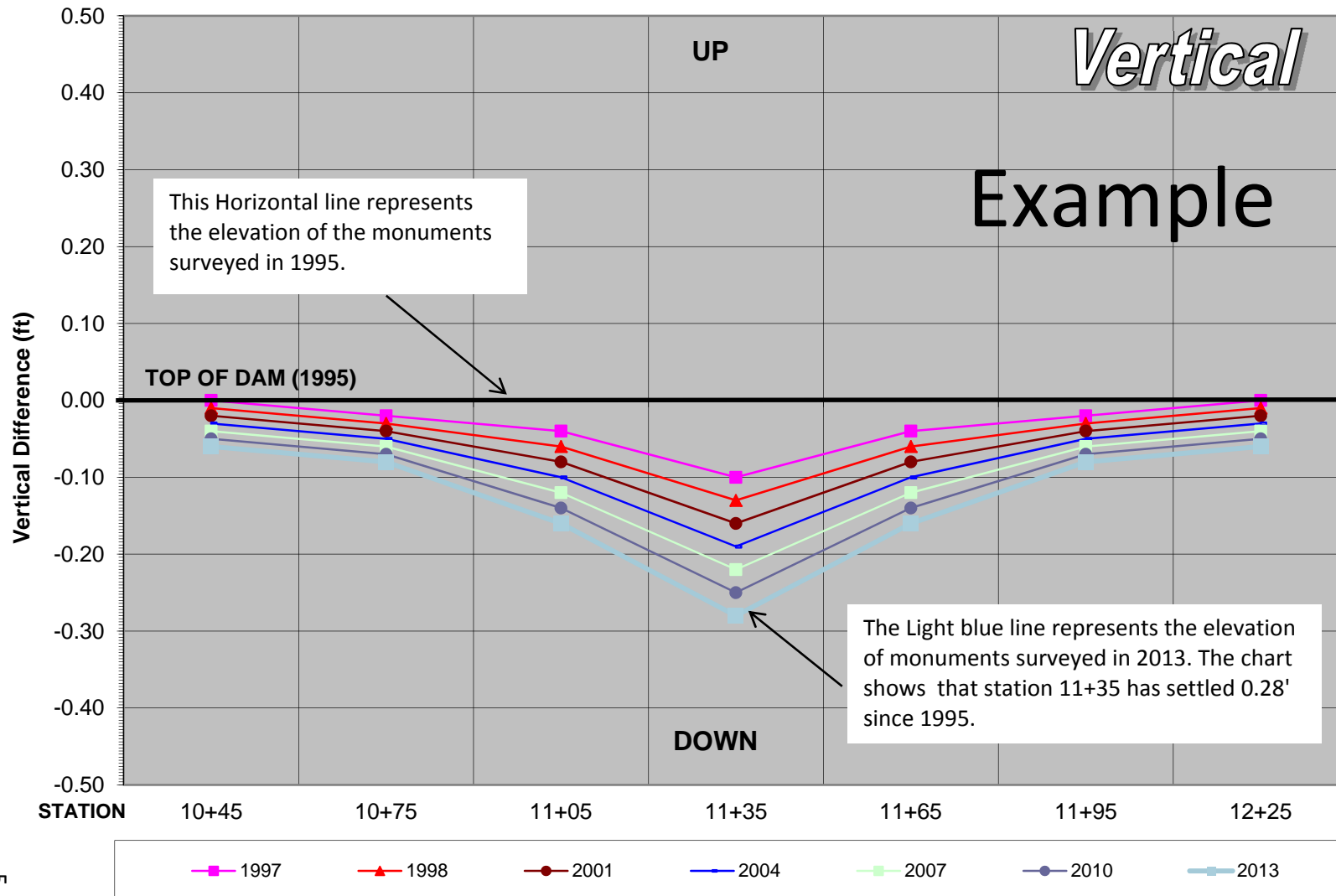
EXAMPLE **Horizontal Movement Perpendicular to Dam Axis (Out From Line) - Plan View**



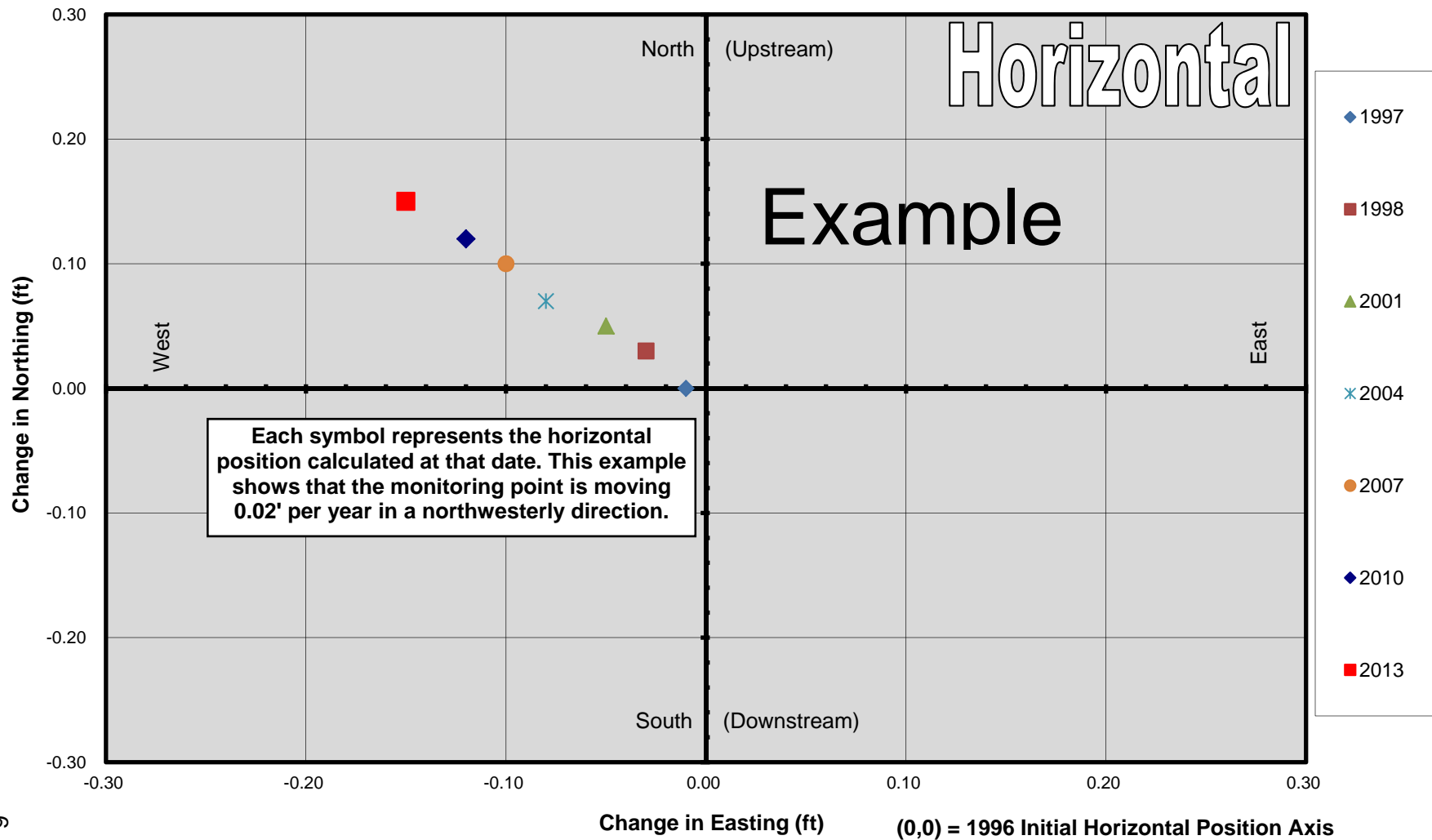
EXAMPLE **Horizontal Movement Along Dam Axis (Difference from Planned Stationing)**



EXAMPLE
Vertical Movement (Difference from 1995 Elevations) - Profile View - *Looking Upstream*



EXAMPLE
Monitoring Point XXXX
Horizontal Movement since the 1996 Initial Survey



1

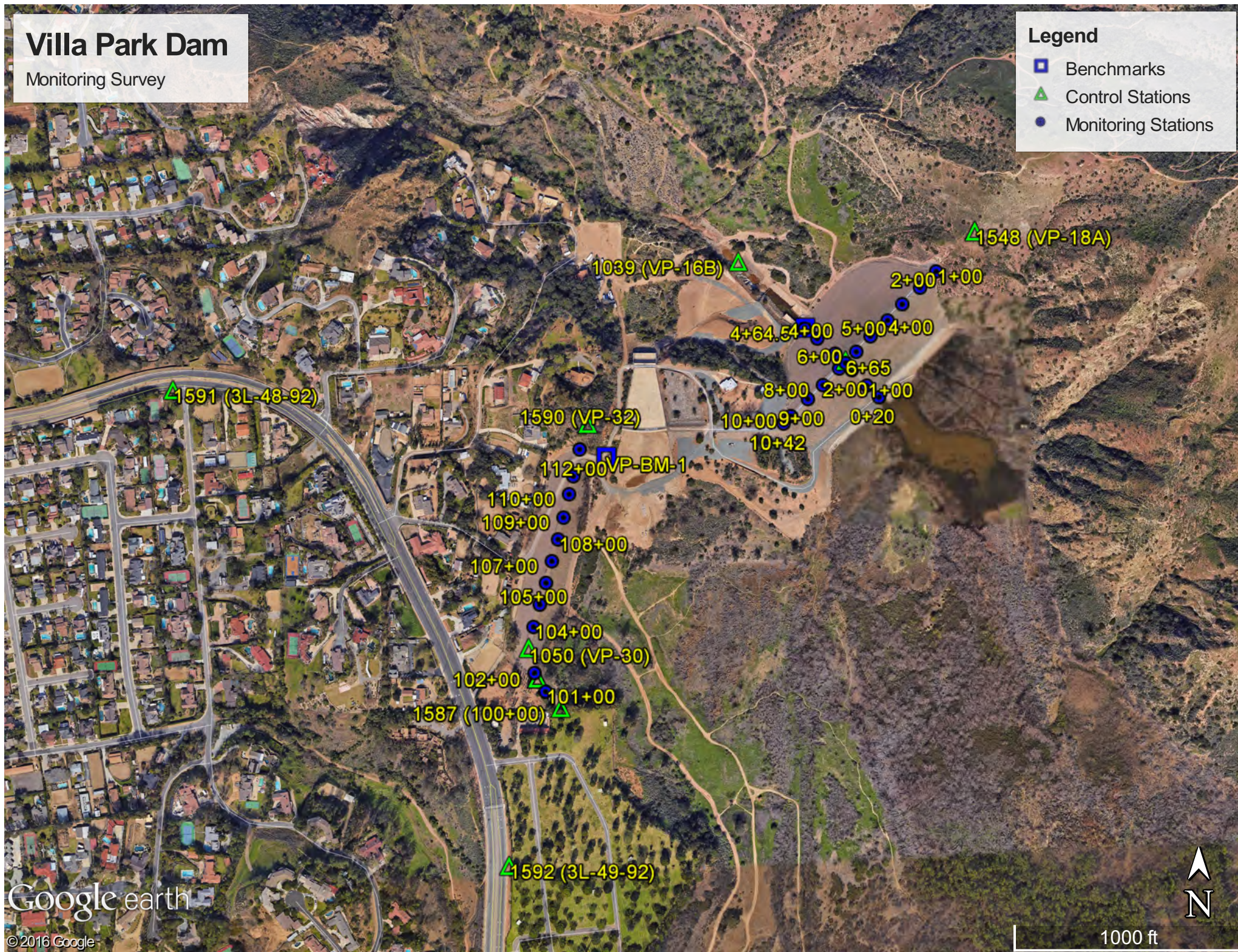
VILLA PARK DAM

Villa Park Dam

Monitoring Survey

Legend

- ▣ Benchmarks
- △ Control Stations
- Monitoring Stations



Google earth

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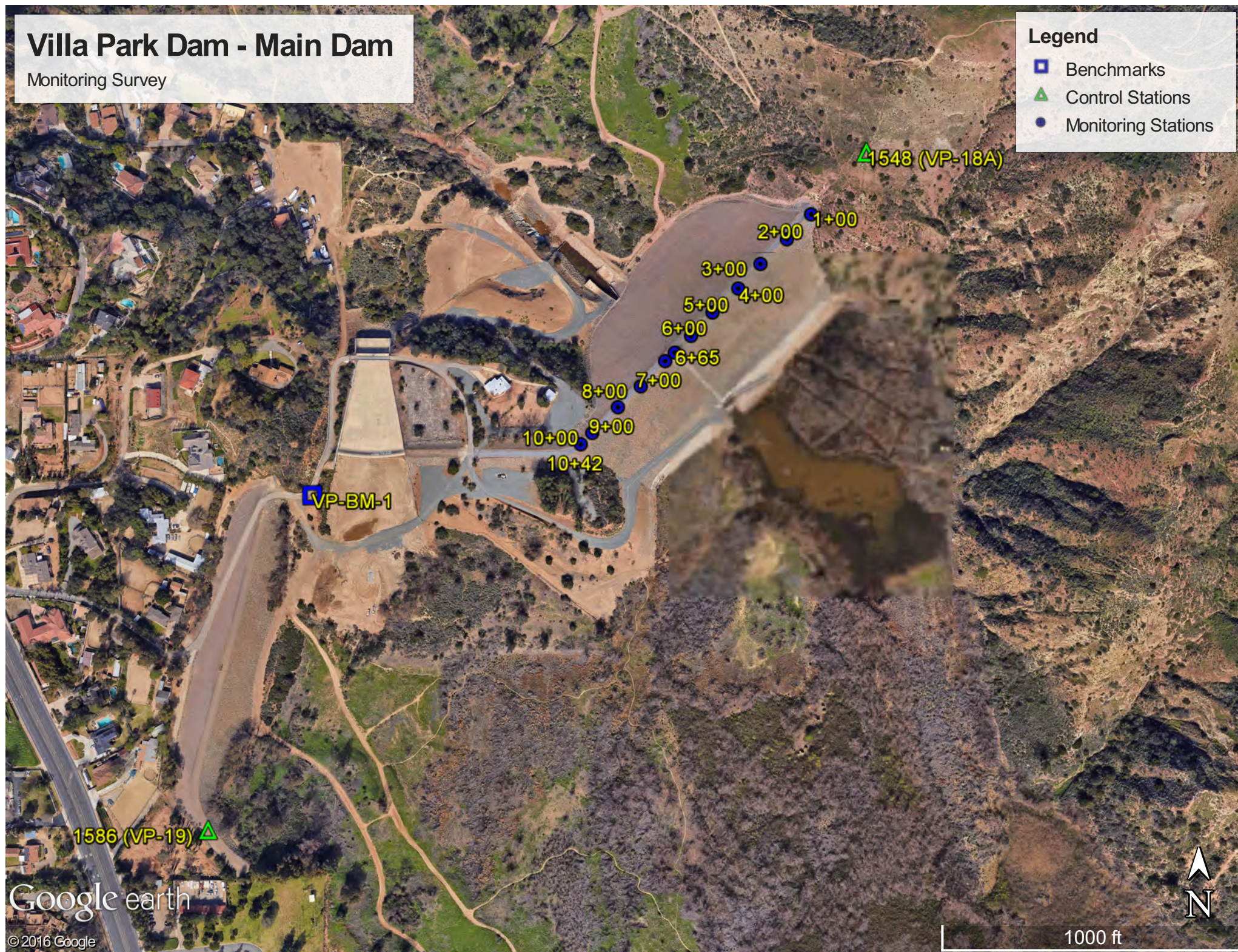
1000 ft

Villa Park Dam - Main Dam

Monitoring Survey

Legend

- ▣ Benchmarks
- △ Control Stations
- Monitoring Stations



Villa Park Dam (Main Dam) (E08D01) - Monitoring Survey

This earthen dam was built in 1963. The first survey was performed in 1963. This report displays all surveys from 1963 to present. Horizontal displacement is compared to dam survey line. Vertical displacement are compared to the 1963 survey.

Chart Details

Horizontal Movement Perpendicular to Dam Axis - shows all data from each year.

Control points "VP-18" ("VP-18A" after 1993) and "VP-19" are held for ***Out From Line*** and along line calculations.

Positive numbers represent monitored stations to the right of line (downstream), negative numbers represent monitored stations to the left of line (upstream).

Horizontal Movement Along Dam Axis (difference from planned stationing) - shows all data from each year.

Control points "VP-18" ("VP-18A" after 1993) are held for stationing calculations.

Positive numbers mean that the distances measured to each station are greater than planned stationing, negative number means less than planned stationing.

Vertical Movement - shows all data from each year.

Vertical differences are calculated comparing the elevation to the "1963 survey" elevation.

Detailed information pertaining to monument descriptions and survey information can be found at OC Survey Divison, Geodetic Control Unit.

All values are shown in U.S. Feet.

Horizontal Datum = CCS83, zone VI, 1991.35 Epoch Adjustment

Vertical Datum = NGVD29, OCS 1976 Adjustment

Villa Park Dam (Main Dam) (E08D01) - Monitoring Survey

Report Summary

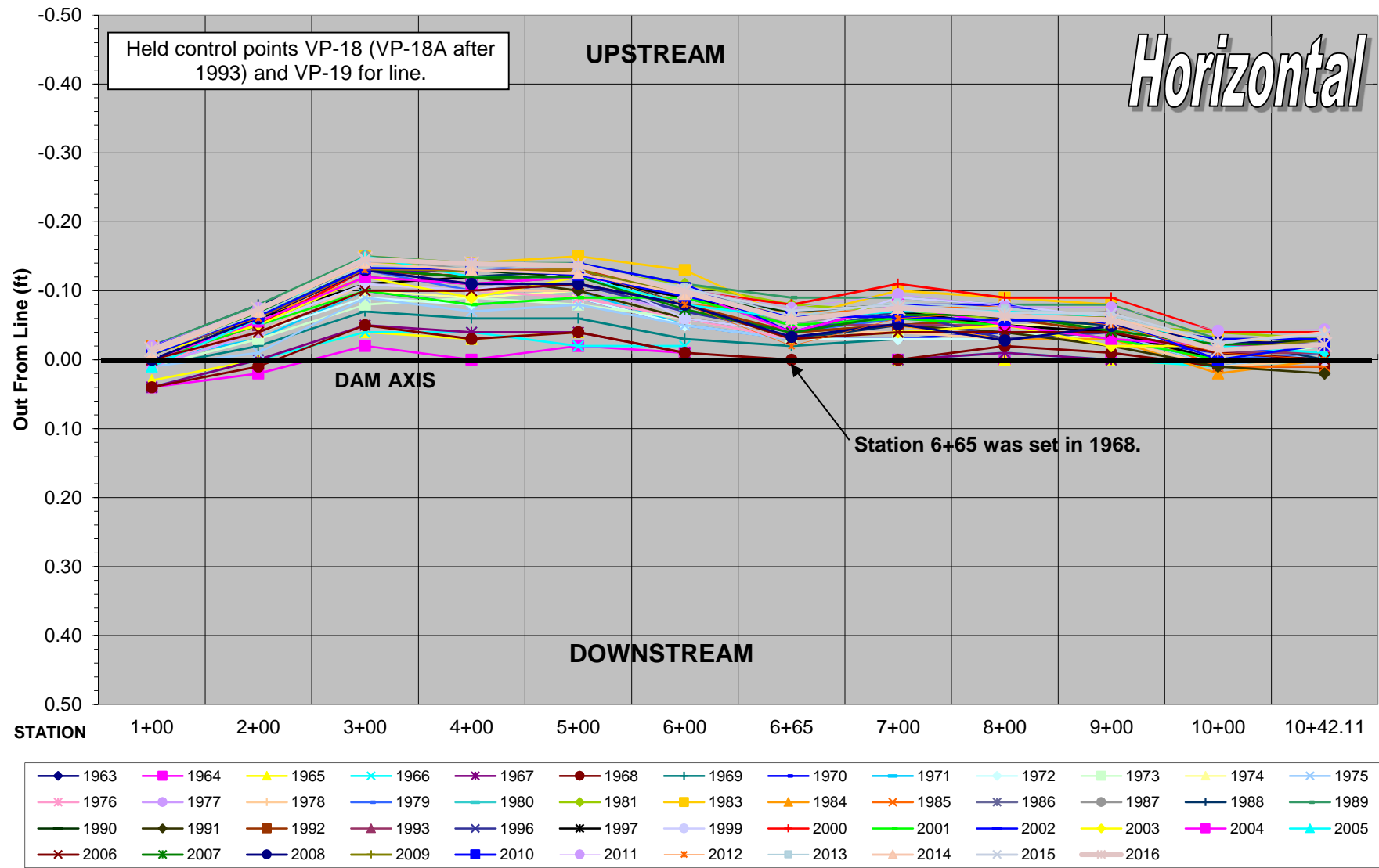
1963-1973	Gradual subsidence measured due to settling of dam. Upstream horizontal movement measured, mostly concentrated around stations 3+00 thru 5+00.
1974-1977	Upstream horizontal movement and subsidence still measured. Rates are Gradually slowing.
1978-1988	Subsidence continues at a very slow rate. Horizontal appears stable.
1989-2000	Vertical subsidence has discontinued. Horizontal appears stable.
2001	No significant movement detected.
2002	No significant movement detected.
2003	No significant movement detected.
2004	No significant movement detected.
2005	No significant movement detected.
2006	No significant movement detected.
2007	No significant movement detected.
2008	No significant movement detected.
2009	No significant movement detected.
2010	No significant movement detected.
2011	No significant movement detected.
2012	No significant movement detected.
2013	No significant movement detected.
2014	No significant movement detected.
2015	No significant movement detected.
2016	No significant movement detected.

Horizontal Datum = CCS83, zone VI, 1991.35 Epoch Adjustment

Vertical Datum = NGVD29, OCS 1976 Adjustment

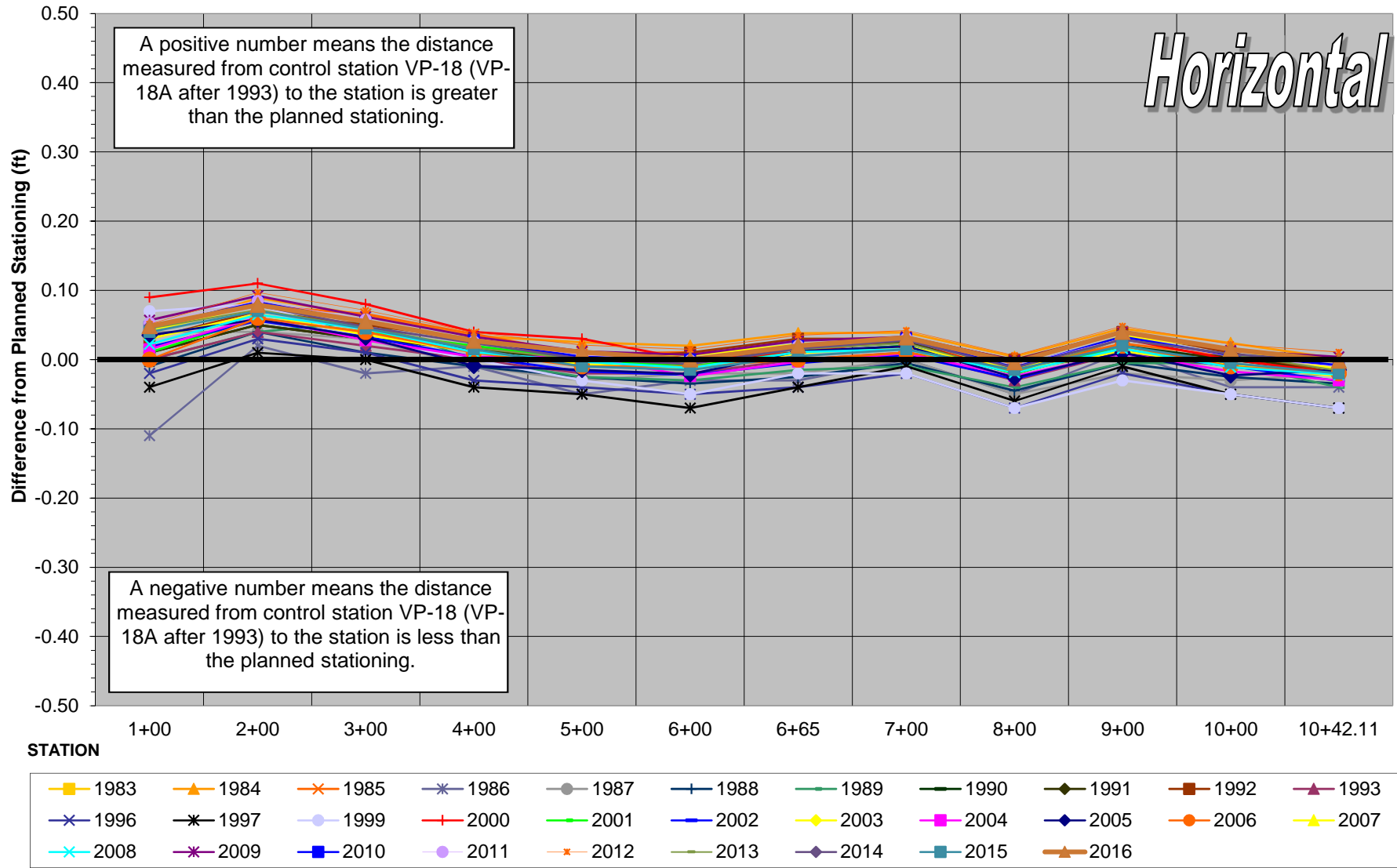
Villa Park (Main) Dam

Horizontal Movement Perpendicular to Dam Axis (Out From Line) - Plan View

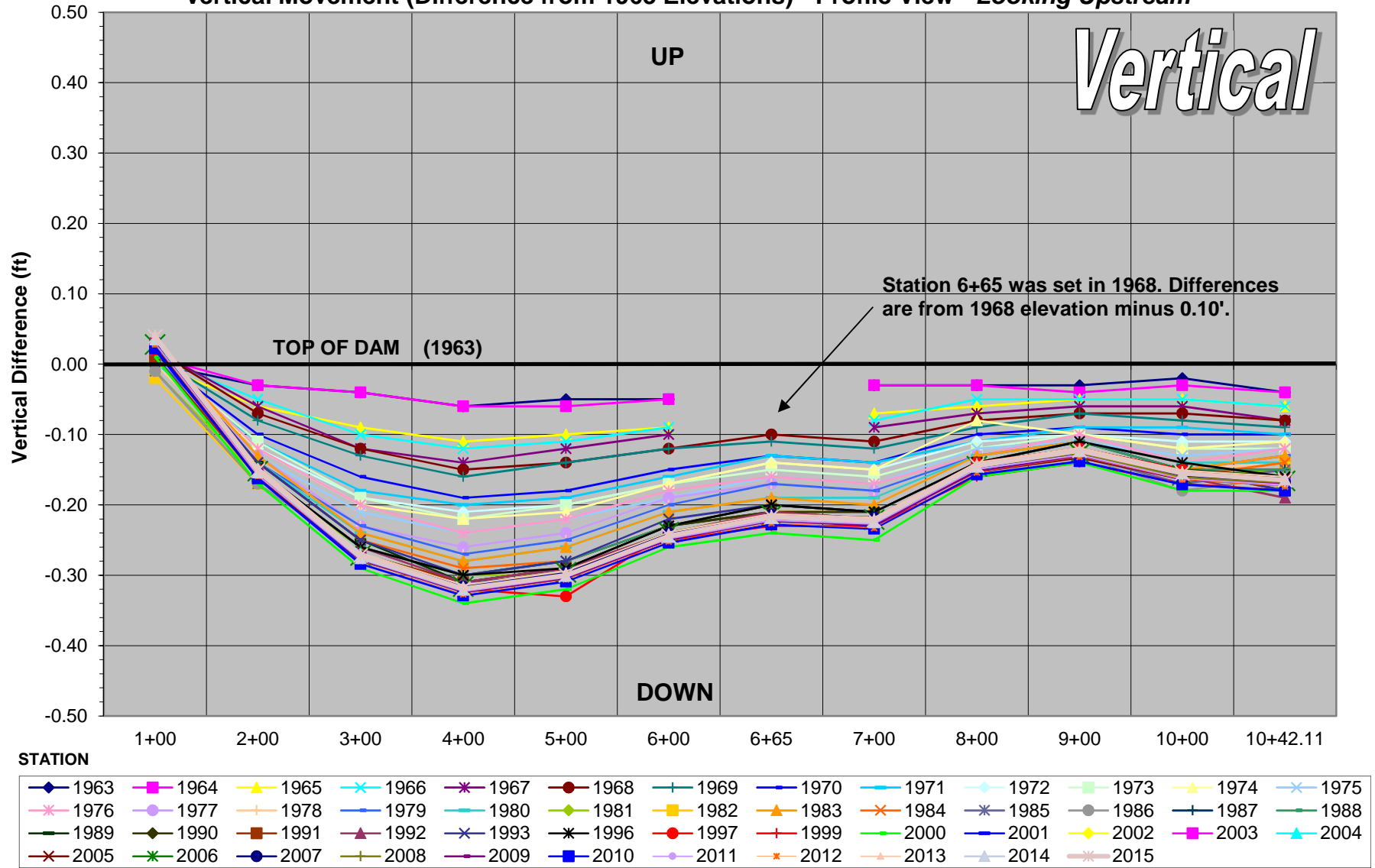


Villa Park (Main) Dam Horizontal Movement Along Dam Axis (Difference from Planned Stationing)

Horizontal



Villa Park (Main) Dam
Vertical Movement (Difference from 1963 Elevations) - Profile View - Looking Upstream



Villa Park Dam - Auxillary Dam

Monitoring Survey

Legend

- Benchmarks
- ▲ Control Stations
- Monitoring Stations



Villa Park Dam (Auxiliary Dam) - Monitoring Survey

The first survey was performed in 1980. This report displays surveys from 1980 to present.

Horizontal displacement is compared to dam survey line. Vertical displacement is compared to 1980 survey.

Chart Details

Horizontal Movement Perpendicular to Dam Axis - shows all data from each year.

Station "100+00" and "VP-19" are held for ***Out From Line*** calculations for station 101+00.

Station "VP-19" and "VP-30" are held for ***Out From Line*** calculations for station 102+00.

Station "VP-30" and "VP-32" are held for ***Out From Line*** calculations for station 104+00 to 112+00.

Positive numbers represent monitored stations to the right of line, (upstream), negative numbers represent monitored stations to the left of line (downstream).

Horizontal Movement Along Dam Axis (difference from planned stationing) - shows all data from each year.

Station "VP-30", VP-32 and "VP-19" are held for ***Along Line*** calculations.

Control point VP-30 and VP-19 are held for stationing calculations.

Positive numbers mean that the distances measured to each station are greater than planned stationing, negative number means less than planned stationing.

Vertical Movement - shows all data from each year.

Vertical differences are calculated comparing the elevation to the "1980 survey" elevation.

Detailed information pertaining to monument descriptions and survey information can be found at OC Survey Division, Geodetic Control Unit.

All values are shown in U.S. Feet.

Horizontal Datum = CCS83, zone VI, 1991.35 Epoch Adjustment

Vertical Datum = NGVD29, OCS 1976 Adjustment

Villa Park Dam (Auxiliary Dam) - Monitoring Survey

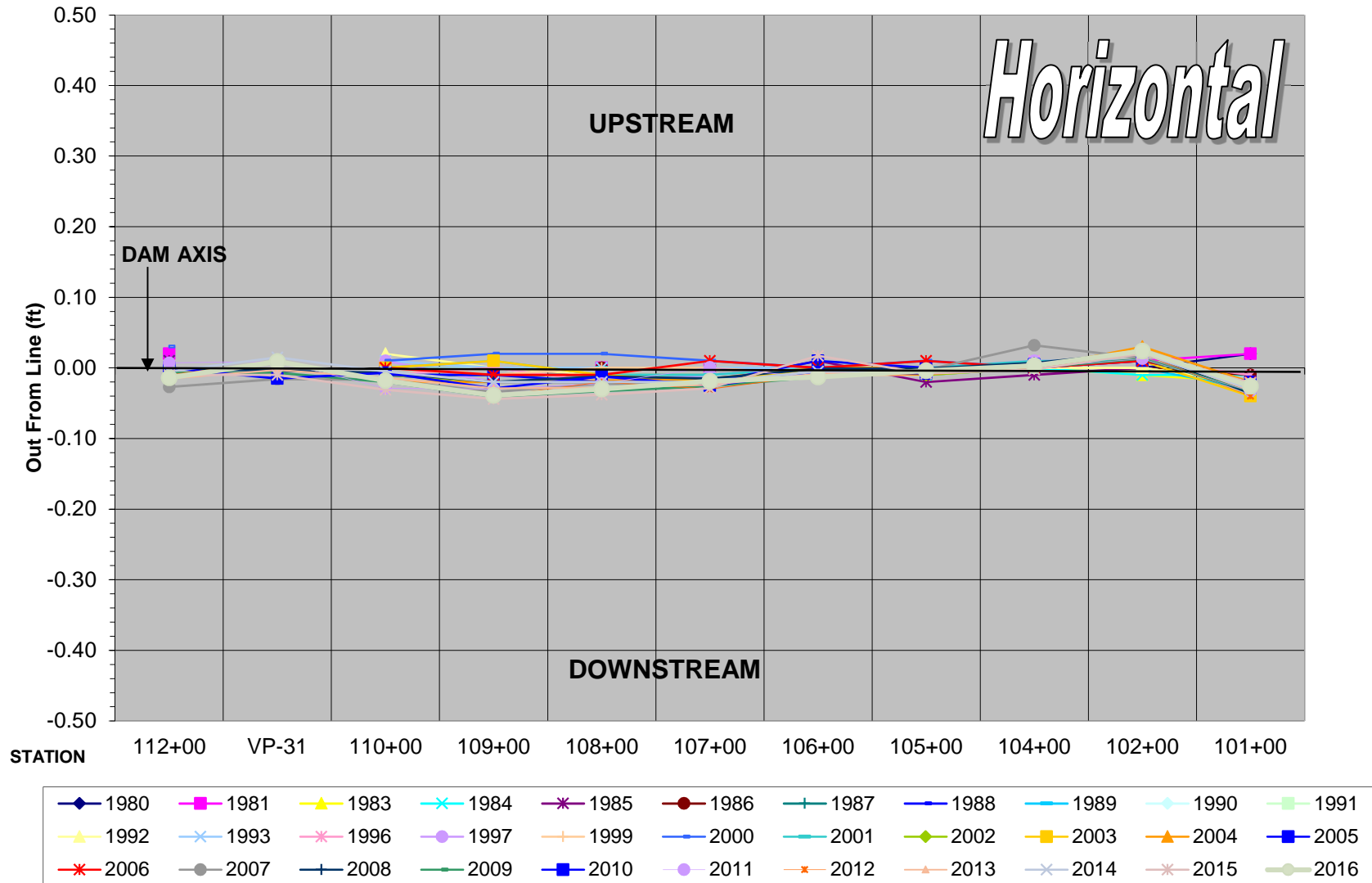
Report Summary

1980-1990	Monuments appear to be stable horizontally and vertically. No significant movement detected.
1991-2000	Monuments continue to be stable horizontally and vertically. No significant movement detected.
2001	No significant movement detected.
2002	No significant movement detected.
2003	No significant movement detected.
2004	No significant movement detected.
2005	No significant movement detected.
2006	No significant movement detected.
2007	No significant movement detected.
2008	No significant movement detected.
2009	No significant movement detected.
2010	No significant movement detected.
2011	No significant movement detected.
2012	No significant movement detected.
2013	No significant movement detected.
2014	No significant movement detected.
2015	No significant movement detected.
2016	100+00 shows subsidence of 0.10'. No significant movement detected.

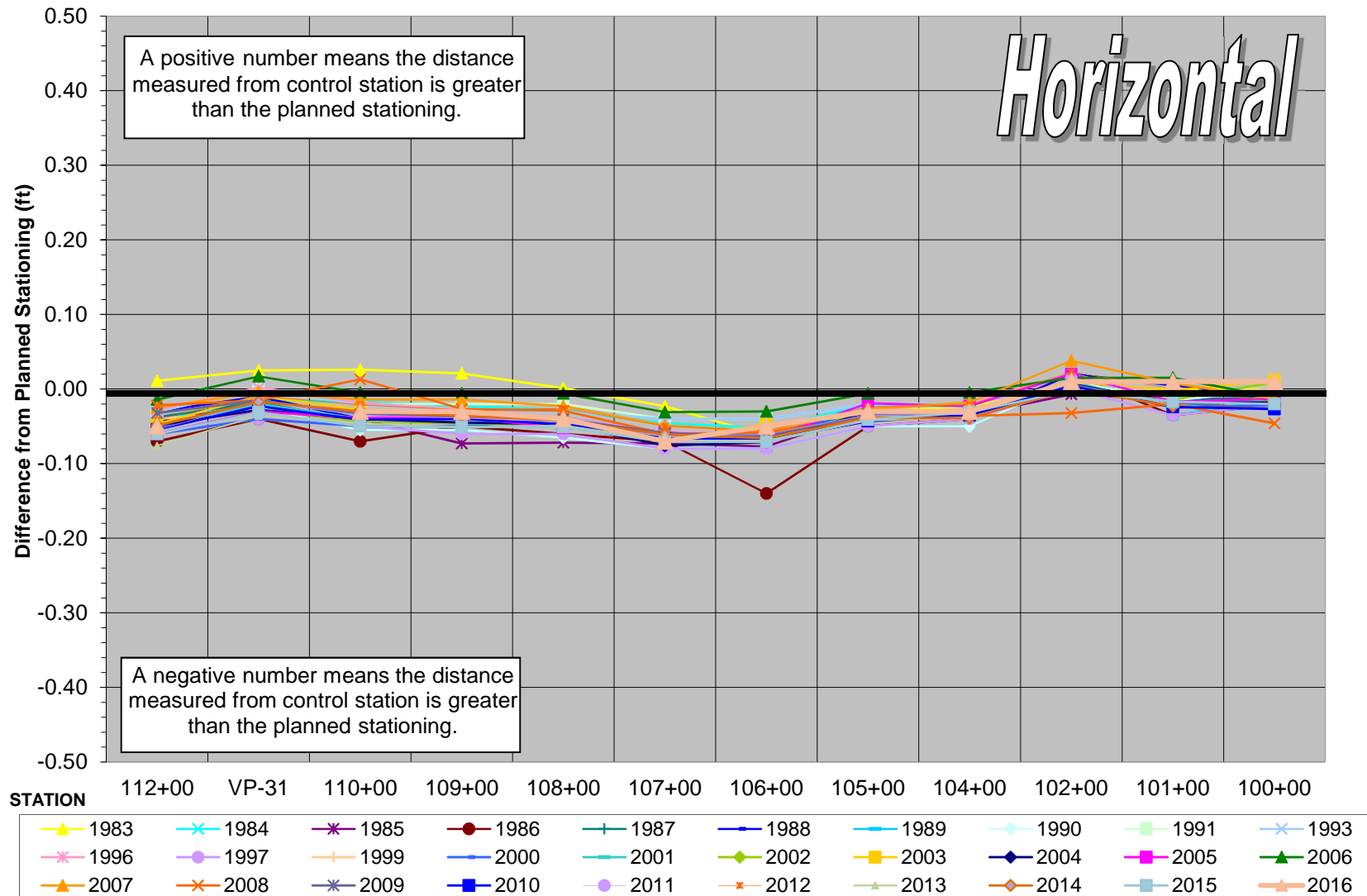
Horizontal Datum = CCS83, zone VI, 1991.35 Epoch Adjustment

Vertical Datum = NGVD29, OCS 1976 Adjustment

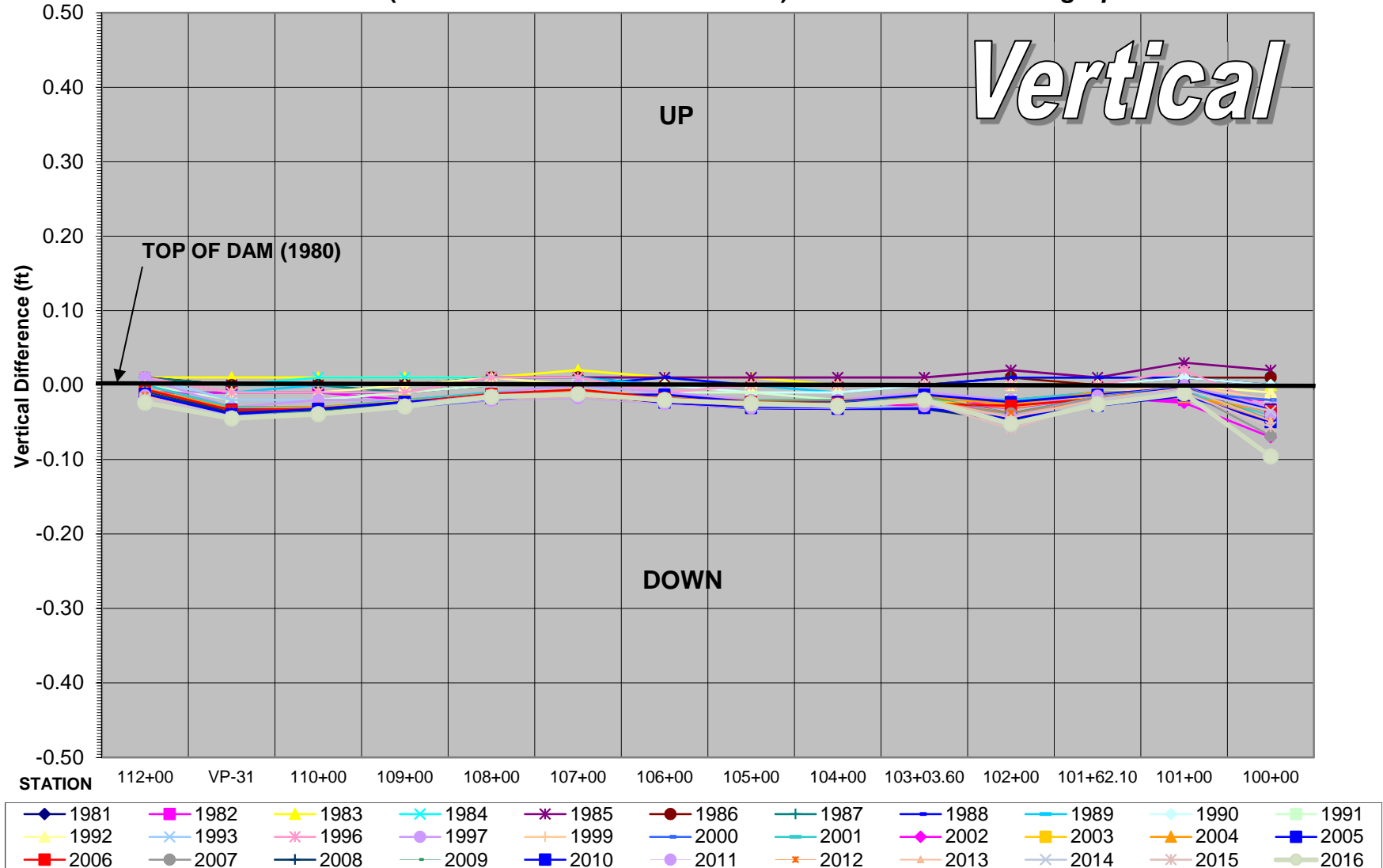
Villa Park (Auxiliary) Dam
Horizontal Movement Perpendicular to Dam Axis (Out From Line) - Plan View



Villa Park (Auxiliary) Dam Horizontal Movement Along Dam Axis (Difference from Planned Stationing)



Vertical Movement (Difference from 1980 Elevations) - Profile View - Looking Upstream



Villa Park Dam - Outlet Structure

Monitoring Survey

Legend

- ▣ Benchmarks
- △ Control Stations
- Monitoring Stations

1039 (VP-16B) △

VP-BM-2 ▣ 4+64.5

4+00 ●

3+00 ●

△ 1588 (6+65)

2+00 ●

1+00 ●

0+20 ●

Google earth

© 2016 Google



400 ft

Villa Park Dam (Outlet Structure) - Monitoring Survey

The first vertical survey was performed in 1964 and the first horizontal survey in 1965. This report displays all surveys from 1964 to present. Horizontal displacement is compared to dam survey line, vertical displacement is compared to 1964 survey.

Chart Details

Horizontal Movement Perpendicular to Tunnel Axis - shows all data from each year.

Stations "VP16, VP16A, and VP16B" and "6+65" are held for ***Out From Line*** calculations. "VP-16B" was set in place of "VP-16A" in 2000 due to the instability of the ground around the monument. All ***Out From Line*** calculations will be done from "VP-16B" and "Main Dam 6+65" after 1999.

Positive numbers represent monitored stations to the right of line (northeasterly), negative numbers represent monitored stations to the left of line (southwesterly).

Horizontal Movement Along Dam Axis (difference from planned stationing) - shows all data from each year.

Control point VP-16A / VP-16B is held for stationing calculations.

Positive numbers mean that the distances measured to each station are greater than planned stationing, negative number means less than planned stationing.

Vertical Movement - shows all data from each year.

Vertical differences are calculated comparing the elevation to the "1964 survey" elevation.

Detailed information pertaining to monument descriptions and survey information can be found at OC Survey Divison, Geodetic Control Unit.

All values are shown in U.S. Feet.

Horizontal Datum = CCS83, zone VI, 1991.35 Epoch Adjustment

Vertical Datum = NGVD29, OCS 1976 Adjustment

Villa Park Dam (Outlet Structure) - Monitoring Survey

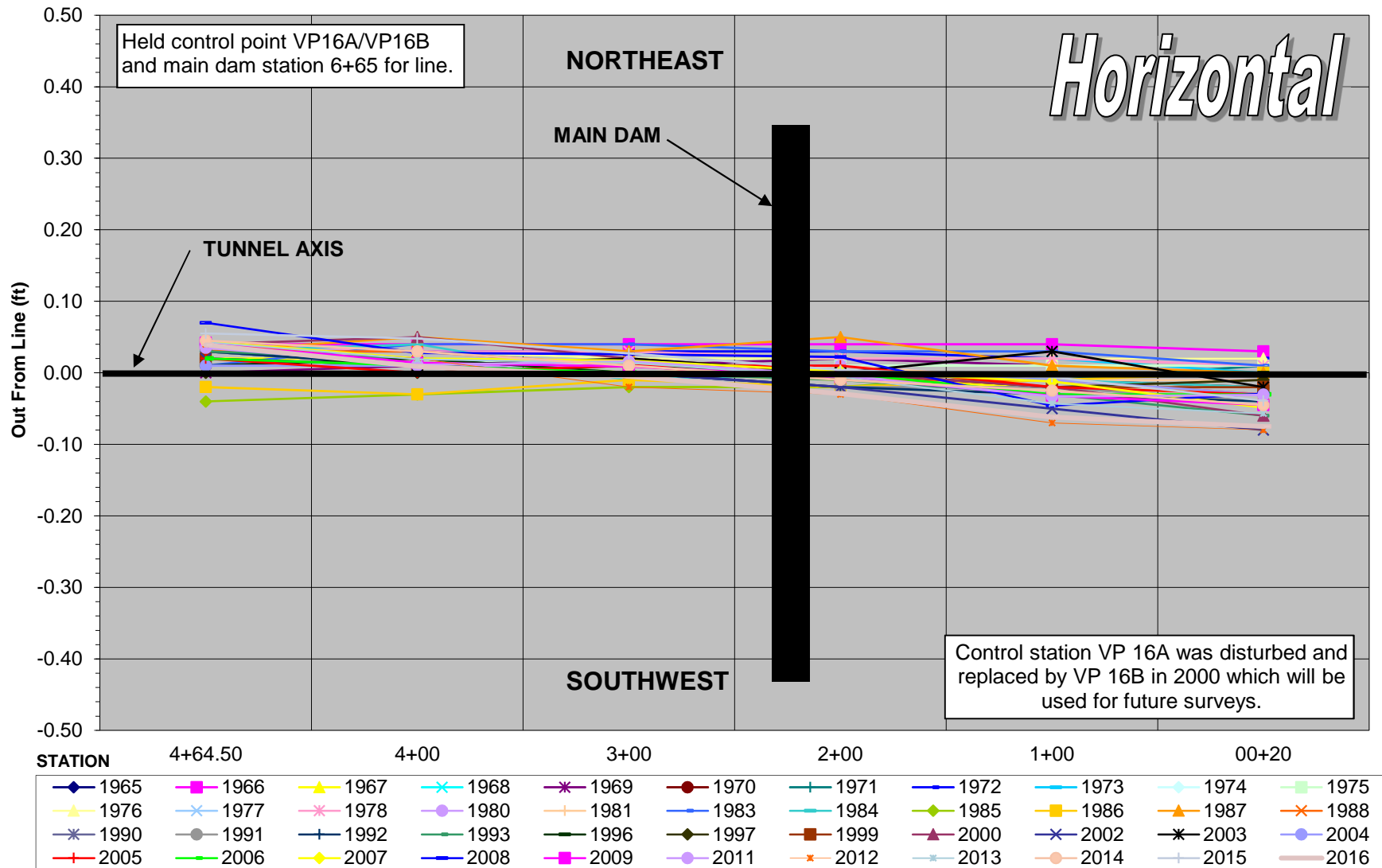
Report Summary

1964-1984	Horizontally stable. Vertical subsidence occurs due to settling of dam
1985-1999	Horizontally stable. Vertical subsidence seems to stop. No significant movement detected.
2000	Horizontal chart differs from previous surveys due to change in control stations. Vertical appears stable. No significant movement detected.
2001	No survey performed due to excessive water in tunnel.
2002	No significant movement detected.
2003	No significant movement detected.
2004	No significant movement detected.
2005	No significant movement detected.
2006	No significant movement detected.
2007	No significant movement detected.
2008	No significant movement detected.
2009	No significant movement detected.
2010	VP Tunnel not monitored. GPS Point #1039 (VP-16B) was underwater; point is unusable until the water is drained from this area.
2011	No significant movement detected.
2012	No significant movement detected.
2013	No significant movement detected.
2014	No significant movement detected.
2015	No significant movement detected.
2016	No significant movement detected.

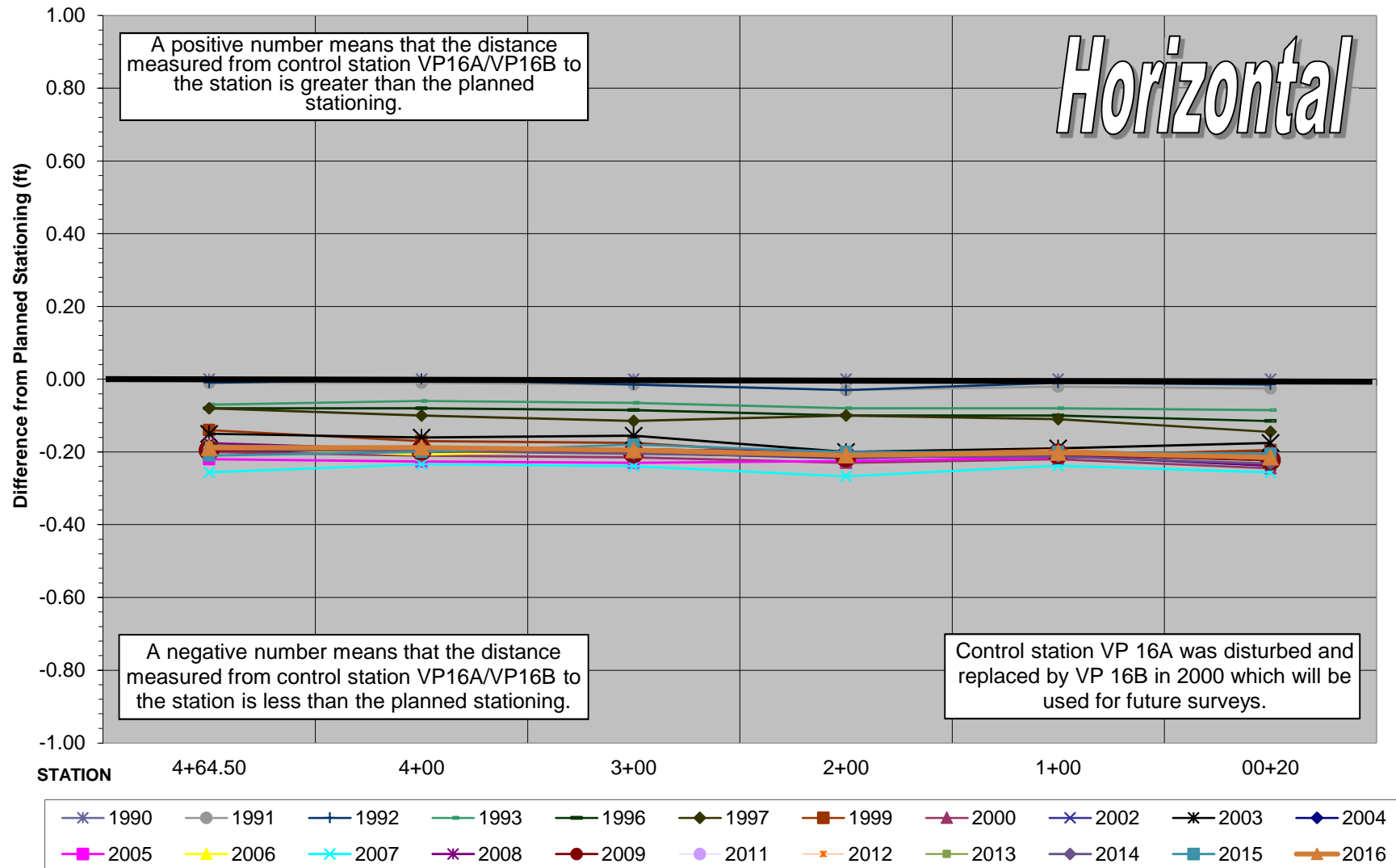
Horizontal Datum = CCS83, zone VI, 1991.35 Epoch Adjustment

Vertical Datum = NGVD29, OCS 1976 Adjustment

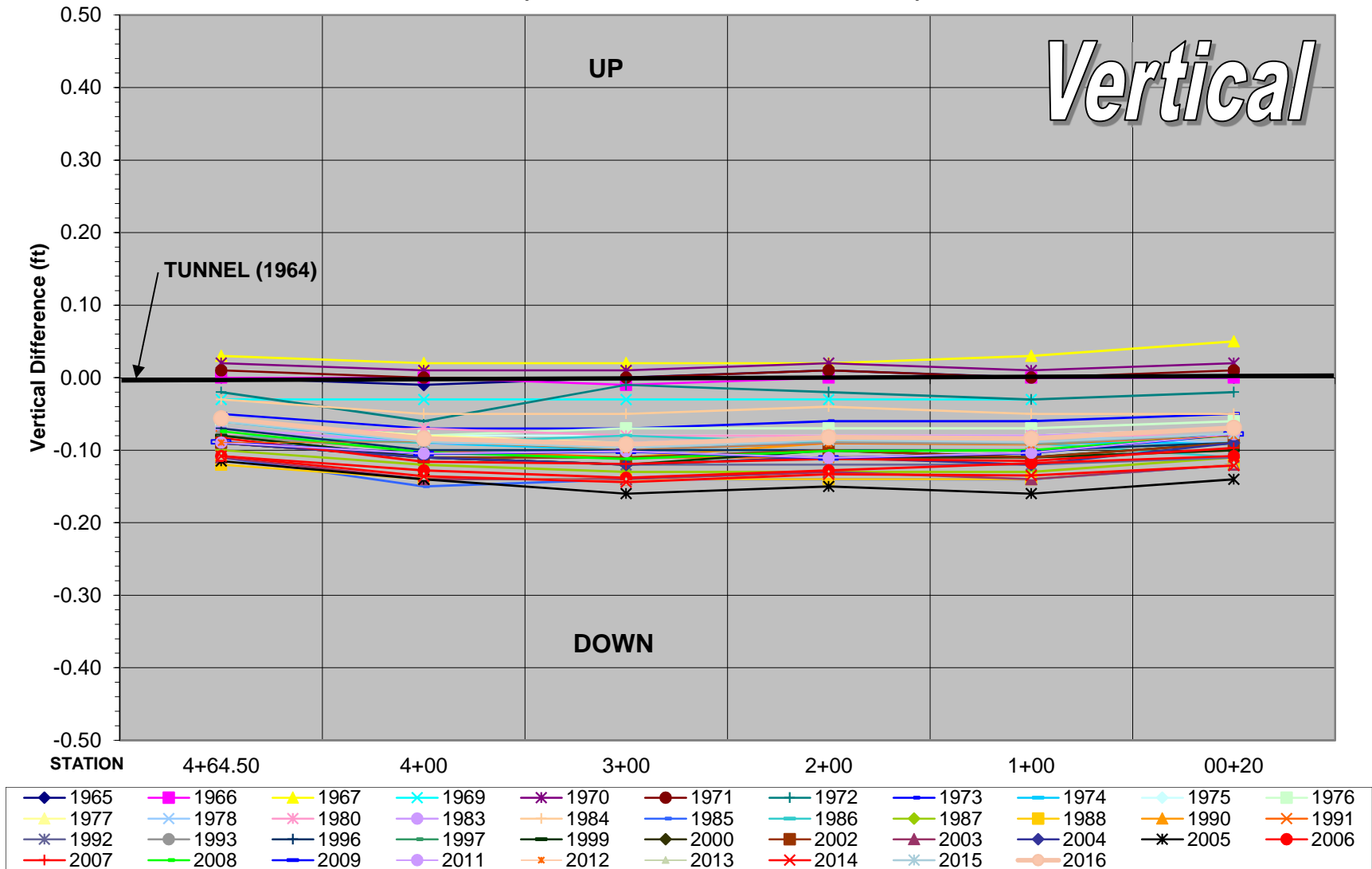
Villa Park (Outlet) Dam Horizontal Movement Perpendicular to Tunnel Axis (Out From Line) - Plan View



Horizontal



Villa Park (Outlet) Dam
Vertical Movement (Difference from 1964 Elevations) - Profile View



2

PETERS CANYON DAM

Peters Canyon Dam

Monitoring Survey

Legend

- ▲ Control Stations
- Benchmarks
- Monitoring Stations



Google earth

© 2016 Google

700 ft



Peters Canyon Dam (F06D01) Monitoring Survey

This earthen dam was built in 1932. The first surveyed was performed in 1996 and is used as the "benchmark" for all future surveys.

Chart Details

Horizontal Movement Perpendicular to Dam Axis - shows all data from each year.

Control points # 1 and # 2 are held for ***Out From Line*** calculations.

Positive numbers represent stations right of line (upstream), negative numbers represent stations left of line (downstream).

Horizontal Movement Along Dam Axis (difference from planned stationing) - shows all data from each year.

Control point # 1 is held for stationing calculations.

Positive numbers mean that the distances measured to each station are greater than planned stationing, negative number means less than planned stationing.

Vertical Movement - shows all data from each year.

Vertical differences are calculated comparing each elevation to the "1996 survey" elevation.

Detailed information pertaining to monument descriptions and survey information can be found at OC Survey Division, Geodetic Control Unit.

All values are shown in U.S. Survey feet. Station name is shown in meters.

Horizontal Datum = CCS83, zone VI, 1991.35 Epoch Adjustment

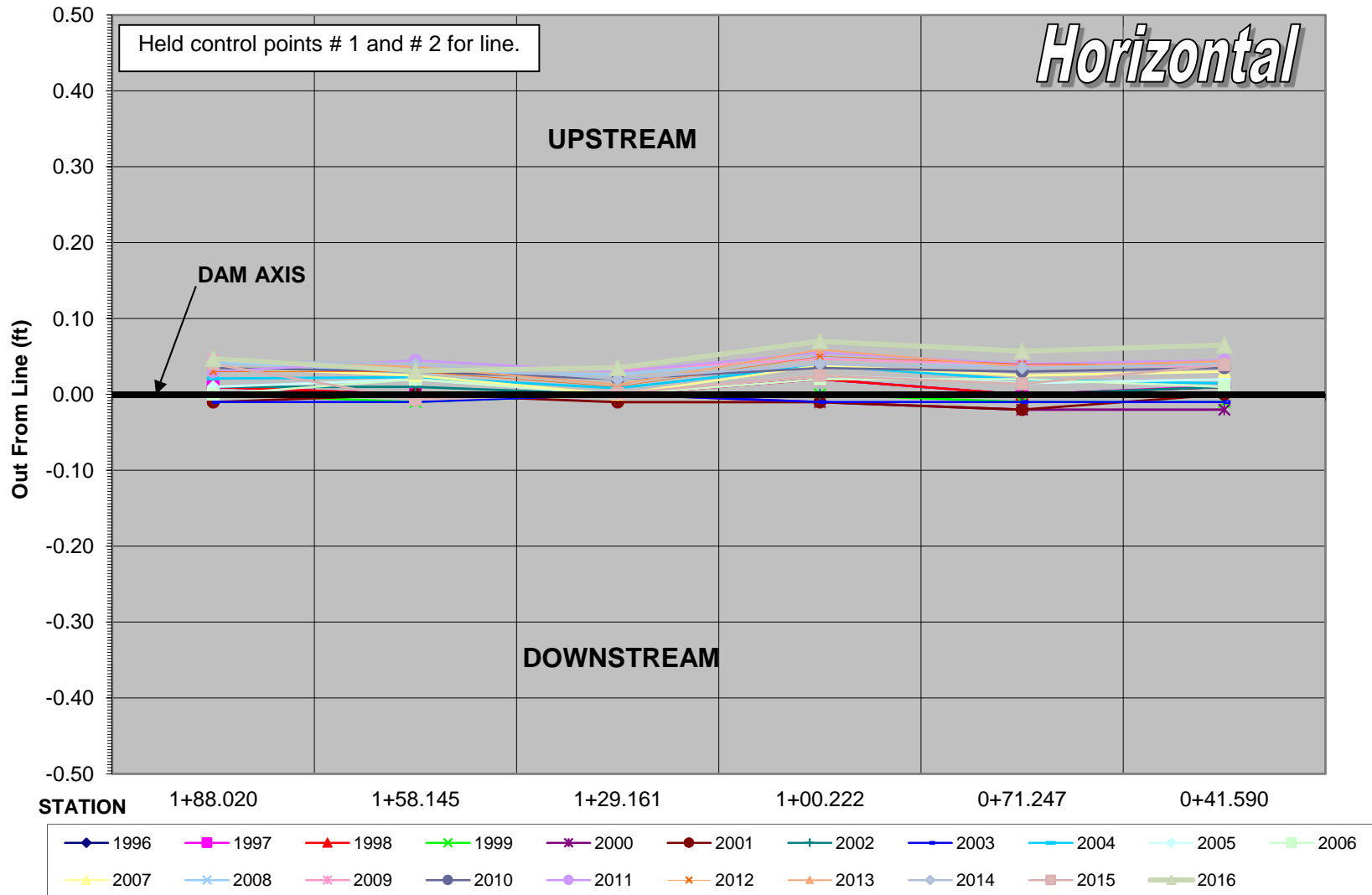
Vertical Datum = NAVD88, OCS 1995 Adjustment

Peters Canyon Dam (F06D01) Monitoring Survey

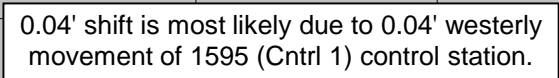
Report Summary

1996	Initial survey performed
1997	No significant movement detected, all monuments appear stable.
1998	No significant movement detected, all monuments appear stable.
1999	No significant movement detected, all monuments appear stable.
2000	No significant movement detected, all monuments appear stable.
2001	No significant movement detected, all monuments appear stable.
2002	No significant movement detected, all monuments appear stable.
2003	No significant movement detected, all monuments appear stable.
2004	No significant movement detected, all monuments appear stable.
2005	No significant movement detected, all monuments appear stable.
2006	No significant movement detected, all monuments appear stable.
2007	No significant movement detected, all monuments appear stable.
2008	No significant movement detected, all monuments appear stable.
2009	No significant movement detected, all monuments appear stable.
2010	No significant movement detected, all monuments appear stable.
2011	No significant movement detected, all monuments appear stable.
2012	No significant movement detected, all monuments appear stable.
2013	No significant movement detected, all monuments appear stable.
2014	No significant movement detected, all monuments appear stable.
2015	No significant movement detected, all monuments appear stable.
2016	1595 (Cntrl 1) appears to have moved westerly 0.04' which displaces the "Difference from Planned Stationing" chart. All dam monuments appear stable.

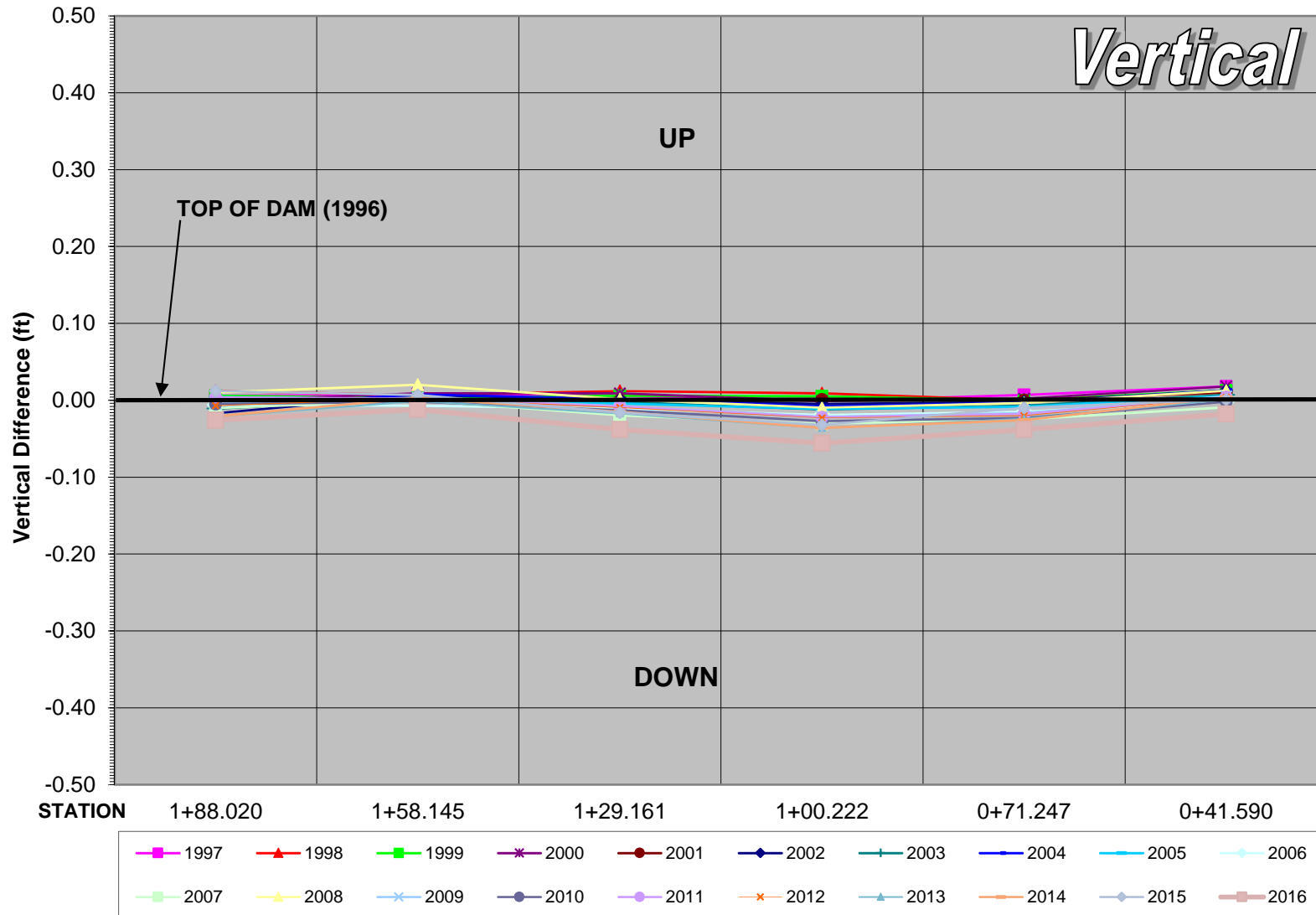
Peters Canyon Dam Horizontal Movement Perpendicular to Dam Axis (Out From Line) - Plan View



Horizontal



Peters Canyon Dam
Vertical Movement (Difference from 1996 Elevations) - Profile View - *Looking Upstream*



3

LOWER PETERS CANYON DAM

Lower Peters Canyon Dam

Monitoring Survey

Legend

- Benchmarks
- Monitoring Stations

3A-127-05

2226

2225

2231

2230

2228

2229

2227

Google earth

© 2016 Google

300 ft



Lower Peters Canyon Dam (F06D02) Monitoring Survey

9/9/2015

Seven survey monuments were set along the top of levee in 1990. The 2004 survey will be used as the "benchmark" for all future surveys.

Chart Details

Seven monuments were three-dimensionally positioned utilizing GPS Static survey techniques. Because of the layout of the monuments, horizontal comparisons will be shown as differences in the northing and easting, instead of the station and offset method.

Vertical differences are calculated comparing the elevation to the "2004 survey" elevation.

Detailed information pertaining to monument descriptions and survey information can be found at OC Survey Division, Geodetic Control Unit.

All values are shown in U.S. Survey feet.

Lower Peters Canyon Dam (F06D02) Monitoring Survey

9/9/2015

Report Summary

2004 Initial survey performed.

2005 No significant movement detected.

2006 No significant movement detected.

2009 No significant movement detected.

2012 No significant movement detected. There is some vertical movement of benchmarks to watch in the future.

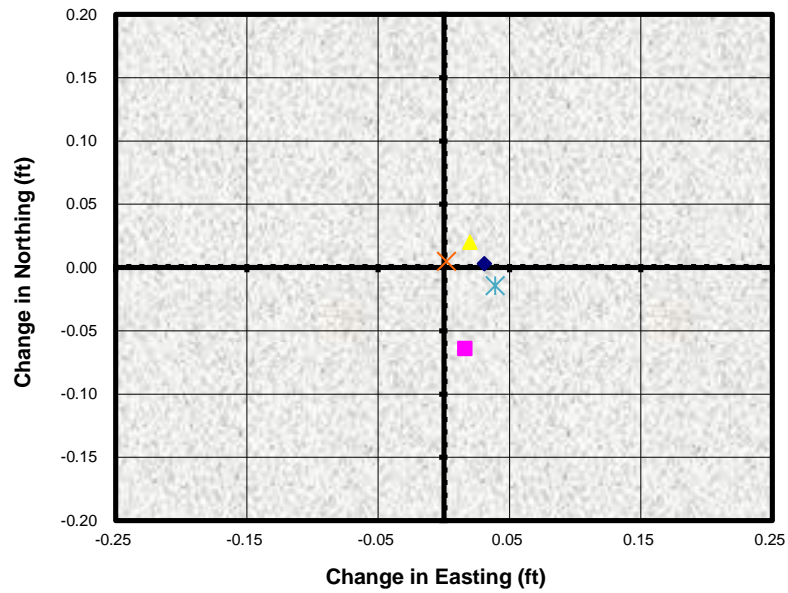
2015 No significant movement detected. Possible settling of #2230.

2018

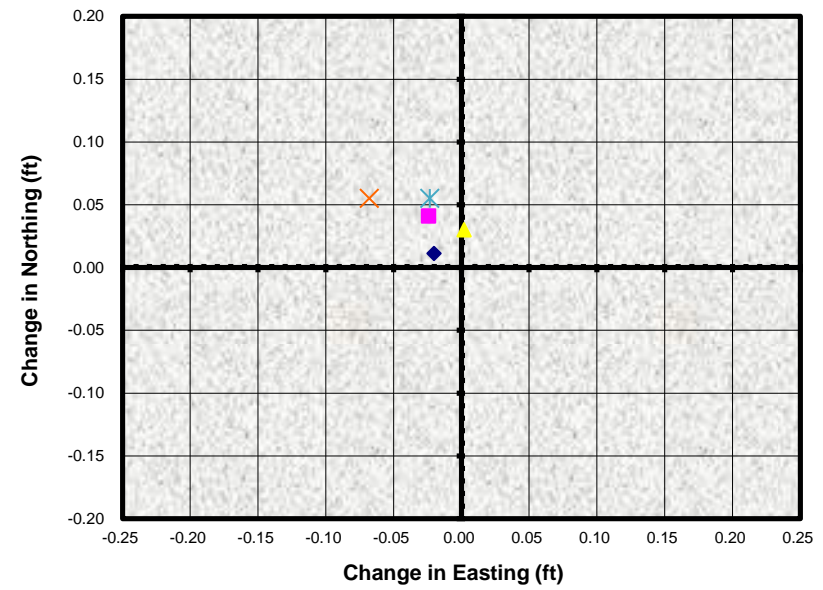
2021

Lower Peters Canyon Dam - (Horizontal) Horizontal Movement since 2004 Initial Survey

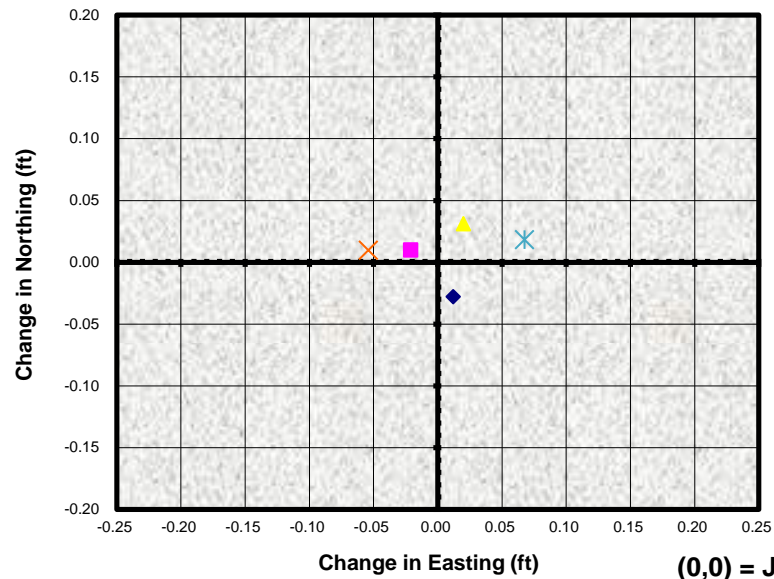
GPS 2225 (#1)



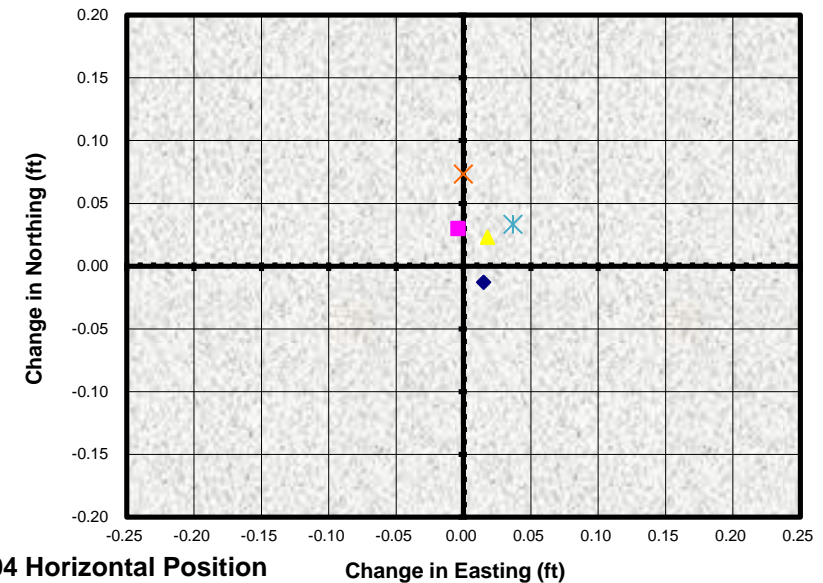
GPS 2226 (#2)



GPS 2227 (#3)



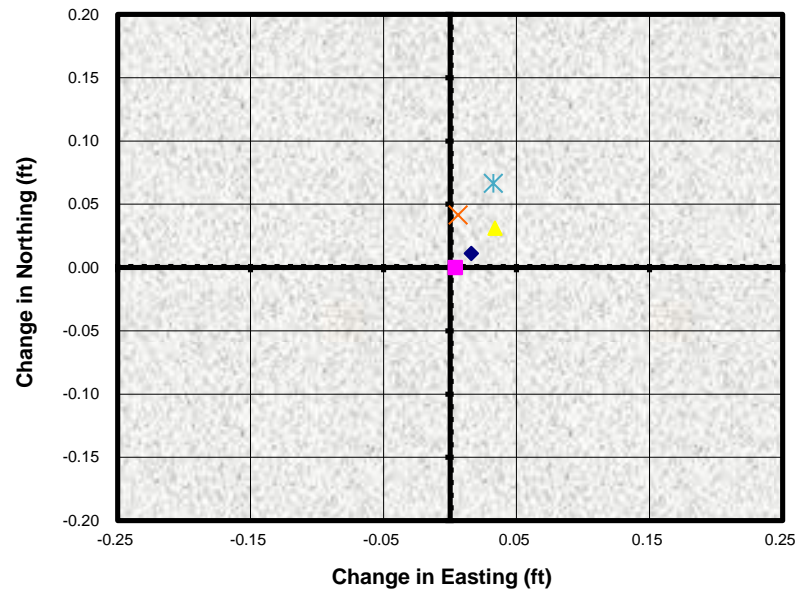
GPS 2228 (#4)



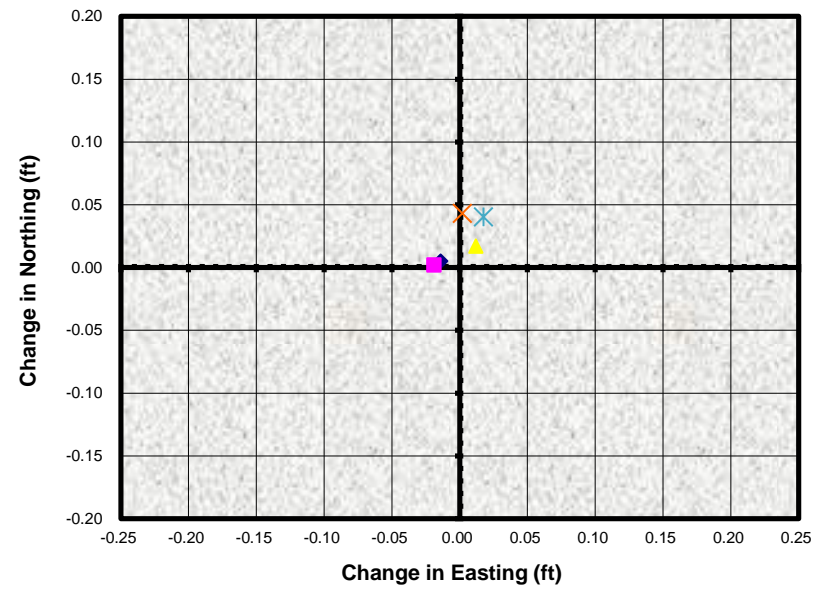
(0,0) = January 2004 Horizontal Position

Lower Peters Canyon Dam - (Horizontal) Horizontal Movement since 2004 Initial Survey

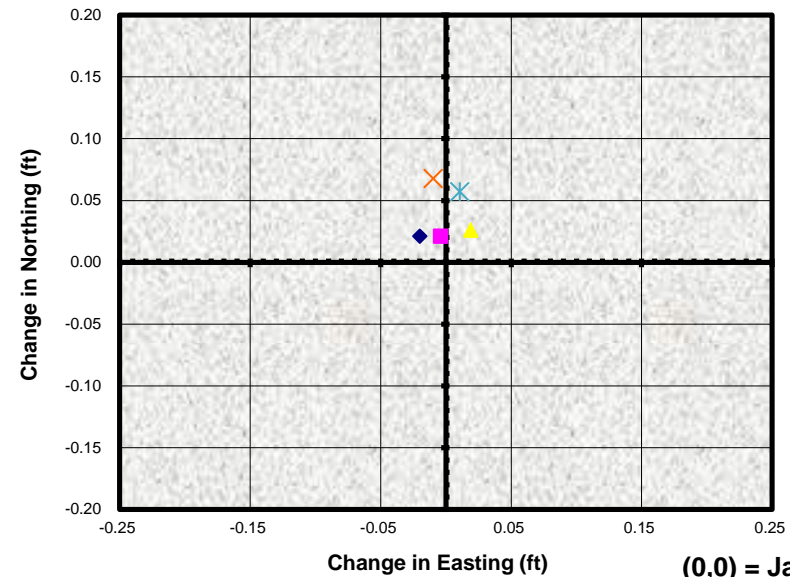
GPS 2229 (#5)



GPS 2230 (#6)

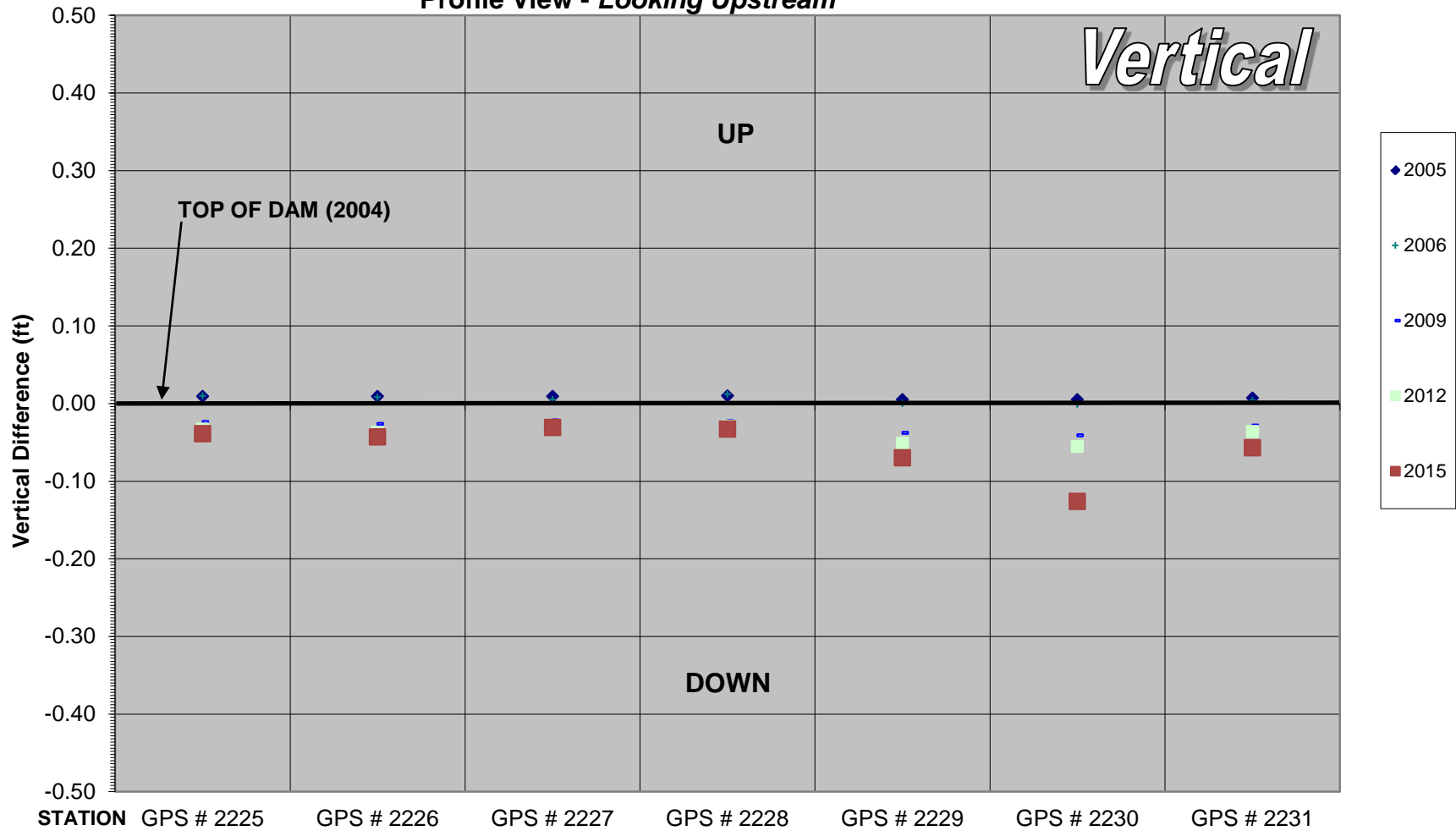


GPS 2231 (#7)



(0,0) = January 2004 Horizontal Position

Lower Peters Canyon Dam
Vertical Movement (Orthometric Height Difference from 2004 Elevations)
Profile View - Looking Upstream



4

MARSHBURN RETARDING BASIN

Marshburn Retarding Basin

Monitoring Survey

Legend

- Benchmarks
- Monitoring Stations



Marshburn Retarding Basin (F16B01) Monitoring Survey

Six survey monuments were set along the top of levee in 2001. This survey will be used as the "benchmark" for all future surveys.

Chart Details

Six monuments were three-dimensionally positioned utilizing GPS Static survey techniques. Because of the layout of the monuments, horizontal comparisons will be shown as differences in the northing and easting, instead of the station and offset method.

Vertical differences are calculated comparing the elevation to the "2001 survey" elevation.

Detailed information pertaining to monument descriptions and survey information can be found at OC Survey Division, Geodetic Control Unit.

All values are shown in U.S. Survey feet.

Horizontal Datum = CCS83, zone VI, 1991.35 Epoch Adjustment
Vertical Datum = NAVD88, OCS 1995 Adjustment

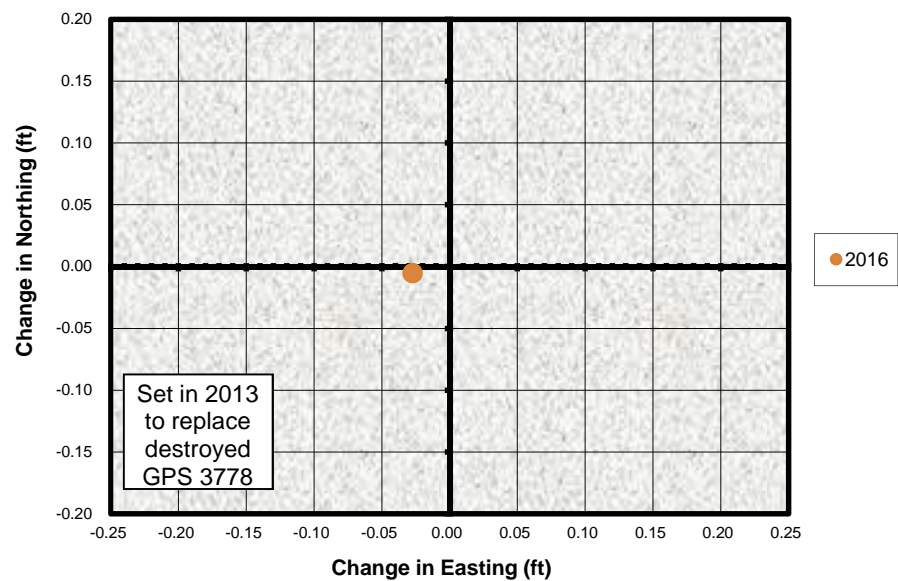
Marshburn Retarding Basin (F16B01) Monitoring Survey

Report Summary

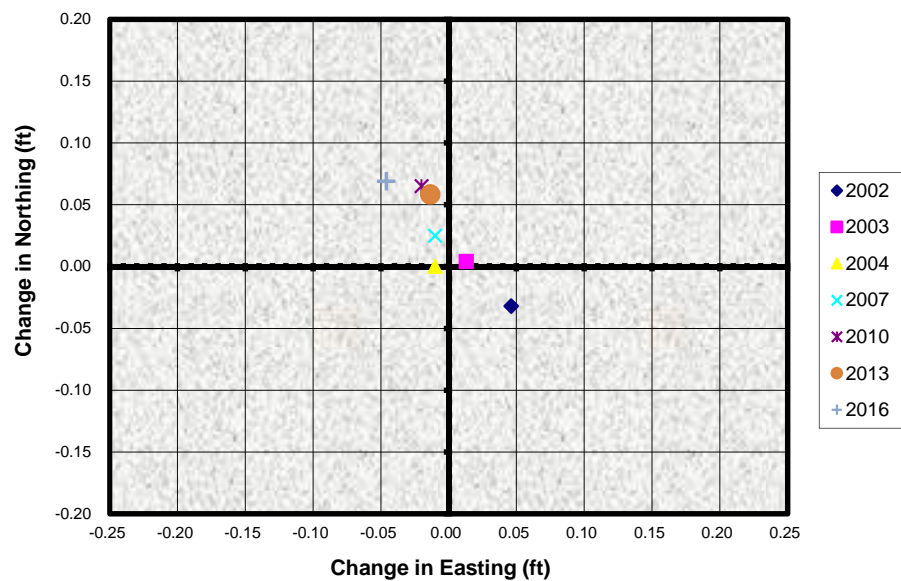
- 2001** Initial survey performed.
- 2002** No significant movement detected.
- 2003** No significant movement detected.
- 2004** No significant movement detected.
- 2007** GPS 3779, 3780 & 3781 have moved vertically -0.05' to -0.08' +/- from 2004 survey. GPS #3778 was destroyed.
- 2010** GPS 3779, 3780 & 3781 have moved vertically -0.02' +/- from 2007 survey.
- 2013** Set GPS #3766 to replace GPS #3778. No significant movement detected.
- 2016** No significant movement detected.
- 2019**
- 2022**
- 2025**

Marshburn Retarding Basin - (Horizontal) Horizontal Movement since 2001 Initial Survey

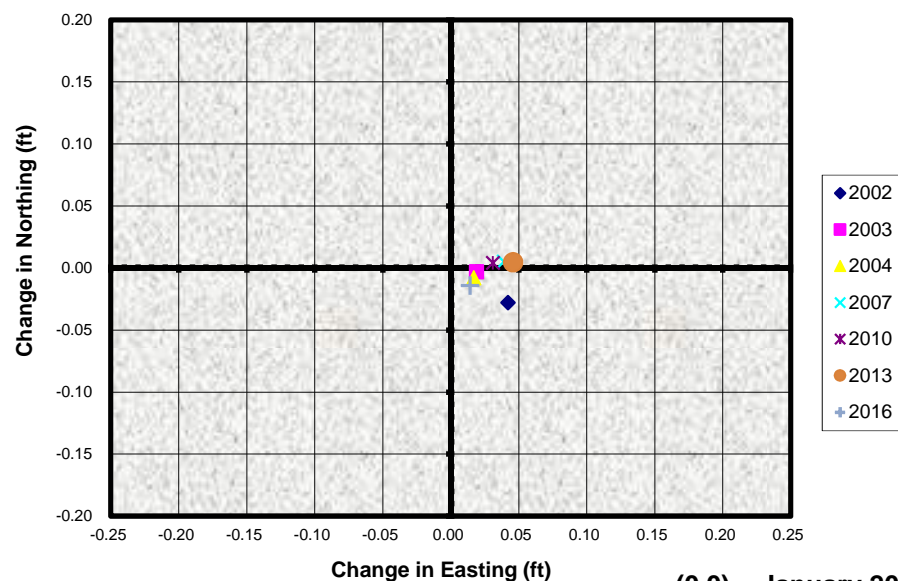
GPS 3766



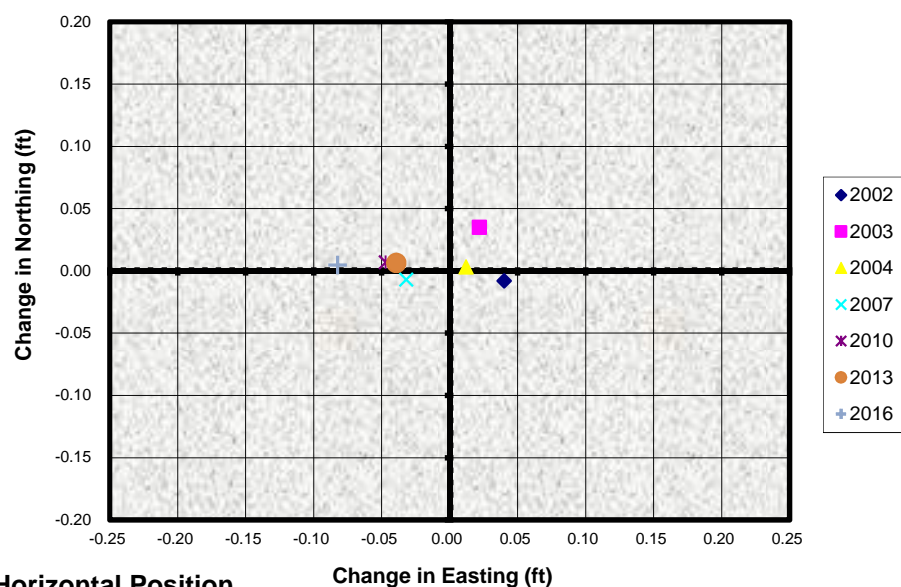
GPS 3779



GPS 3780



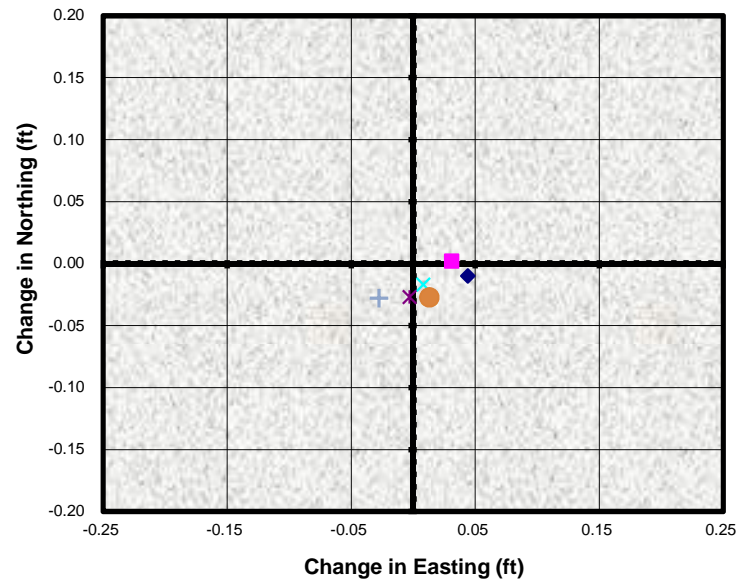
GPS 3781



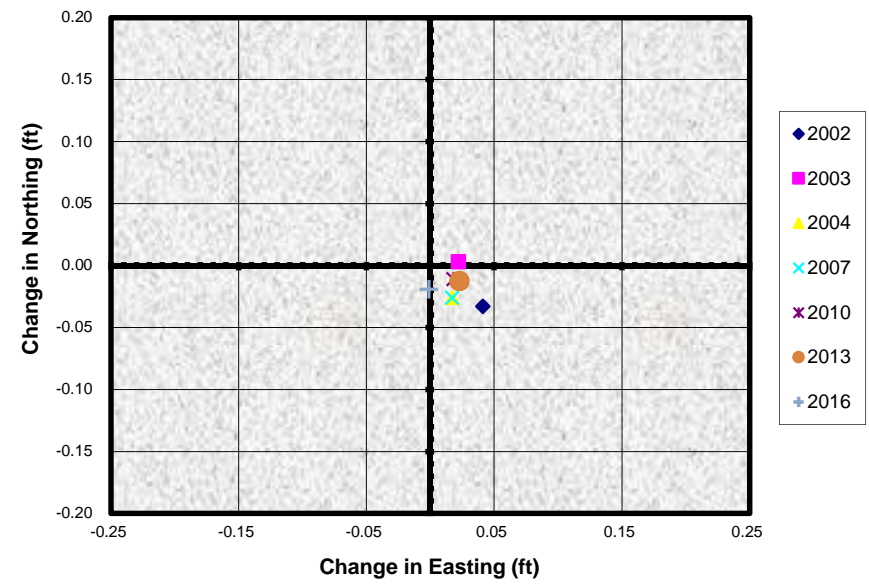
(0,0) = January 2001 Horizontal Position

Marshburn Retarding Basin - (Horizontal)
Horizontal Movement since 2001 Initial Survey

GPS 3782

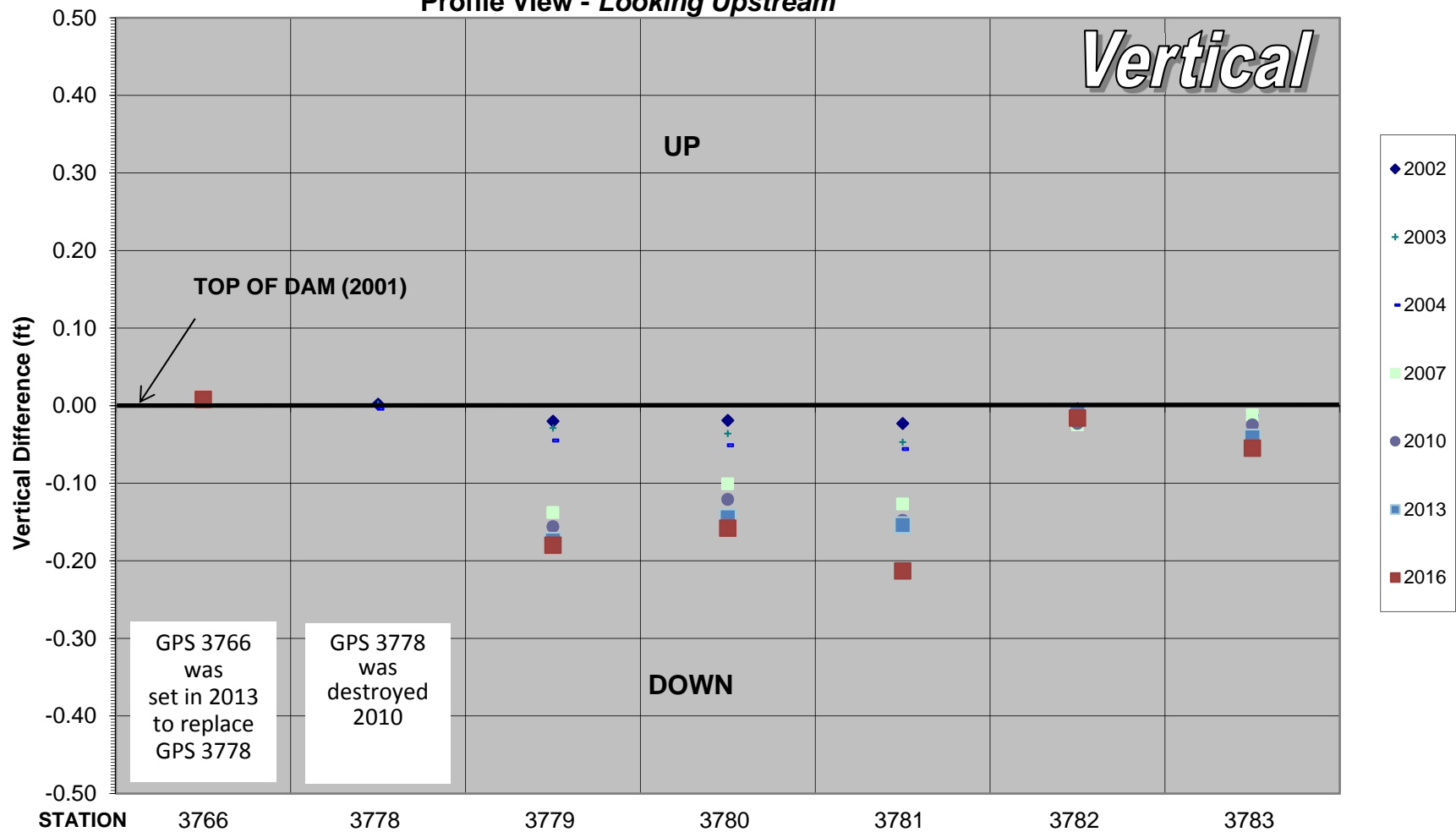


GPS 3783



(0,0) = January 2001 Horizontal Position

Marshburn Retarding Basin
Vertical Movement (Orthometric Height Difference from 2001 Elevations)
Profile View - Looking Upstream



5

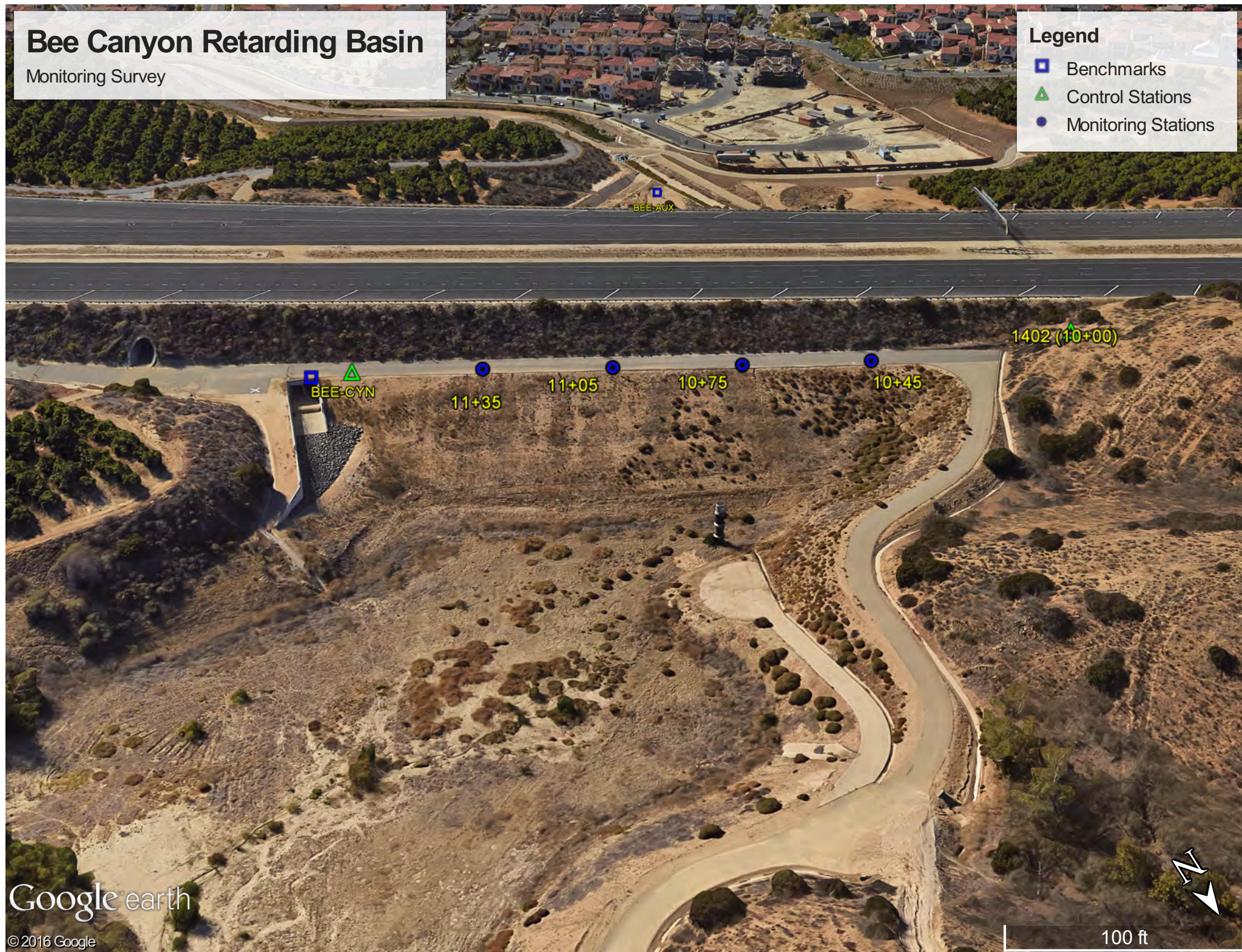
BEE CANYON RETARDING BASIN

Bee Canyon Retarding Basin

Monitoring Survey

Legend

- Benchmarks
- ▲ Control Stations
- Monitoring Stations



Google earth

© 2016 Google

100 ft

Bee Canyon Retarding Basin (F16B02) Monitoring Survey

This earthen dam was built in 1995. The first surveyed was performed in 1995 and is used as the "benchmark" for all future surveys.

Chart Details

Horizontal Movement Perpendicular to Dam Axis - shows all data from each year.

Stations 10+00 and 11+65 are held for ***Out From Line*** calculations.

Positive numbers represent stations left of line (upstream), negative numbers represent stations right of line (downstream).

Horizontal Movement Along Dam Axis (difference from planned stationing) - shows all data from each year.

Station 10+00 is held for stationing calculations.

Positive numbers mean that the distances measured to each station are greater than planned stationing, negative number means less than planned stationing.

Vertical Movement - shows all data from each year.

Vertical differences are calculated comparing the elevation to the "1995 survey" elevation.

Detailed information pertaining to monument descriptions and survey information can be found at OC Survey Division, Geodetic Control Unit.

All values shown are in U.S. Survey feet. Station names are in meters.

Horizontal Datum = CCS83, zone VI, 1991.35 Epoch Adjustment

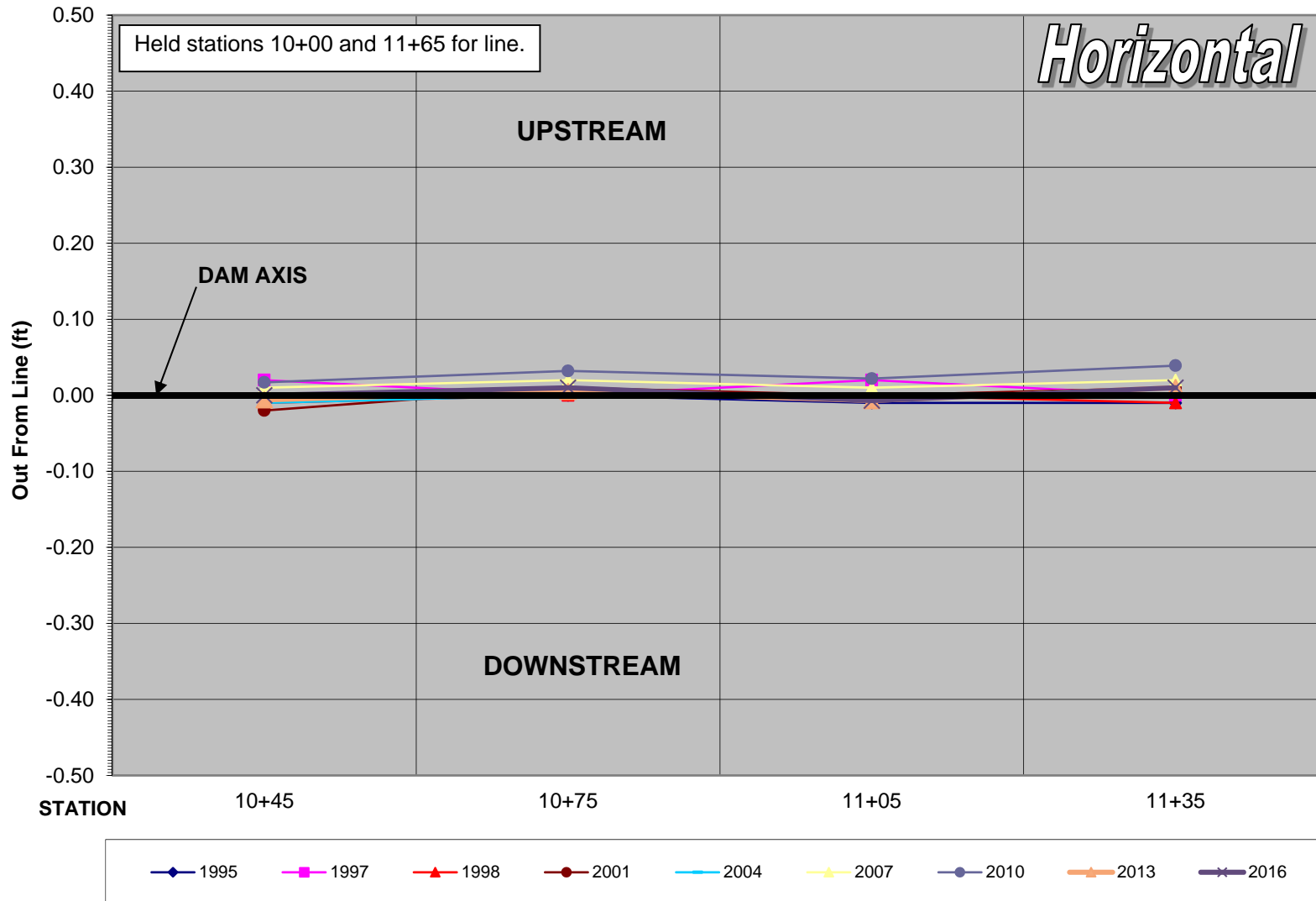
Vertical Datum = NAVD88, OCS 1995 Adjustment

Bee Canyon Retarding Basin (F16B02) Monitoring Survey

Report Summary

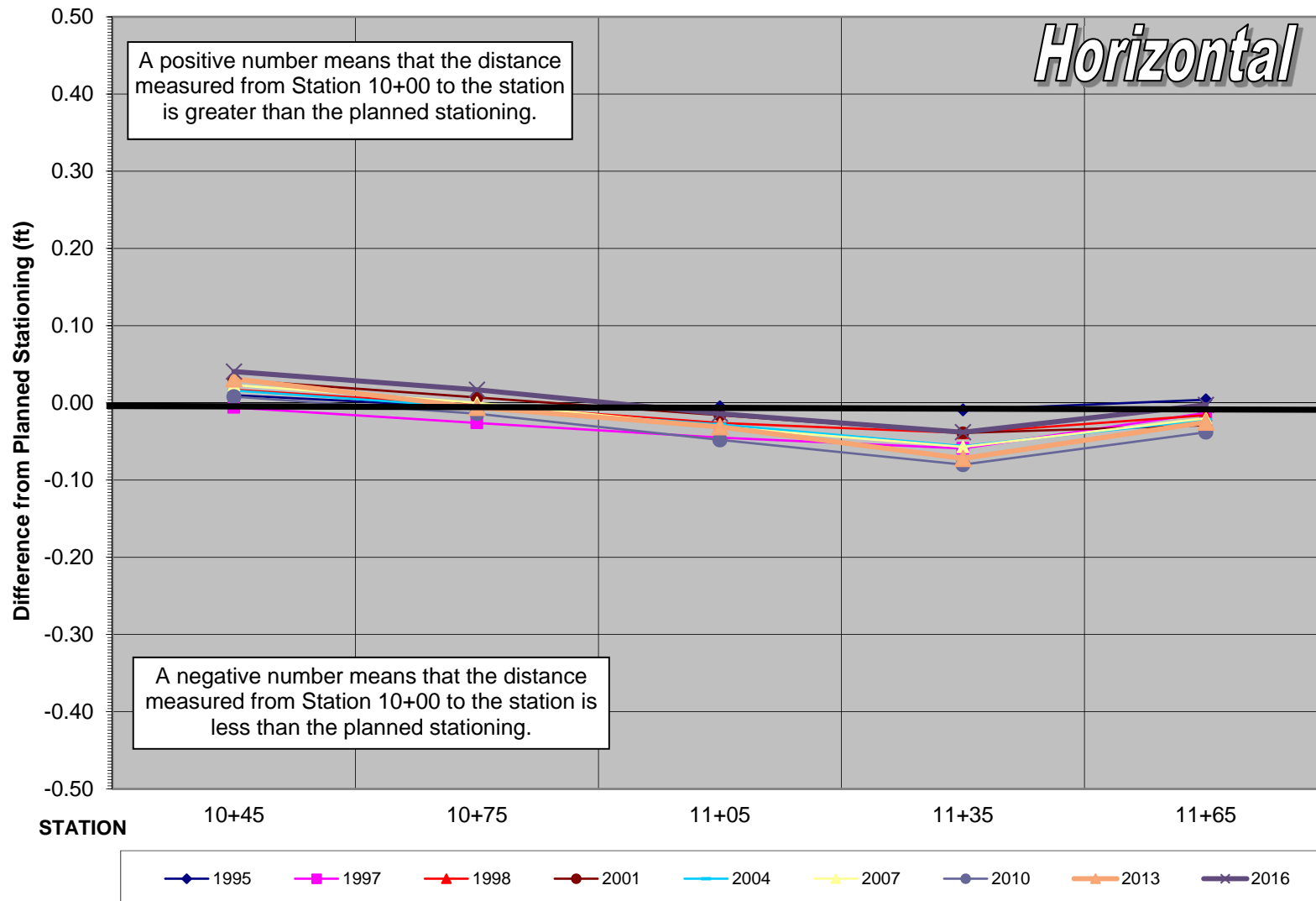
1995	Initial survey performed
1996	No survey performed
1997	Stations 10+75 and 11+05 subside approximately 0.07 feet. 11+35 subsides 0.04 feet. This could be due to settlement of the dam.
1998	Elevations for stations 10+75, 11+05, and 11+35 agree with the 1997 elevations within 0.01 ft. The 1997 movement seems to have stopped which was probably due to settlement of the earthen dam. Construction has been continual for the last two years for the Foothill Transportation Corridor which abutts up against the downstream side of the dam.
2001	No significant movement detected. Vertical subsidence trend continues.
2004	No significant movement detected.
2007	No significant movement detected.
2010	No significant movement detected. Corrected data errors discovered in the "Horizontal Movement Perpendicular to Dam Axis" for 2007.
2013	No significant movement detected.
2016	No significant movement detected.
2019	

Bee Canyon Dam
Horizontal Movement Perpendicular to Dam Axis (Out From Line) - Plan View

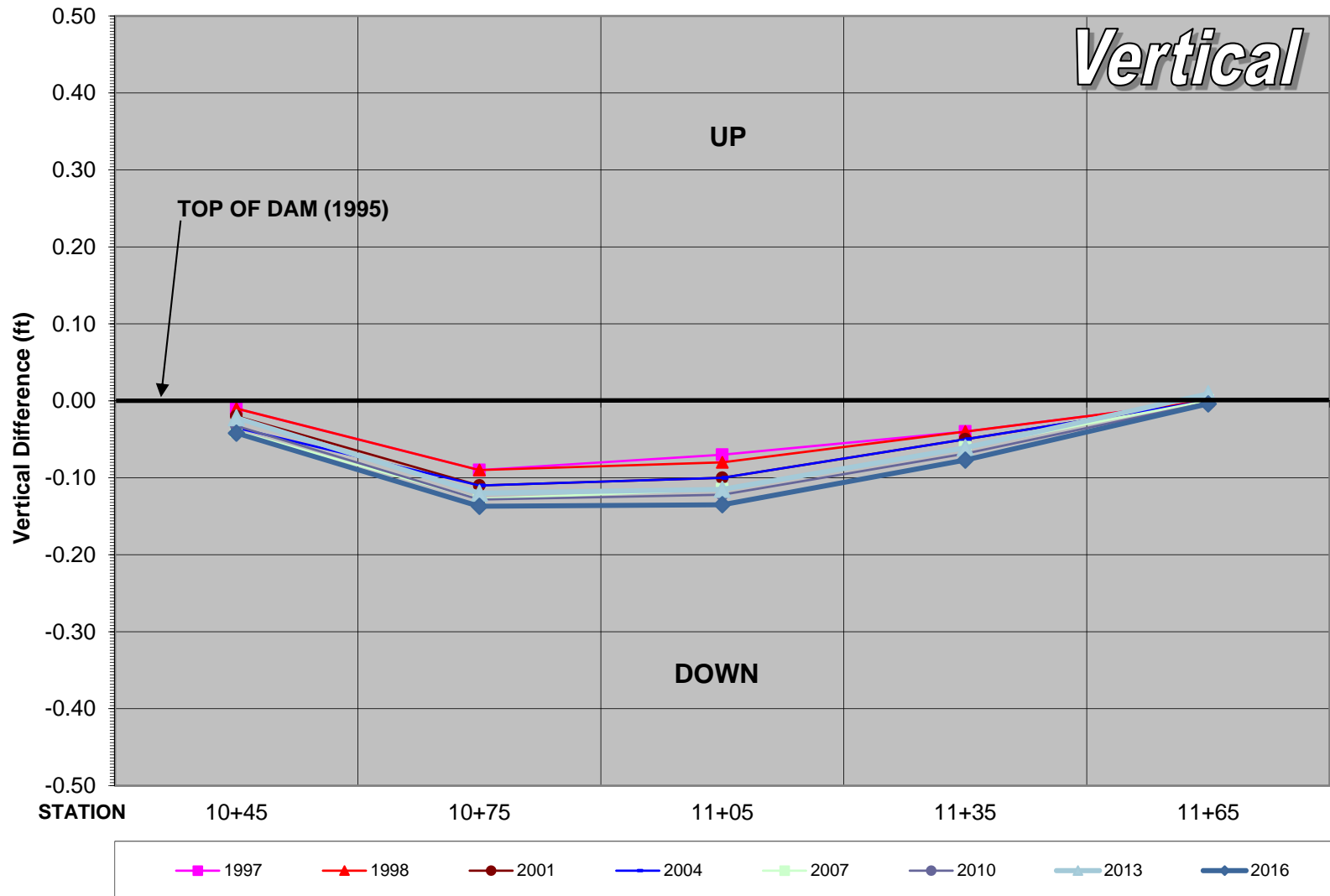


Bee Canyon Dam

Horizontal Movement Along Dam Axis (Difference from Planned Stationing)



Bee Canyon Dam
Vertical Movement (Difference from 1995 Elevations) - Profile View - *Looking Upstream*



6

ROUND CANYON RETARDING BASIN

Round Canyon Retarding Basin

Monitoring Survey

Legend

- Benchmarks
- ▲ Control Stations
- Monitoring Stations



Round Canyon Retarding Basin (F16B03) Monitoring Survey

This earthen dam was built in 1995. The first surveyed was performed in 1995 and is used as the "benchmark" for all future surveys.

Chart Details

Horizontal Movement Perpendicular to Dam Axis - shows all data from each year.

Stations 10+75 and 12+25 are held for ***Out From Line*** calculations starting 1997. The original monitoring stations were destroyed shortly after 1995 survey.

Positive numbers represent stations left of line (upstream), negative numbers represent stations right of line (downstream).

Horizontal Movement Along Dam Axis (difference from planned stationing) - shows all data from each year.

Station 12+25 is held for stationing calculations.

Positive numbers mean that the distances measured to each station are greater than planned stationing, negative number means less than planned stationing.

Vertical Movement - shows all data from each year.

Vertical differences are calculated comparing the elevation to the "1995 survey" elevation.

Detailed information pertaining to monument descriptions and survey information can be at OC Survey Division, Geodetic Control Unit.

All values shown are in U.S. Survey feet. Station names are in meters.

Horizontal Datum = CCS83, zone VI, 1991.35 Epoch Adjustment

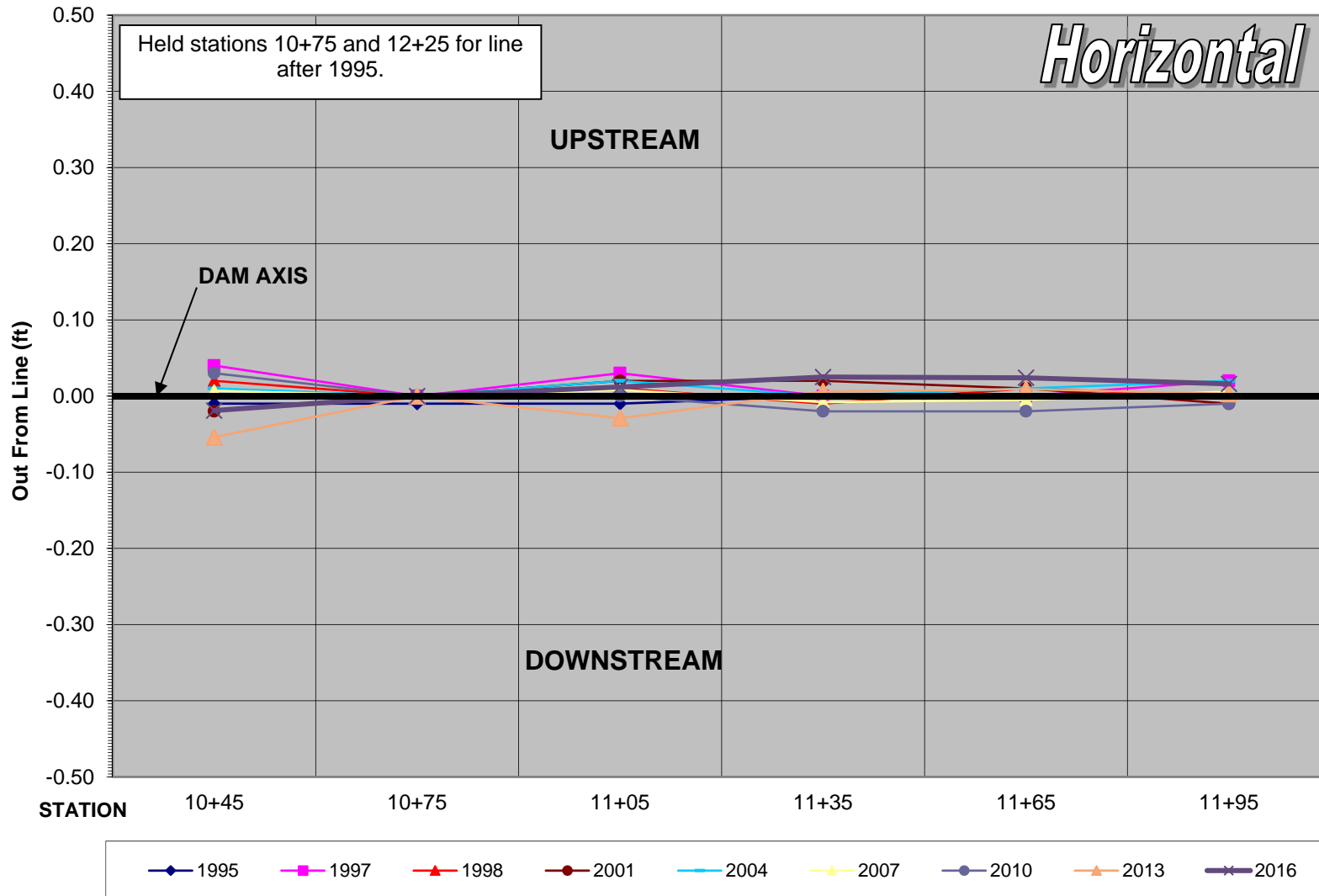
Vertical Datum = NAVD88, OCS 1995 Adjustment

Round Canyon Retarding Basin (F16B03) Monitoring Survey

Report Summary

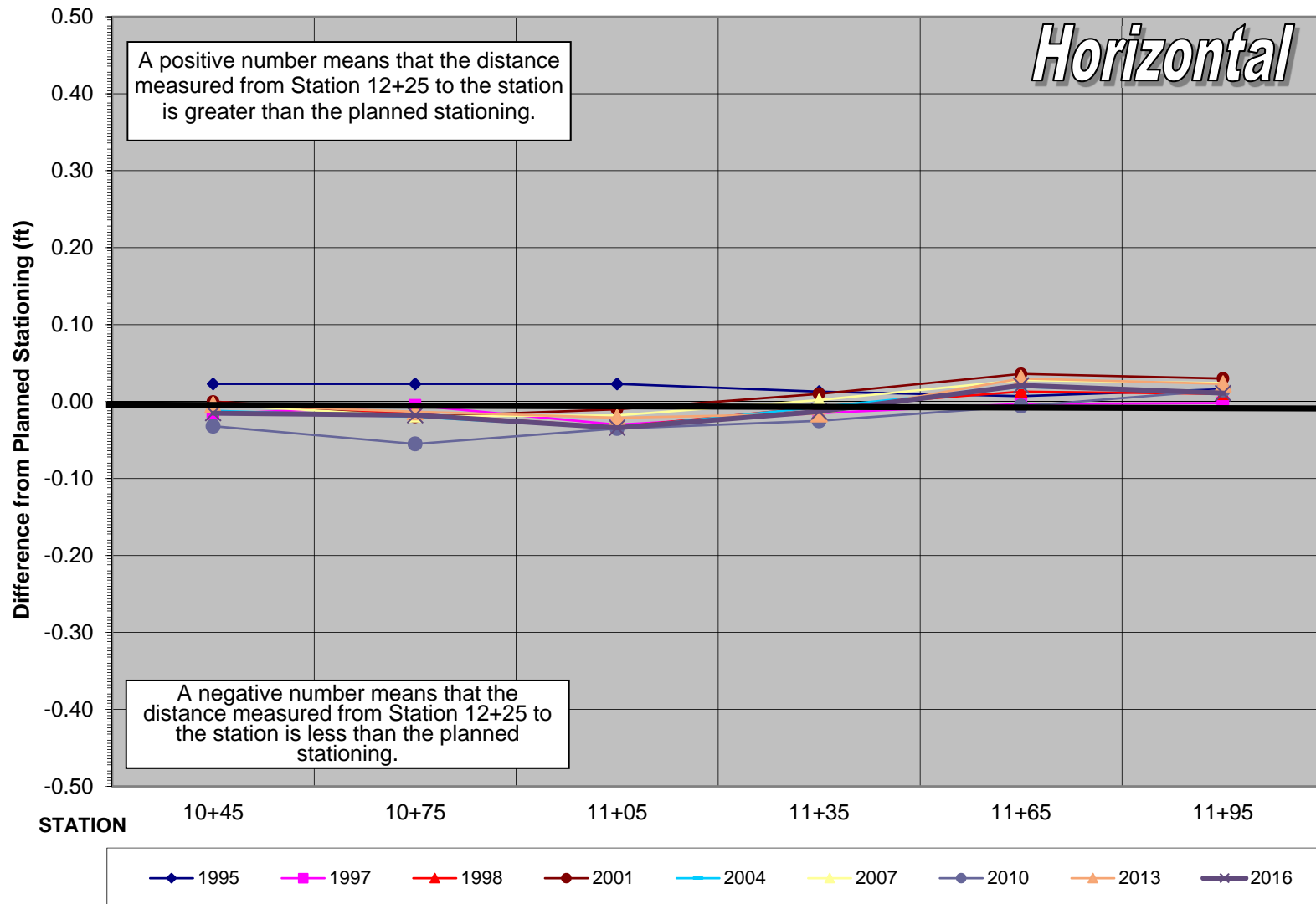
1995	Initial survey performed.
1996	No survey performed.
1997	All stations show subsidence of approximately 0.05 feet. 12+25 shows none. This is probably due to settlement of the dam. Horizontal positions seem stable.
1998	The same stations from the 1997 survey show a decrease in the subsidence down to approximately 0.02 feet. Horizontal positions seem stable. Construction has been continual for the last two years for the Foothill Transportation Corridor which abuts up against the downstream side of the dam.
2001	No significant movement detected. Vertical subsidence trend continues.
2004	No significant movement detected.
2007	No significant movement detected.
2010	No significant movement detected.
2013	No significant movement detected.
2016	No significant movement detected. Vertical subsidence trend continues.
2019	

Round Canyon Dam
Horizontal Movement Perpendicular to Dam Axis (Out From Line) - Plan View

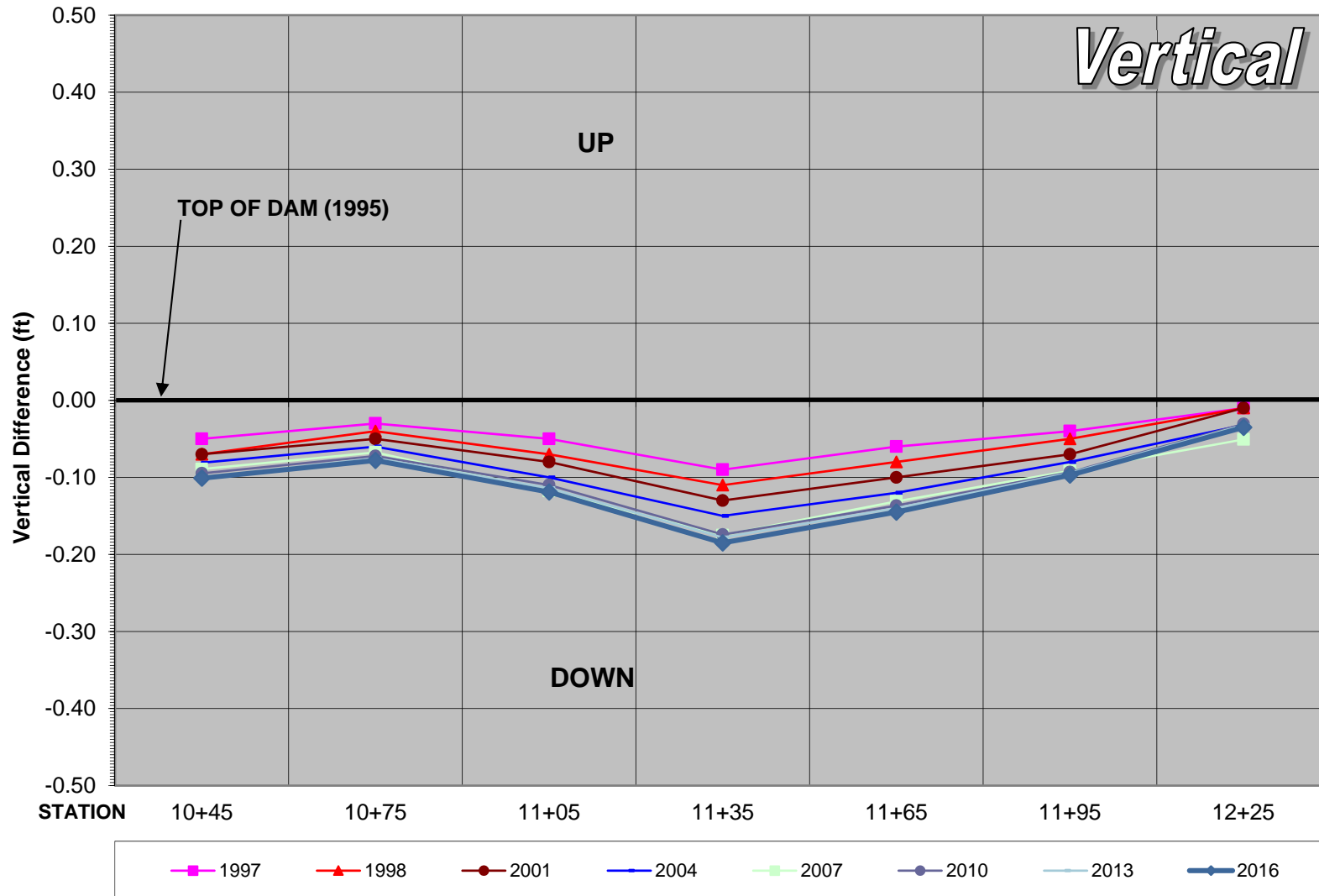


Round Canyon Dam

Horizontal Movement Along Dam Axis (Difference from Planned Stationing)



Round Canyon Dam
Vertical Movement (Difference from 1995 Elevations) - Profile View - *Looking Upstream*



7

AGUA CHINON RETARDING BASIN

Agua Chinon Map

Monitoring Survey

Legend

- Benchmarks
- Monitoring Stations



Agua Chinon Retarding Basin (F18B01) Monitoring Survey

9/9/2015

This earthen dam was built and first surveyed in 1998. This survey will be used as the "benchmark" for all future surveys.

Chart Details

Four monuments were three-dimensionally positioned utilizing GPS Static survey techniques. Because of the layout of the monuments, horizontal comparisons will be shown as differences in the northing and easting, instead of the station and offset method.

Vertical differences are calculated comparing the elevation to the "1998 survey" elevation.

Detailed information pertaining to monument descriptions and survey information can be found at OC Survey Division, Geodetic Control Unit.

All values are shown in U.S. Survey feet.

Agua Chinon Retarding Basin (F18B01) Monitoring Survey

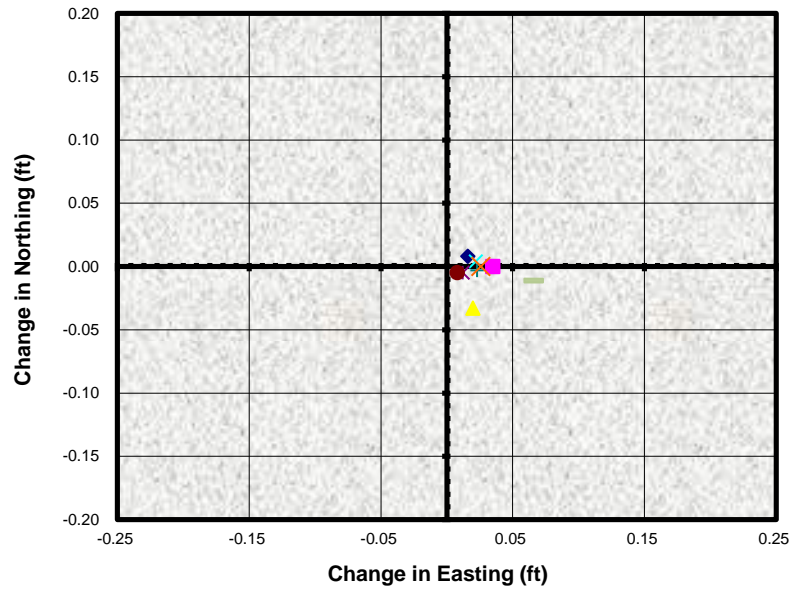
9/9/2015

Report Summary

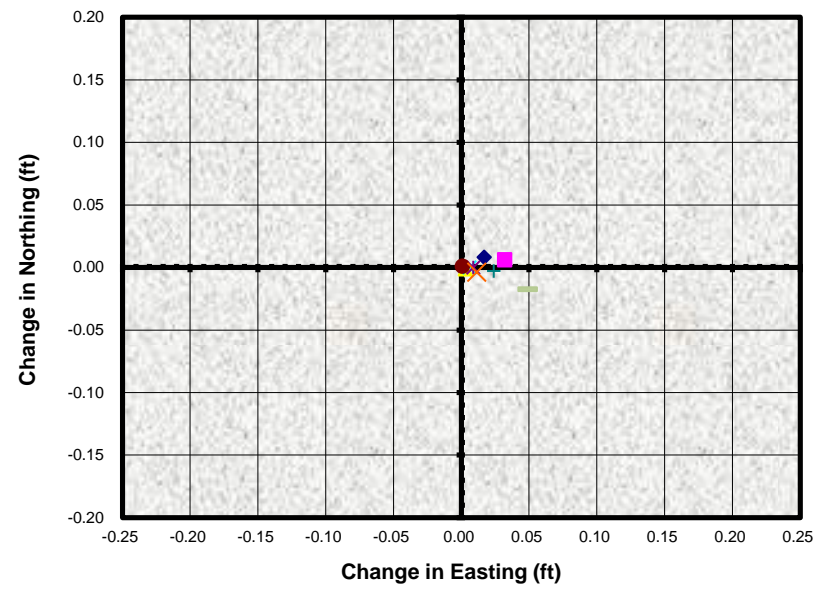
1998 Initial survey performed
1999 No significant movement detected.
2000 No significant movement detected.
2001 No significant movement detected.
2002 No significant movement detected.
2003 No significant movement detected.
2006 No significant movement detected.
2009 No significant movement detected.
2012 No significant movement detected.
2015 No significant movement detected.
2018
2021
2024

Agua Chinon Dam - (Horizontal) Horizontal Movement from 1998 Initial Survey

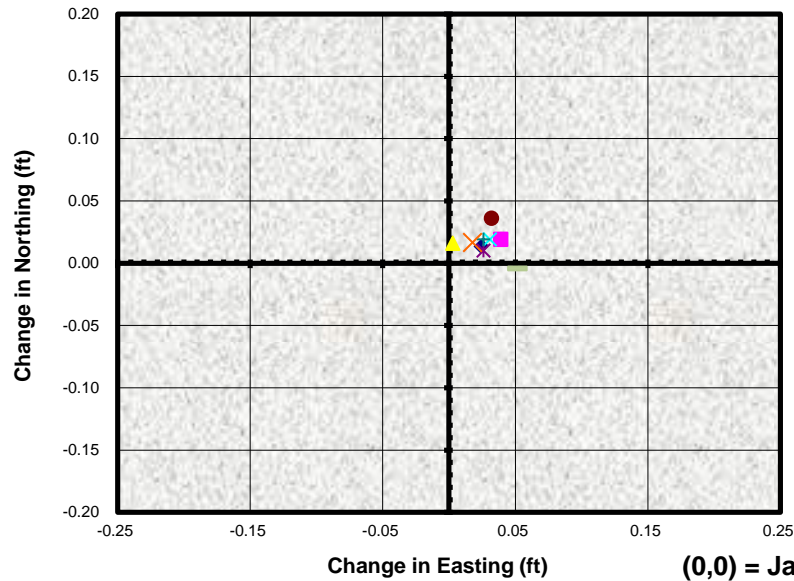
GPS 0980 (14+39)



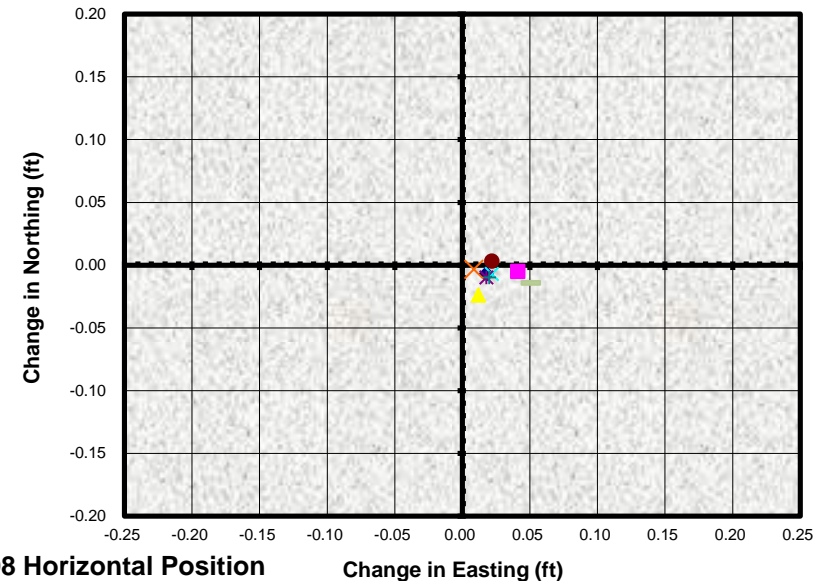
GPS 0981 (12+64)



GPS 0982 (11+46)



GPS 0983 (10+00)



(0,0) = January 1998 Horizontal Position

Profile View - Looking Upstream






8

TRABUCO RETARDING BASIN

Trabuco Retarding Basin

Monitoring Survey

Legend

-  Benchmarks
-  Control Stations
-  Monitoring Stations



Trabuco Retarding Basin (F25B01) Monitoring Survey

Seven survey monuments were set along the top of levee in 2001. This survey will be used as the "benchmark" for all future surveys.

Chart Details

Seven monuments were three-dimensionally positioned utilizing GPS Static survey techniques. Because of the layout of the monuments, horizontal comparisons will be shown as differences in the northing and easting, instead of the station and offset method.

Vertical differences are calculated comparing the elevation to the "2001 survey" elevation.

Detailed information pertaining to monument descriptions and survey information can be found at OC Survey Division, Geodetic Control Unit.

All values are shown in U.S. Survey feet.

Horizontal Datum = CCS83, zone VI, 1991.35 Epoch Adjustment
Vertical Datum = NAVD88, OCS 1995 Adjustment

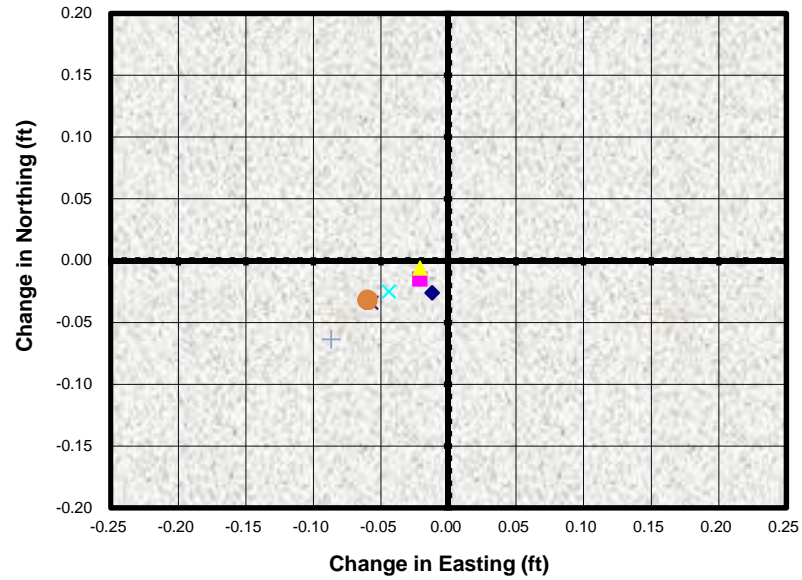
Trabuco Retarding Basin (F25B01) Monitoring Survey

Report Summary

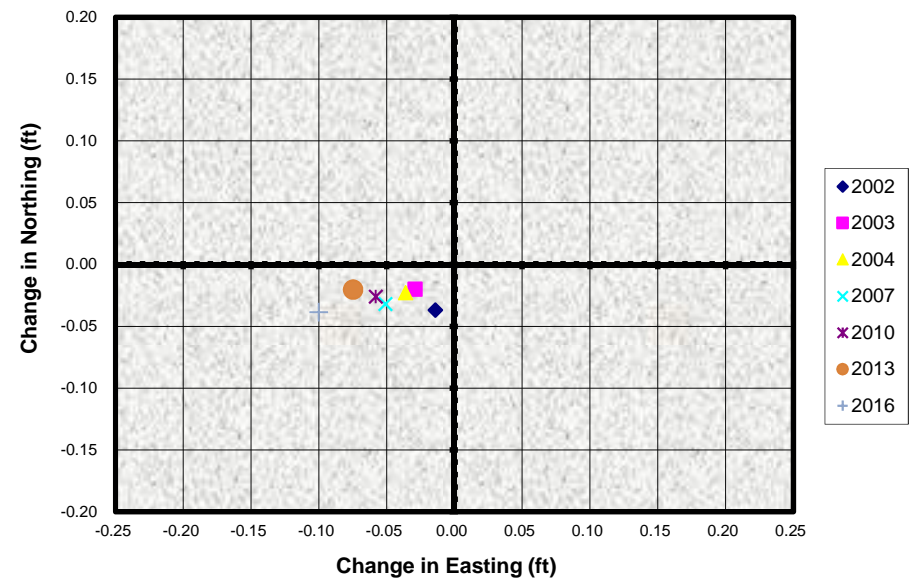
2001	Initial survey performed.
2002	No significant movement detected.
2003	No significant movement detected.
2004	No significant movement detected.
2007	No significant movement detected. GPS # 3774 appears to have disturbed by construction.
2010	GPS #3773 & #3776 were destroyed by construction.
2013	Set GPS #3764 & #3765 to replace monuments destroyed in 2010. No significant movement detected.
2016	GPS #3764 not found. Possible SW movement on GPS#3770.
2019	

Trabuco Retarding Basin - (Horizontal) Horizontal Movement since 2001 Initial Survey

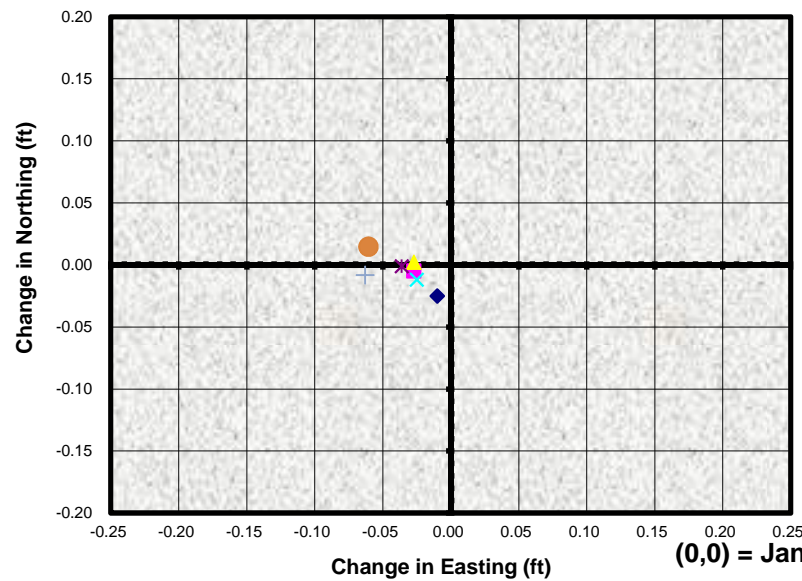
GPS 3770



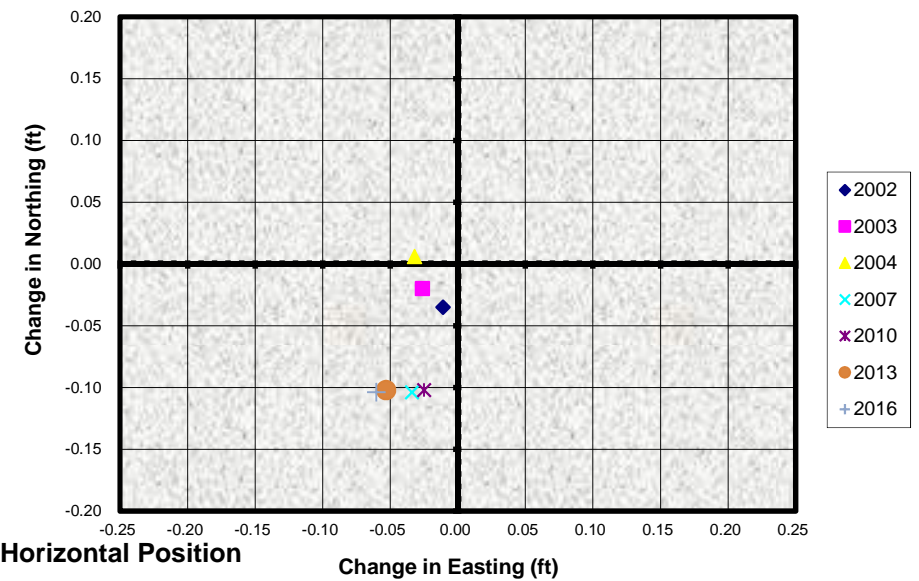
GPS 3771



GPS 3772



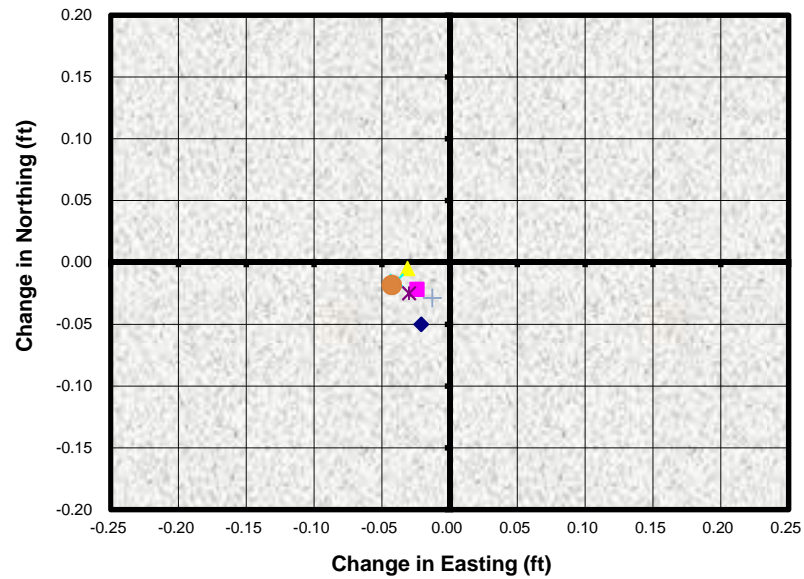
GPS 3774



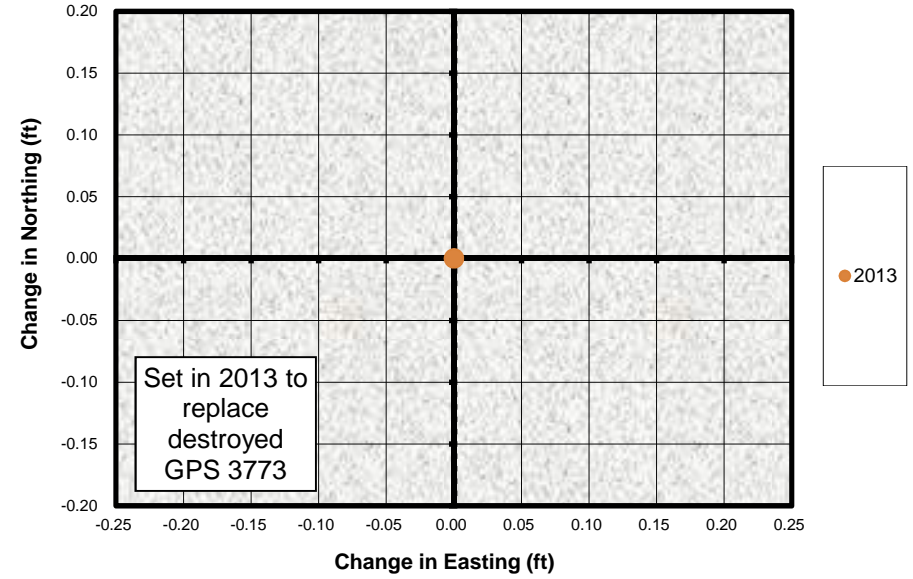
(0,0) = January 2001 Horizontal Position

Trabuco Retarding Basin - (Horizontal) Horizontal Movement since 2001 Initial Survey

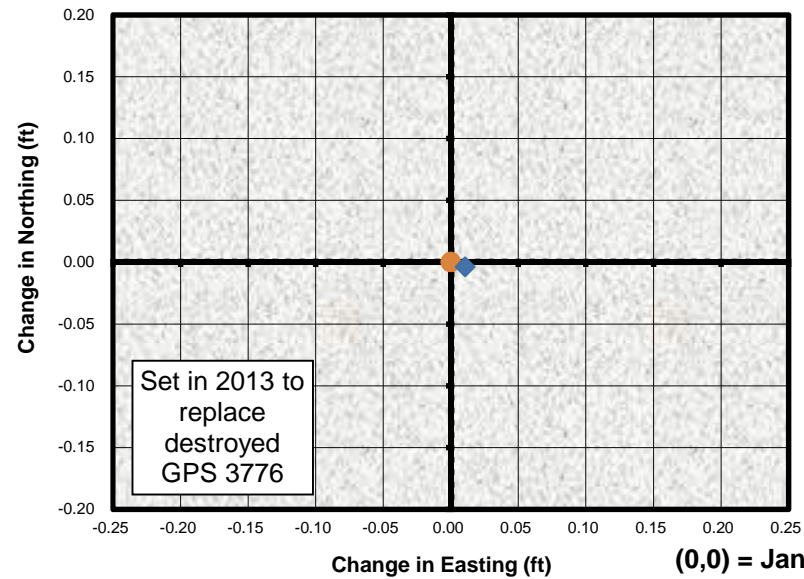
GPS 3775



GPS 3764

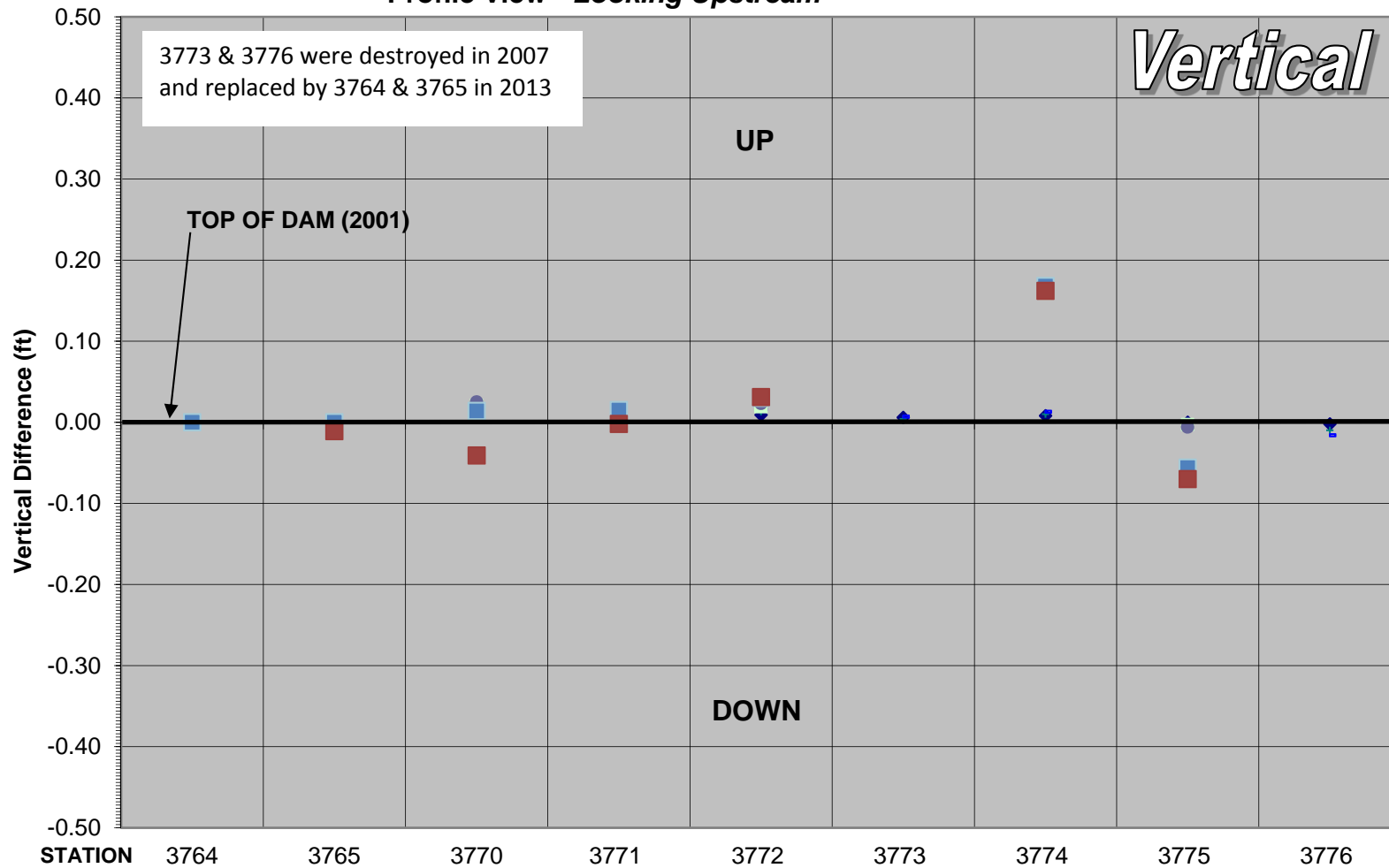


GPS 3765



(0,0) = January 2001 Horizontal Position

Trabuco Retarding Basin
Vertical Movement (Orthometric Difference from 2001 Elevations)
Profile View - Looking Upstream



◆ 2002

+ 2003

- 2004

■ 2007

● 2010

■ 2013

■ 2016

9

ORCHARD ESTATES RETARDING BASIN

Orchard Estates Retarding Basin

Monitoring Survey

Legend

- ▲ Control Stations
- Benchmarks
- Monitoring Stations



Google earth

© 2016 Google

600 ft

Orchard Estates Retarding Basin (F26B02) Monitoring Survey

Seven survey monuments were set along the top of levee in 2001. This survey will be used as the "benchmark" for all future surveys.

Chart Details

Horizontal Movement Perpendicular to Dam Axis - shows all data from each year.

Stations 1+00 and 10+00 are held for ***Out From Line*** calculations.

Positive numbers represent stations right of line (upstream), negative numbers represent stations left of line (downstream).

Horizontal Movement Along Dam Axis (difference from planned stationing) - shows all data from each year.

Station 1+00 is held for stationing calculations.

Positive numbers mean that the distances measured to each station are greater than planned stationing, negative number means less than planned stationing.

Vertical Movement - shows all data from each year.

Vertical differences are calculated comparing each elevation to the "2001 survey" elevation.

Detailed information pertaining to monument descriptions and survey information can be found at OC Survey Division, Geodetic Control Unit.

All values are shown in U.S. Survey feet.

Horizontal Datum = CCS83, zone VI, 1991.35 Epoch Adjustment

Vertical Datum = NAVD88, OCS 1995 Adjustment

Orchard Estates Retarding Basin (F26B02) Monitoring Survey

Report Summary

2001	Initial survey performed. Comparisons will begin 2002.
2002	No Significant Movement Detected on dam monitoring points. 2002 height of benchmark "Orchard" located on spillway headwall differs by -0.10' than 2001 height.
2003	Stations 7+00 and 8+50 show gradual settling.
2004	No Significant Movement Detected.
2007	No Significant Movement Detected.
2010	No Significant Movement Detected.
2013	Station 7+00 shows slight horizontal movement downstream. Stations 7+00 and 8+00 show continual vertical settling.
2016	Stations 7+00 and 8+00 show continual vertical settling.
2019	

Horizontal

UPSTREAM

DOWNSTREAM

DAM AXIS

Out From Line (ft)

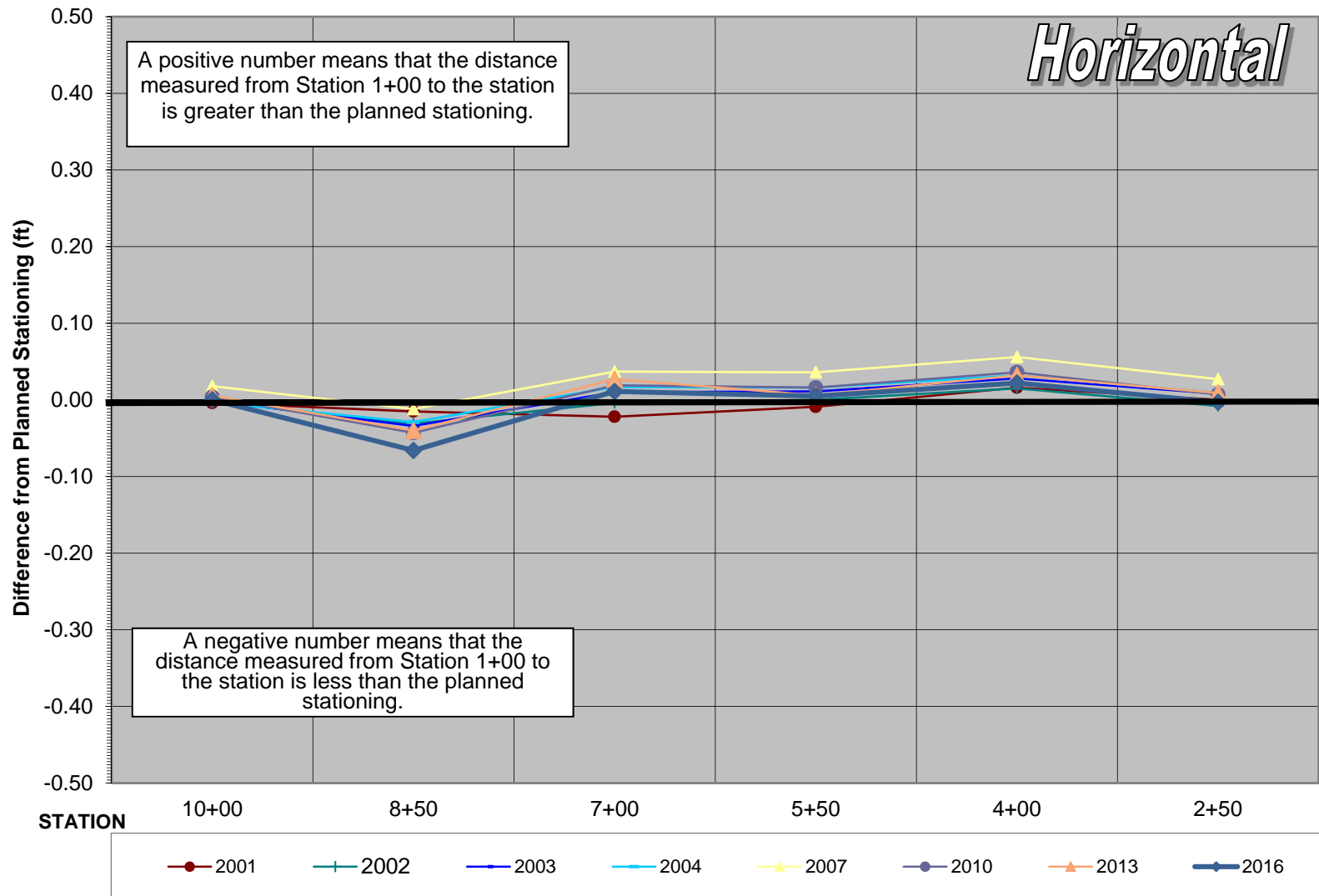
STATION

Held stations 1+00 and 10+00 for line.

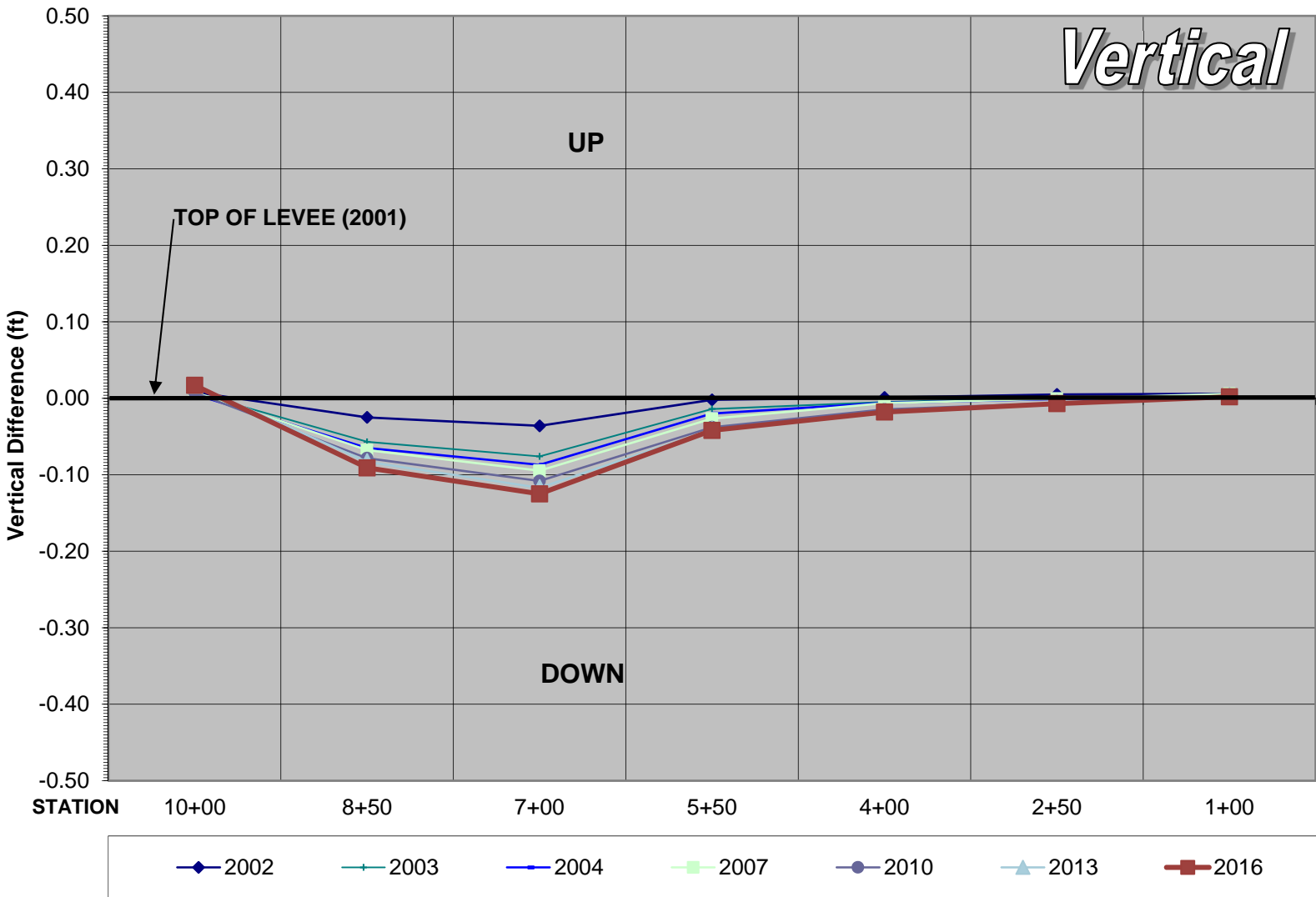
Legend:

- 2001
- 2002
- 2003
- 2004
- 2007
- 2010
- 2013
- 2016

Orchard Estates Retarding Basin Horizontal Movement Along Dam Axis (Difference from Planned Stationing)



Orchard Estates Retarding Basin
Vertical Movement (Difference from 2001 Elevations) - Profile View - *Looking Upstream*



10

HICKS CANYON RETARDING BASIN

Hicks Canyon Retarding Basin

Monitoring Survey

Legend

- Benchmarks
- ▲ Control Stations
- Monitoring Stations



Hicks Canyon Retarding Basin (F27B01) Monitoring Survey

This earthen dam was built in 1997. The first survey was performed in 1997 and is used as the "benchmark" for all future surveys.

Chart Details

Horizontal Movement Perpendicular to Dam Axis - shows all data from each year.

Stations 6+00 and 8+00 are held for ***Out From Line*** calculations.

Positive numbers represent stations right of line (upstream), negative numbers represent stations left of line (downstream).

Horizontal Movement Along Dam Axis (difference from planned stationing) - shows all data from each year.

Station 6+00 is held for stationing calculations.

Positive numbers mean that the distances measured to each station are greater than planned stationing, negative number means less than planned stationing.

Vertical Movement - shows all data from each year.

Vertical differences are calculated comparing the current elevation to the "1997 survey" elevation.

Detailed information pertaining to monument descriptions and survey information can be found at OC Survey Division, Geodetic Control Unit.

All values shown are in U.S. Survey feet. Station names are in meters.

Horizontal Datum = CCS83, zone VI, 1991.35 Epoch Adjustment

Vertical Datum = NAVD88, OCS 1995 Adjustment

Hicks Canyon Retarding Basin (F27B01) Monitoring Survey

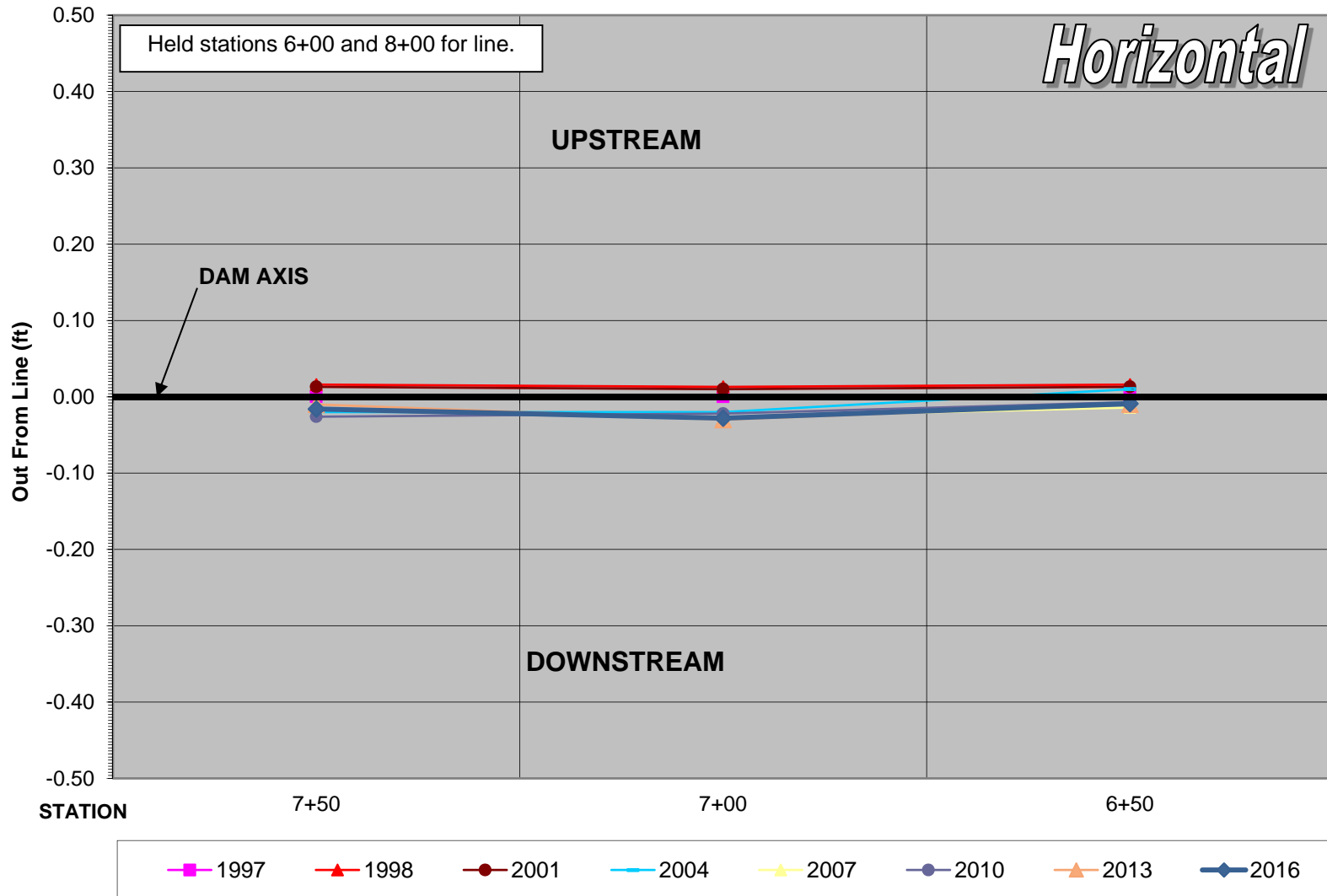
Report Summary

1997	Initial survey performed.
1998	All distances measured from station 6+00 differ from 0.02 to 0.03 feet. This could indicate that station 6+00 may be settling. Construction has being continual this past year for the Eastern Transportation Corridor. These differences are not significant but will be watched closely in the future.
2001	No significant movement. Dam monument elevations show settling trend. "Difference From Stationing" measurement for 7+00 is questionable.
2004	No significant movement. Difference from planned stationing are larger than expected.
2007	No significant movement. Difference from planned stationing are larger than expected.
2010	No significant movement.
2013	No significant movement.
2016	No significant movement.
2019	

Horizontal Datum = CCS83, zone VI, 1991.35 Epoch Adjustment

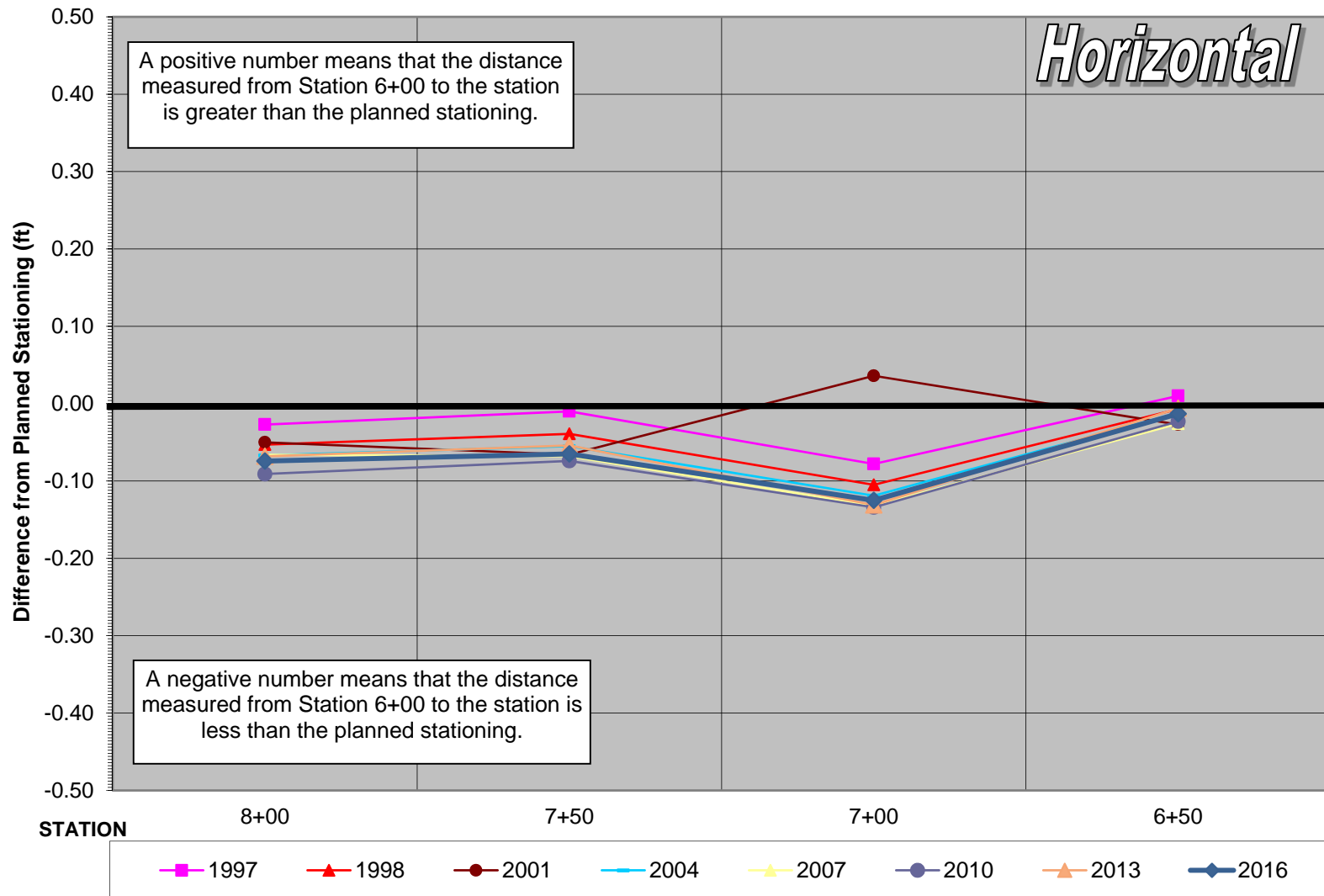
Vertical Datum = NAVD88, OCS 1995 Adjustment

Hicks Canyon Dam
Horizontal Movement Perpendicular to Dam Axis (Out From Line) - Plan View

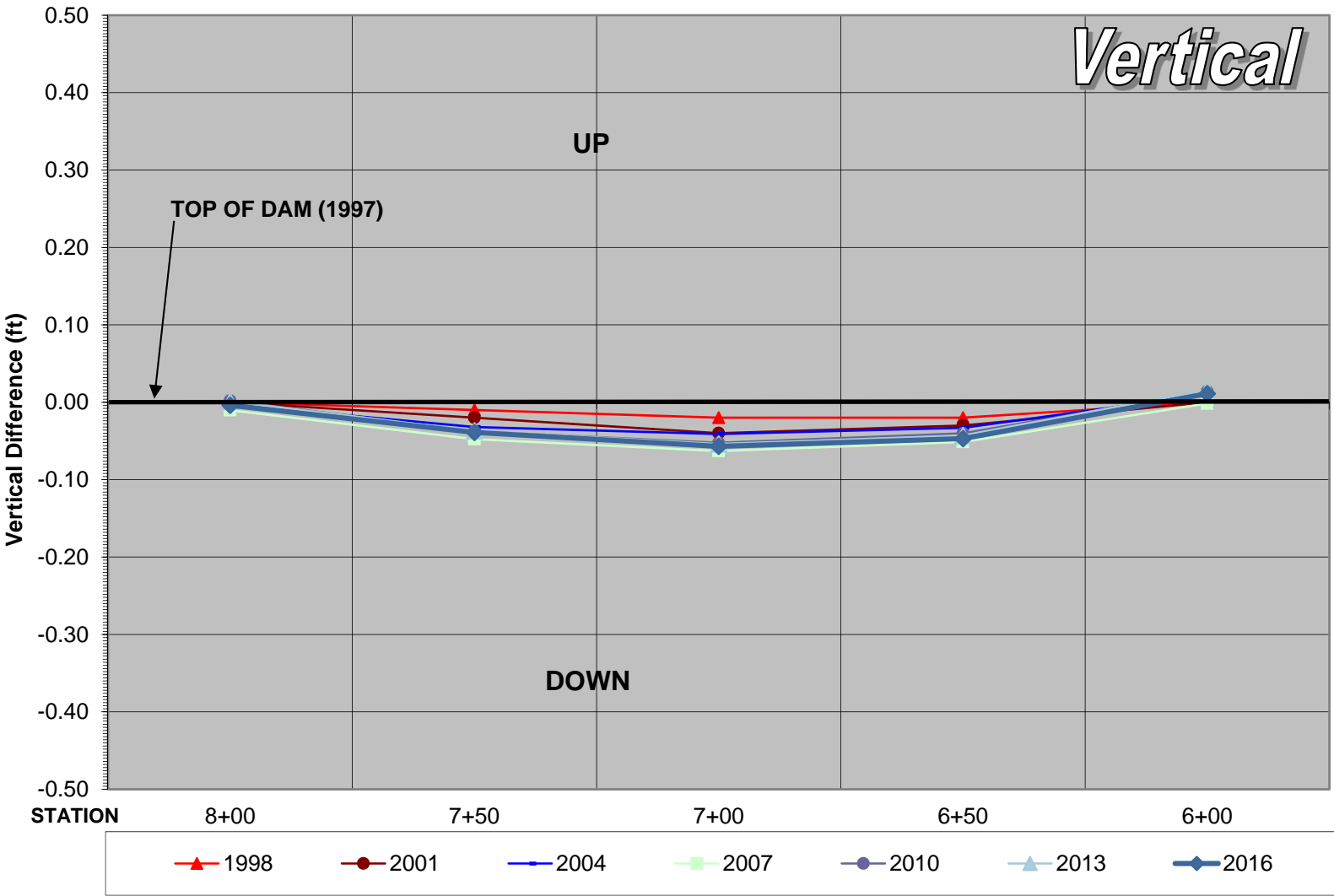


Hicks Canyon Dam

Horizontal Movement Along Dam Axis (Difference from Planned Stationing)



Hicks Canyon Dam
Vertical Movement (Difference from 1997 Elevations) - Profile View - *Looking Upstream*



11

EAST HICKS
CANYON
RETARDING BASIN

East Hicks Canyon Retarding Basin

Monitoring Survey

Legend

- Benchmarks
- ▲ Control Stations
- Monitoring Stations

0088 (1+00) EAST-HICKS-6-97 1+50 2+00 2+50 3+00 3+50 4+00 0089 (4+50)

Google earth

© 2016 Google



300 ft

East Hicks Canyon Retarding Basin (F27B02) Monitoring Survey

This earthen dam was built in 1997. The first survey was performed in 1997 and is used as the "benchmark" for all future surveys.

Chart Details

Horizontal Movement Perpendicular to Dam Axis - shows all data from each year.

Stations 1+00 and 4+50 are held for ***Out From Line*** calculations.

Positive numbers represent stations right of line (upstream), negative numbers represent stations left of line (downstream).

Horizontal Movement Along Dam Axis (difference from planned stationing) - shows all data from each year.

Station 1+00 is held for stationing calculations.

Positive numbers mean that the distances measured to each station are greater than planned stationing, negative number means less than planned stationing.

Vertical Movement - shows all data from each year.

Vertical differences are calculated comparing the current elevation to the "1997 survey" elevation.

Detailed information pertaining to monument descriptions and survey information can be found at OC Survey Division, Geodetic Control Unit.

All values shown are in U.S. Survey feet. Station names are in meters.

Horizontal Datum = CCS83, zone VI, 1991.35 Epoch Adjustment

Vertical Datum = NAVD88, OCS 1995 Adjustment

East Hicks Canyon Retarding Basin (F27B02) Monitoring Survey

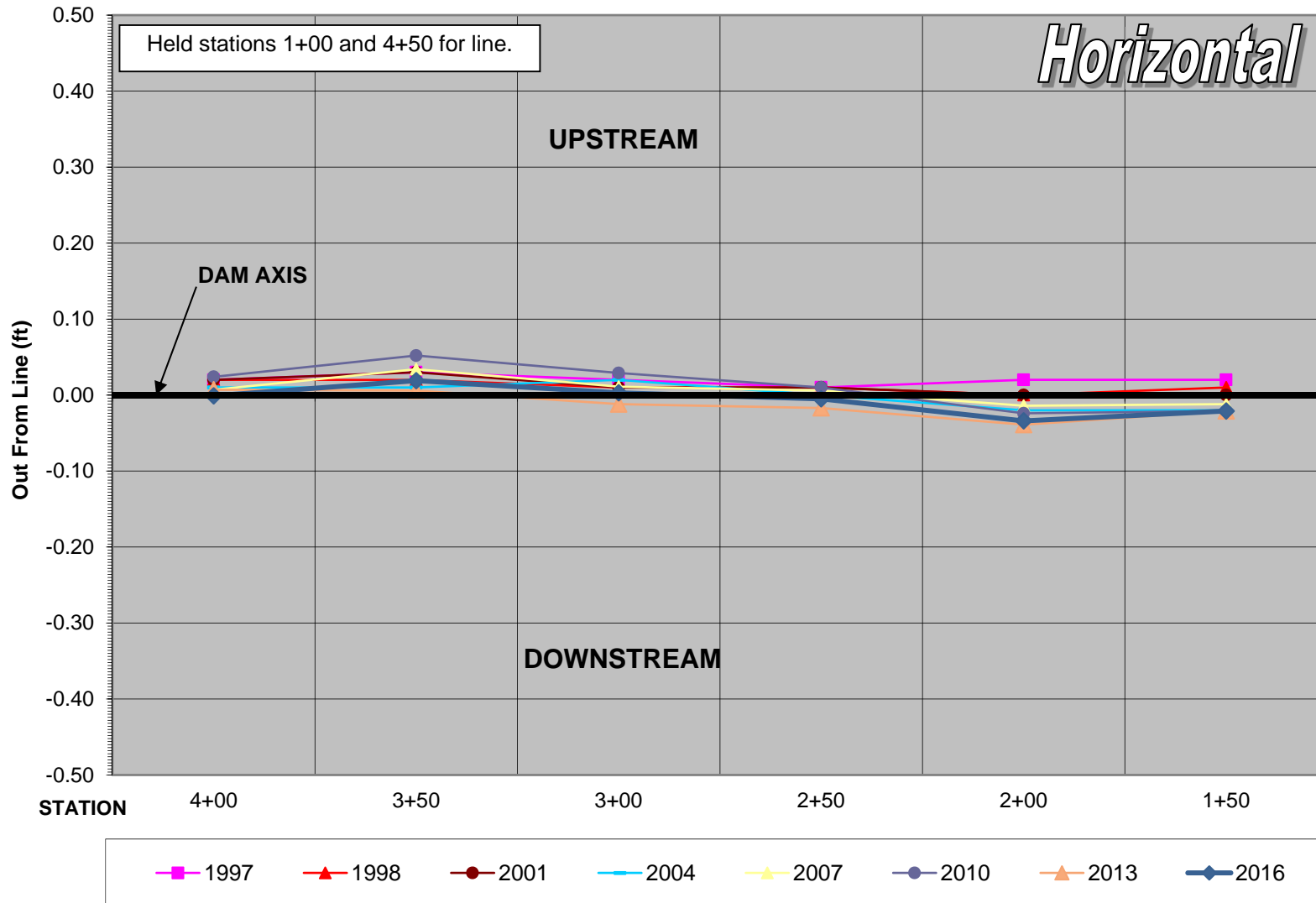
Report Summary

1997	Initial survey performed.
1998	Most stations show subsidence with an average of 0.02 feet. This could be due to settlement of the dam. Horizontal positions seem stable. Construction has been continual for the last two years for the Eastern Transportation Corridor which abuts up against the downstream side of the dam.
2001	No significant movement detected.
2004	Nov-2003, The lids have been scraped off and the last monument may have been disturbed. No significant movement detected.
2007	Elevations appear to have a systematic difference of +0.03'. No horizontal significant movement detected.
2010	No significant movement detected.
2013	All well lids are missing and well monuments appear to have been disturbed from heavy equipment scrapping the asphalt surface. Monuments appear stable horizontally but 3+00 has sank 0.05'.
2016	No significant movement detected. The 3+00 comment in 2013 appears to be an error.
2019	

Horizontal Datum = CCS83, zone VI, 1991.35 Epoch Adjustment

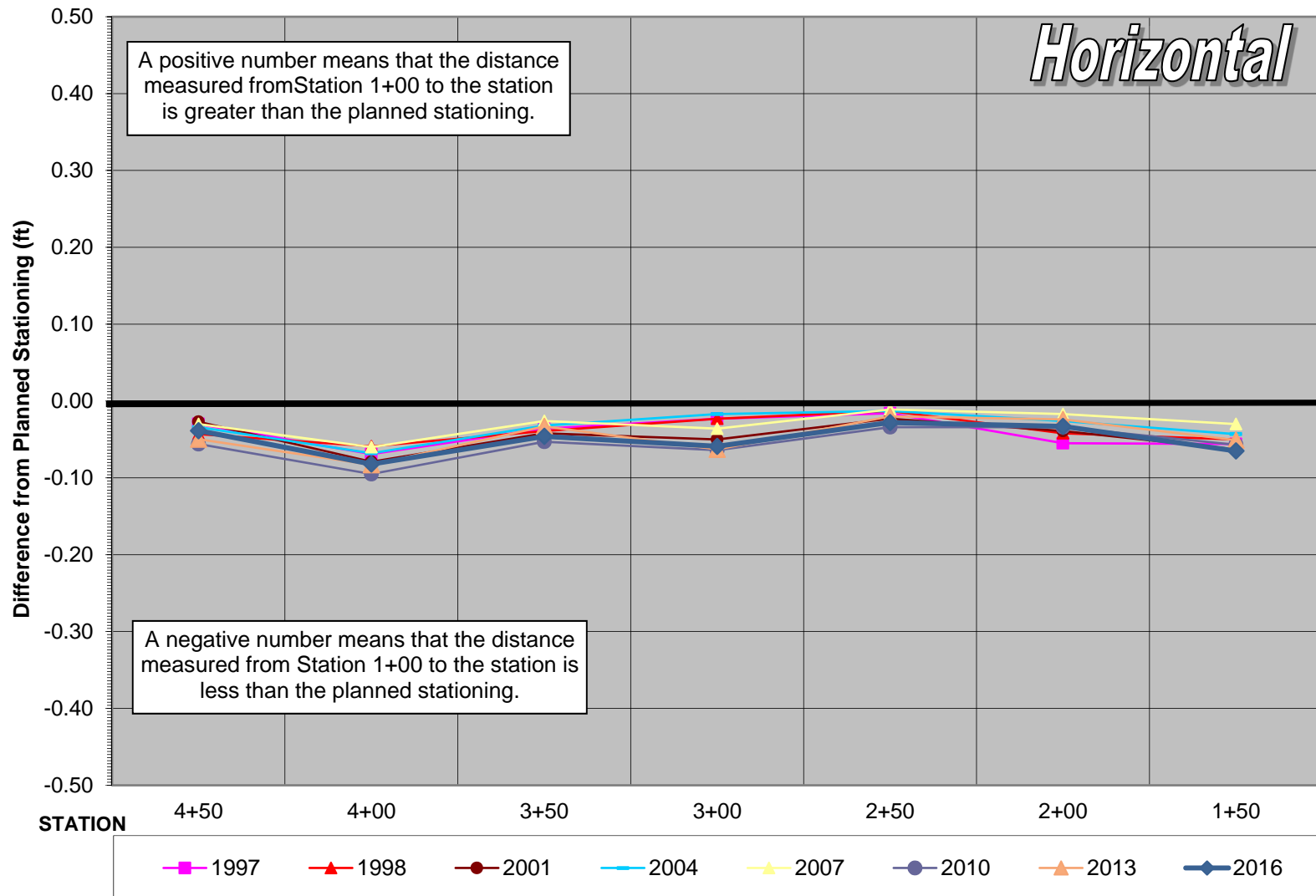
Vertical Datum = NAVD88, OCS 1995 Adjustment

East Hicks Canyon Dam
Horizontal Movement Perpendicular to Dam Axis (Out From Line) - Plan View

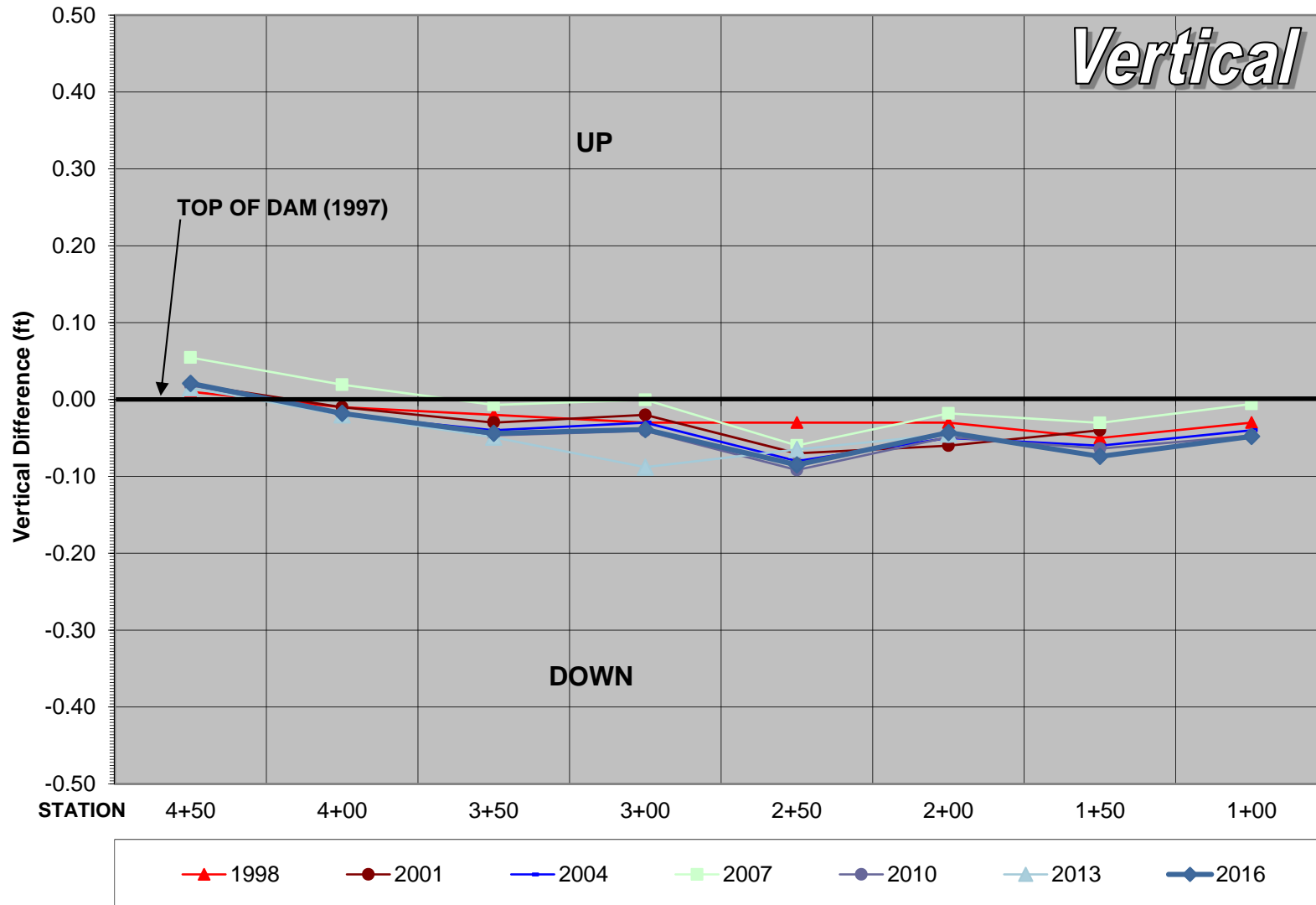


East Hicks Canyon Dam

Horizontal Movement Along Dam Axis (Difference from Planned Stationing)



East Hicks Canyon Dam
Vertical Movement (Difference from 1997 Elevations) - Profile View - *Looking Upstream*



12

SULPHUR CREEK DAM

Suphur Creek Dam

Monitoring Survey

Legend

- ▲ Control Stations
- Benchmarks
- Monitoring Stations

0249 (SC-1)

M-1

M-2

0251 (M-3)

M-4

C-5

C-8

0259 (C-7)

3XX-4-84

3XX-5-84

Google earth

Data SIO, NOAA, U.S. Navy, NGA, GEBCO

Image Landsat / Copernicus

Data LDEO-Columbia, NSF, NOAA

© 2016 Google

200 ft

Sulphur Creek Dam (J03D01) Monitoring Survey

This earthen dam was built in 1966. The first vertical monitoring survey was performed in 1979. The first horizontal survey was performed in 1981.

Horizontal displacement is compared to dam survey line. Vertical displacement is compared to 1968 elevations from 1984 Subsidence Report.

Chart Details

Horizontal Movement Perpendicular to Dam Axis - shows all data from each year.

Control points "SC-1" and "SC-2" are held for ***Out From Line*** calculations until 1993. In 1993, "SC-2" was found disturbed and replaced by "C-7" for line. Negative numbers represent stations right of line (downstream), positive numbers represent stations left of line (upstream).

Horizontal Movement Along Dam Axis (difference from 1985 survey) - shows all data from each year.

GPS 0249 (SC-1) Control point is held for stationing calculations.

Positive numbers mean that the distances measured to each station are greater than 1985 survey, negative number means less than 1985 survey.

Vertical Movement - shows all data from each year.

Vertical differences are calculated comparing the elevation to the "1968 survey" elevation.

Control Checks - shows all data from each year.

Horizontal movement of control stations in a cardinal direction relative to the initial 1995 GPS survey.

Detailed information pertaining to monument descriptions and survey information can be found at OC Survey Division, Geodetic Control Unit.

All values are shown in U.S. Survey feet.

Horizontal Datum = CCS83, zone VI, 1991.35 Epoch Adjustment

Vertical Datum = NGVD29, OCS 1976 Adjustment

Sulphur Creek Dam (J03D01) Monitoring Survey

Report Summary

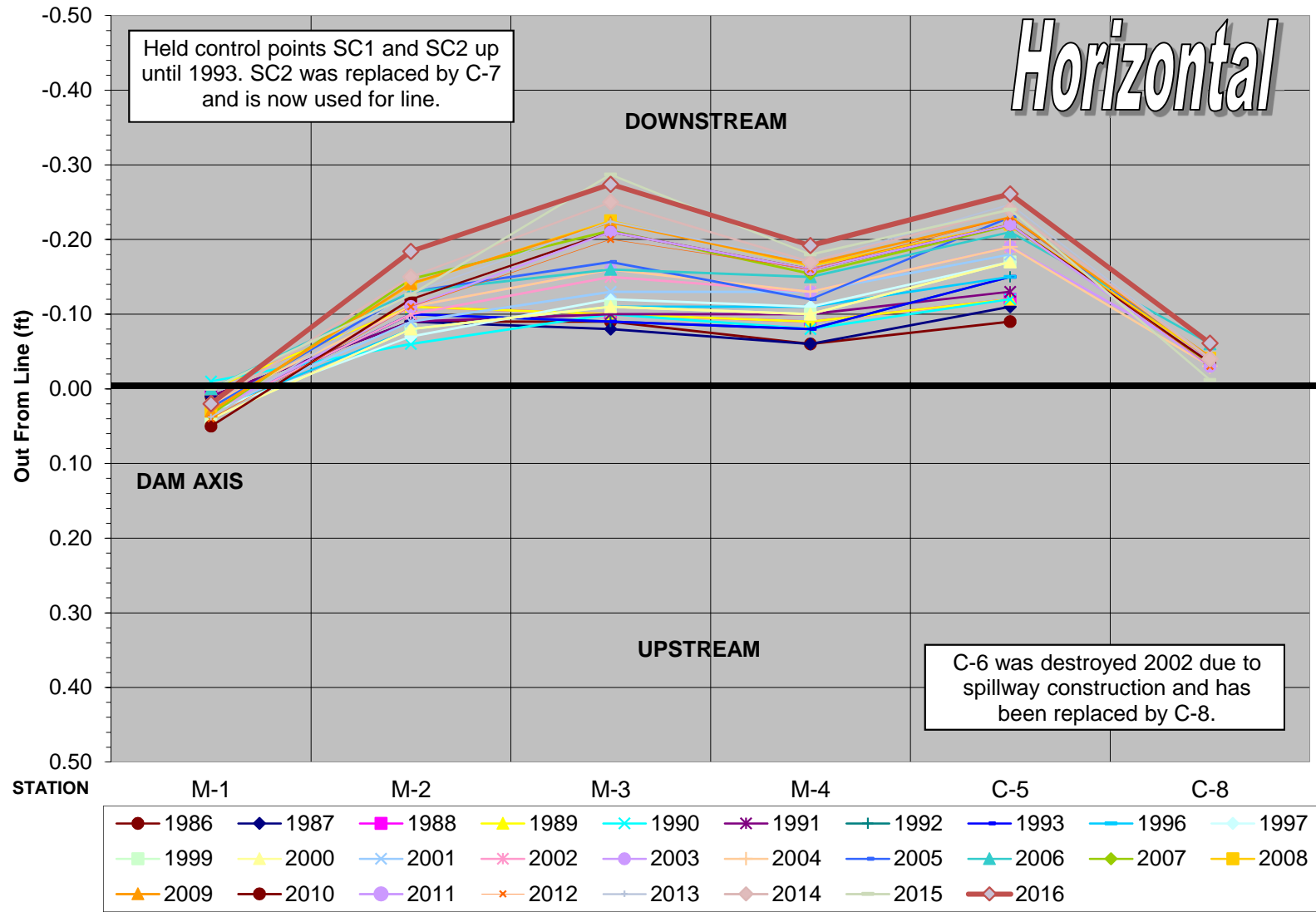
1981-1990	Downstream horizontal movement measured on all stations located on top of dam. Vertical uplift is found on all stations.
1990-2000	Downstream horizontal movement continues with the greatest amount at station C-5. Vertical uplift also continues with the greatest amount at both end stations, M-1 and C-7.
2001	Same horizontal and vertical trends continue
2002	Same horizontal trend continues. Vertical appears stable. C-6 was destroyed due to spillway construction and has been replaced by C-8.
2003	Same horizontal trend continues. Vertical appears stable.
2004	No significant movement found.
2005	C-5 shows downstream horizontal movement. Vertical uplift also continues with the greatest amount at both end stations, M-1 and C-7.
2006	All stations except M-3 show vertical uplift. M-3 shows settling.
2007	M-3 shows vertical settlement for past 7 years.
2008	M-3 continues to settle, all other monuments show uplift with the greatest amount on M-1 and C-7. All stations show slight downstream movement.
2009	M-3 continues to settle, all other monuments show uplift with the greatest amount on M-1 and C-7. All stations show slight downstream movement.
2010	M-3 appears to have vertically stabilized. C-7 shows horizontal movement in a southwest direction based on "Control Checks" chart.
2011	C-7 shows horizontal movement in a southwest direction based on "Control Checks" chart.
2012	No significant movement found.
2013	No significant movement found.
2014	M-3 continues to settle, all other monuments show uplift with the greatest amount on M-1 and C-7. All stations show slight downstream movement.
2015	All stations continue to show slight downstream movement with the greatest being M-3. See note below.
2016	No significant movement found.
2017	

Note: "Out From Line" chart shows that stations have moved downstream. This may not actually be movement on the dam but due to the instability of control station C-7 that has been annually monitored using GPS.

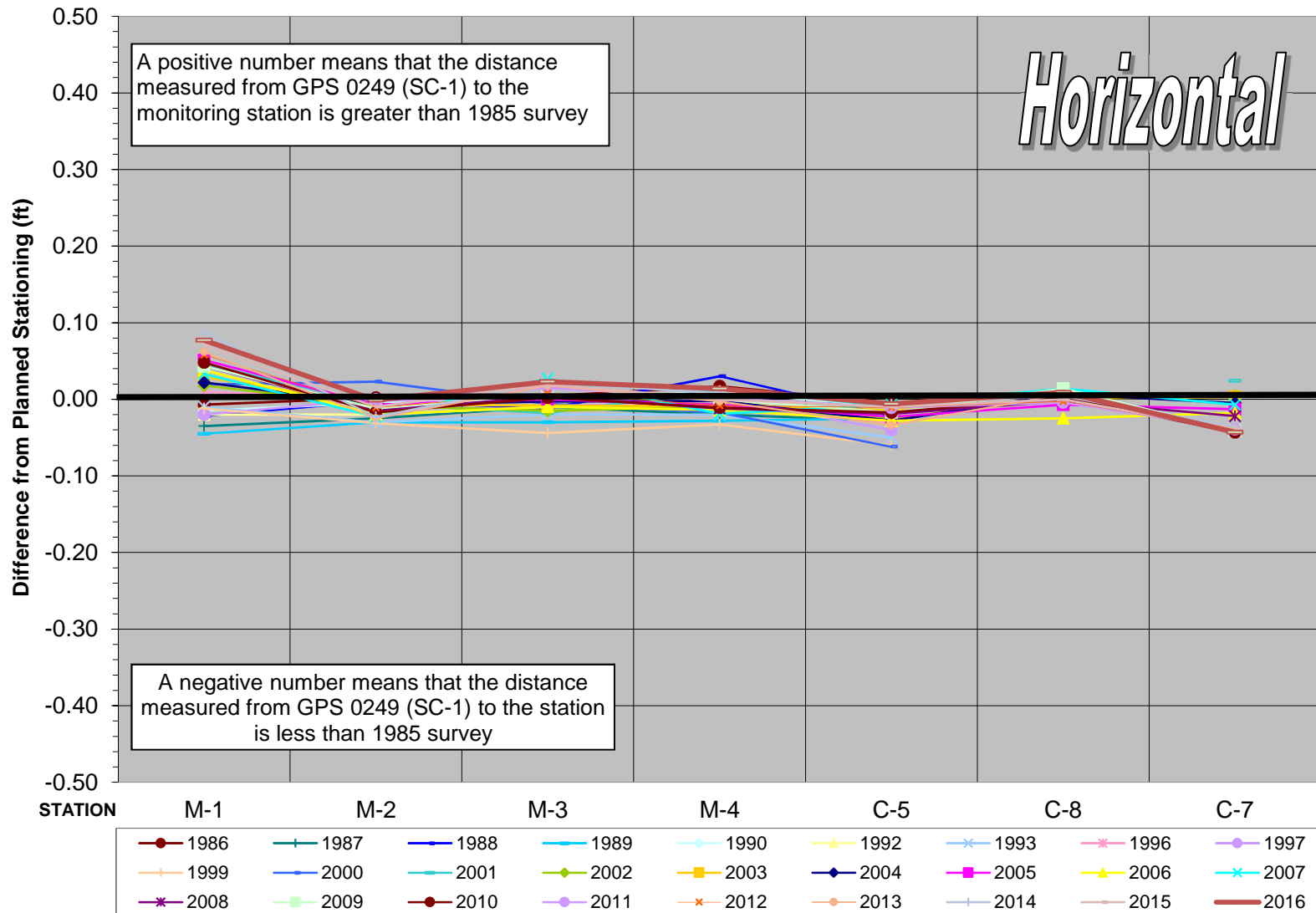
Horizontal Datum = CCS83, zone VI, 1991.35 Epoch Adjustment

Vertical Datum = NGVD29, OCS 1976 Adjustment

Sulphur Creek Dam Horizontal Movement Perpendicular to Dam Axis (Out From Line) Plan View

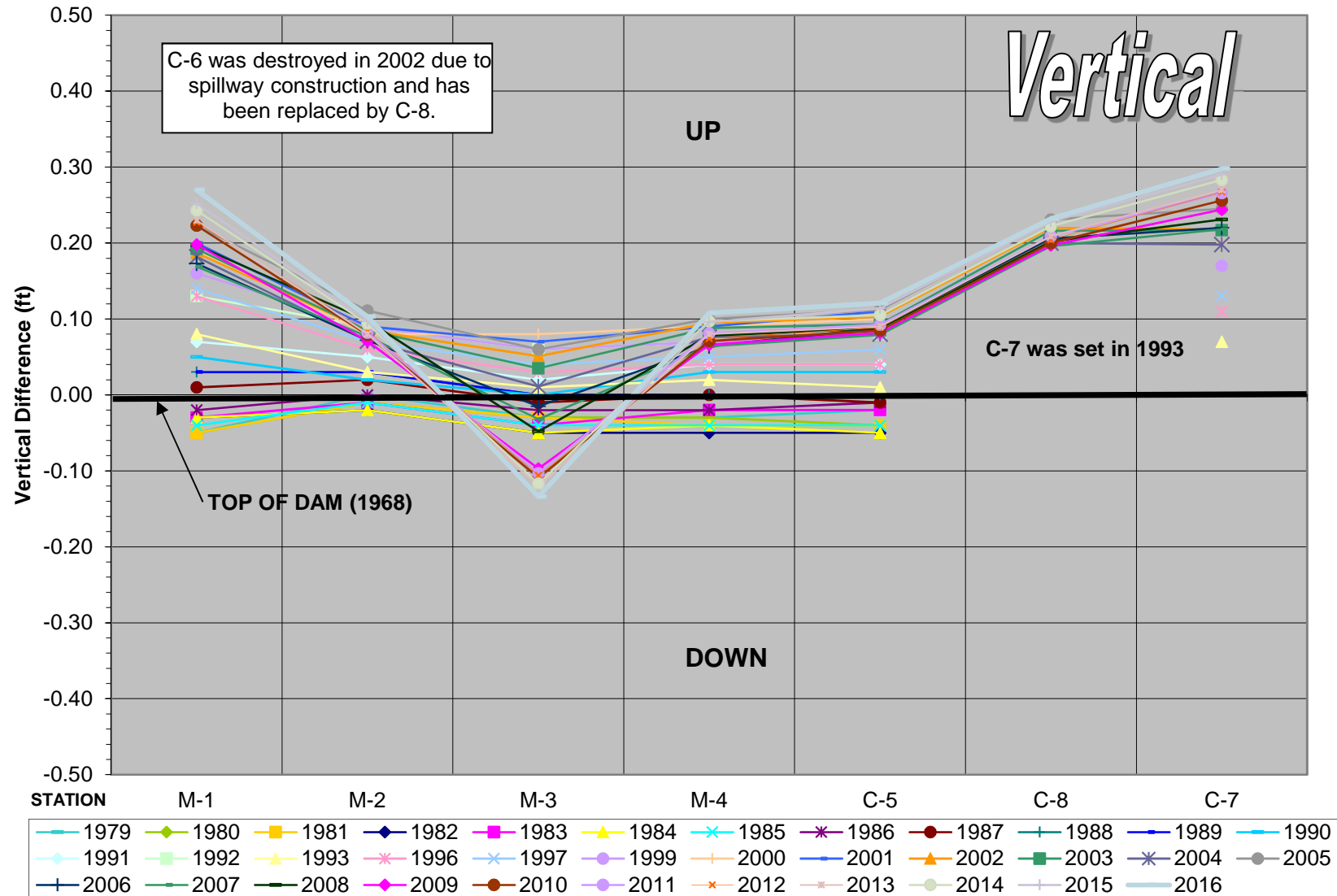


Sulphur Creek Dam **Horizontal Movement Along Dam Axis (Difference from 1985 Survey)**



Sulphur Creek Dam

Vertical Movement (Difference from 1968 Elevations) - Profile View - Looking Upstream



13

COVE ROAD CRIB WALL

Cove Road - Crib Wall

Monitoring Survey



Google earth

Data SIO, NOAA, U.S. Navy, NGA, GEBCO

© 2016 Google

Data CSUMB SFML, CA OFC

Image Landsat / Copernicus

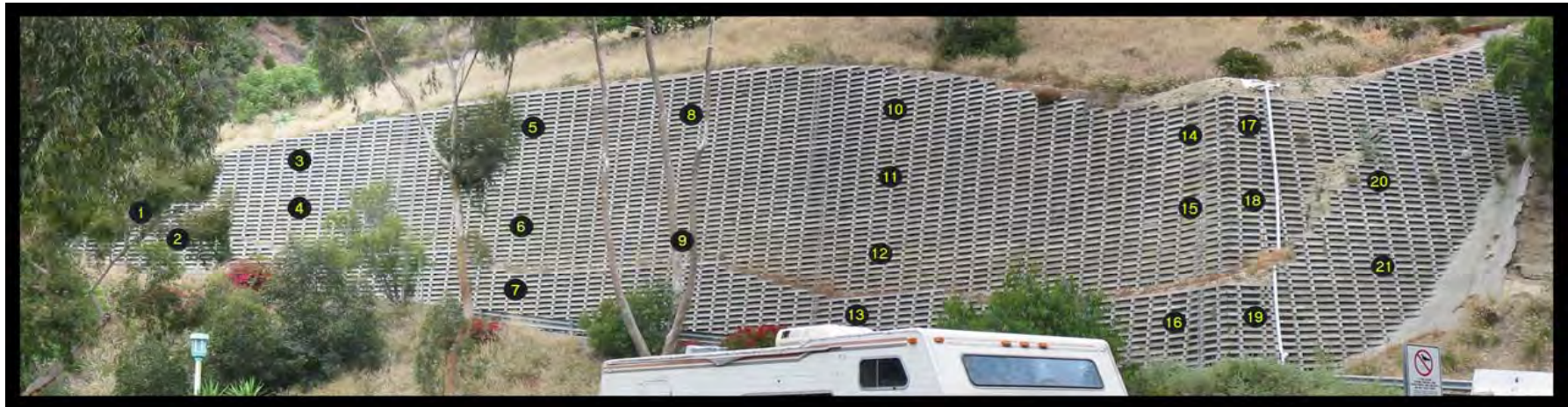
70 ft

Cove Road - Crib Wall Monitoring Survey

This crib-type retaining wall was built in 1985 after the top of the bluff located under Cannons Restaurant failed during heavy rains in the winter of 1980-1981.

Chart Details:

Each chart contains movement (change in northing, easting, elevation) from each survey relative to the 1997 base survey for each station. All data is shown in U.S. Survey Feet.



21 mini-prisms were set into the Crib Wall for monitoring targets July, 1997.

See following sheet for procedures and chart details.

Horizontal Datum = CCS83, Zone VI, OCS 1991.35 Adjustment
Vertical Datum = NAVD88, OCS 1995 Adjustment

Cove Road - Crib Wall Monitoring Survey

Survey Report Summary

Aug 1997: Initial survey performed.

Nov 1998: No significant movement found.

May 1999: No significant movement found.

May 2000: No significant movement found.

May 2001: No significant movement found.

July 2002: No significant movement found.

June 2004: No significant movement found.

June 2006: No significant movement found. Heights on all targets show an average change of -0.02' which is related to the recomputed height of control point "CRIB" and is not movement of the crib wall.

May 2008: No significant movement found.

June 2010: No significant movement found. The Leica TCA 1100 Total Station was serviced for calibration in March 2010.

June 2012: No significant movement found. Leica TCA had a card reading problem-gun not used. TPS 1203 (SN: 214338) was used.

Sep 2014: No significant movement found. Trimble S8 was used for this survey. Survey delayed due to trimming trees.

Dec 2016: Targets located along the top of the Crib wall have shown slight downslope horizontal movement in the last two surveys with the largest amount being targets 14 and 17 located at the top corner of the wall. Survey delayed due to trimming trees.

Cove Road - Crib Wall Monitoring Survey

Monitoring Procedures:

All surveys are performed following the steps listed below:

STEP # 1

Utilizing GPS Static survey techniques, measure stations "CRBX", "A" and "D" to two OCS CGPS Horizontal control stations SBCC & TRAK which are located outside of the project area. GPS data is post-processed and a minimally constrained adjustment is done constraining the same control station (SBCC) each survey if possible. Positions are compared to the 1997 survey. This data is used to check the stability, horizontally and vertically, of the three monitoring stations. Positions for stations "B", "C", and "BH3" are verified from the GPS stations using conventional techniques.

STEP # 2

Utilizing Precise leveling techniques following 2nd Order - Class II specifications, measure the vertical differences between all monitoring stations relative to four OCS Vertical control stations. This data is used to monitor any subsidence and/or uplift on the monitoring stations.

STEP # 3

Utilize conventional surveying techniques with a Total Station. Measure each target 4 times (2 direct, 2 reverse).

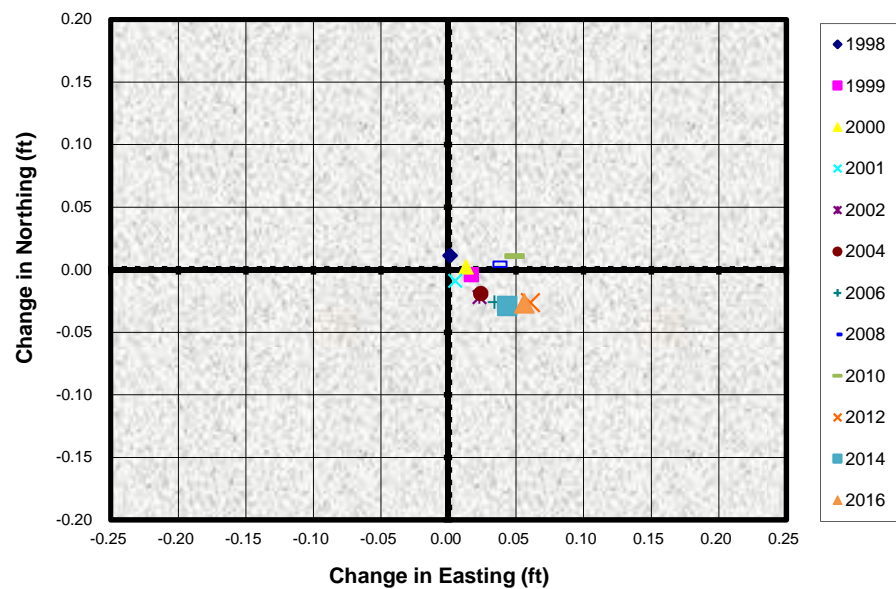
All 5 control stations observe all possible targets to achieve sufficient redundancy. The observations are then entered into a StarNet least-squares adjustment for calculation of final positions.

Comments:

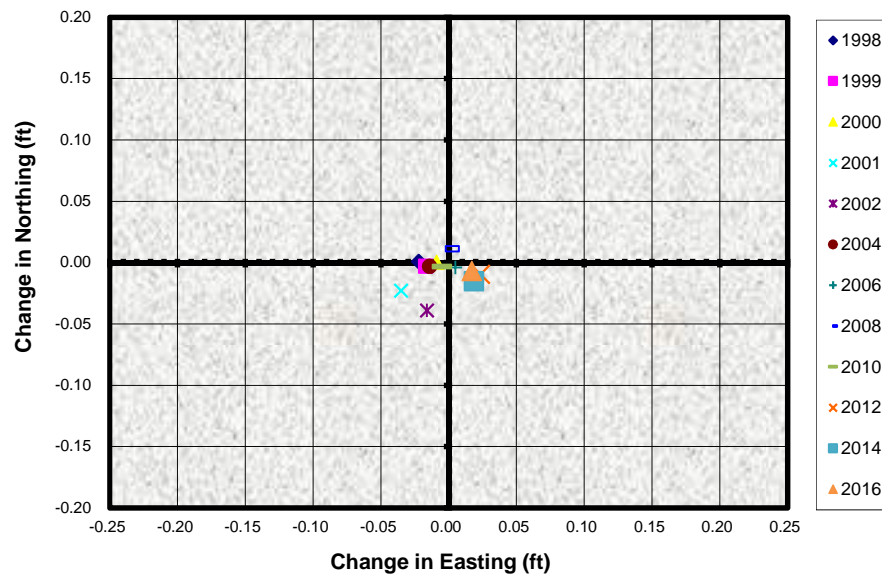
Each survey is done using the same techniques with the same survey equipment if possible. A "Report Summary" is given on the first sheet and contains a short comment on each survey. Detailed information pertaining to monument descriptions and survey information are not included in this report, but can be obtained at OC Survey Division, Geodetic Control Unit.

Cove Road Crib Wall Movement from 1997 Initial Survey

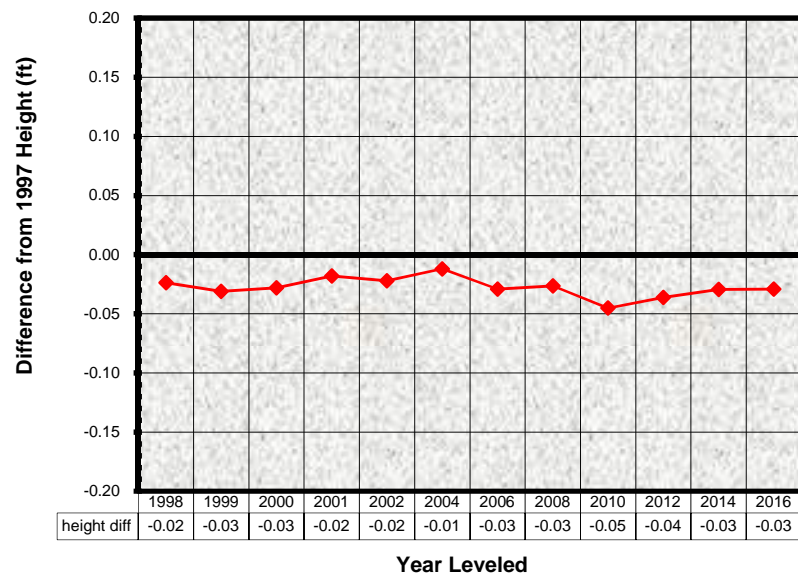
Station # 1 - Horizontal



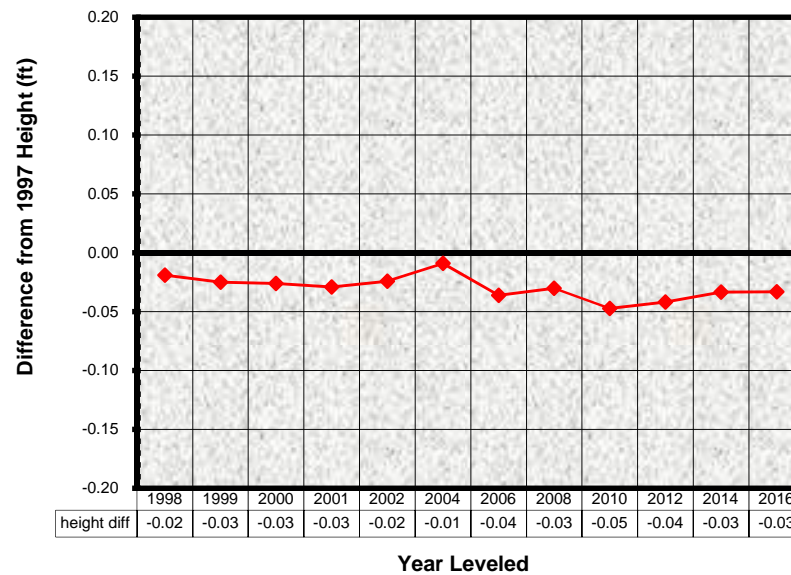
Station # 2 - Horizontal



Station # 1 - Vertical

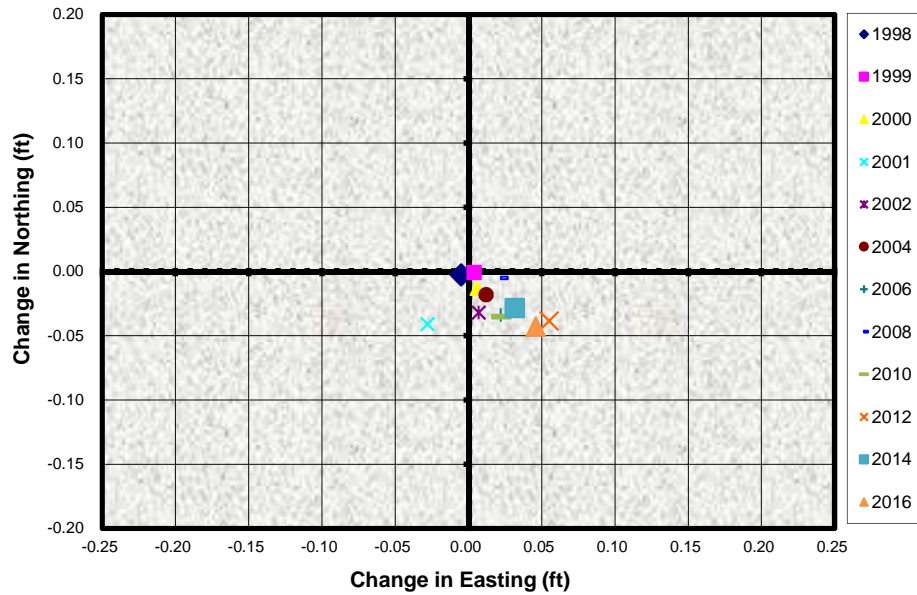


Station # 2 - Vertical

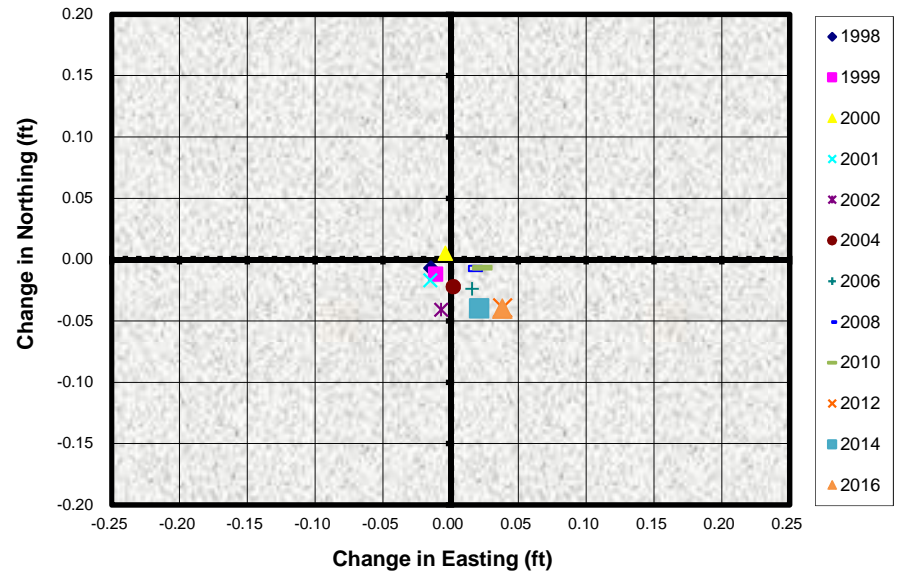


Cove Road Crib Wall Movement from 1997 Initial Survey

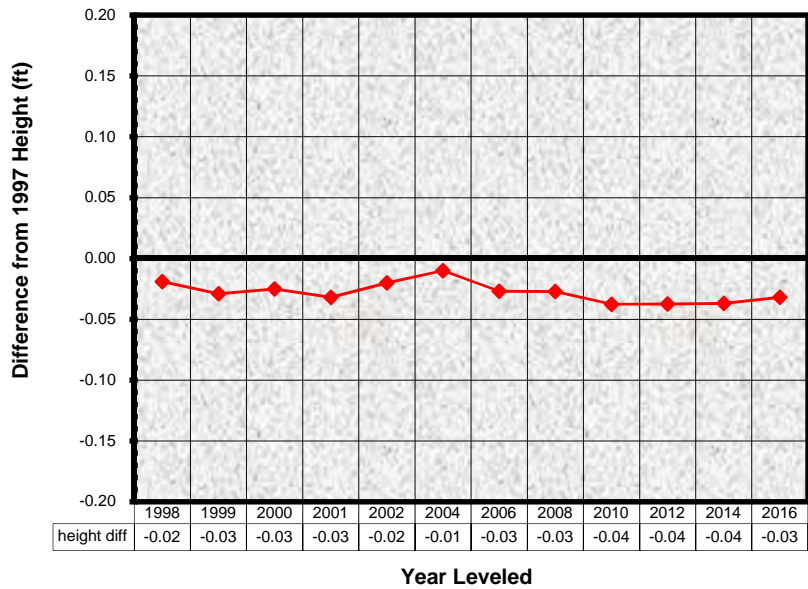
Station # 3 - Horizontal



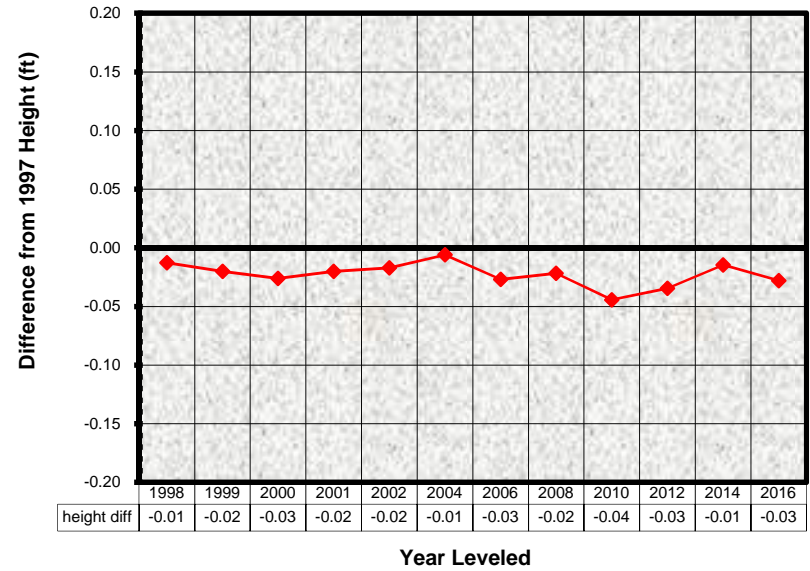
Station # 4 - Horizontal



Station # 3 - Vertical

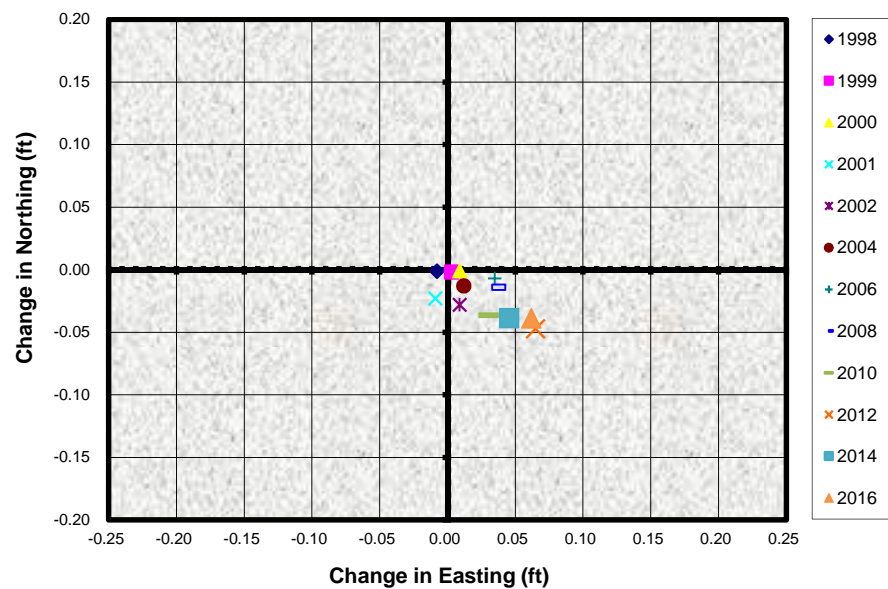


Station # 4 - Vertical

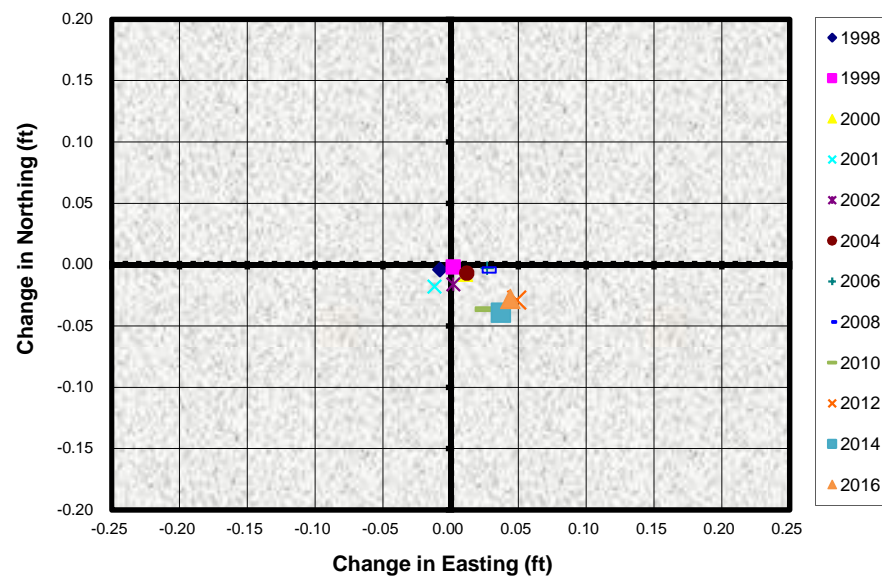


Cove Road Crib Wall Movement from 1997 Initial Survey

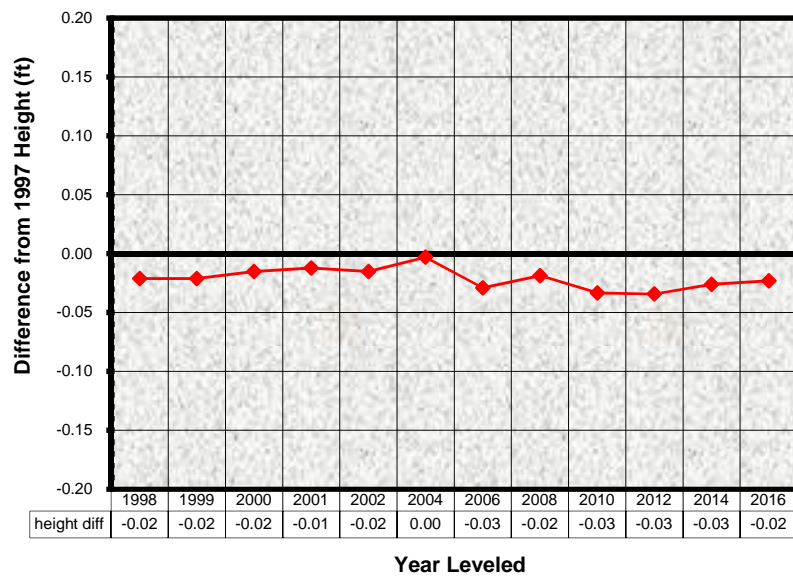
Station # 5 - Horizontal



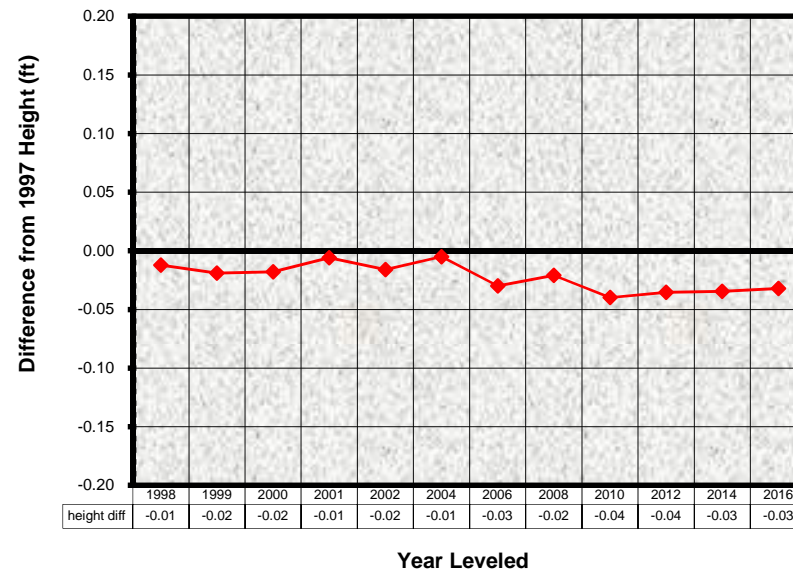
Station # 6 - Horizontal



Station # 5 - Vertical

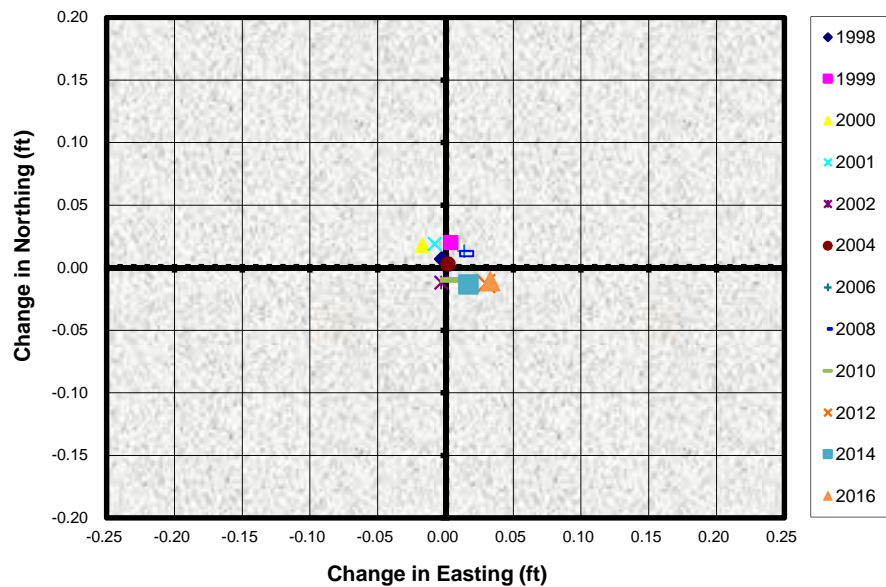


Station # 6 - Vertical

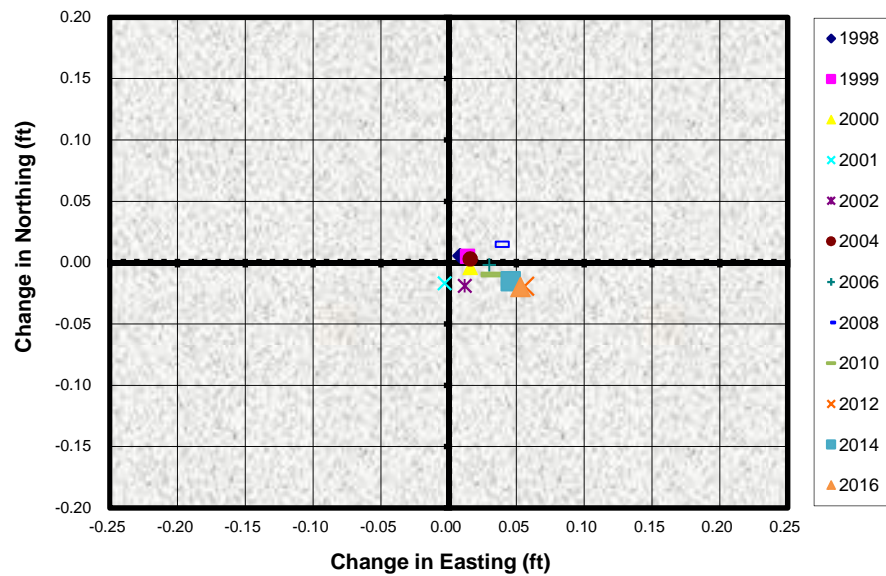


Cove Road Crib Wall Movement from 1997 Initial Survey

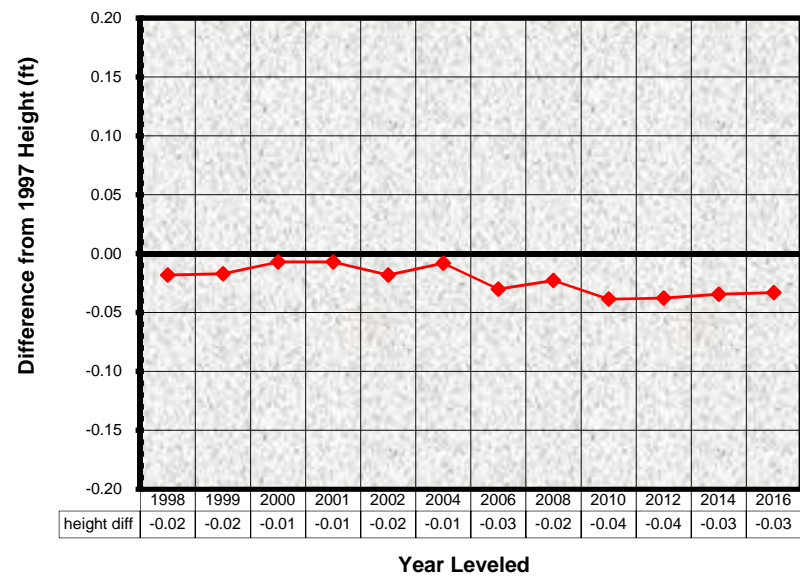
Station # 7 - Horizontal



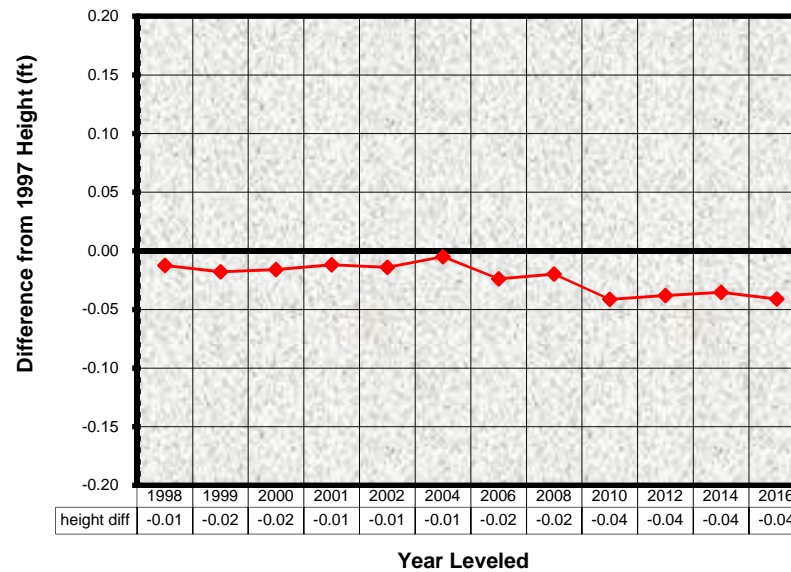
Station # 8 - Horizontal



Station # 7 - Vertical



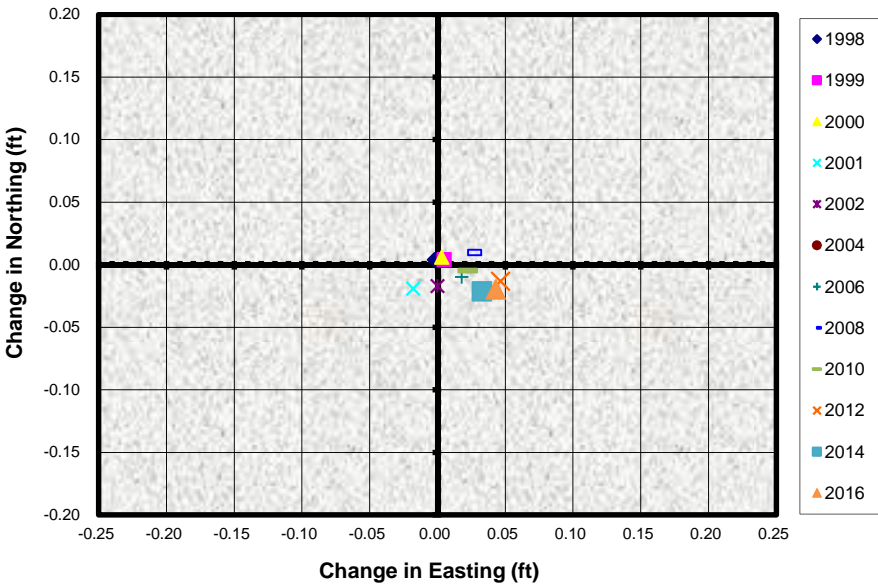
Station # 8 - Vertical



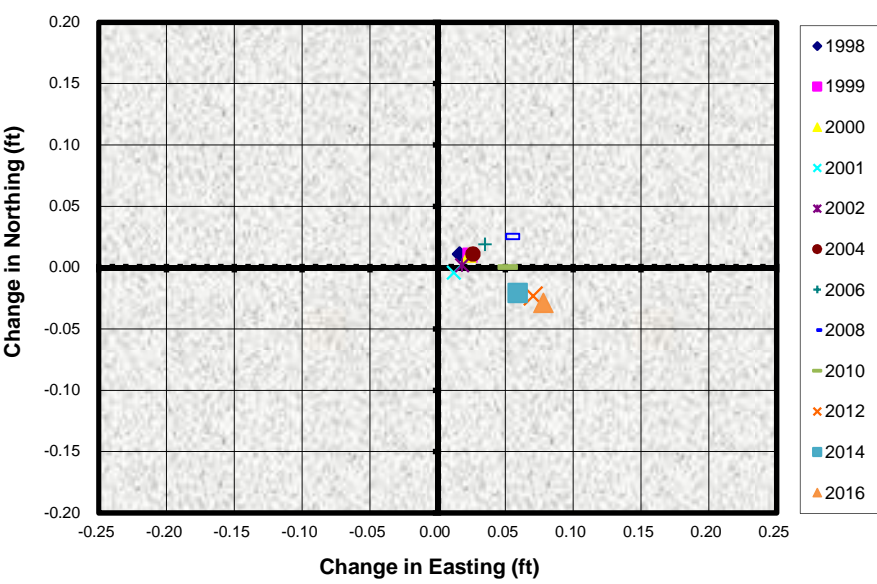
Cove Road Crib Wall

Movement from 1997 Initial Survey

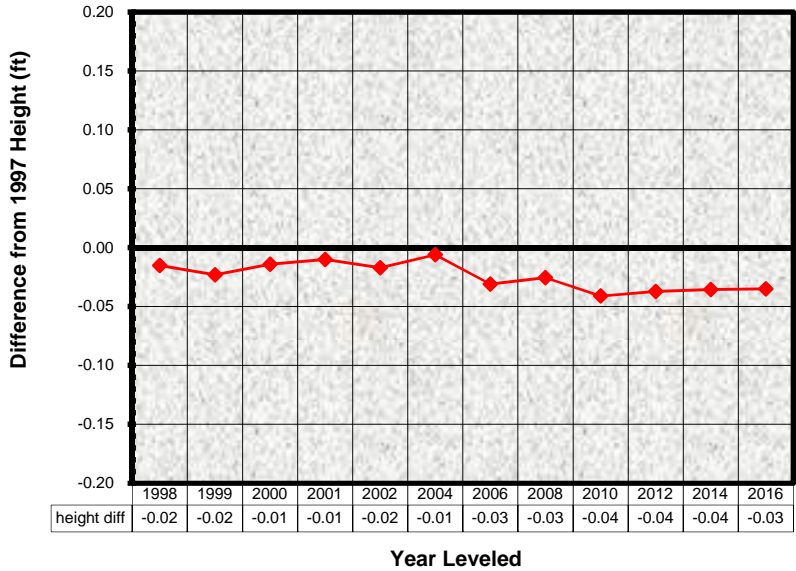
Station # 9 - Horizontal



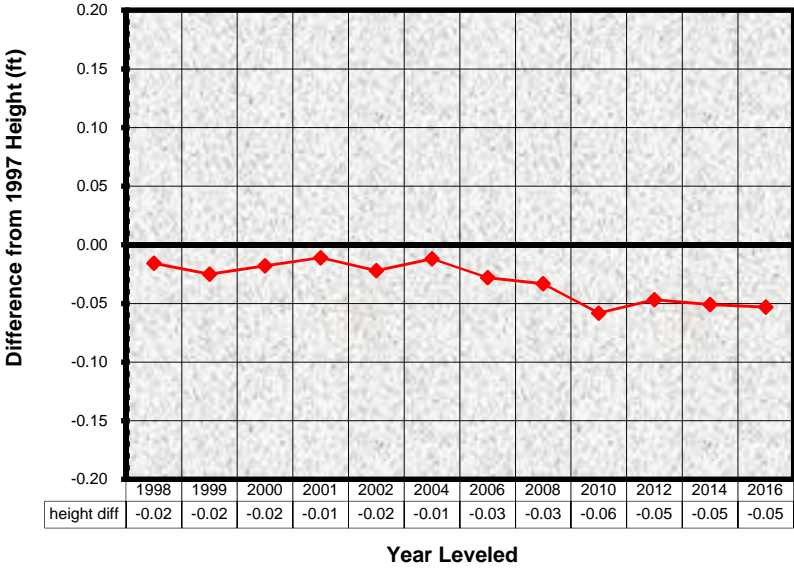
Station # 10 - Horizontal



Station # 9 - Vertical

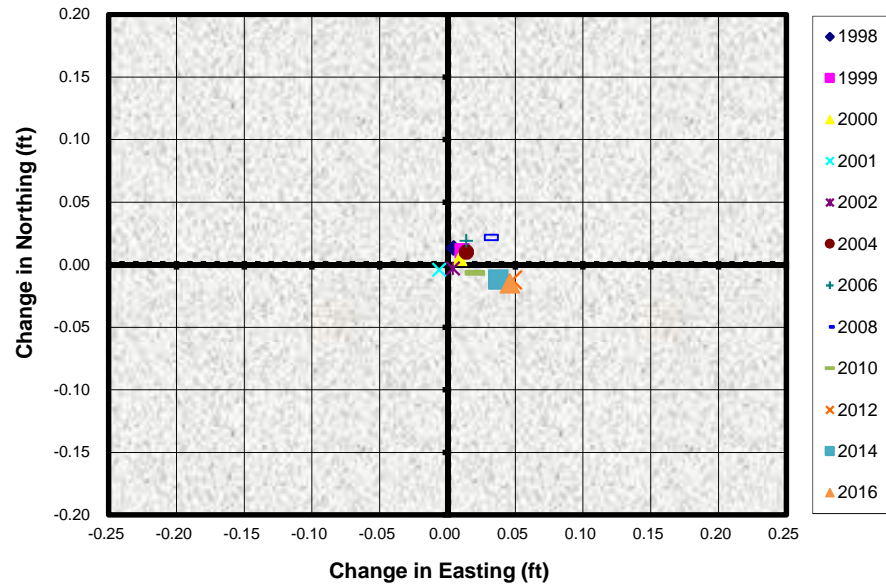


Station # 10 - Vertical

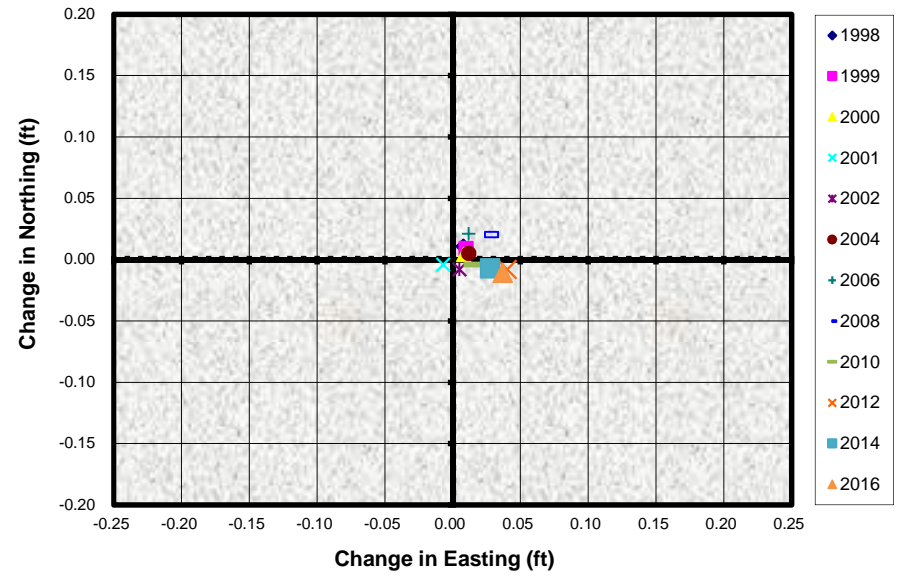


Cove Road Crib Wall Movement from 1997 Initial Survey

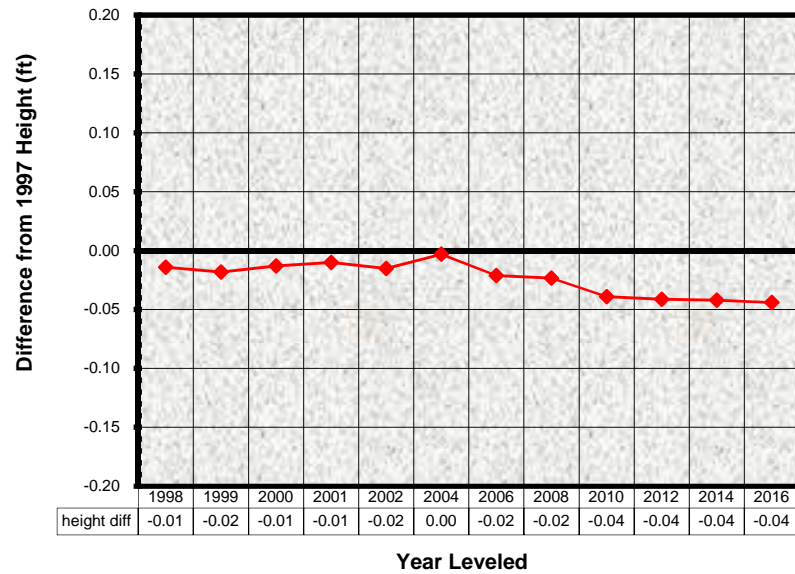
Station # 11 - Horizontal



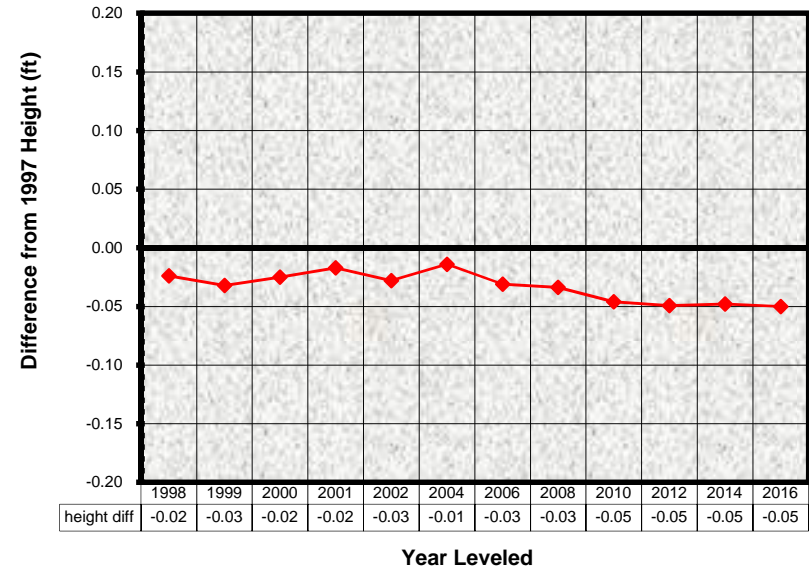
Station # 12 - Horizontal



Station # 11 - Vertical

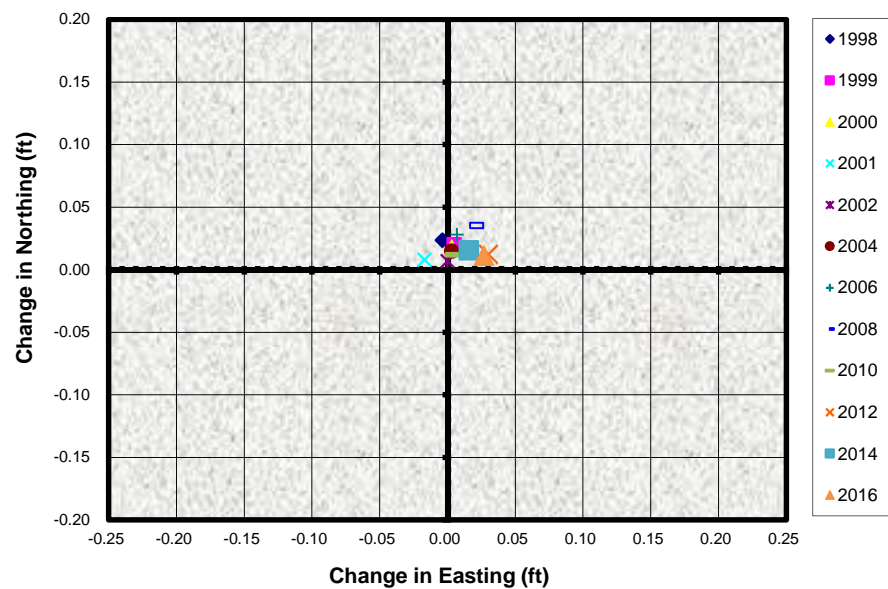


Station # 12 - Vertical

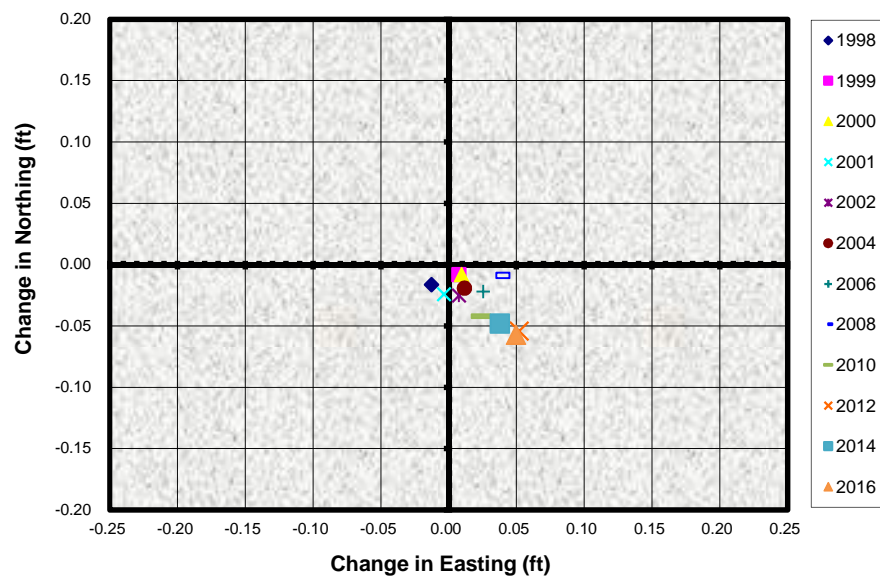


Cove Road Crib Wall Movement from 1997 Initial Survey

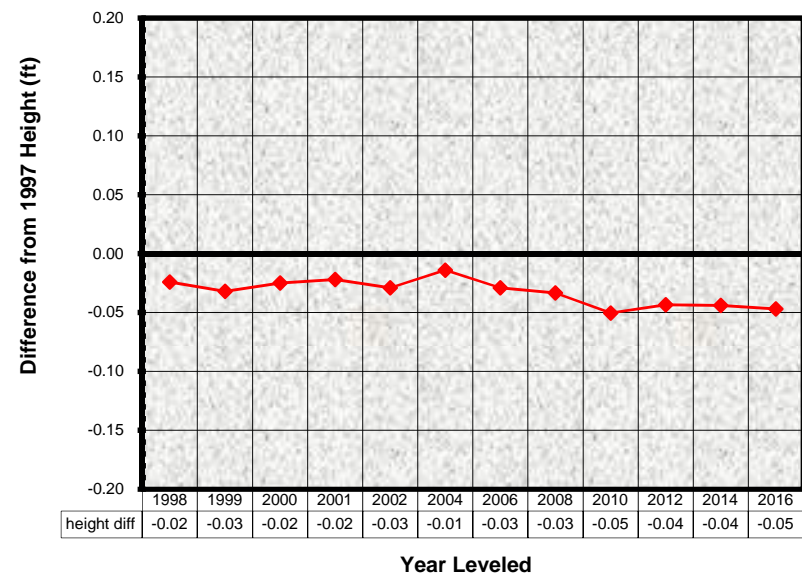
Station # 13 - Horizontal



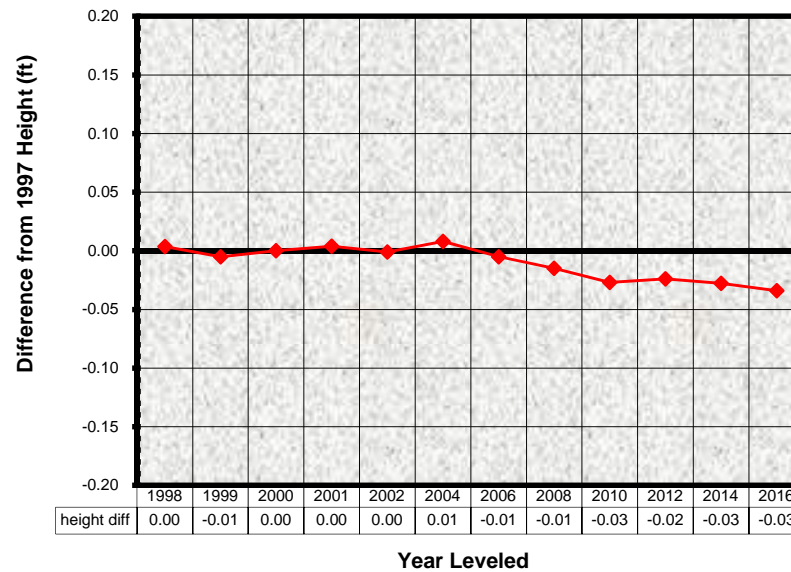
Station # 14 - Horizontal



Station # 13 - Vertical

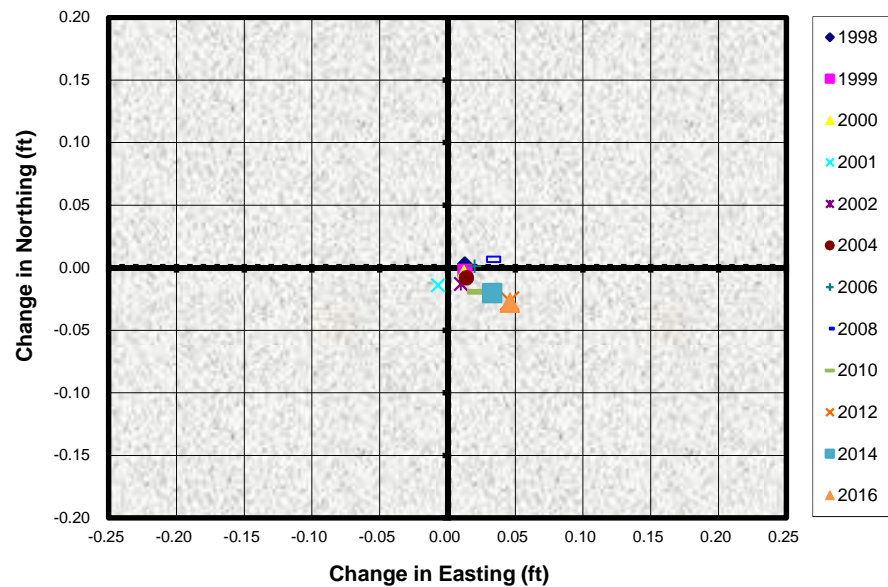


Station # 14 - Vertical

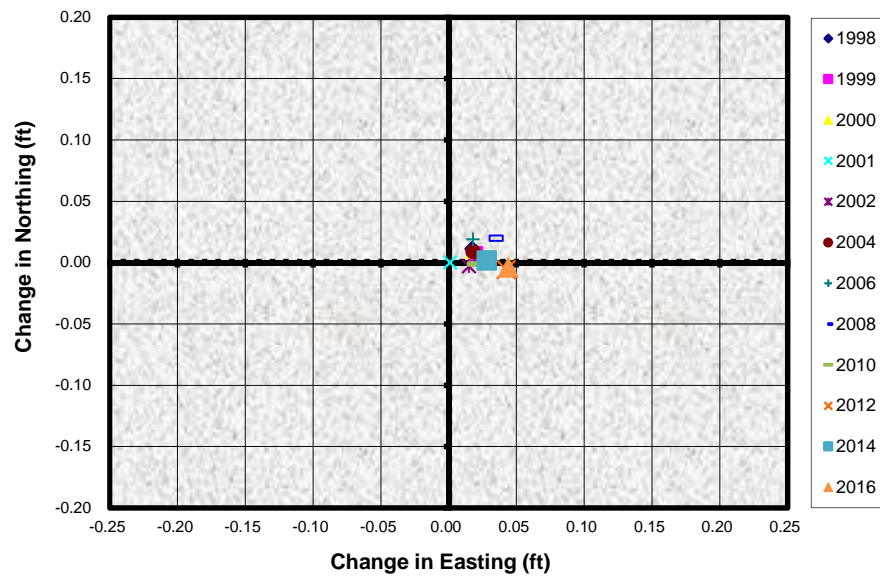


Cove Road Crib Wall Movement from 1997 Initial Survey

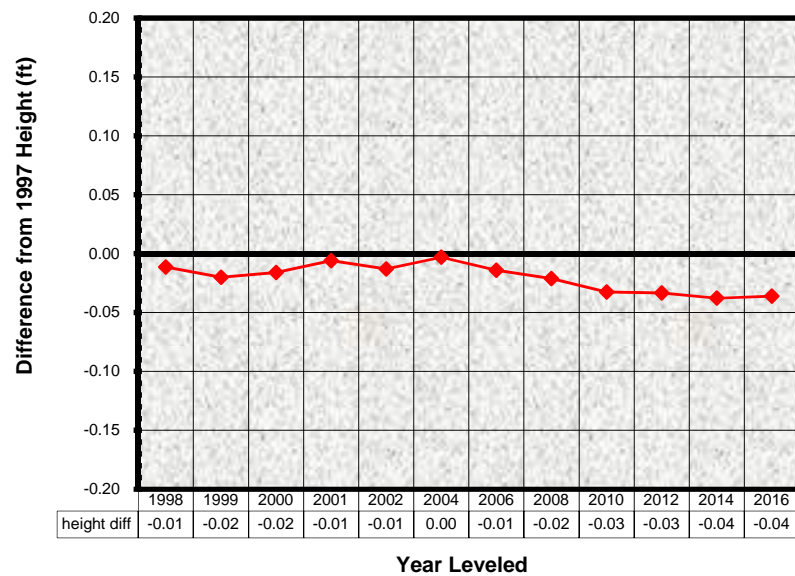
Station # 15 - Horizontal



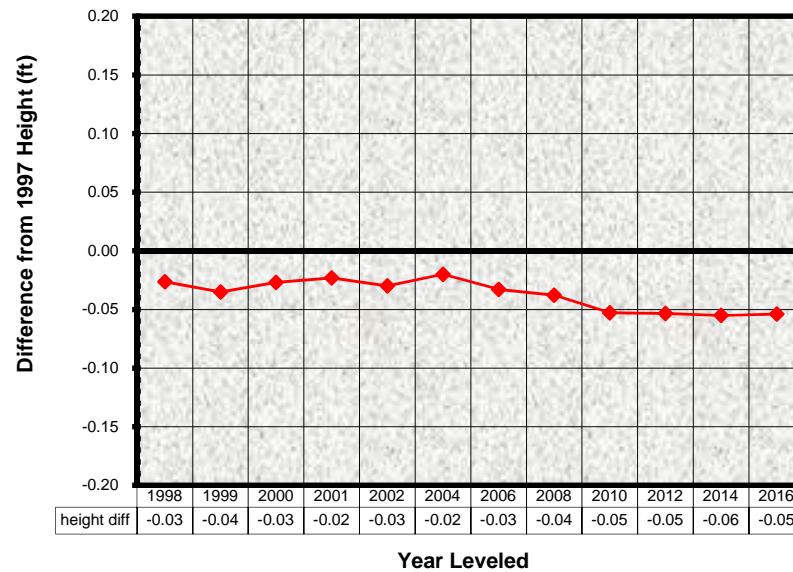
Station # 16 - Horizontal



Station # 15 - Vertical

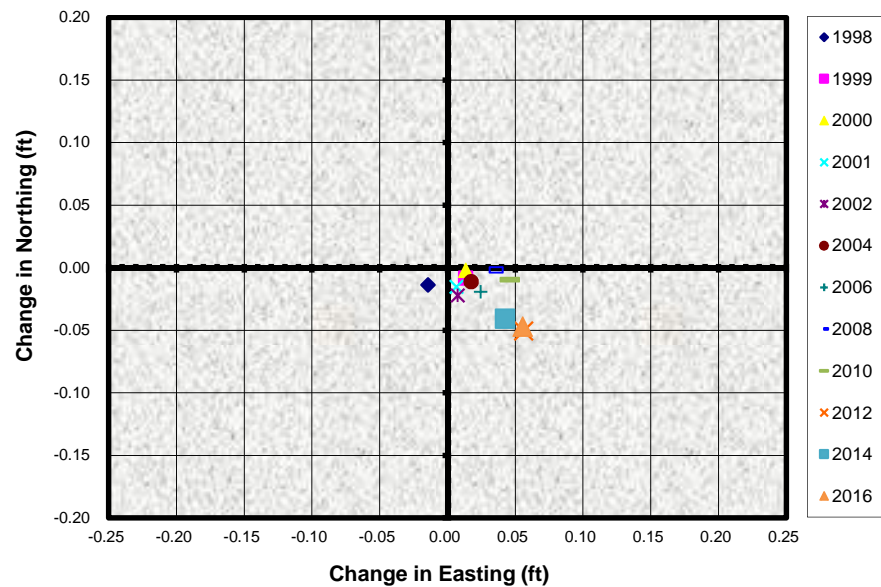


Station # 16 - Vertical

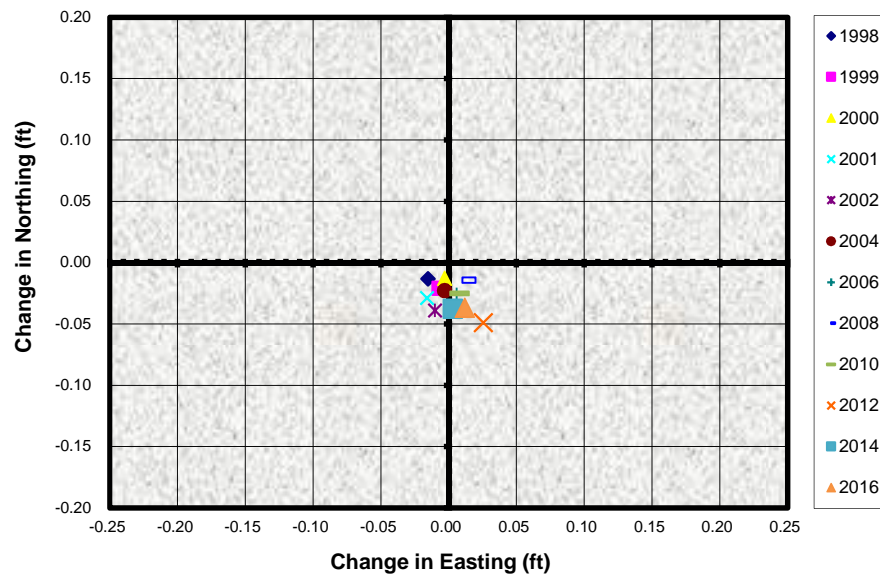


Cove Road Crib Wall Movement from 1997 Initial Survey

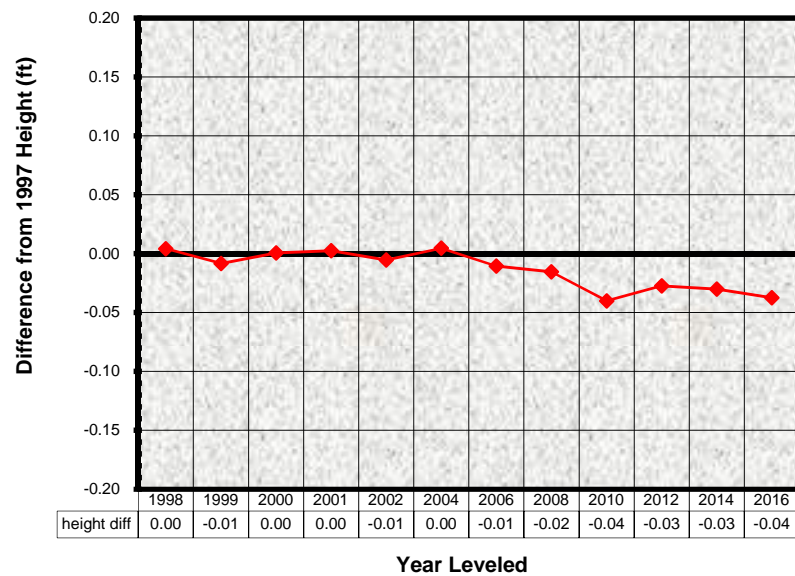
Station # 17 - Horizontal



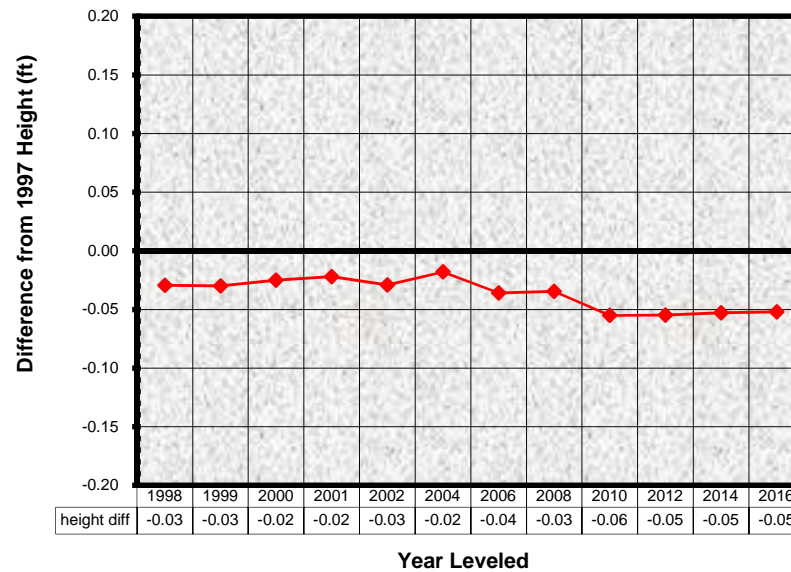
Station # 18 - Horizontal



Station # 17 - Vertical

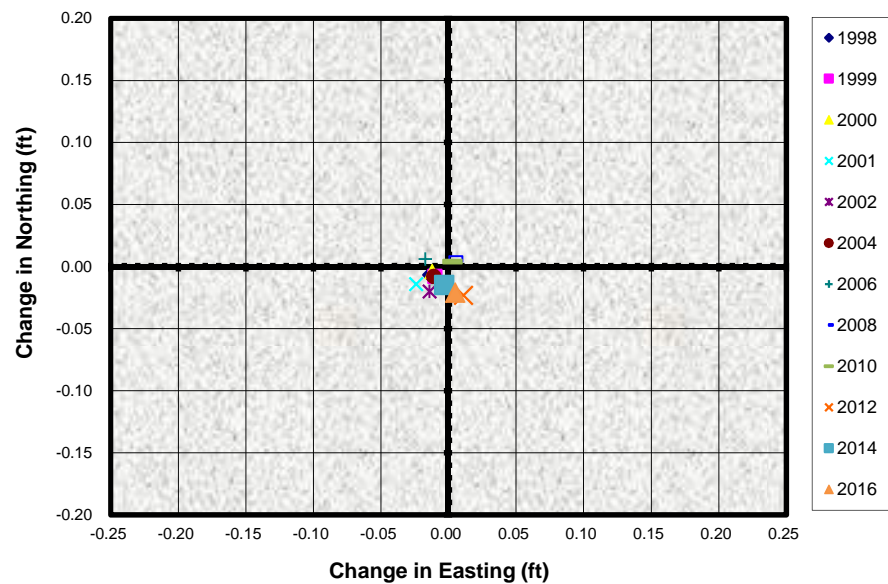


Station # 18 - Vertical

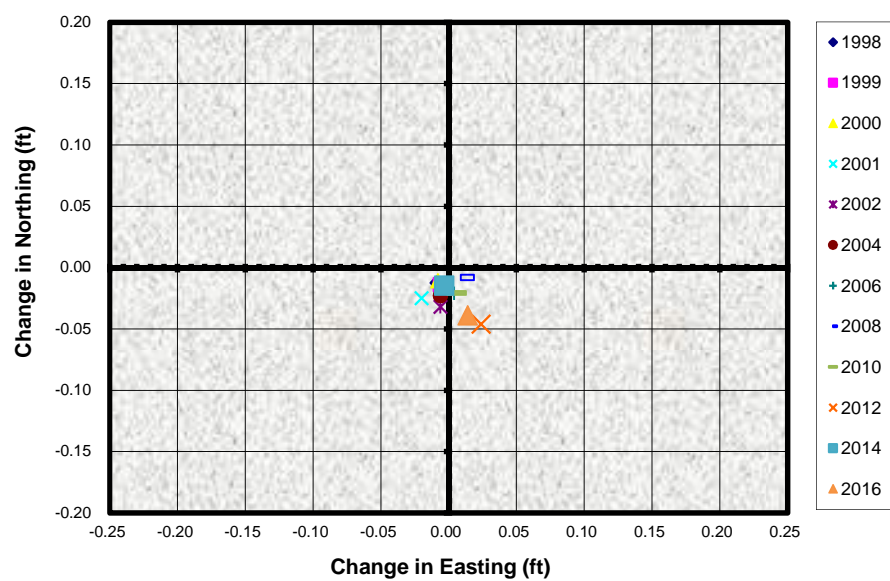


Cove Road Crib Wall Movement from 1997 Initial Survey

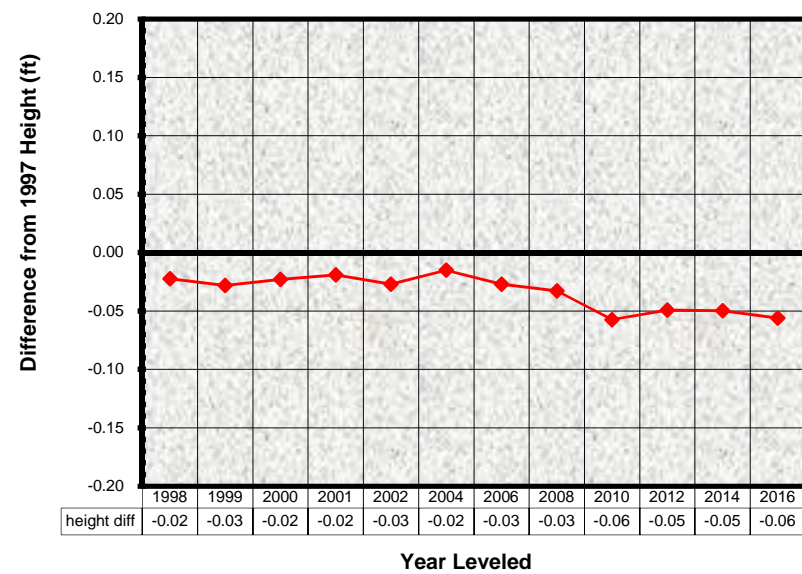
Station # 19 - Horizontal



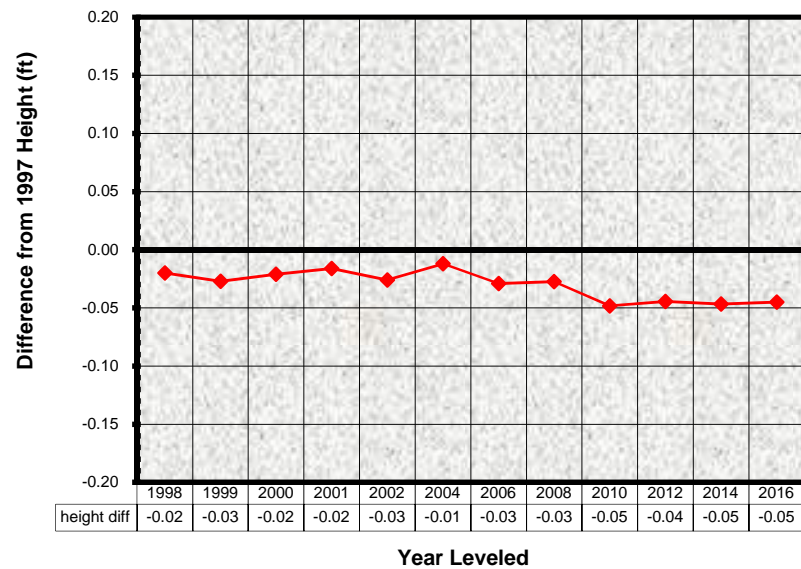
Station # 20 - Horizontal



Station # 19 - Vertical



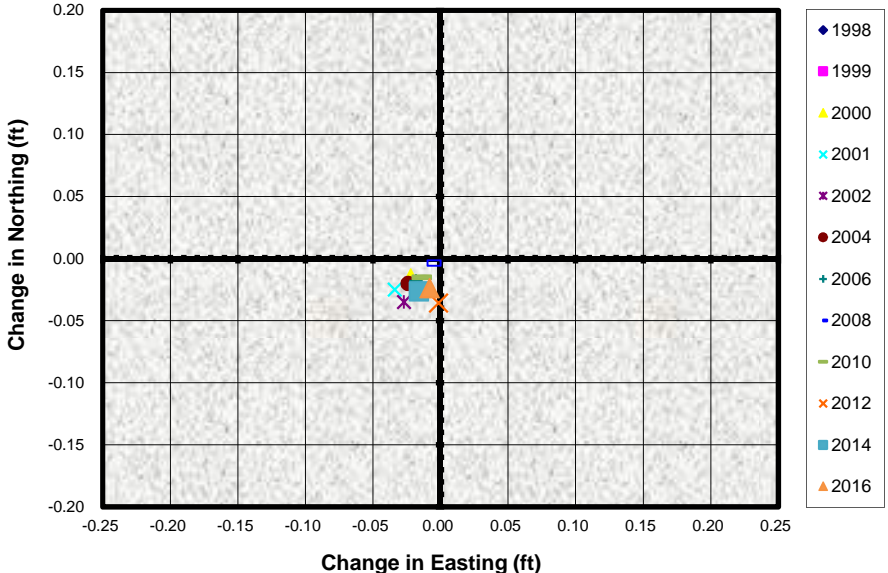
Station # 20 - Vertical



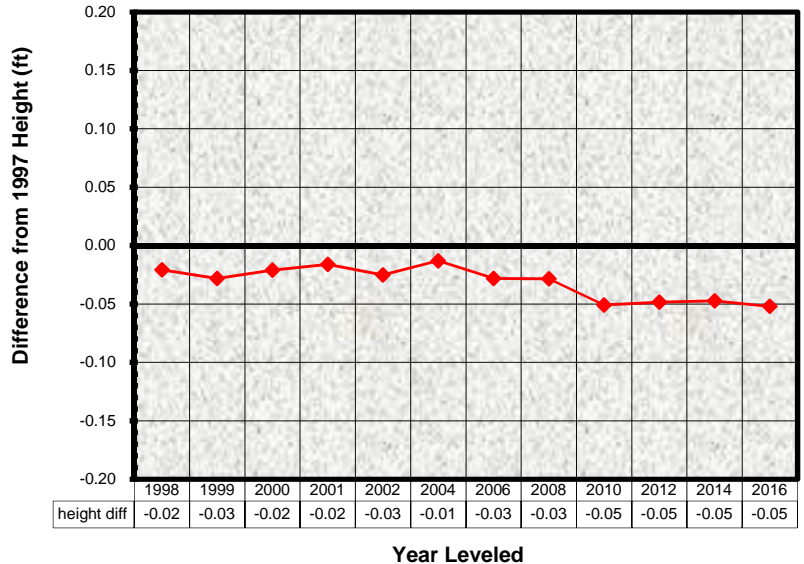
Cove Road Crib Wall

Movement from 1997 Initial Survey

Station # 21 - Horizontal



Station # 21 - Vertical



14

SEVEN OAKS DAM










Data Index (TAB)

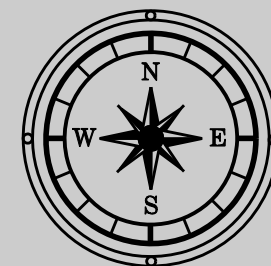
Dn 2310'
Dn 2510'
Dn 2560'
Dn Top of Dam
Up Top of Dam
Up 2530'
Up 2360'

Inclinometer

See these sections for each data set

Intake (TAB)

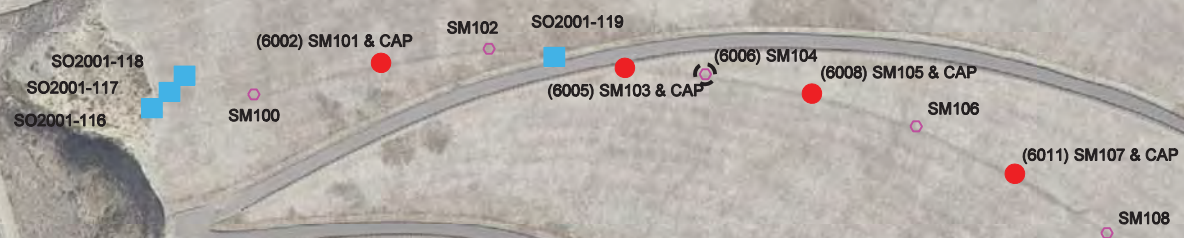
-  PILLAR MONUMENT
-  OTHER H & V MONUMENT
-  BENCHMARK
-  SETTLEMENT MONUMENT 77 mon
-  SETTLEMENT MONUMENT (SUBSET) 33 mon
-  INCLINOMETER 6 mon
-  CORS SITE
-  TUNNEL MONUMENT 22 mon
-  X-SECTION MONUMENT 7 mon












250' 250'

Seven Oaks Dam Monitoring Survey

Downstream 2310' Level - Monitoring Points



LEGEND

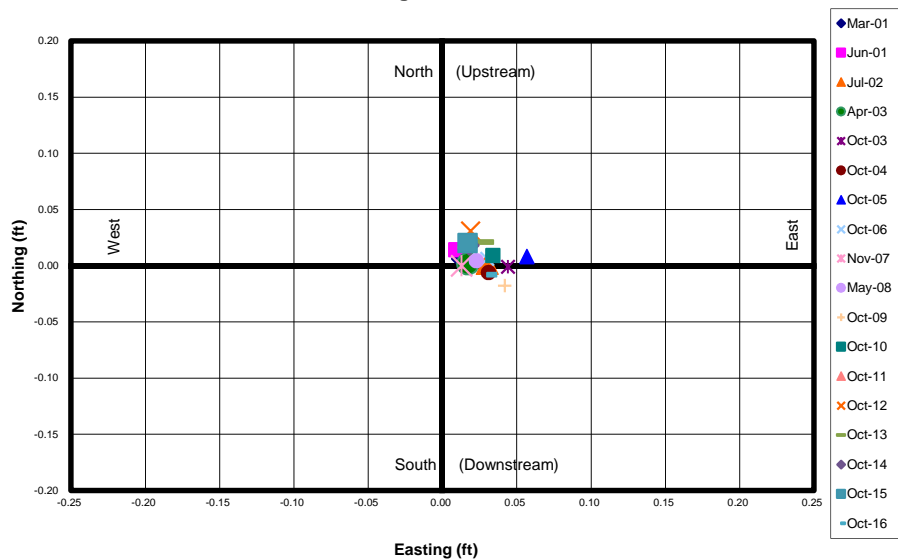
-  PILLAR MONUMENT
-  OTHER H & V MONUMENT
-  BENCHMARK
-  SETTLEMENT MONUMENT 77 mon
-  SETTLEMENT MONUMENT (SUBSET) 33 mon
-  INCLINOMETER 6 mon
-  CORS SITE
-  TUNNEL MONUMENT 22 mon
-  X-SECTION MONUMENT 7 mon



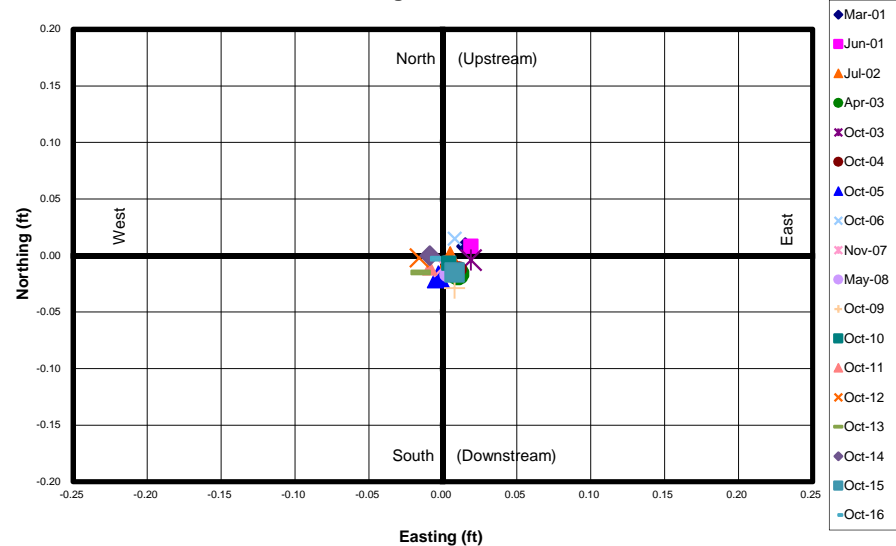
Seven Oaks Dam - Downstream 2310' Level (Horizontal)

Horizontal Movement since January 2001 Initial Survey

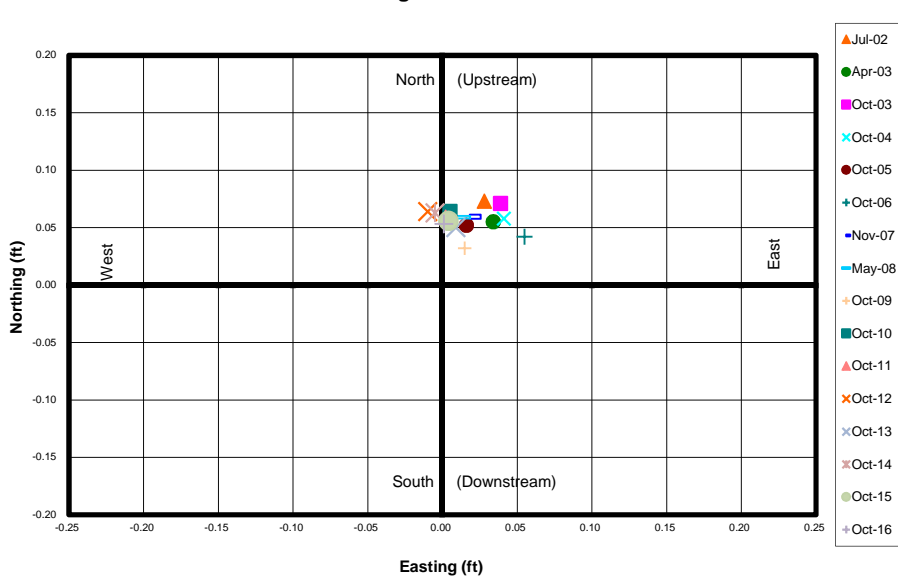
Monitoring Point SM101



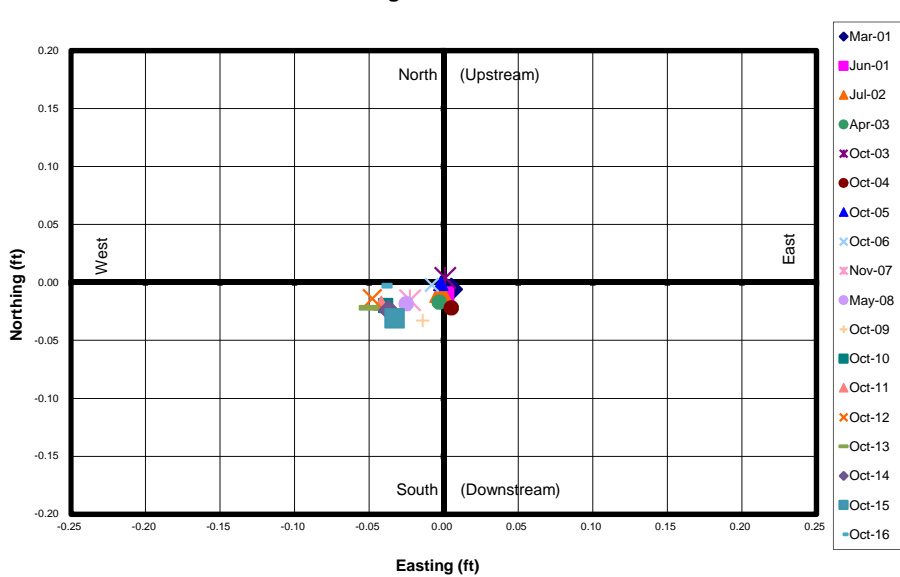
Monitoring Point SM103



Monitoring Point SM104

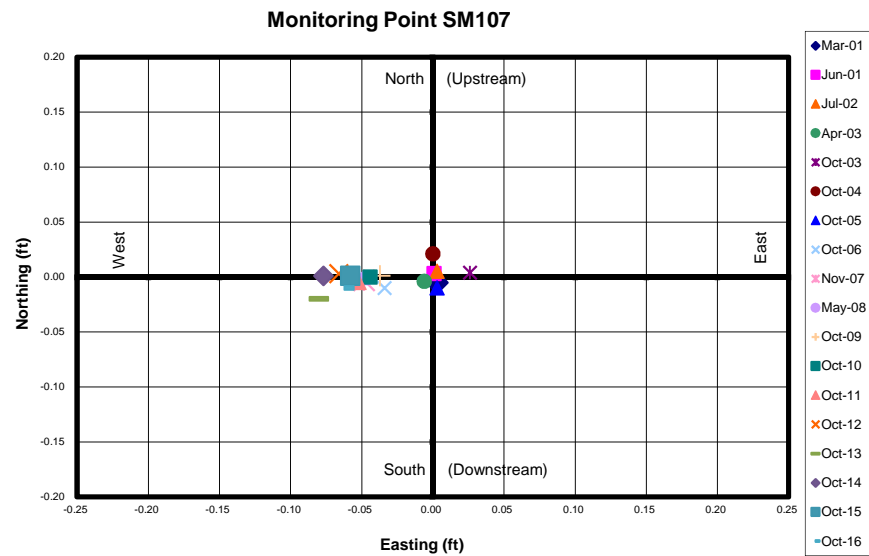


Monitoring Point SM105



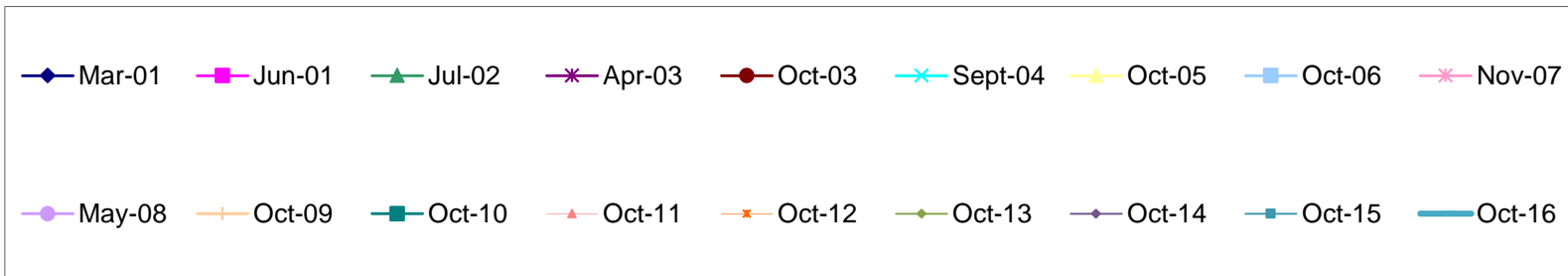
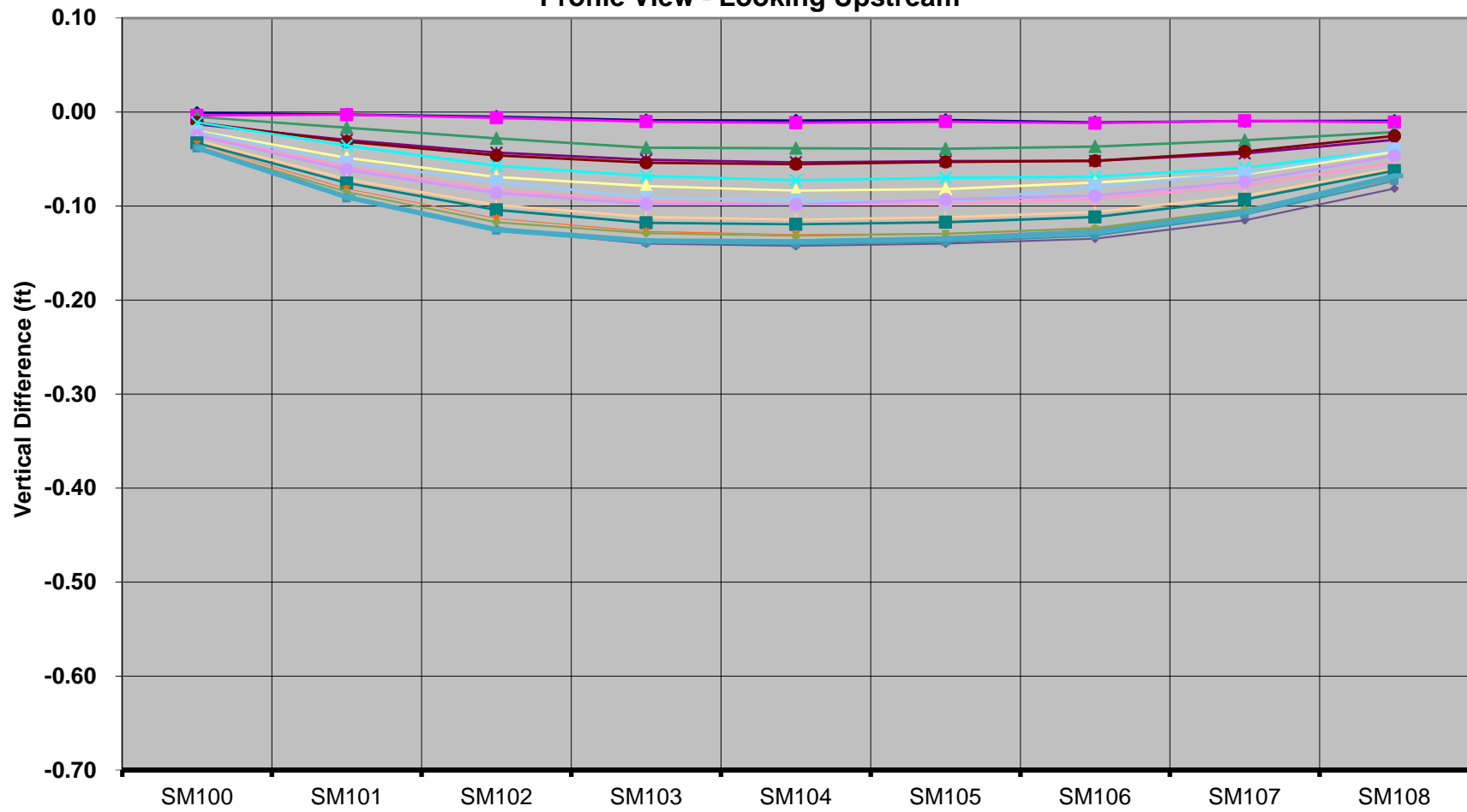
(0,0) = January 2001 Horizontal Position

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



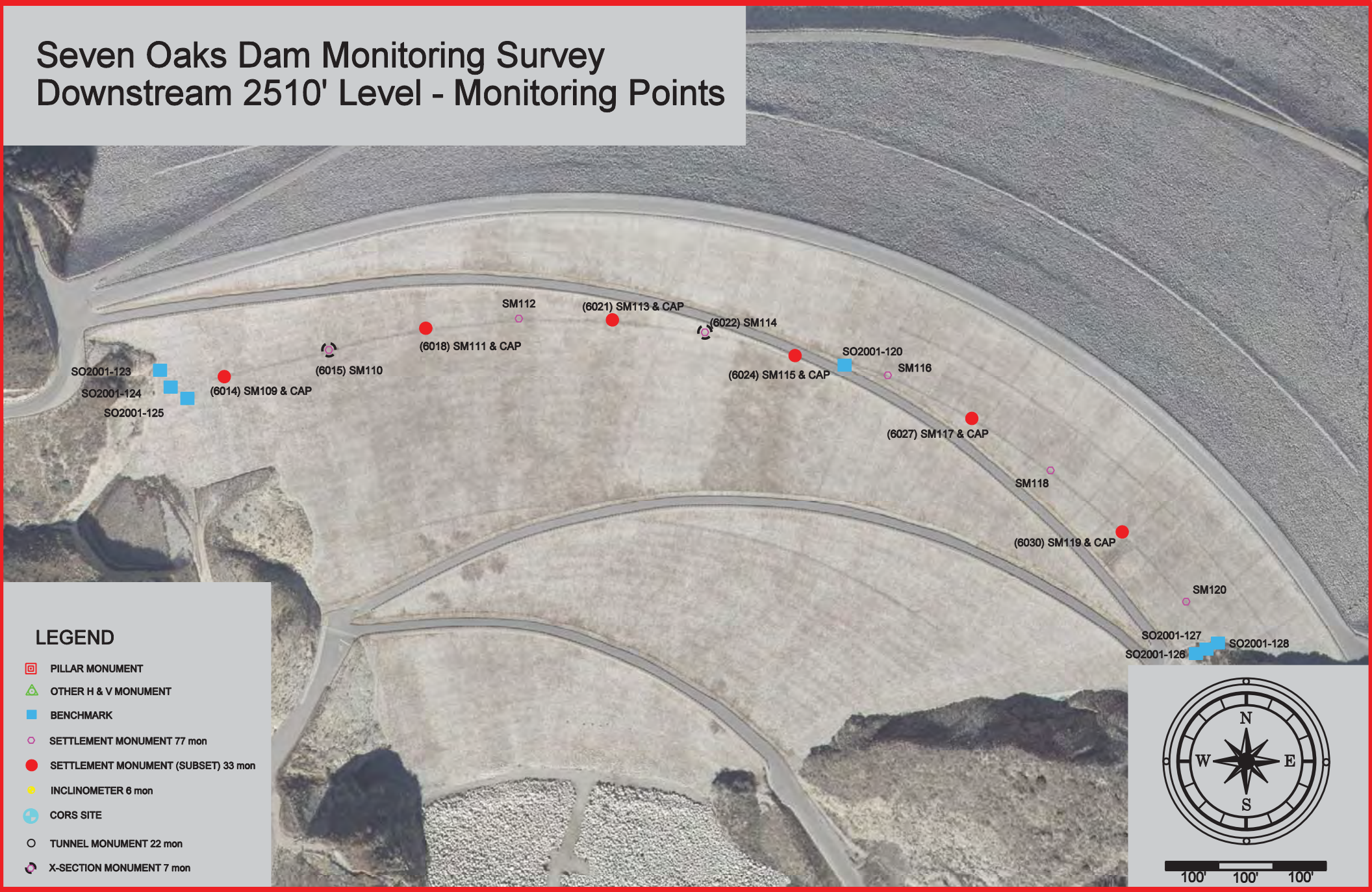
(0,0) = January 2001 Horizontal Position

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












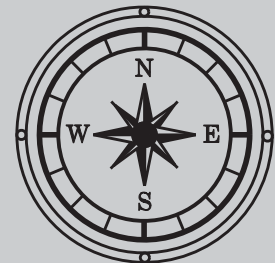
Seven Oaks Dam Monitoring Survey

Downstream 2510' Level - Monitoring Points



LEGEND

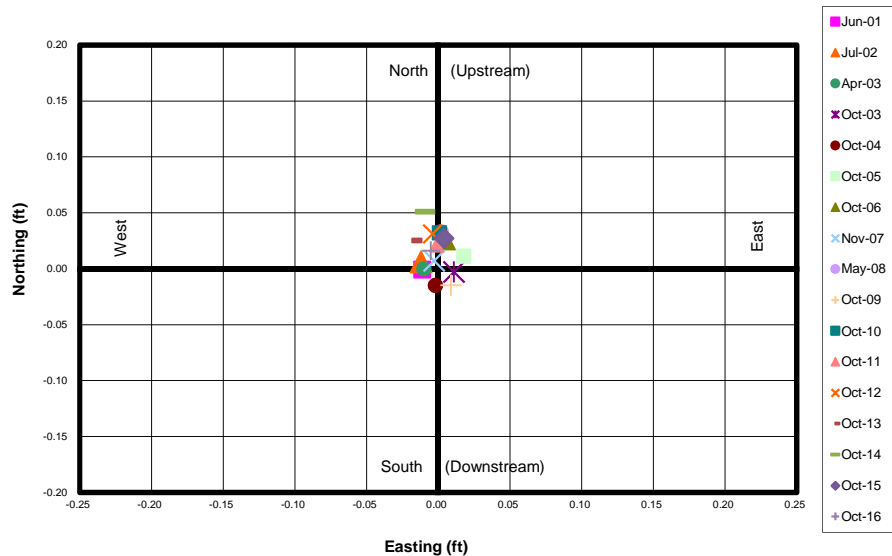
-  PILLAR MONUMENT
-  OTHER H & V MONUMENT
-  BENCHMARK
-  SETTLEMENT MONUMENT 77 mon
-  SETTLEMENT MONUMENT (SUBSET) 33 mon
-  INCLINOMETER 6 mon
-  CORS SITE
-  TUNNEL MONUMENT 22 mon
-  X-SECTION MONUMENT 7 mon



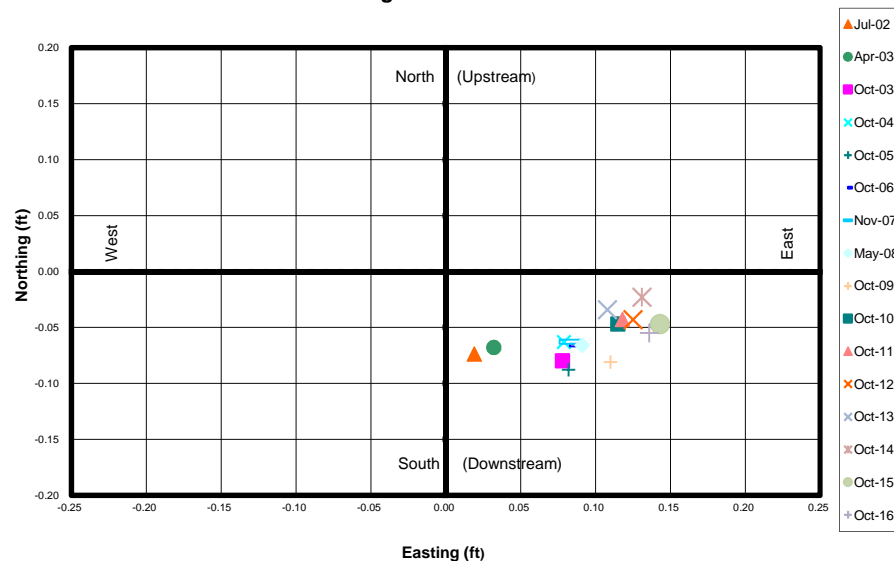
Seven Oaks Dam - Downstream 2510' Level (Horizontal)

Horizontal Movement since January 2001 Initial Survey

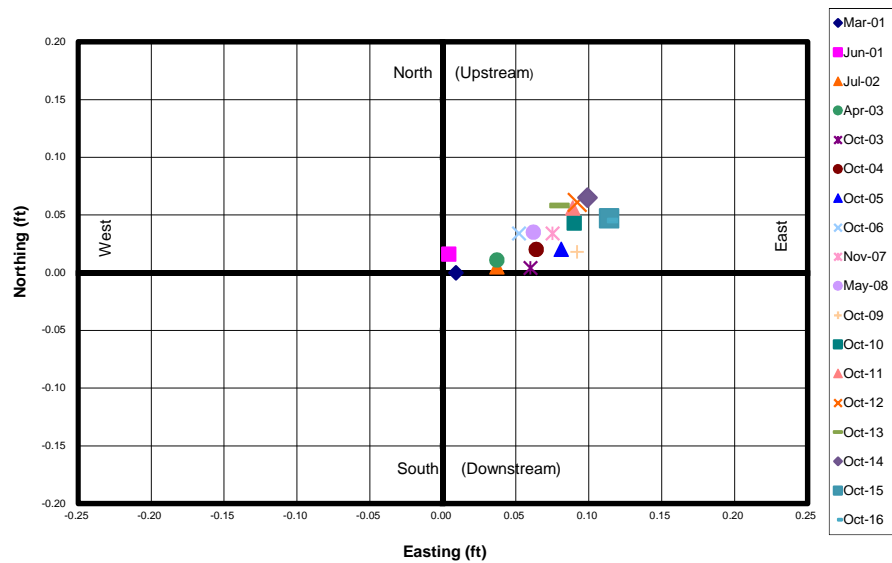
Monitoring Point SM109



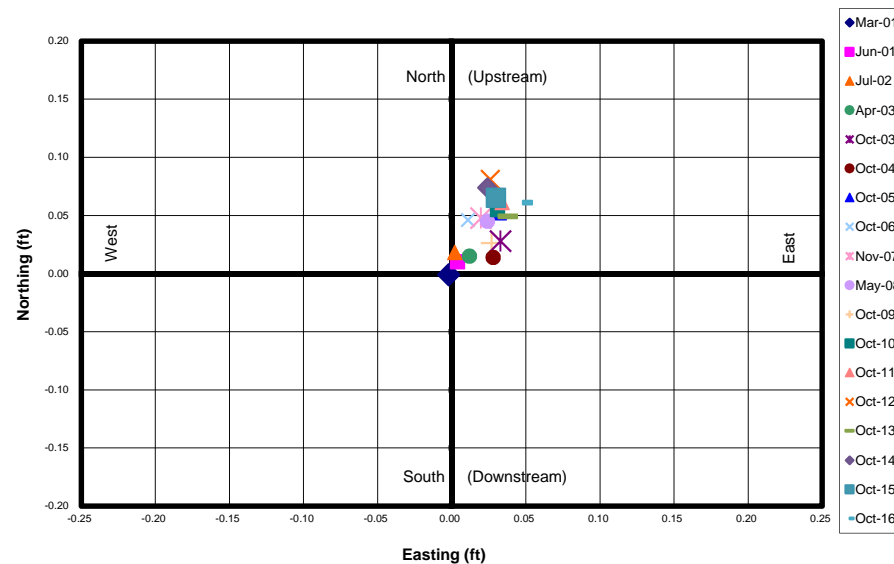
Monitoring Point SM110



Monitoring Point SM111



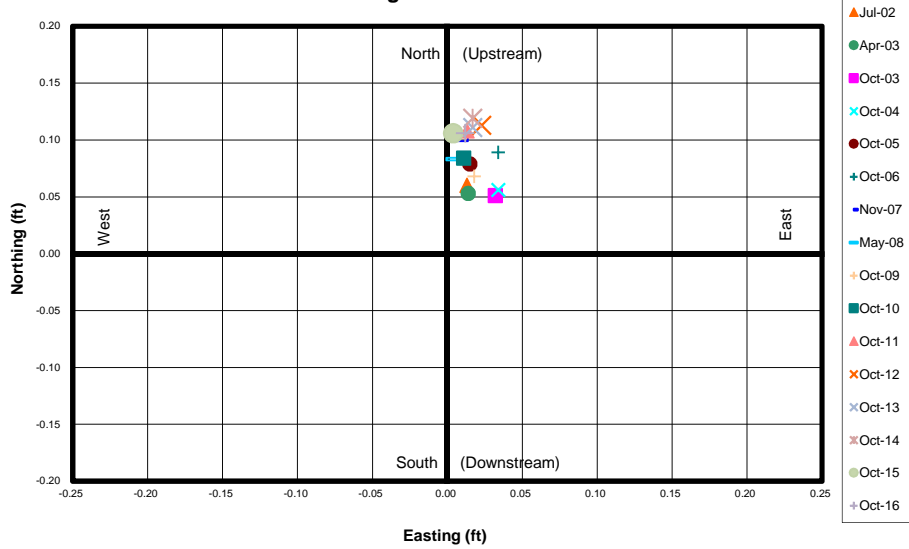
Monitoring Point SM113



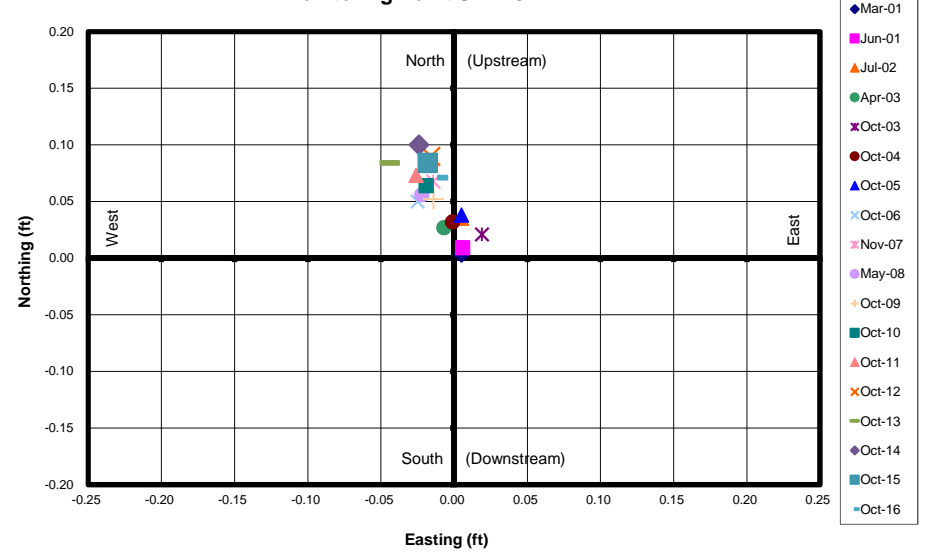
(0,0) = January 2001 Horizontal Position

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

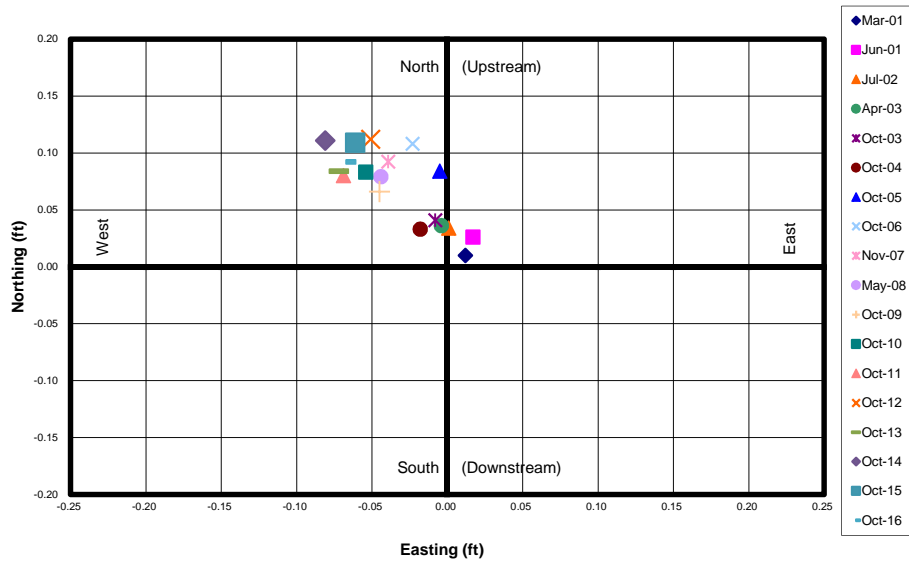
Monitoring Point SM114



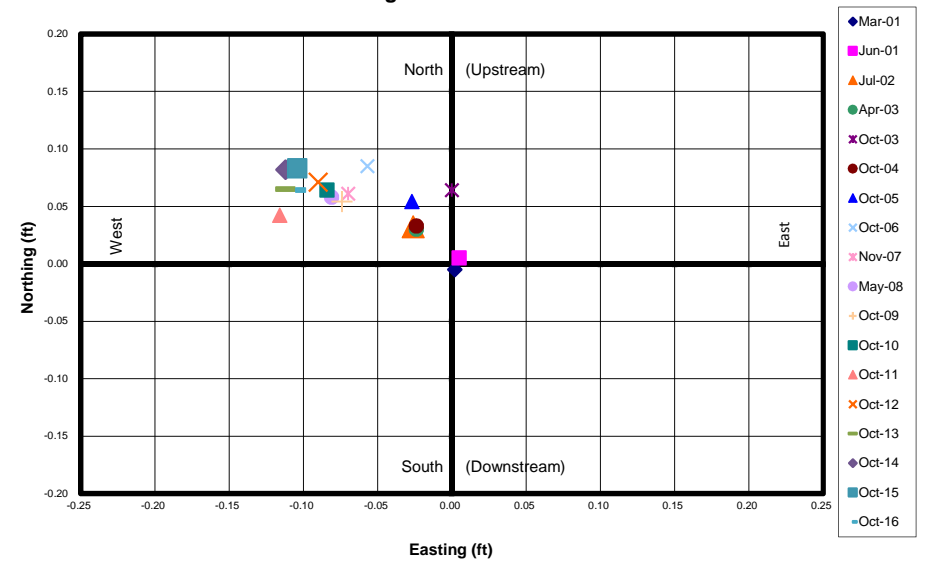
Monitoring Point SM115



Monitoring Point SM117

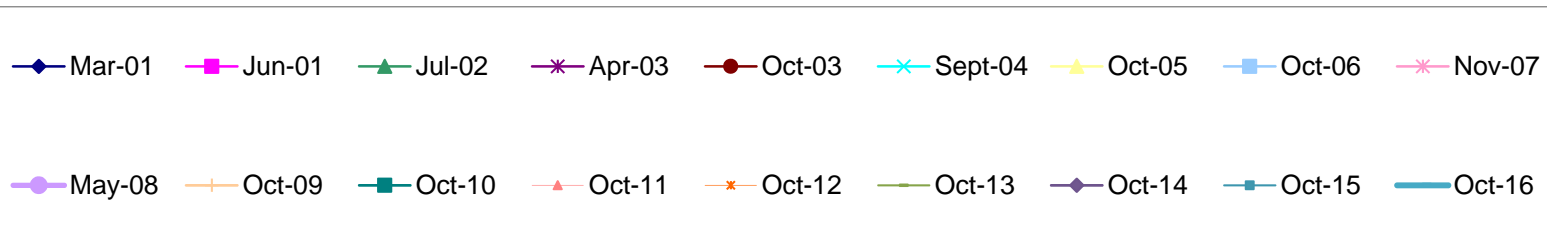
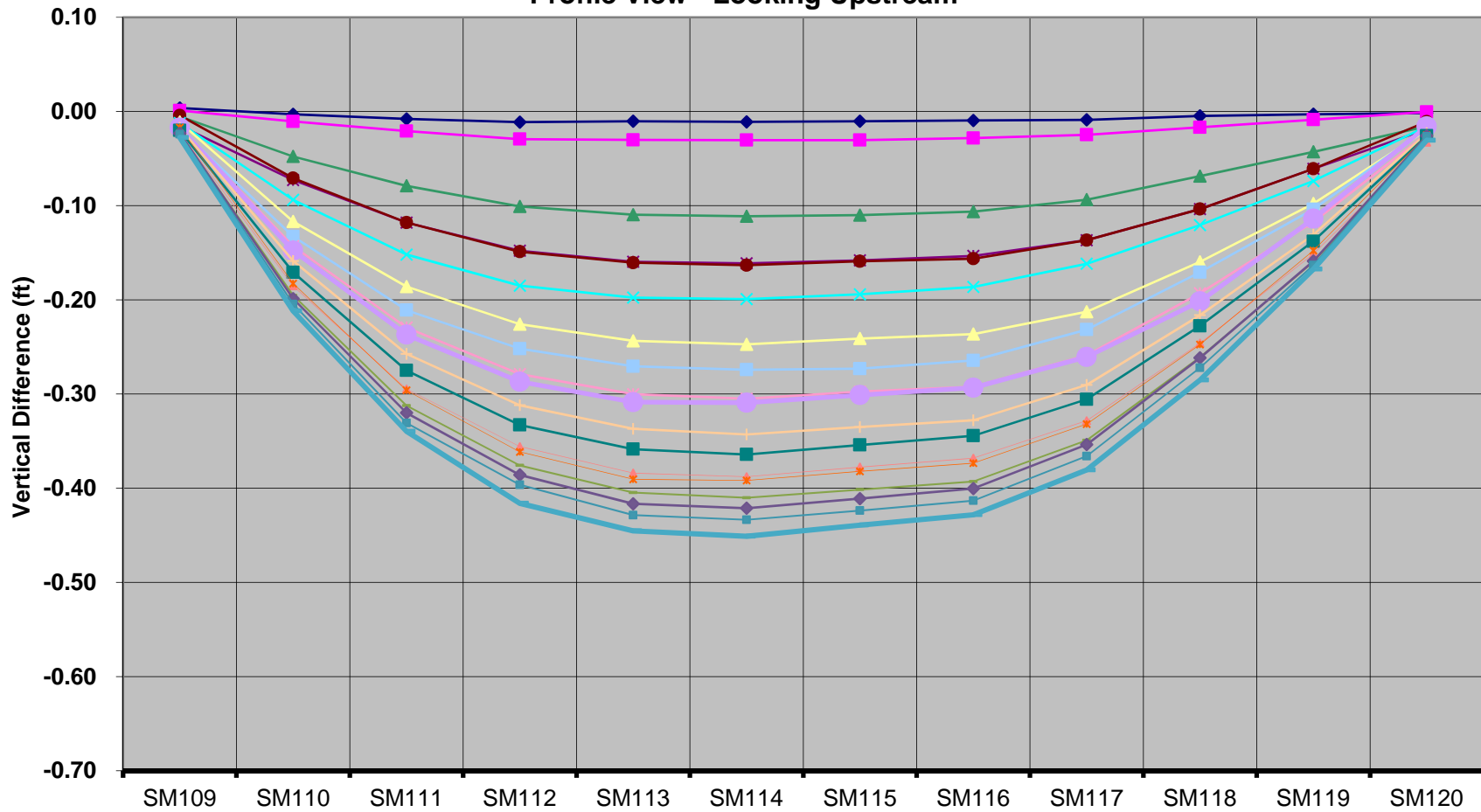


Monitoring Point SM119



(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

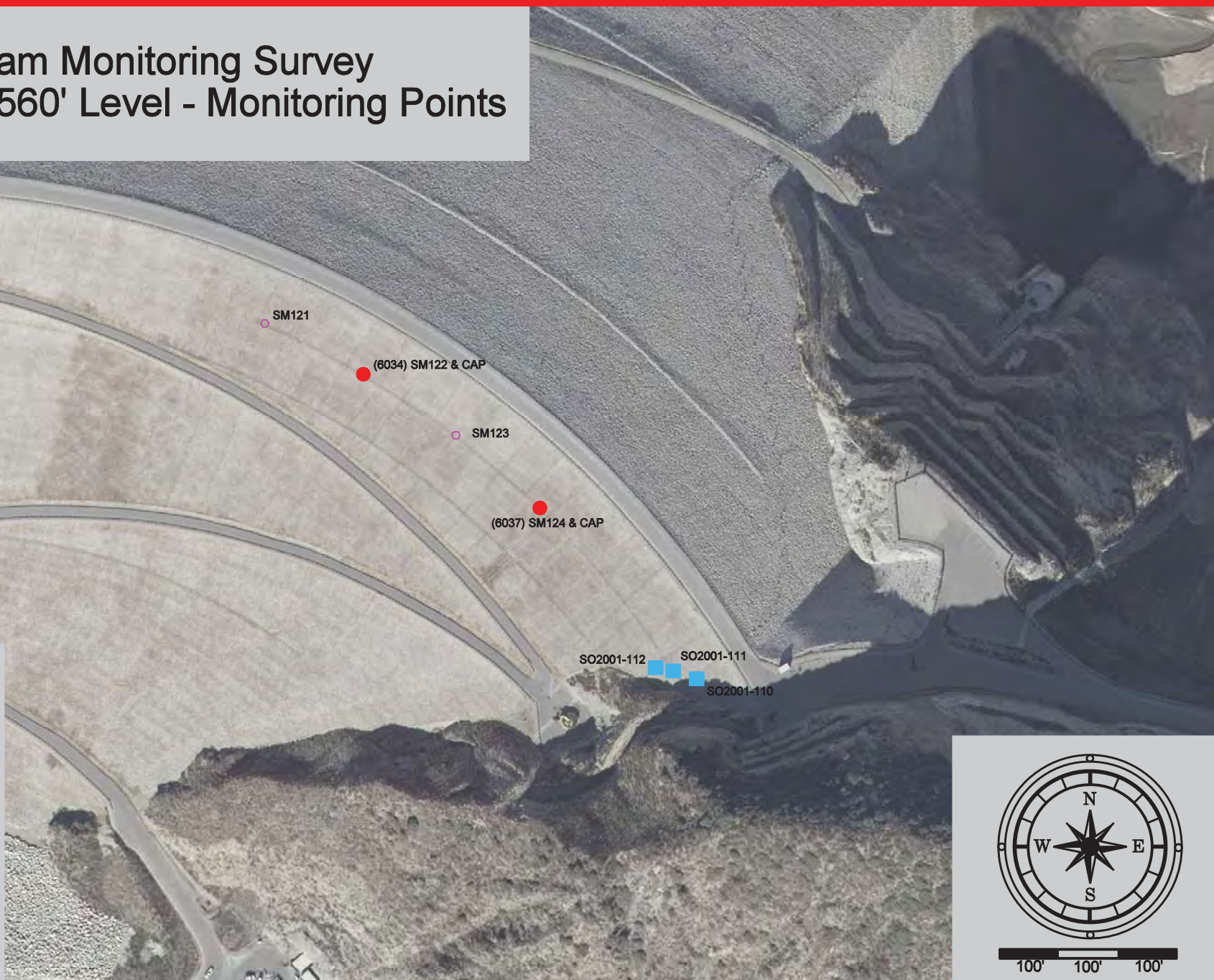
SETTLEMENT MONUMENT (SUBSET) 33 mon


INCLINOMETER 6 mon


CORS SITE

TUNNEL MONUMENT 22 mon

X-SECTION MONUMENT 7 mon

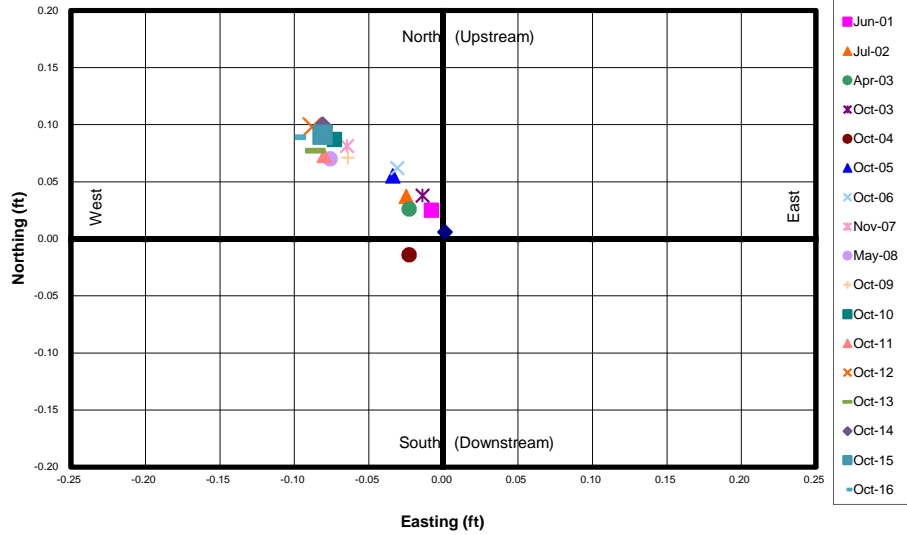




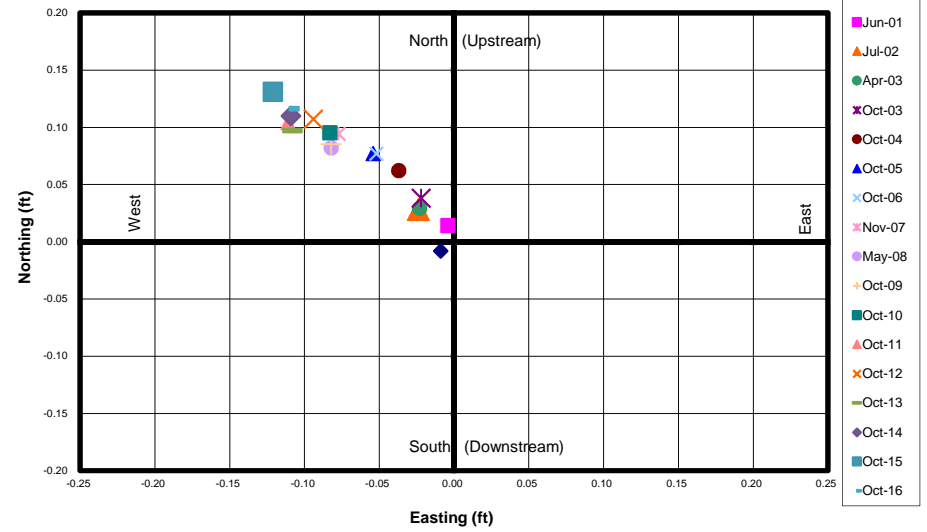


Seven Oaks Dam - Downstream 2560' Level (Horizontal) **Horizontal Movement since January 2001 Survey**

Monitoring Point SM122

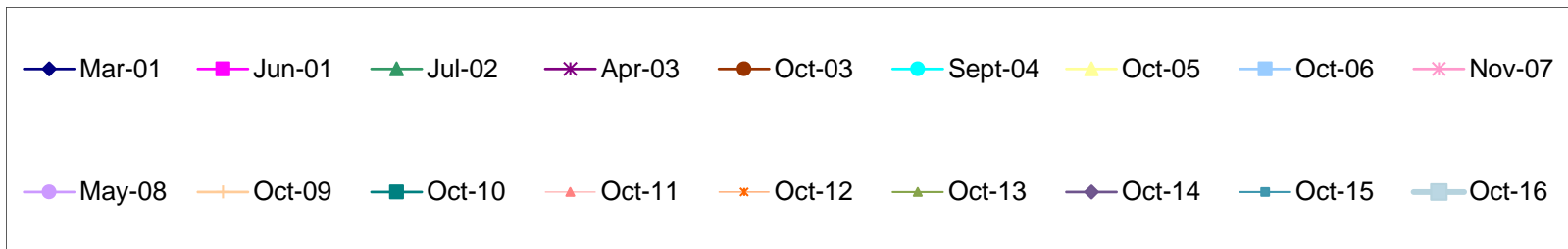
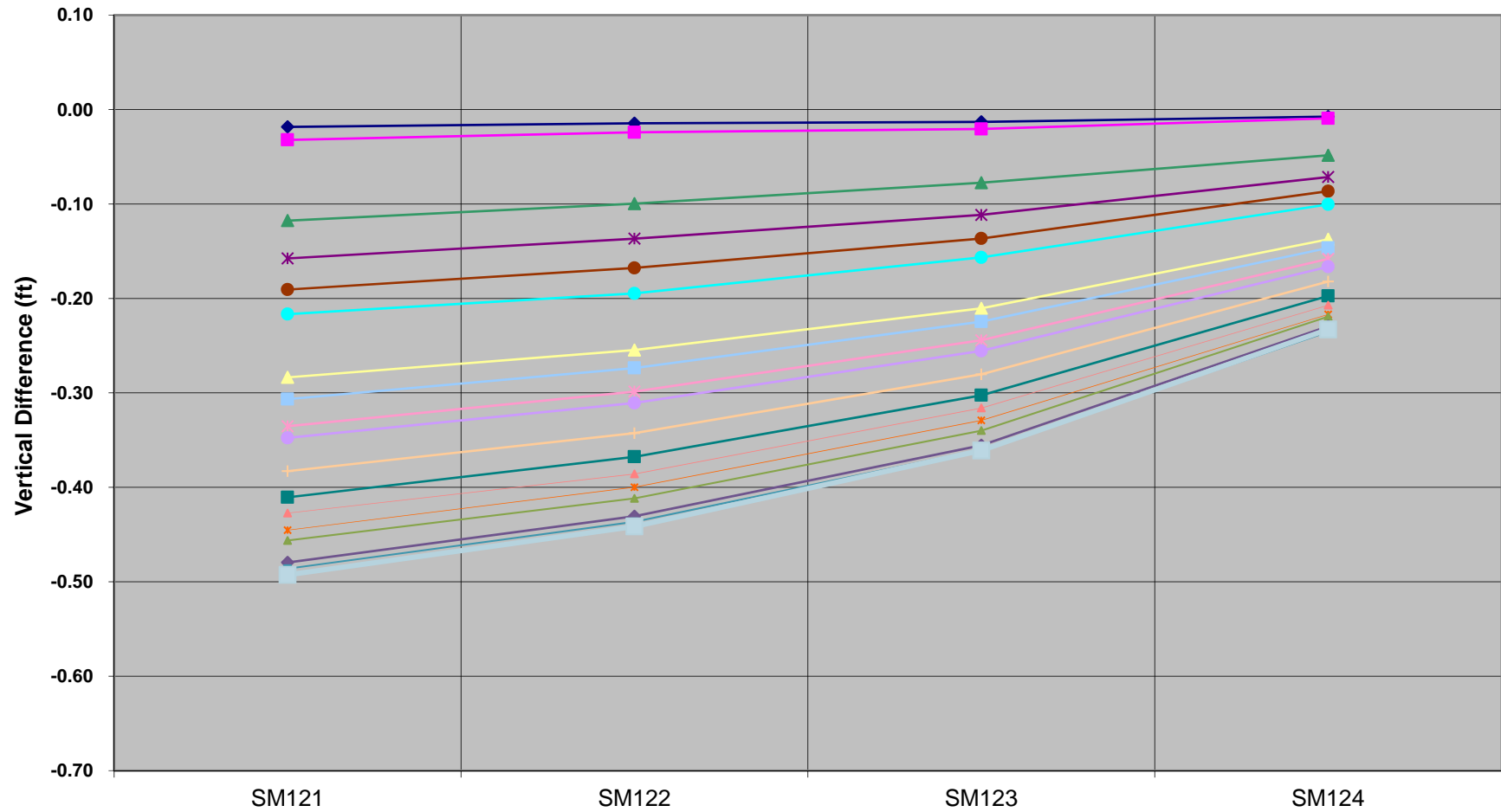


Monitoring Point SM124



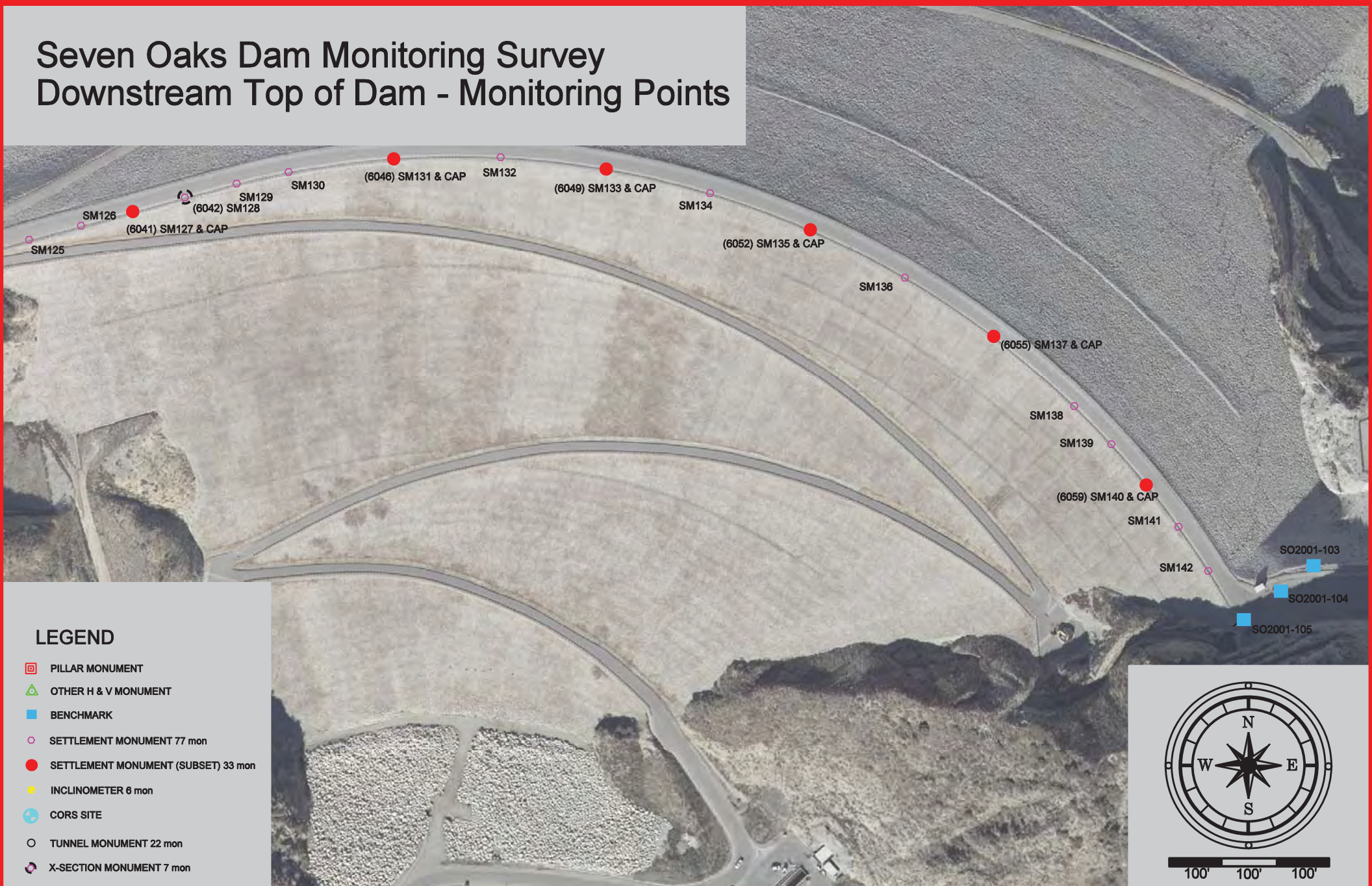
(0,0) = January 2001 Horizontal Position

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

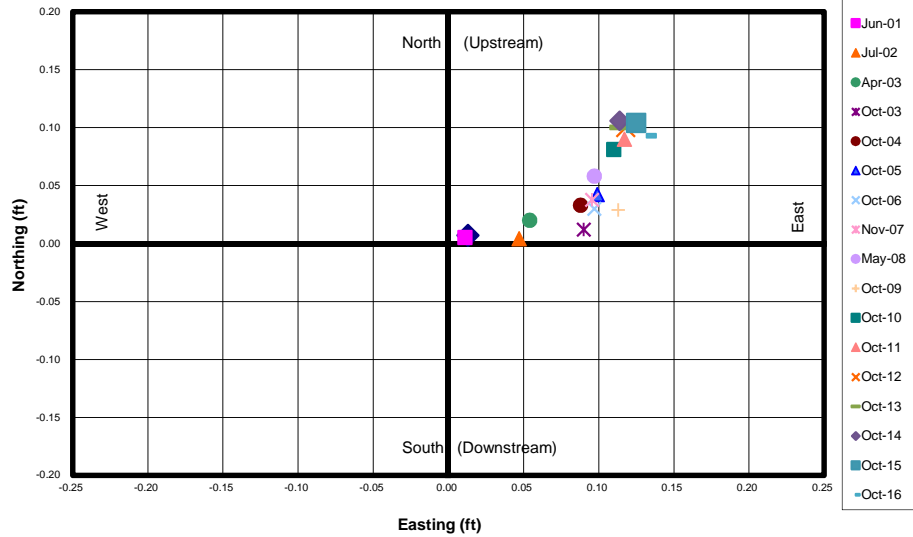


- LEGEND**
- PILLAR MONUMENT
 - OTHER H & V MONUMENT
 - BENCHMARK
 - SETTLEMENT MONUMENT 77 mon
 - SETTLEMENT MONUMENT (SUBSET) 33 mon
 - INCLINOMETER 6 mon
 - CORS SITE
 - TUNNEL MONUMENT 22 mon
 - X-SECTION MONUMENT 7 mon

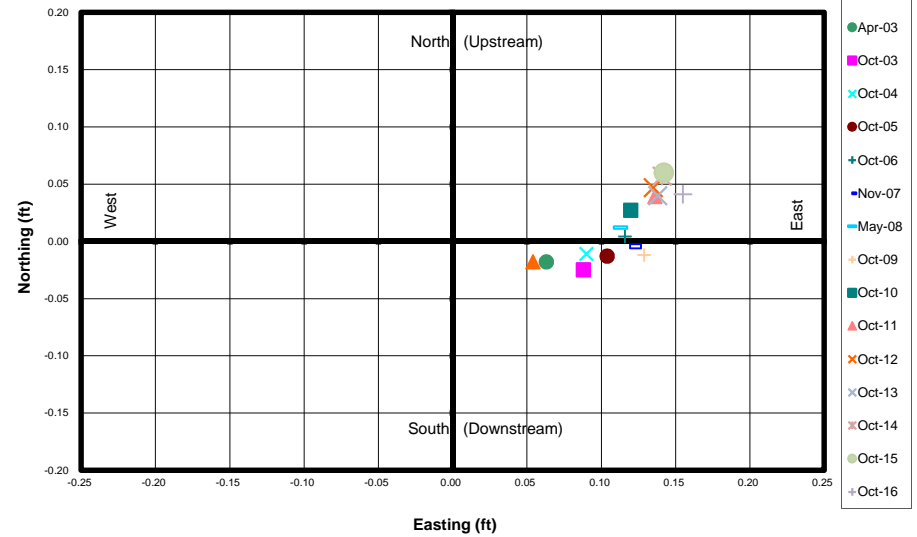


Seven Oaks Dam - Downstream Top of Dam (Horizontal) Horizontal Movement since January 2001 Survey

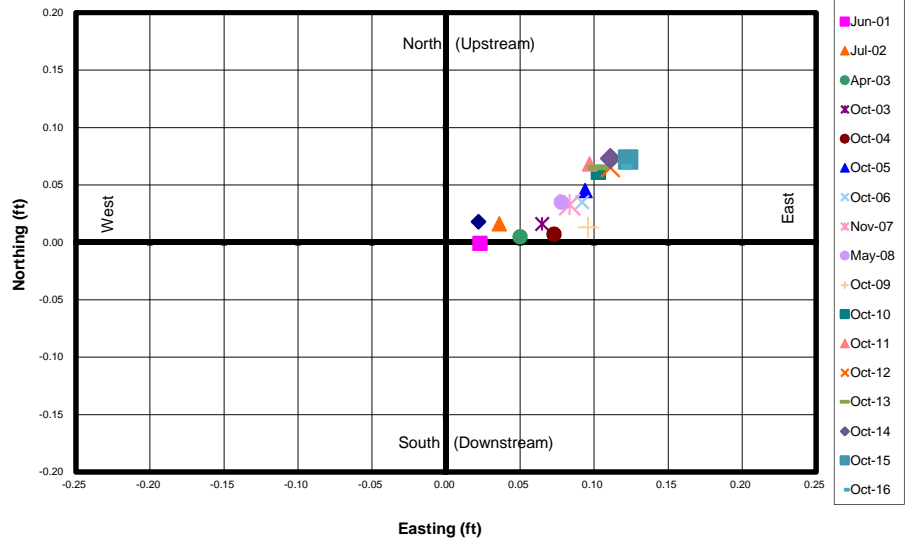
Monitoring Point SM127



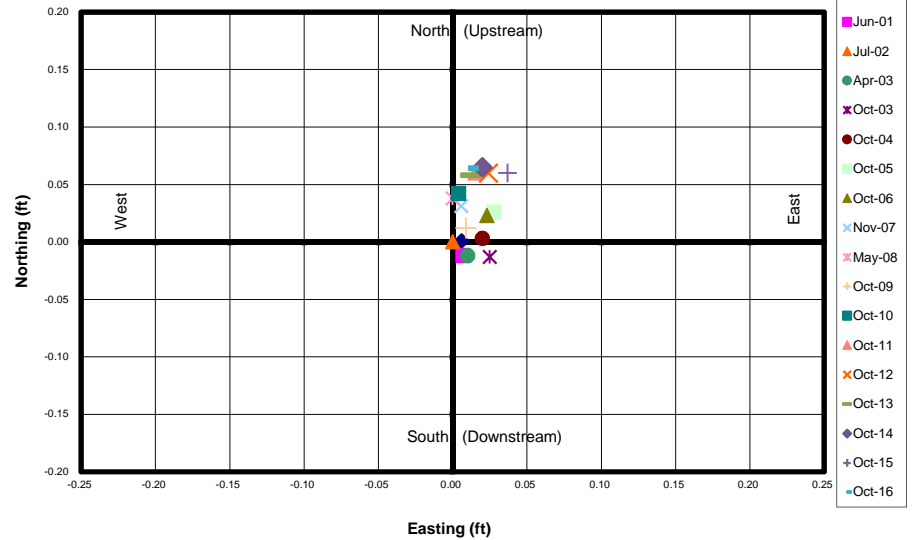
Monitoring Point SM128



Monitoring Point SM131



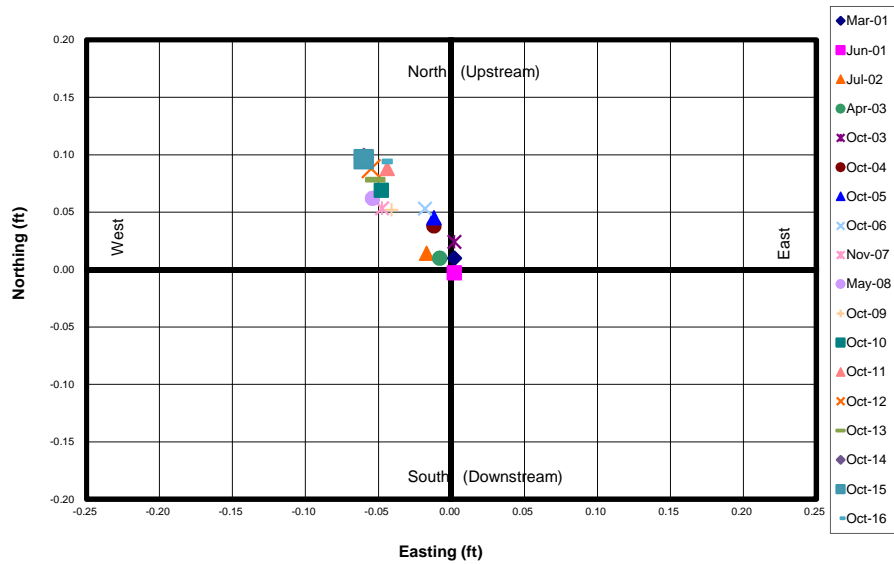
Monitoring Point SM133



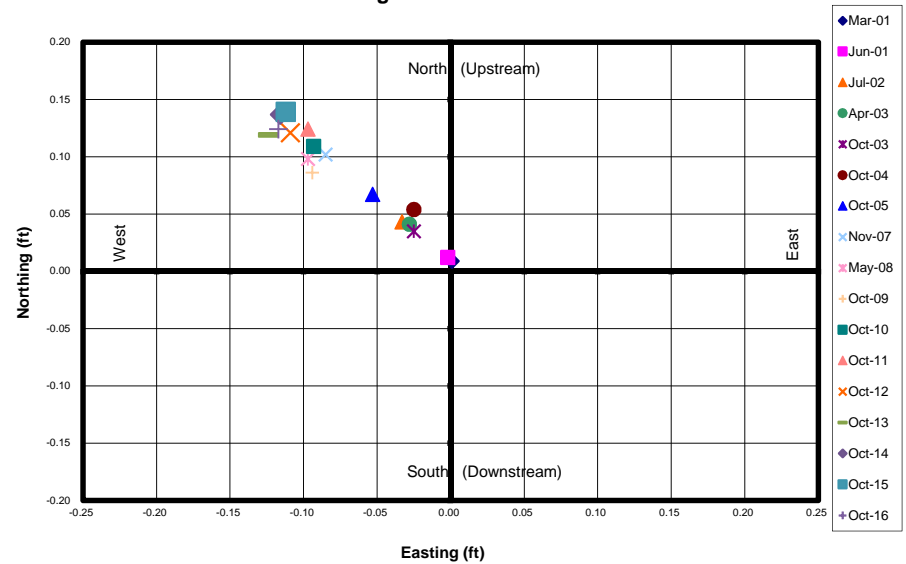
(0,0) = January 2001 Horizontal Position

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

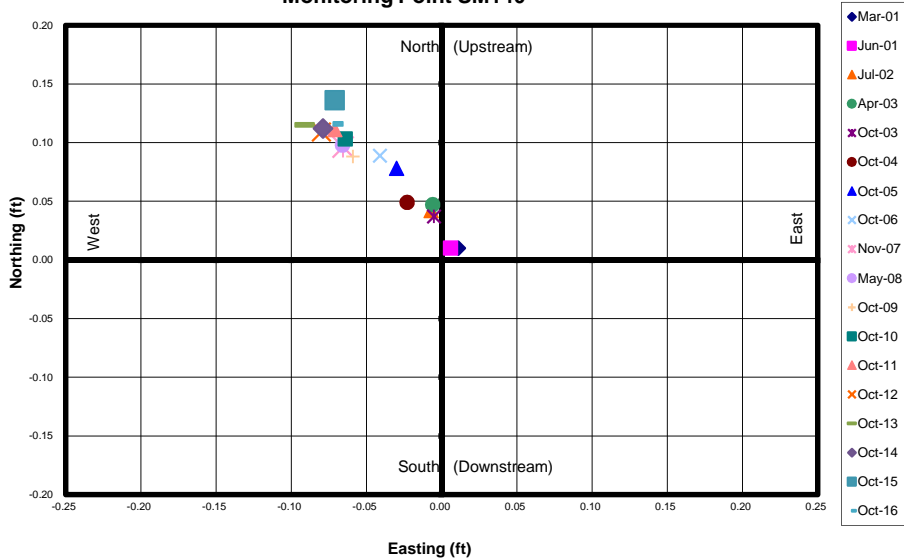
Monitoring Point SM135



Monitoring Point SM137

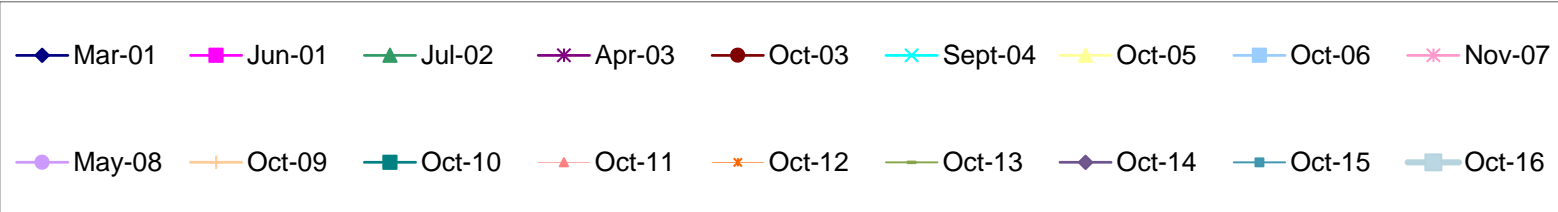


Monitoring Point SM140



(0,0) = January 2001 Horizontal Position

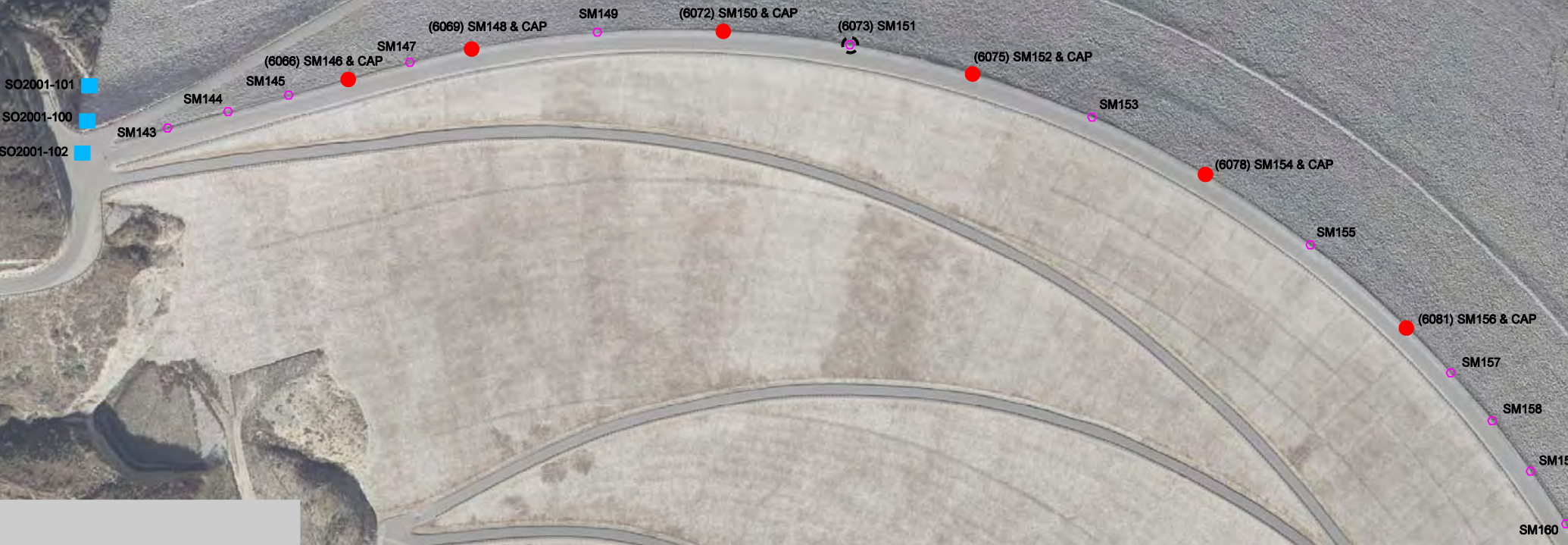
Profile View - Looking Upstream



Seven Oaks Dam Monitoring Survey

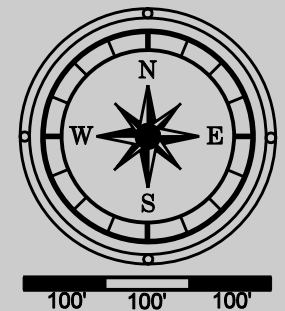
Upstream Top of Dam - Monitoring Points

SO2001-101
SO2001-100
SO2001-102

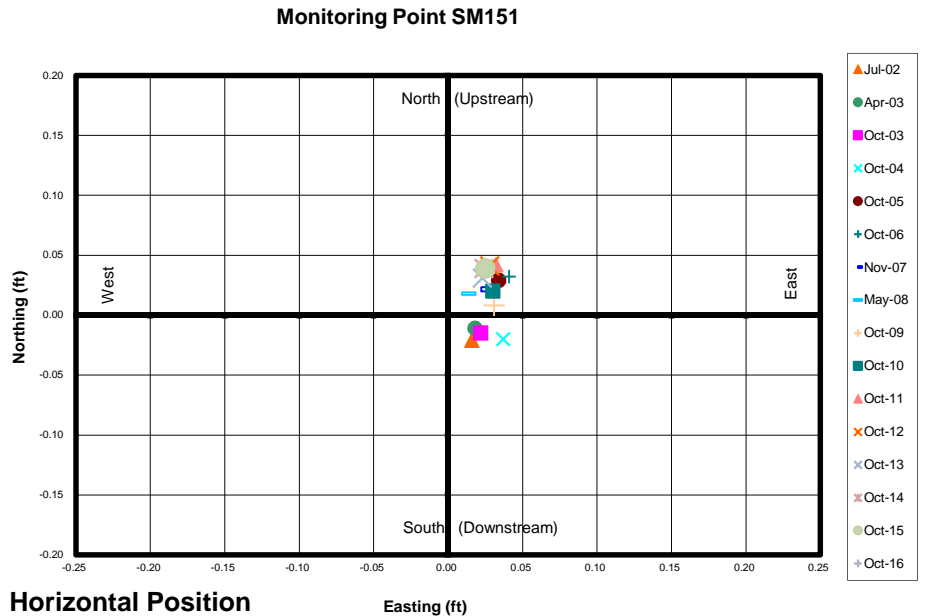
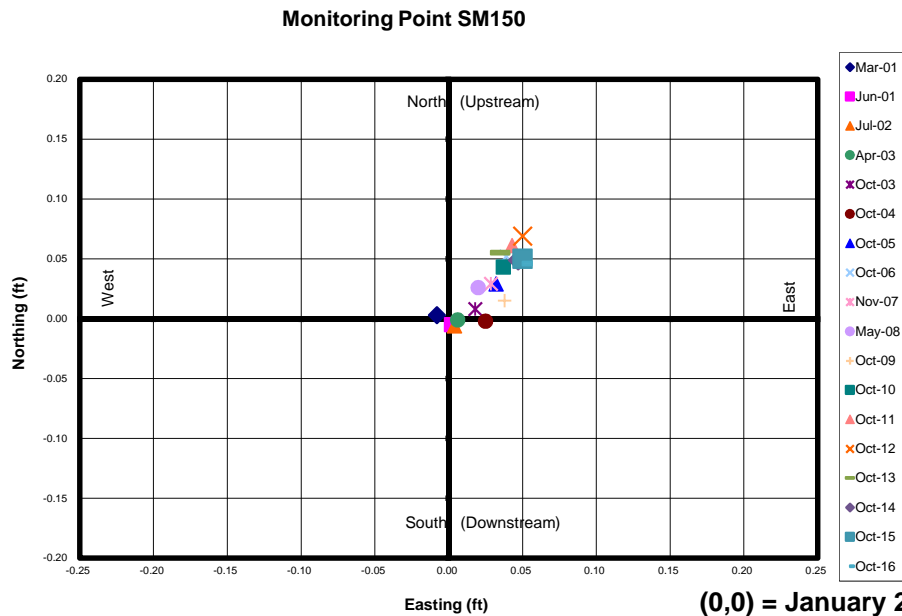
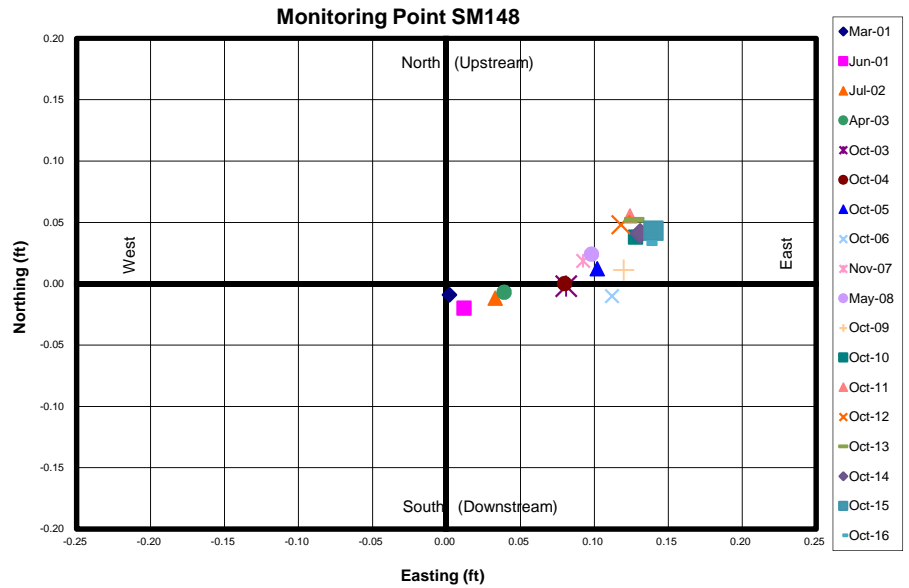
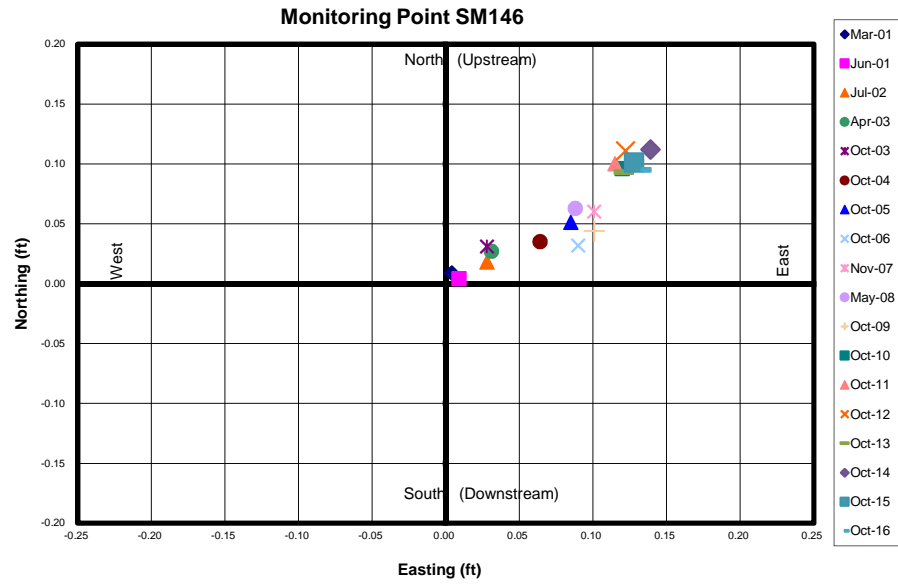


LEGEND

- 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



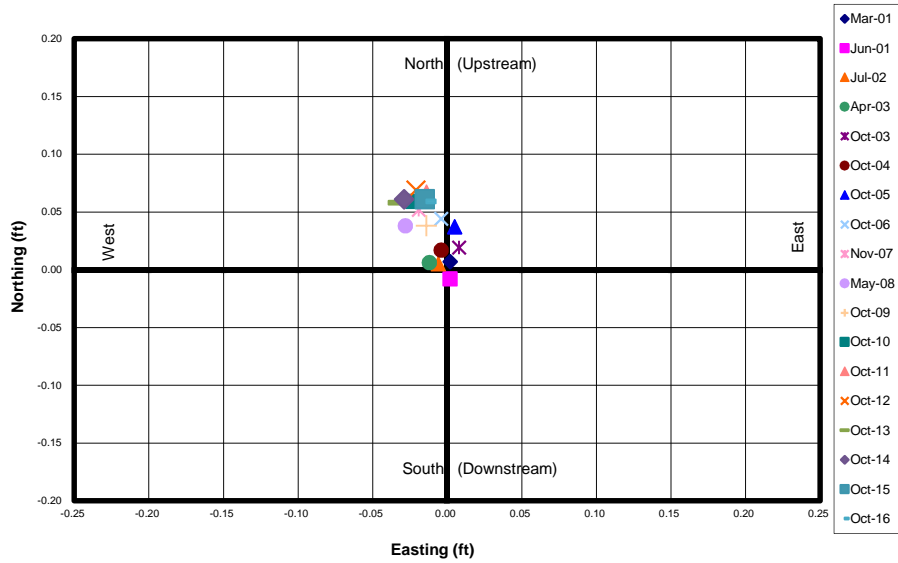
Seven Oaks Dam - Upstream Top of Dam (Horizontal) Horizontal Movement since January 2001 Survey



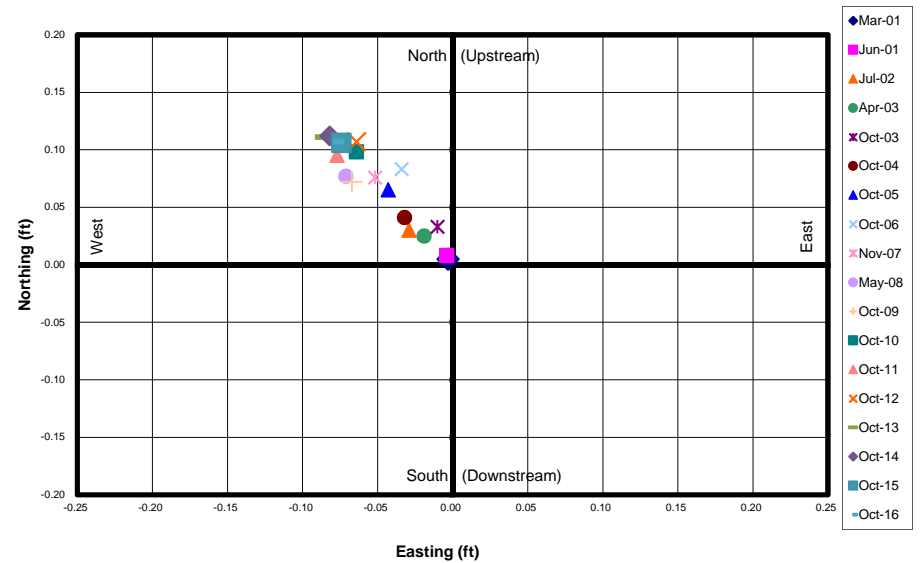
(0,0) = January 2001 Horizontal Position

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

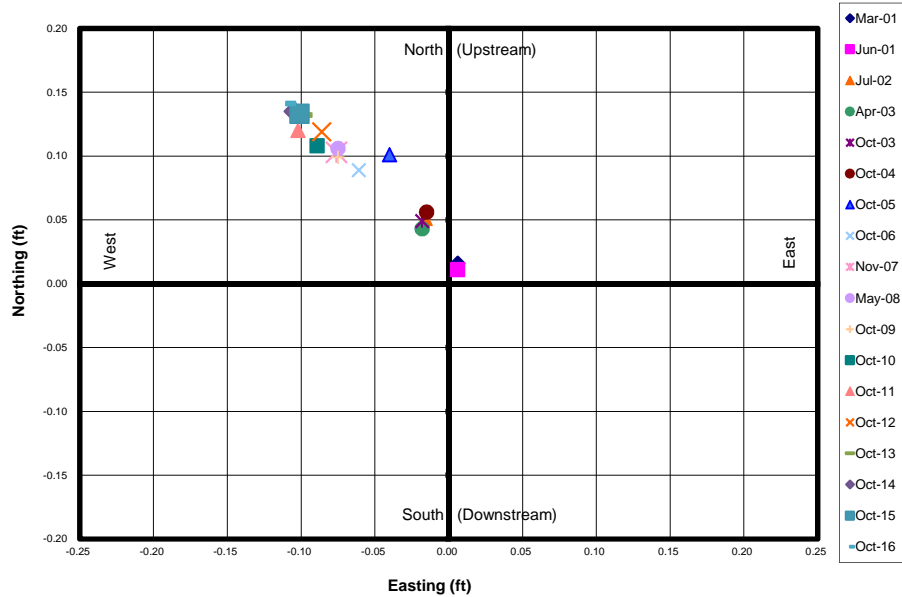
Monitoring Point SM152



Monitoring Point SM154

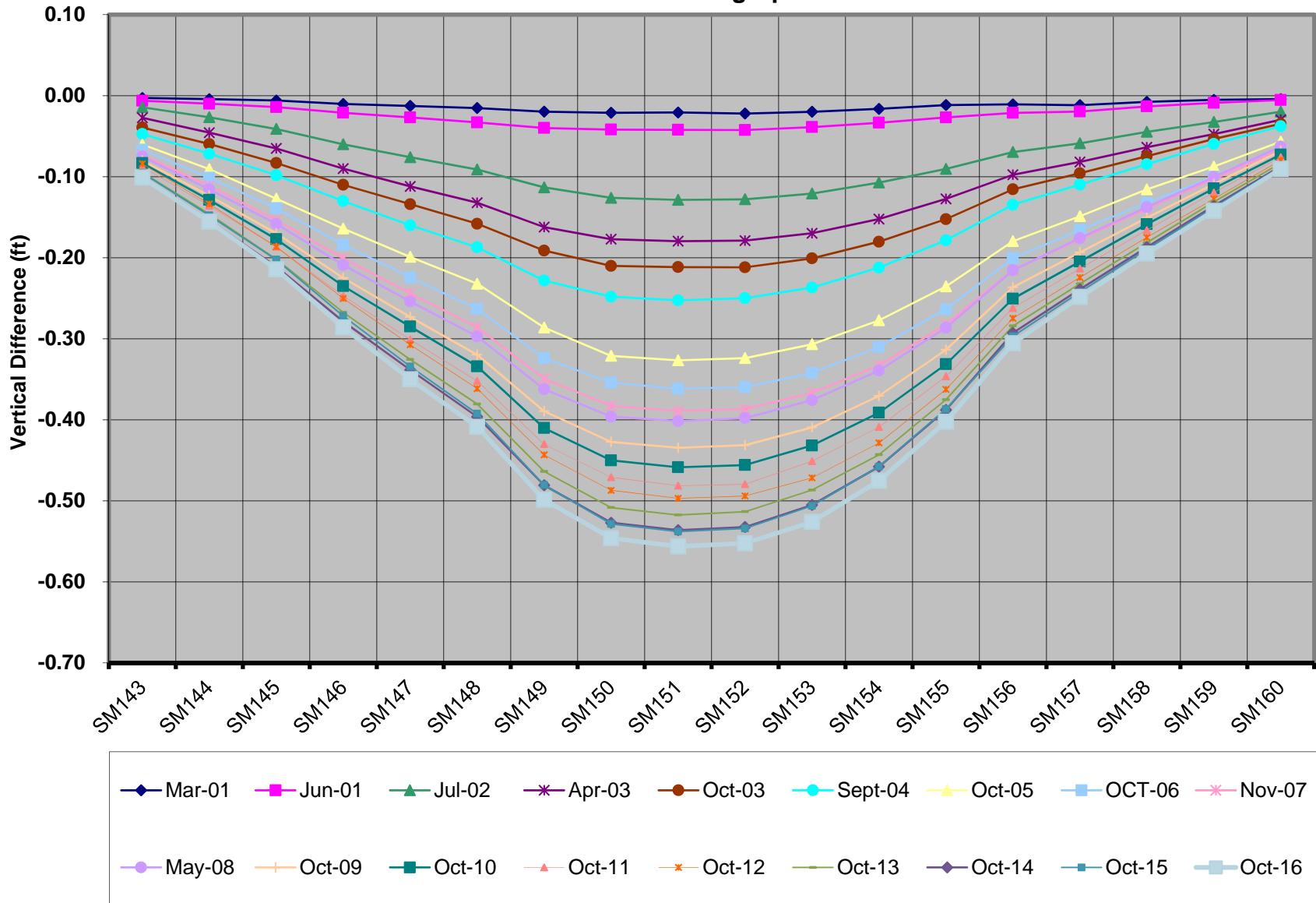


Monitoring Point SM156



(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

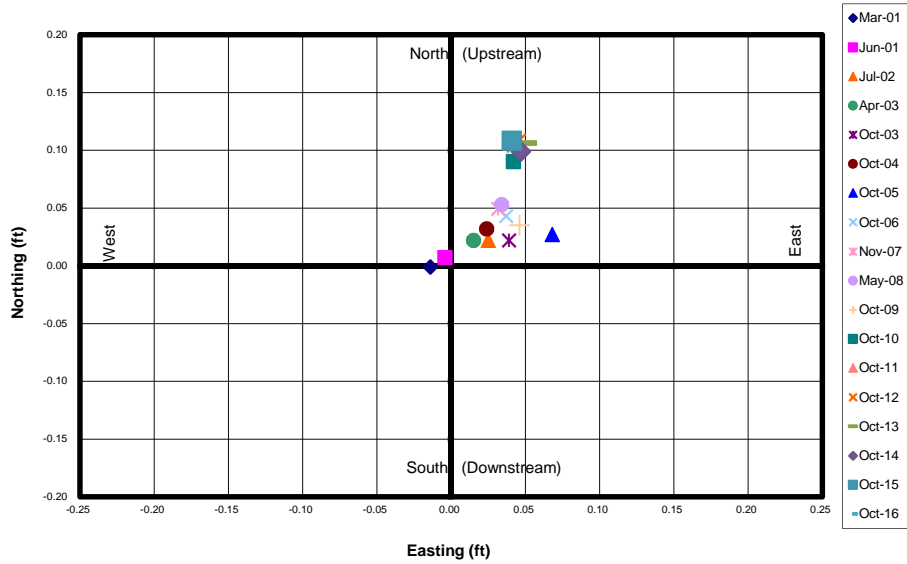
Upstream 2530' Level - Monitoring Points



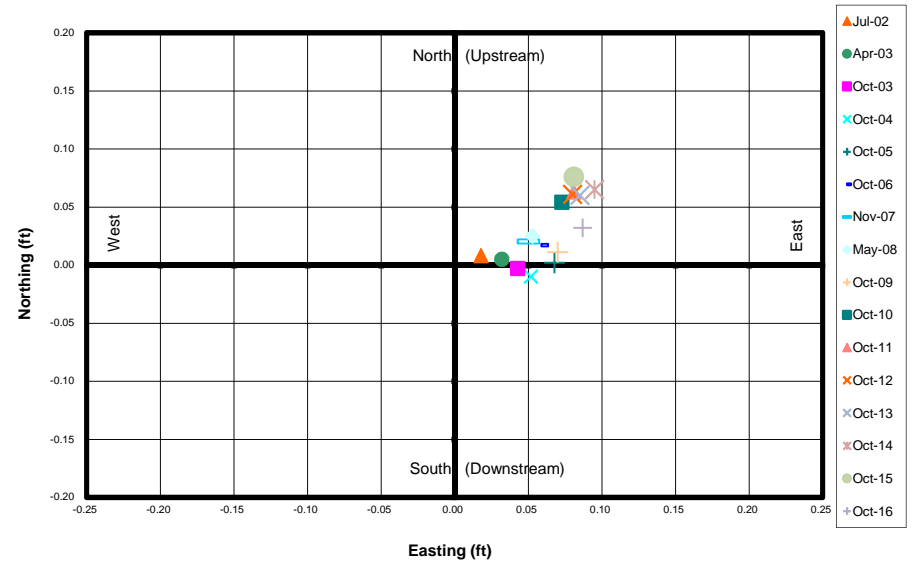
Seven Oaks Dam - Upstream 2530' level (Horizontal)

Horizontal Movement since January 2001 Survey

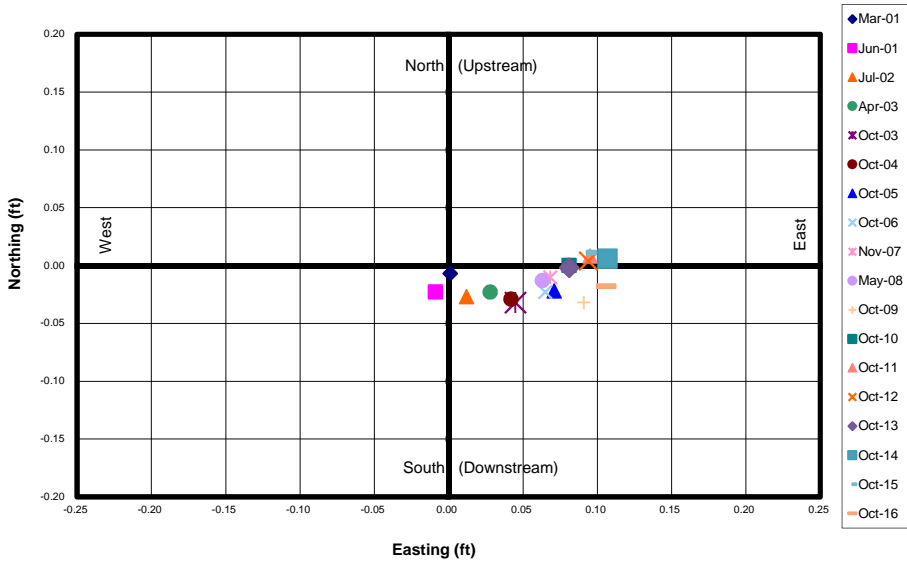
Monitoring Point SM161



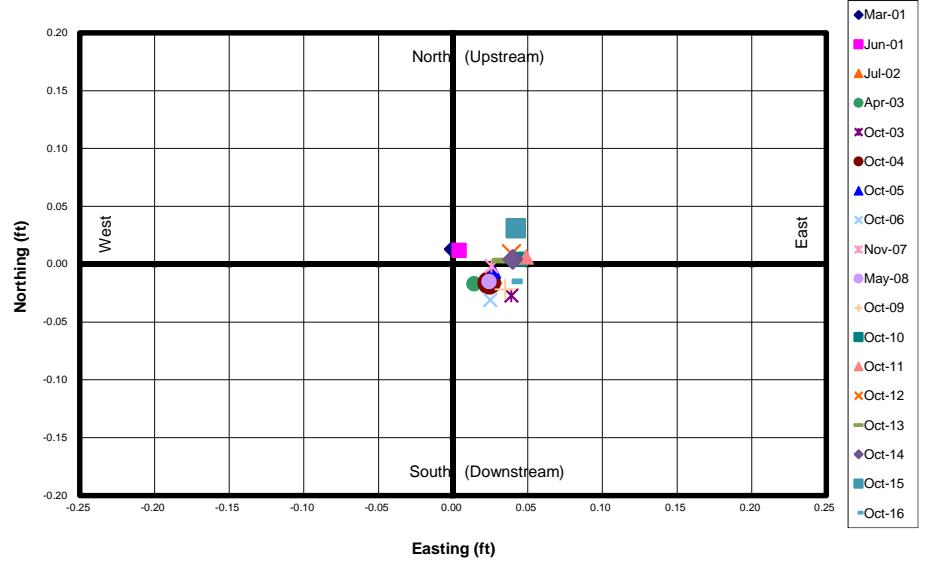
Monitoring Point SM162



Monitoring Point SM163



Monitoring Point SM165

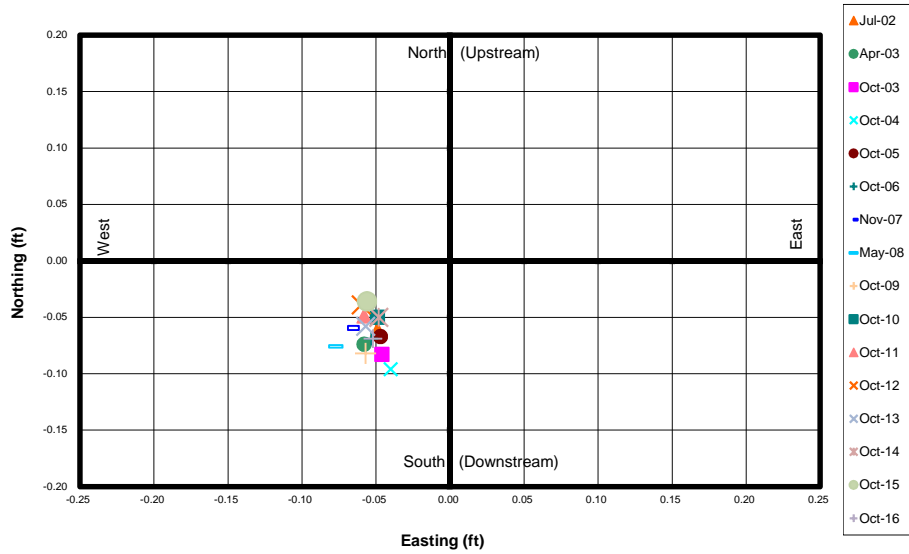


(0,0) = January 2001 Horizontal Position

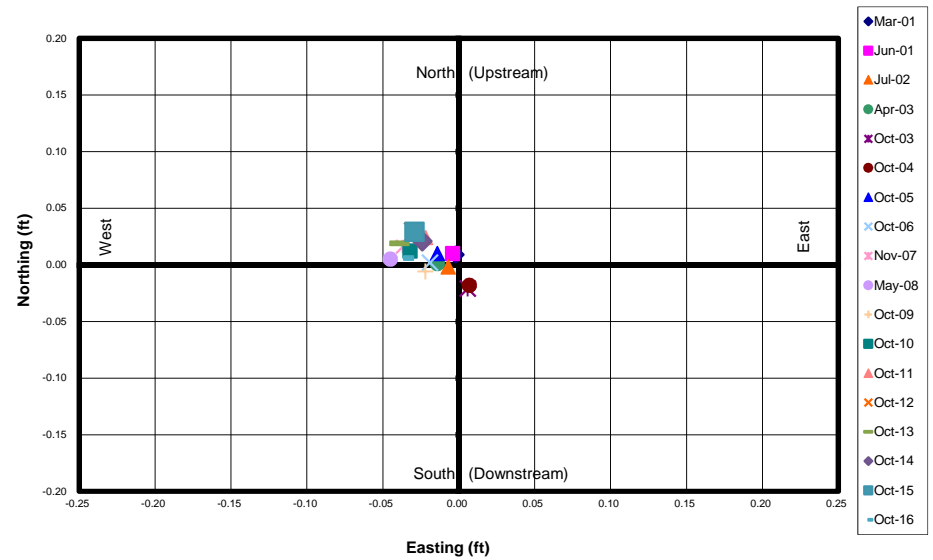
Seven Oaks Dam - Upstream 2530' level (Horizontal)

Horizontal Movement since January 2001 Survey

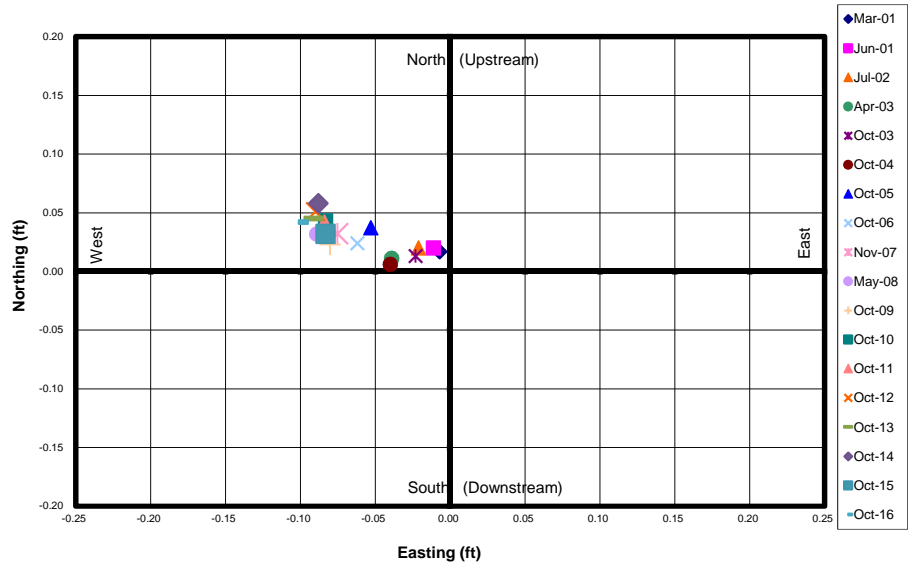
Monitoring Point SM166



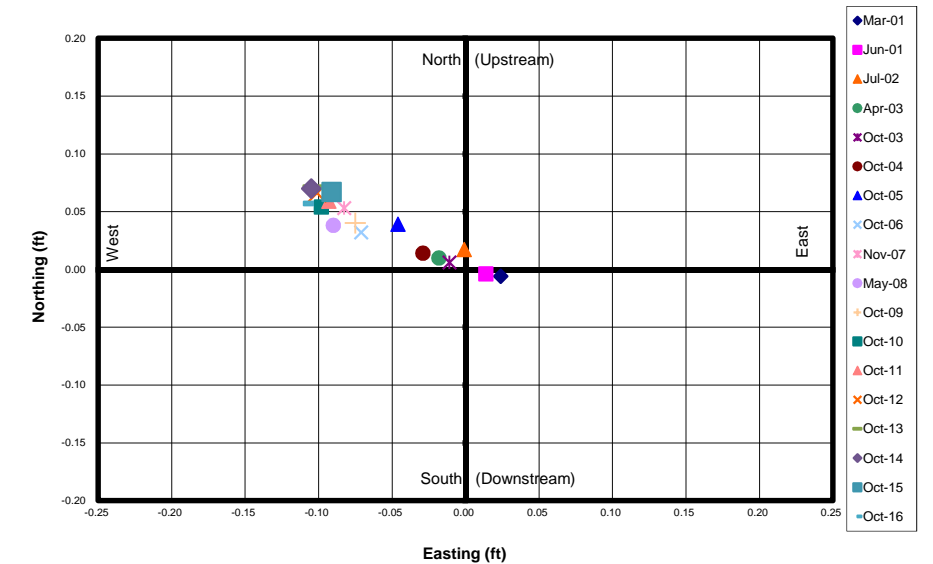
Monitoring Point SM167



Monitoring Point SM169

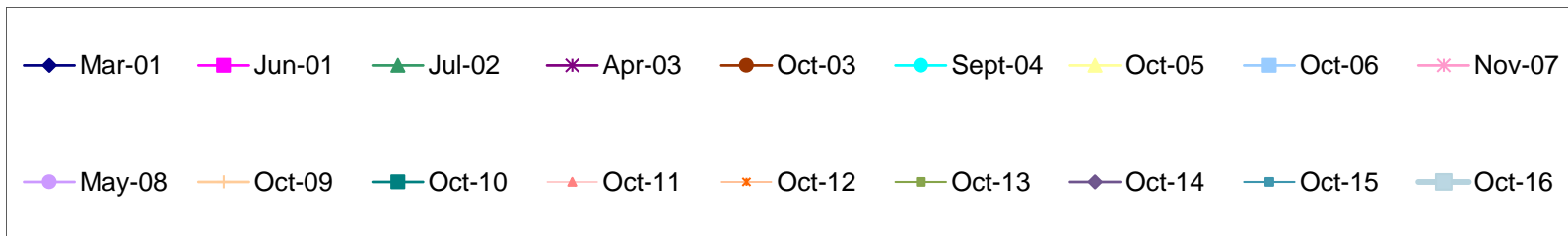
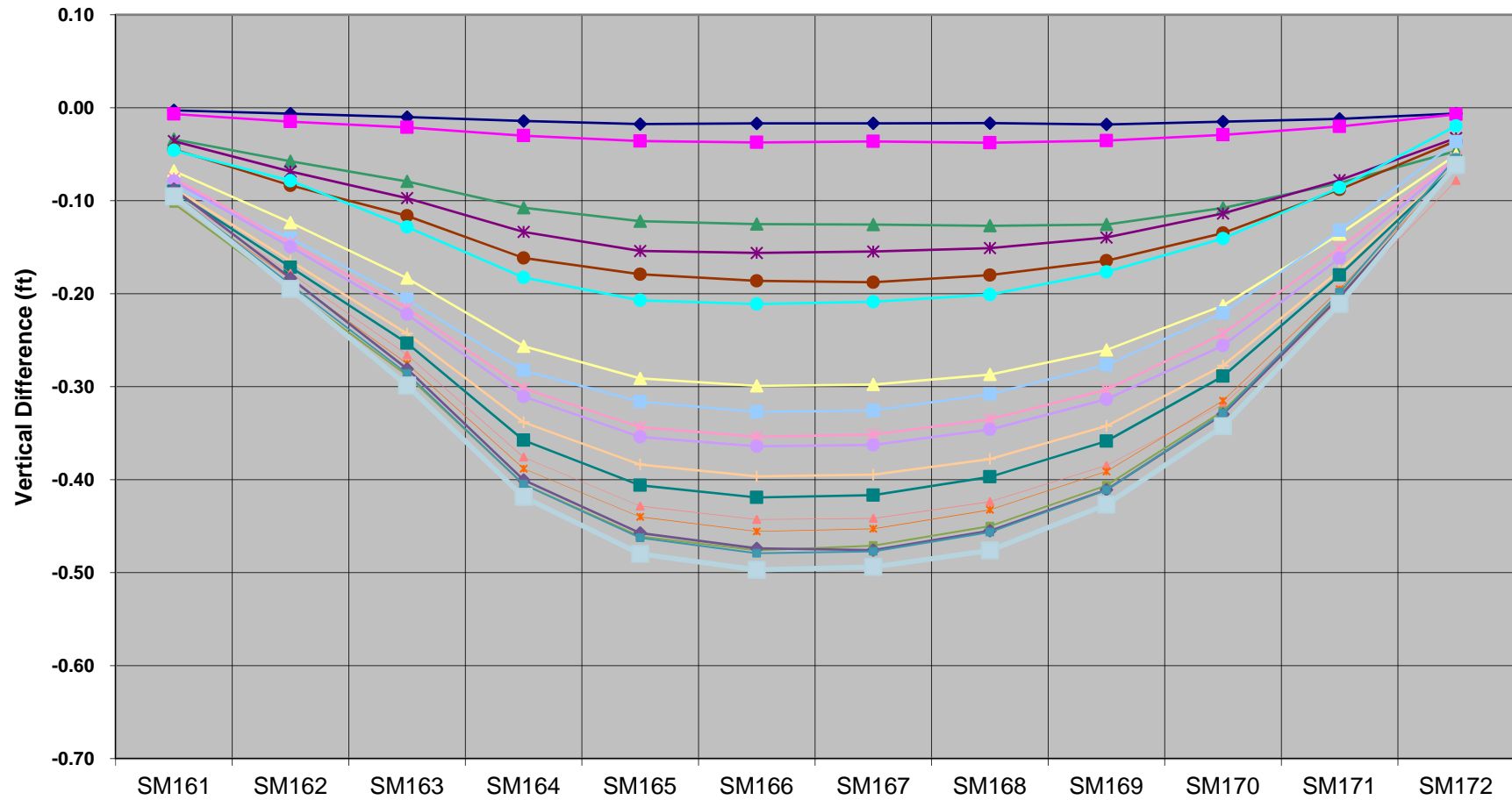


Monitoring Point SM171



(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

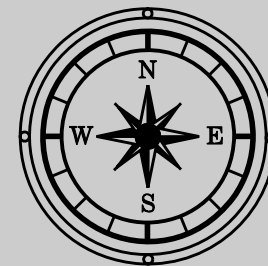
SO2001-113

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

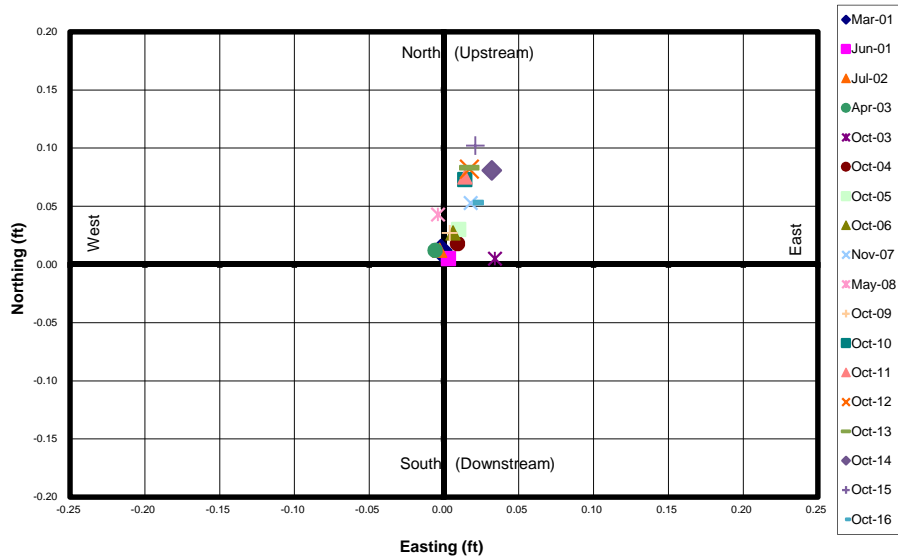


100' 100' 100'

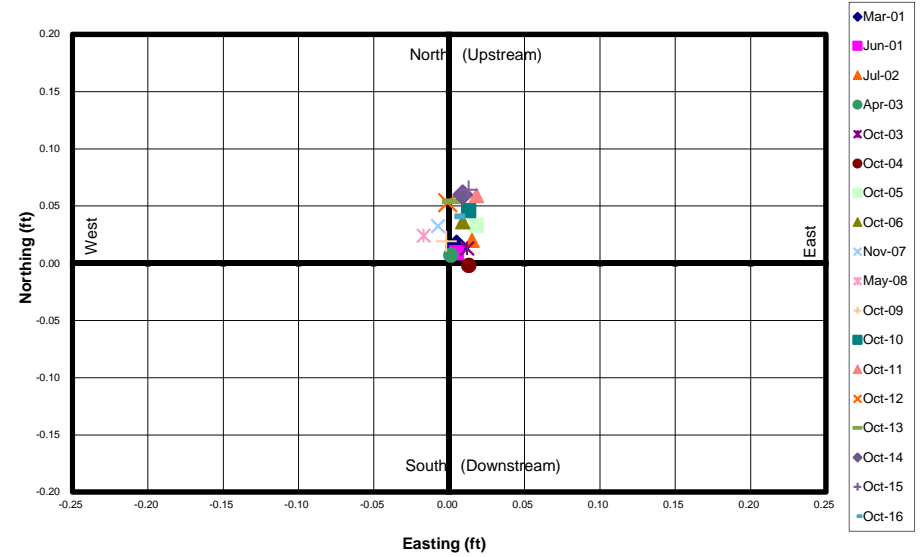
Seven Oaks Dam - Upstream 2360' level (Horizontal)

Horizontal Movement since January 2001 Survey

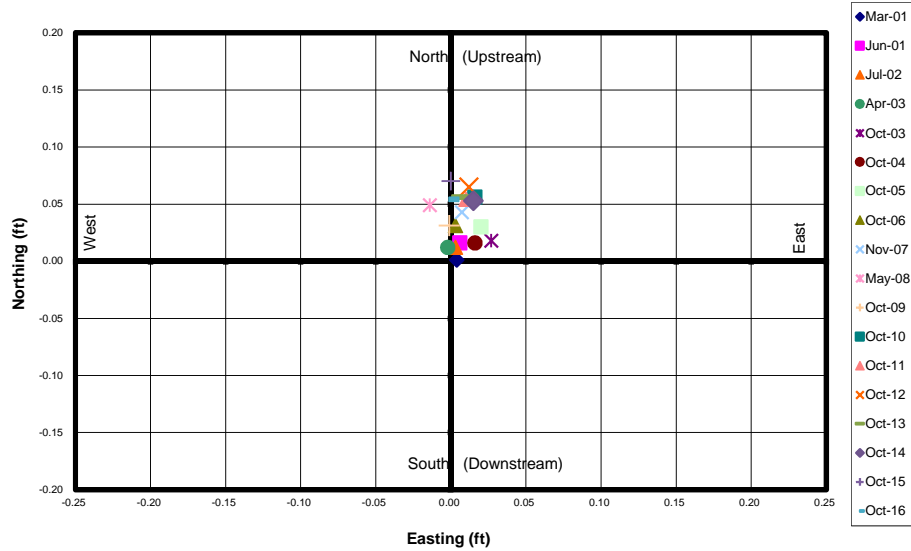
Monitoring Point SM173



Monitoring Point SM175

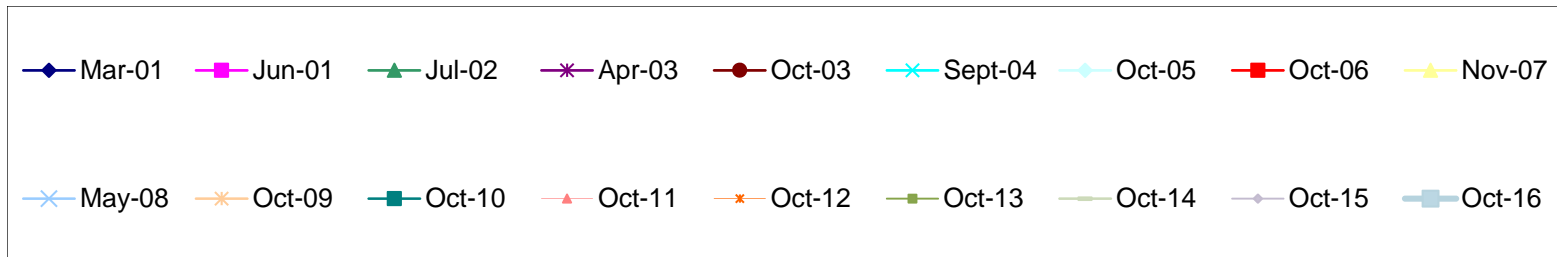
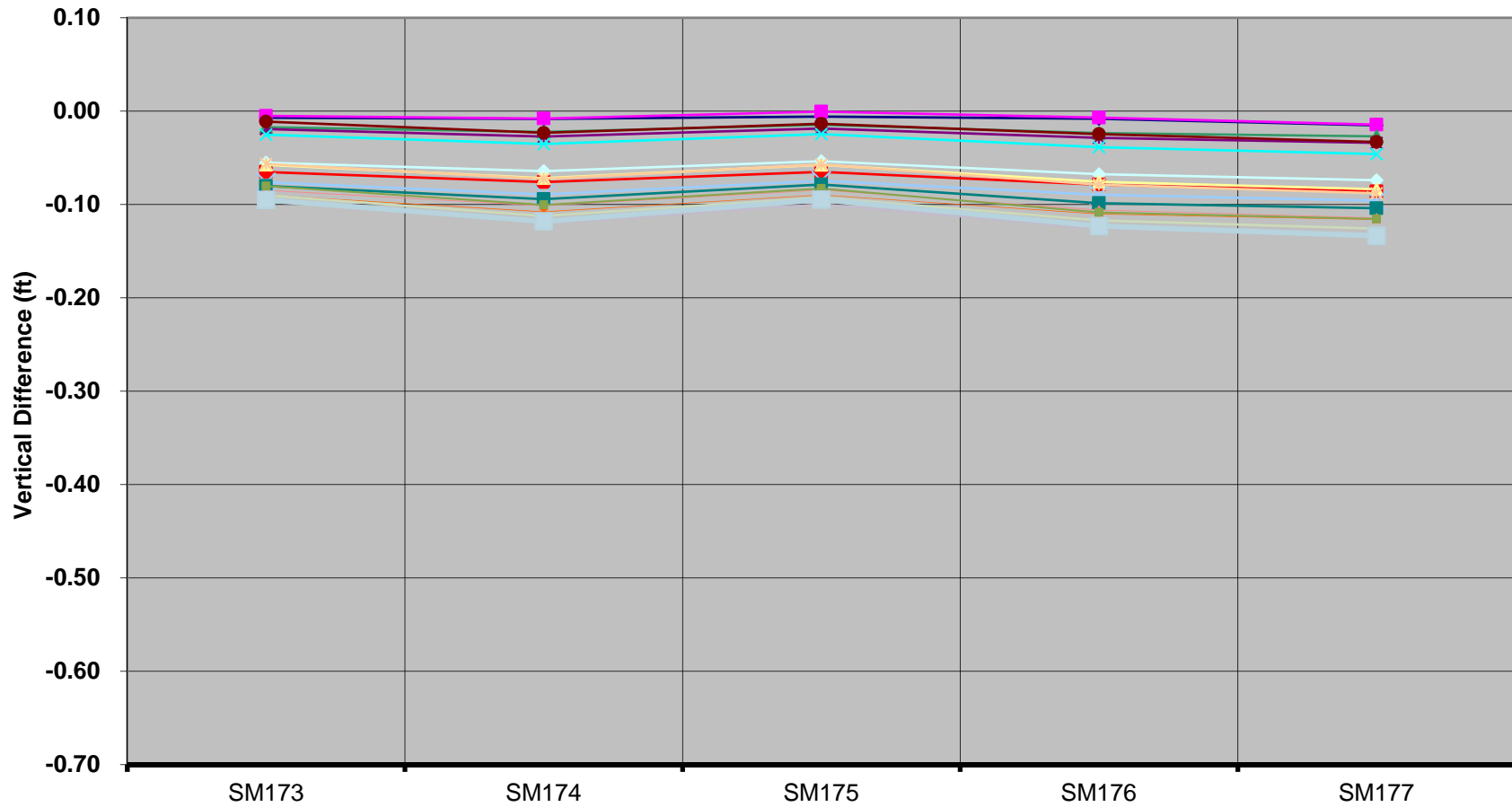


Monitoring Point SM177



(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

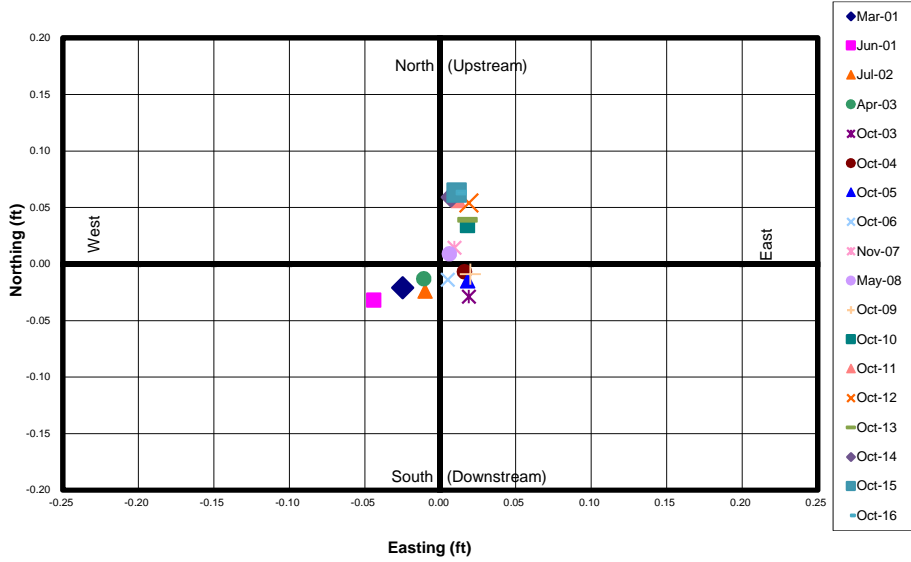
Inclinometer Locations - Monitoring Points



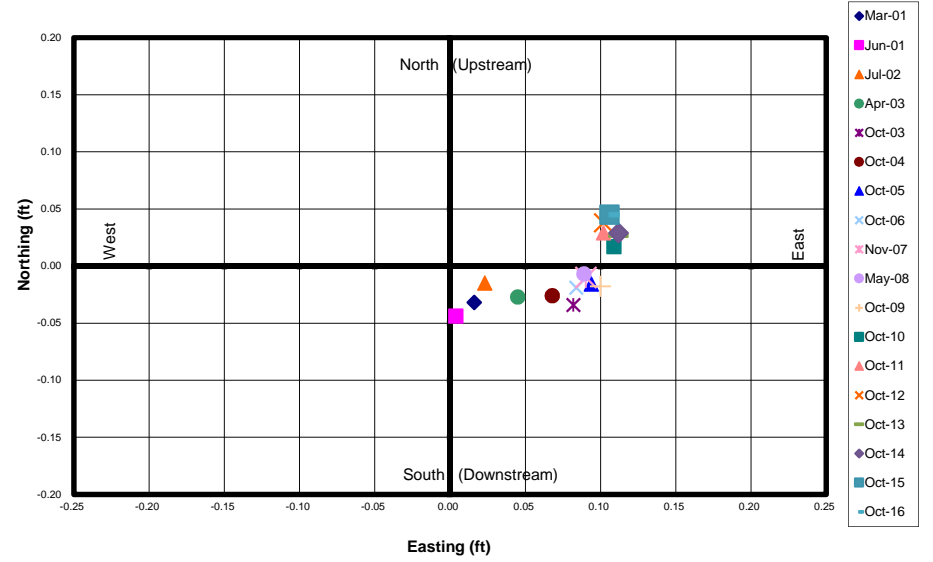
Seven Oaks Dam - Inclinometers (Horizontal)

Horizontal Movement since January 2001 Survey

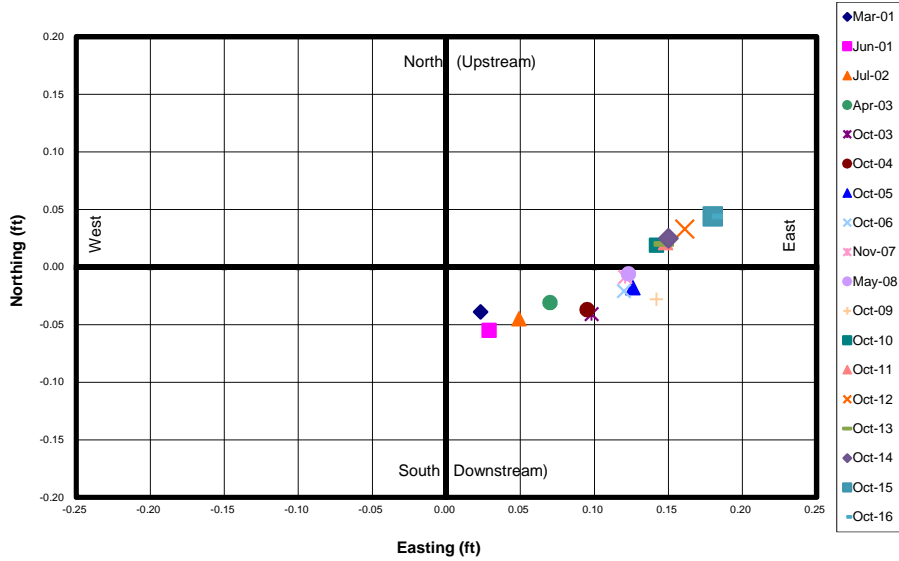
Inclinometer Monitoring Point SI-1



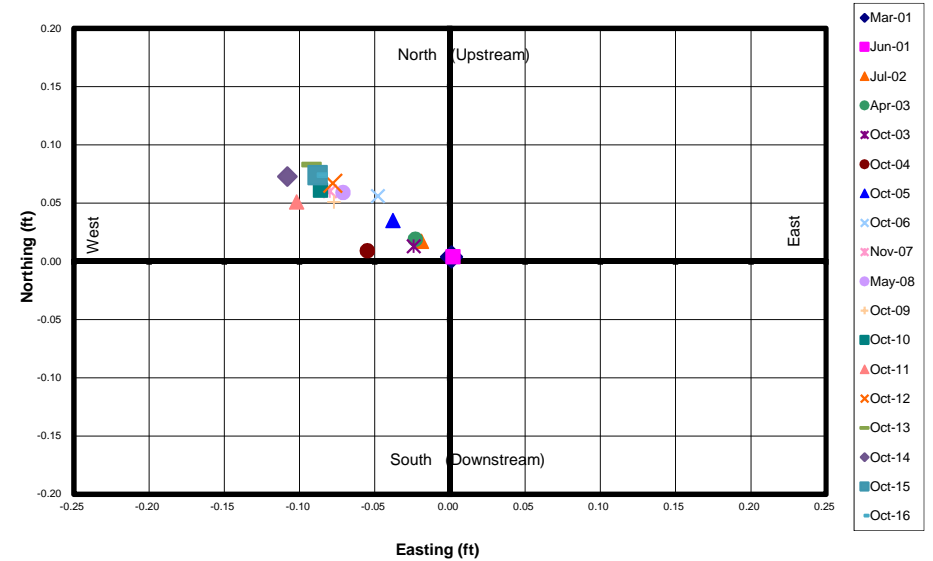
Inclinometer Monitoring Point SI-2



Inclinometer Monitoring Point SI-3



Inclinometer Monitoring Point SI-4

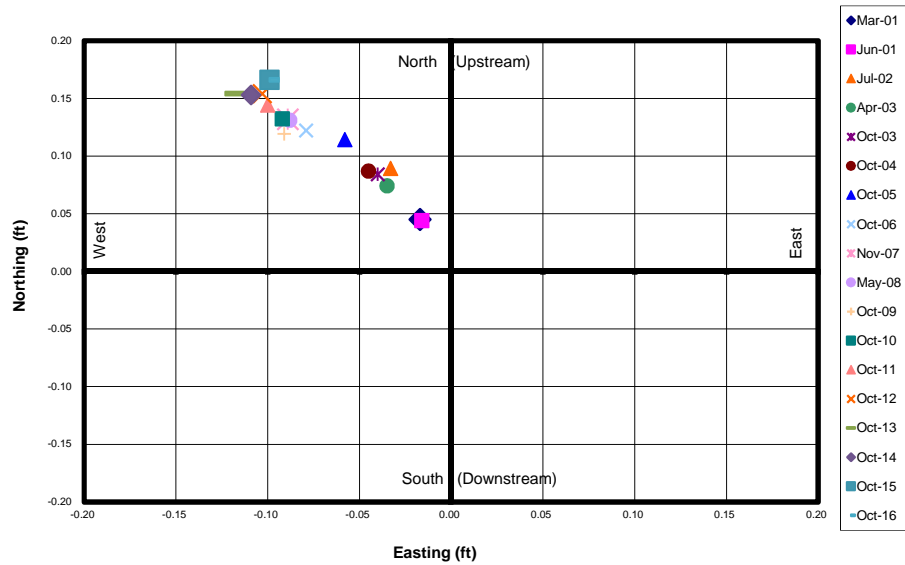


(0,0) = January 2001 Horizontal Position

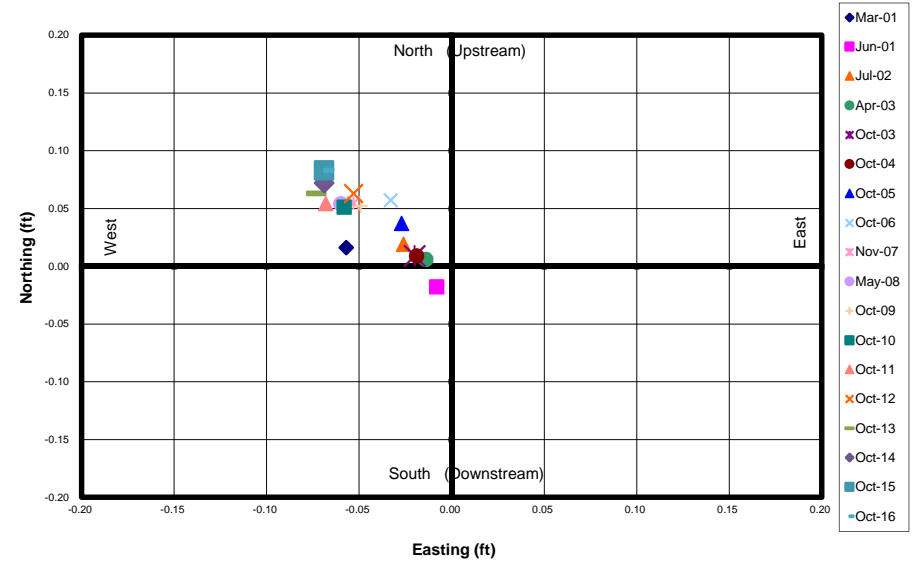
Seven Oaks Dam - Inclinometers (Horizontal)

Horizontal Movement since January 2001 Survey

Inclinometer Monitoring Point SI-5

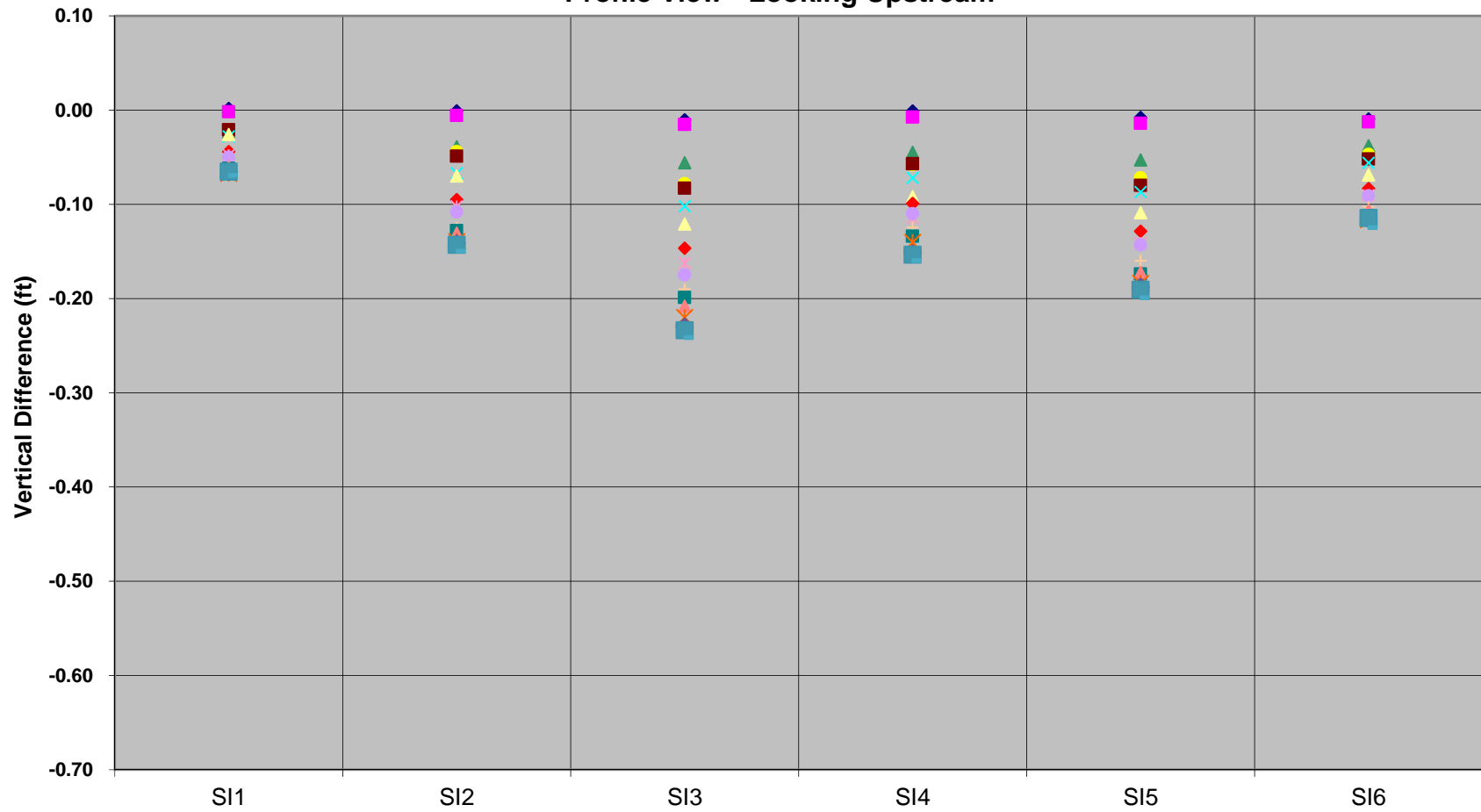


Inclinometer Monitoring Point SI-6



(0,0) = January 2001 Horizontal Position

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



◆ Mar-01	■ Jun-01	▲ Jul-02	● Apr-03	■ Oct-03	✕ Sept-04	▲ Oct-05	◆ Oct-06	✕ Nov-07
● Oct-08	✕ Oct-09	■ Oct-10	▲ Oct-11	✕ Oct-12	— Oct-13	◆ Oct-14	■ Oct-15	— Oct-16

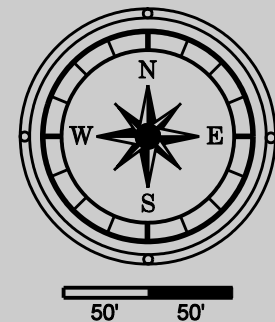
Seven Oaks Dam Monitoring Survey

Outlet Tunnel Structure - Monitoring Points

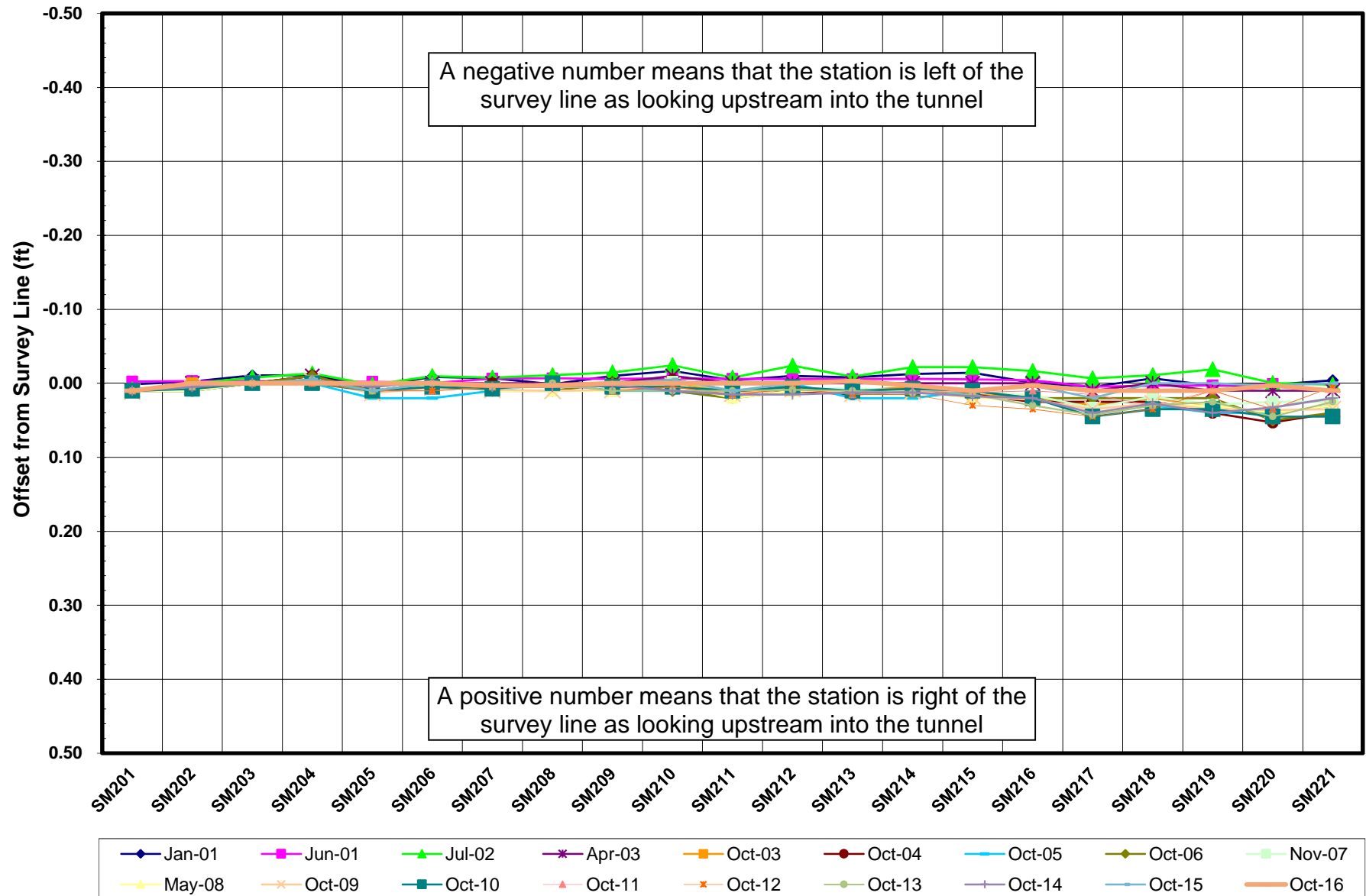


LEGEND

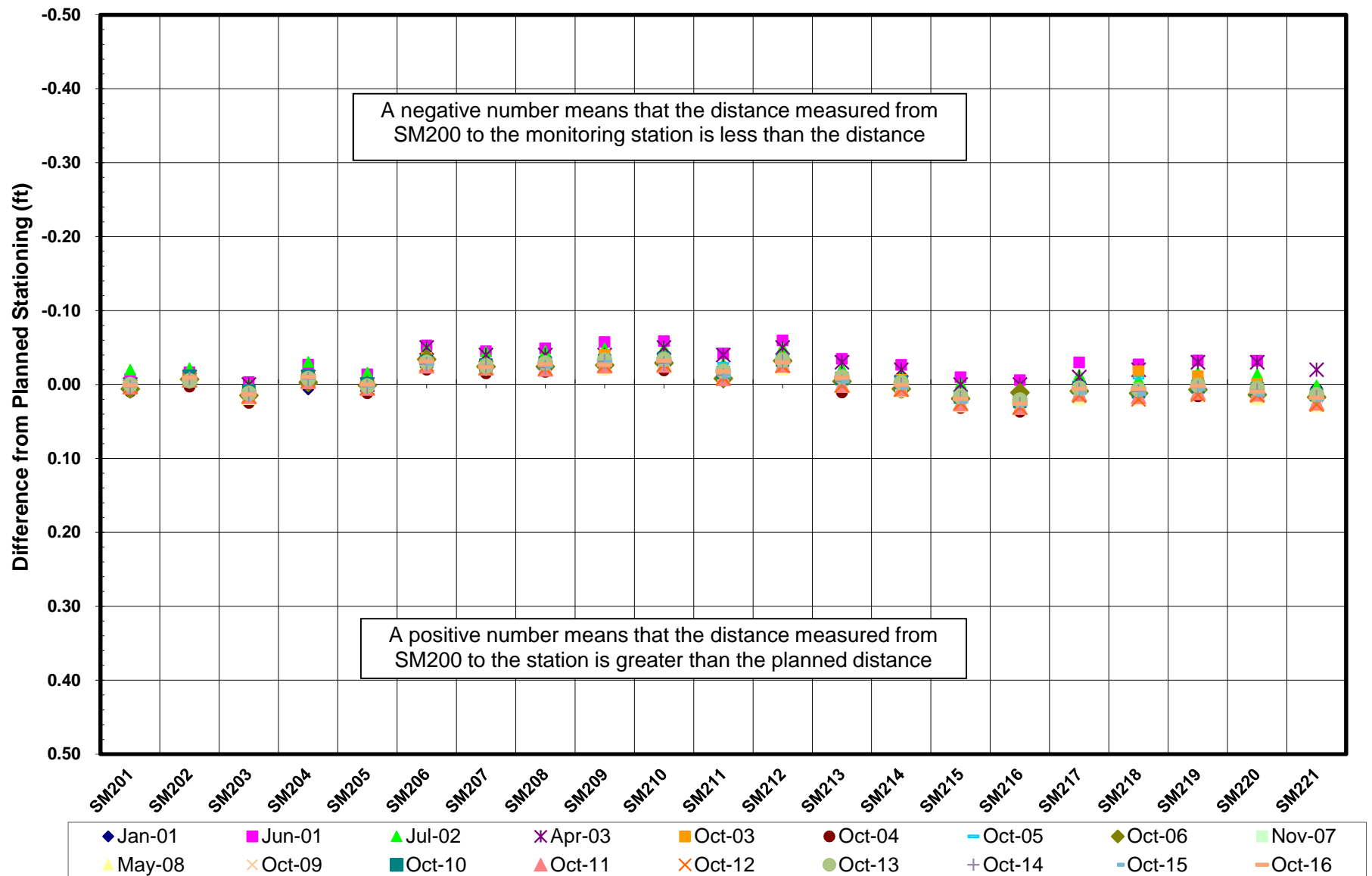
- PILLAR MONUMENT
- OTHER H & V MONUMENT
- BENCHMARK
- SETTLEMENT MONUMENT 77 mon
- SETTLEMENT MONUMENT (SUBSET) 33 mon
- INCLINOMETER 6 mon
- CORS SITE
- TUNNEL MONUMENT 22 mon
- X-SECTION MONUMENT 7 mon



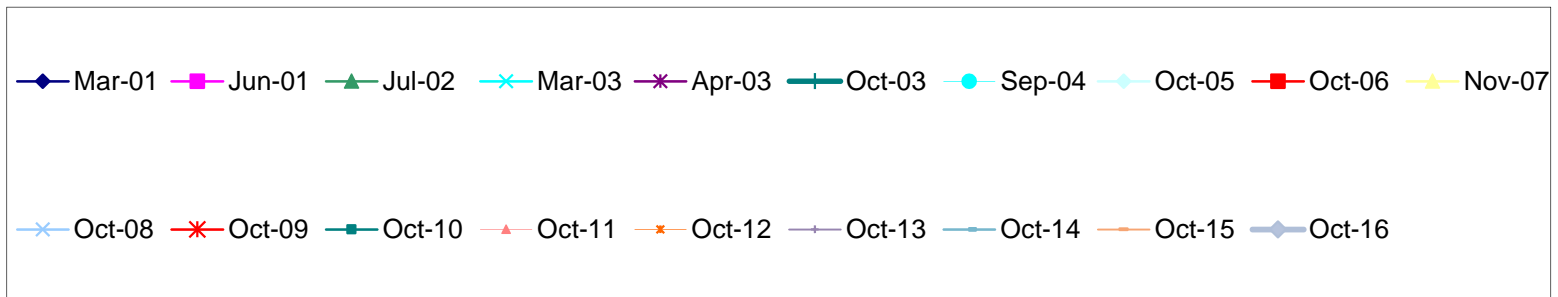
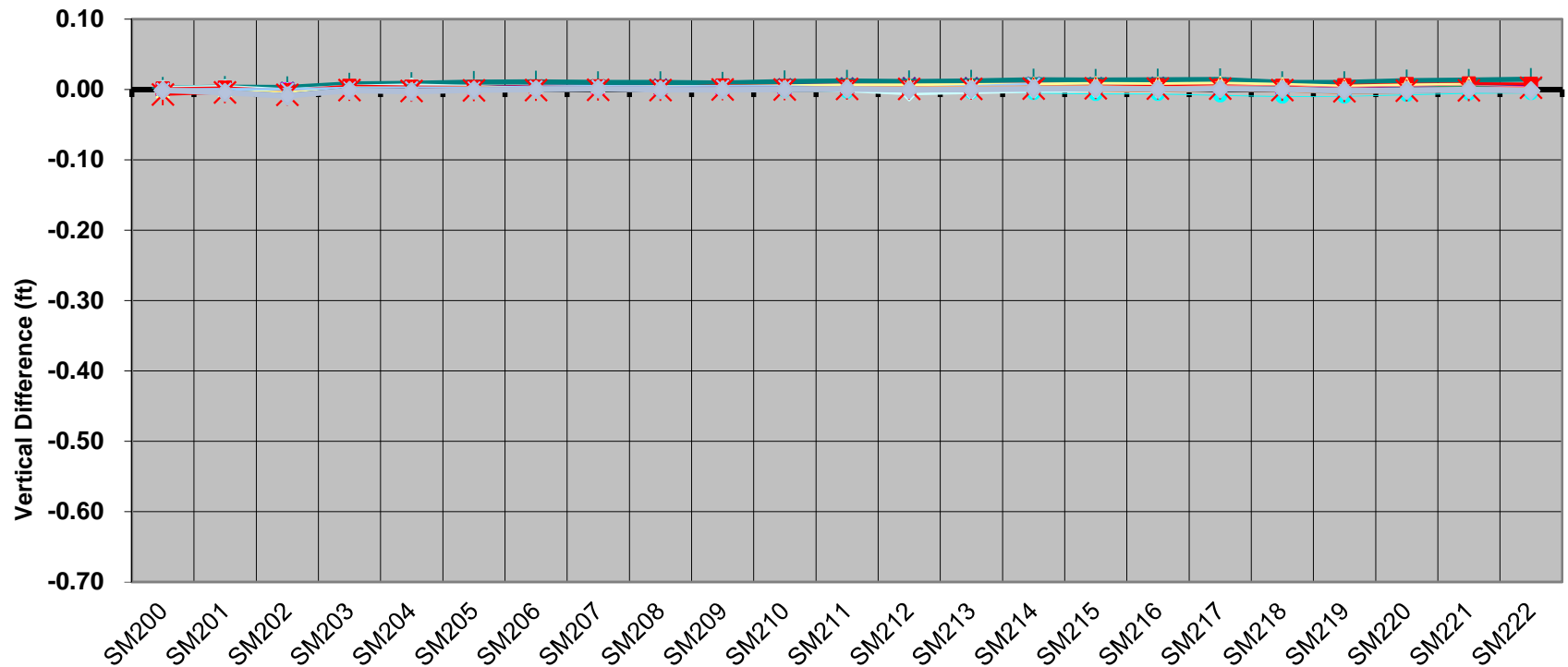
A negative number means that the station is left of the survey line as looking upstream into the tunnel



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



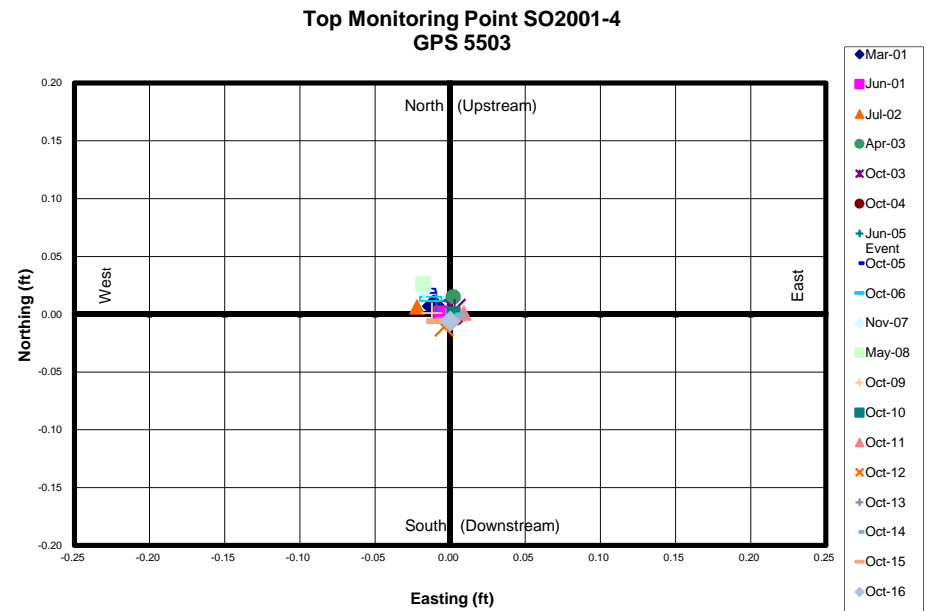
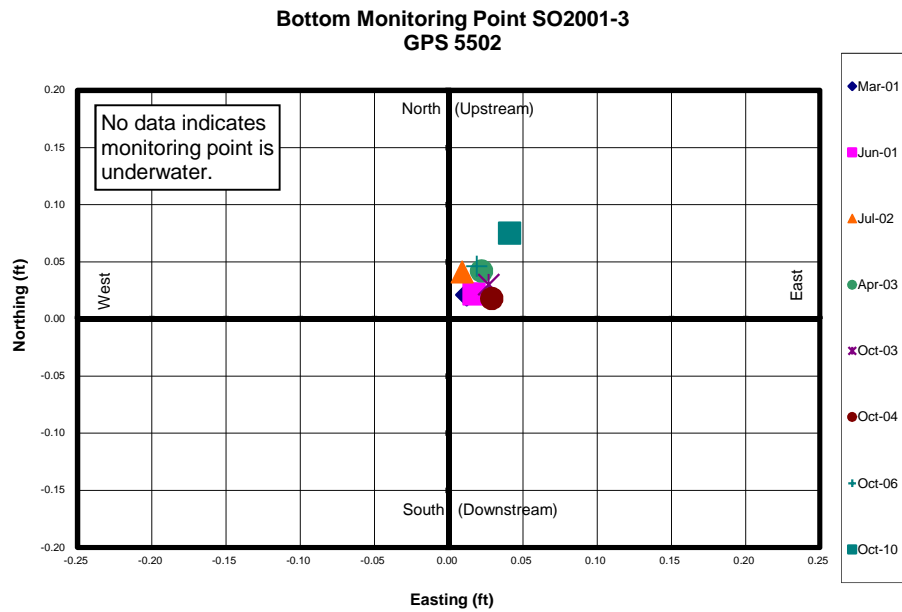
Seven Oaks Dam - Outlet Tunnel Structure Vertical Movement since January 2001 Survey Profile View - Looking from Right Side



Seven Oaks Dam Monitoring Survey Intake Tower - Monitoring Points



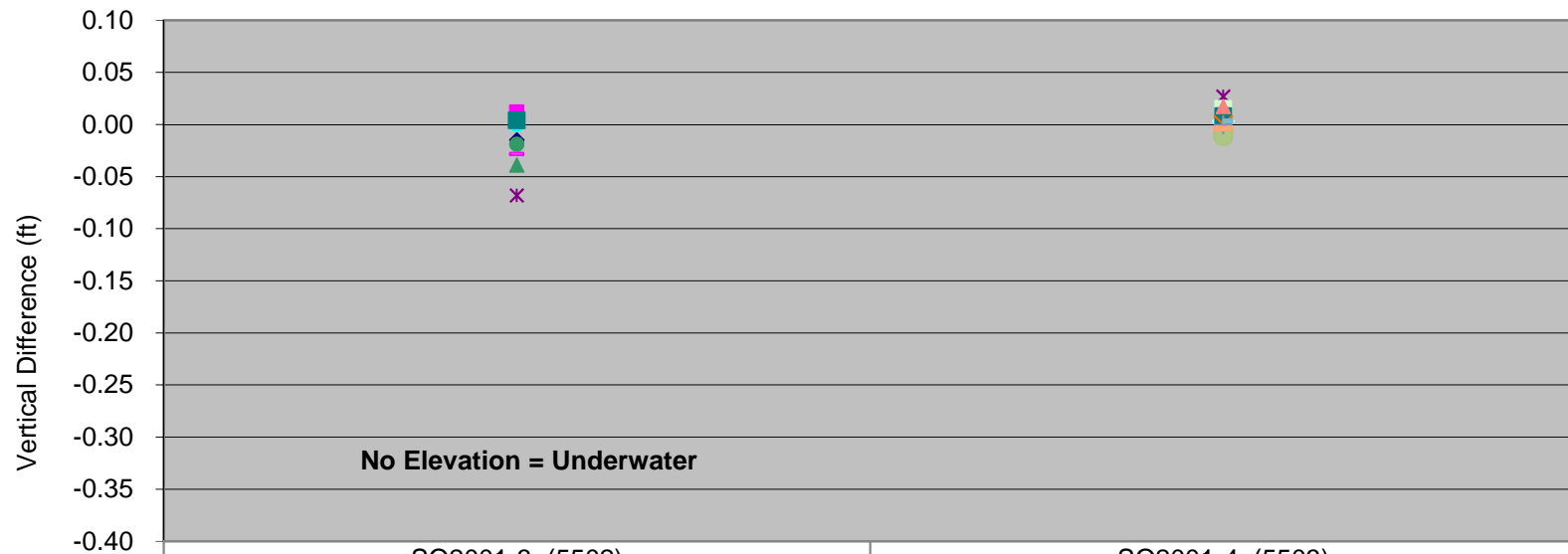
Seven Oaks Dam - Intake Tower Structure (Horizontal) Horizontal Movement since January 2001 Initial Survey



(0,0) = January 2001 Horizontal Position

Seven Oaks Dam - Intake Structure

Vertical Movement since January 2001 Survey



	SO2001-3 (5502)	SO2001-4 (5503)
◆ Mar-01	-0.015	-0.002
■ Jun-01	0.012	0.012
▲ Jul-02	-0.039	0.014
● Apr-03	-0.019	0.003
✱ Oct-03	-0.068	0.027
● Sept-04	0.000	0.008
- Oct-05		-0.005
- Oct-06	-0.028	0.001
● Nov-07		0.003
■ May-08		0.015
▲ Oct-09		0.009
■ Oct-10	0.004	0.008
▲ Oct-11		0.017
✱ Oct-12		0.000
● Oct-13		-0.011
+ Oct-14		-0.001
- Oct-15		0.003
- Oct-16		-0.004