

**Well Sites Survey  
(1994-2012)  
Arnold, Broad Creek and Crofton Meadows  
Well Fields in Anne Arundel County  
Maryland**

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# Report of GPS Surveys

## ***Abstract***

This report describes the most recent year of surveys performed by the Maryland State Highway Administration (MDSHA), Division of Plats and Surveys, for the Maryland Geological Survey (MGS).

The survey was part of efforts by the MGS to monitor for changes at three well sites in Anne Arundel County. Height differences were measured using the Global Positioning System (GPS).

This report describes the results of the current survey.

## ***Purpose***

The goal of this survey is to monitor one survey monument at three separate well sites in Anne Arundel County.

## ***History***

This survey was undertaken as part of an effort begun in 1994 to determine the relationship of the well sites to a monument in the stable Piedmont region of the state as well as to sites in the National Geodetic Survey's Continuously Operating Reference Station (CORS) network.

Measurements were made on 7, 8, and 9 June 2011 using GPS.

Table 1 - Sites used in survey

Station	Site Name	Nearby Community
GORF GPS N	Howard High School	Columbia, MD
ARNOLD-1	Arnold Well Field	Arnold, MD
BROAD-1	Broad Creek Well Field	Annapolis, MD
CROFTON-1	Crofton Meadows Well Field	Crofton, MD
ANP5	Annapolis CORS site	Annapolis, MD
GODE	NASA Goddard CORS	Greenbelt, MD
USNO	US Naval Observatory CORS	Washington, DC

## ***Monumentation***

No new survey monuments were established in 2012.

## ***Specifications***

Observations at well sites consisted of five and one-half hour sessions on three separate days. One session was offset from the others by four (4) hours. The offset session uses a different satellite constellation and thereby provides an accuracy check.

## ***Equipment used***

Four MDSHA GPS receivers were used during this project. They are Thales Navigation Z-MAX dual frequency units capable of logging the full L2 wavelength. NGS antenna calibrations are available for the antennas.

**Table 2 - CORS site equipment**

<b>Site</b>	<b>Receiver</b>	<b>Antenna</b>
ANP5	TRIMBLE NET-RS	TRM41429
GODE	ASHTECH UZ-12	AOAD/M_T
USNO	ASHTECH ZXII3T	AOAD/M_T

## ***Conditions effecting surveys***

The schedule this year had to be moved a few weeks due to some schedule conflicts. The survey was performed in early June instead of the target for May. The condition of the site ARN-1 was similar to 2011. The area around the marker itself was still covered with large gravel and it was being used for parking. As far as the equipment, there were no issues. It all worked properly.

## ***Vector reduction***

GPS observations were initially reduced to vectors using the Topcon Tools software package (version 7.2). The position of station GORF GPS N was verified by observations with respect to three NGS CORS sites.

## ***Adjustment***

The GPS vectors were then adjusted with the Topcon Tools software package (version 7.2). Adjusted coordinates for the well site stations were determined with respect to the NAD 83 (1991) coordinates and NAVD 88 height for station GORF GPS N. As the primary interest is the vertical component, these values were extracted from the adjustment and tabulated below.

**Table 3 - Fixed station coordinate**

<b>Station Name</b>	<b>Latitude</b>	<b>Longitude</b>	<b>NAVD 88 height</b>	<b>Datum</b>
GORF GPS N	N39 13 34.24168	W076 48 50.46404	156.886	NAD 83 (1991)

Geoid heights were determined for well site stations using the model GEOID 2003. These values are used to convert ellipsoid heights derived from GPS observations into NAVD 88 compatible values.

**Table 4 - Heights determined by GPS (all values shown as meters)**

YEAR	ARNOLD-1	sigma	BROAD-1	sigma	CROFTON-1	sigma
1994	38.223	0.036	28.282	0.057	41.180	0.086
1995	38.224	0.023	28.303	0.021	41.212	0.017
1996	38.216	0.009	28.306	0.010	41.243	0.009
1997	38.219	0.029	28.309	0.024	41.233	0.017
1998	38.208	0.005	28.304	0.005	41.233	0.005
1999	38.201	0.025	28.323	0.025	41.240	0.025
2000	38.210	0.012	28.318	0.012	41.246	0.012
2001	38.221	0.006	28.322	0.007	41.247	0.006
2002	38.203	0.012	28.289	0.012	41.223	0.012
2003	38.197	0.032	28.289	0.019	41.200	0.019
2004	38.205	0.007	28.293	0.007	41.203	0.007
2005	38.184	0.009	28.288	0.011	41.206	0.008
2006	38.186	0.009	28.296	0.009	41.211	0.006
2007	38.180	0.014	28.281	0.015	41.206	0.011
2008	38.181	0.021	28.272	0.021	41.204	0.016
2009	38.184	0.020	28.293	0.019	41.224	0.015
2010	38.176	0.012	28.286	0.012	41.222	0.009
2011	38.194	0.024	28.295	0.025	41.227	0.027
2012	38.182	0.012	28.292	0.012	41.212	0.009
<b>mean</b>	<b>38.200</b>		<b>28.297</b>		<b>41.220</b>	
<b>max</b>	38.224		28.323		41.247	
<b>min</b>	38.176		28.272		41.180	
<b>range</b>	0.048		0.051		0.067	
<b>stdev</b>	0.016		0.015		0.020	

**Note:** The data from the January 2006 observations are listed in the following charts under the year 2005 since there were no observations in 2005 and there were two sets in 2006. There cannot be two sets of data for one year due to the format of the charts.

**Note:** The NAVD 88 height data, determined by precise leveling in 1994 and seen in table 5, has been added to the charts in figures 1 through 3 to allow a graphical comparison between GPS values and the original leveled heights.

Figure 1 - ARNOLD-1 values and uncertainties

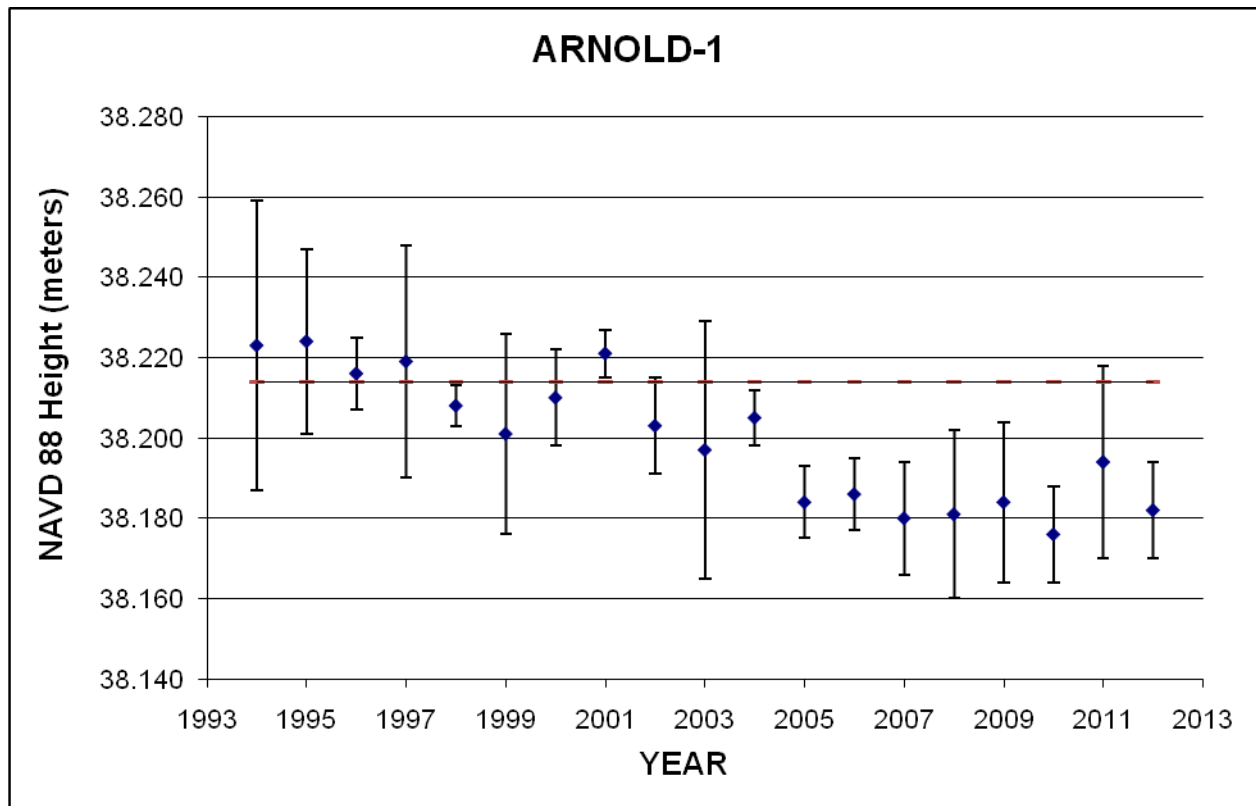
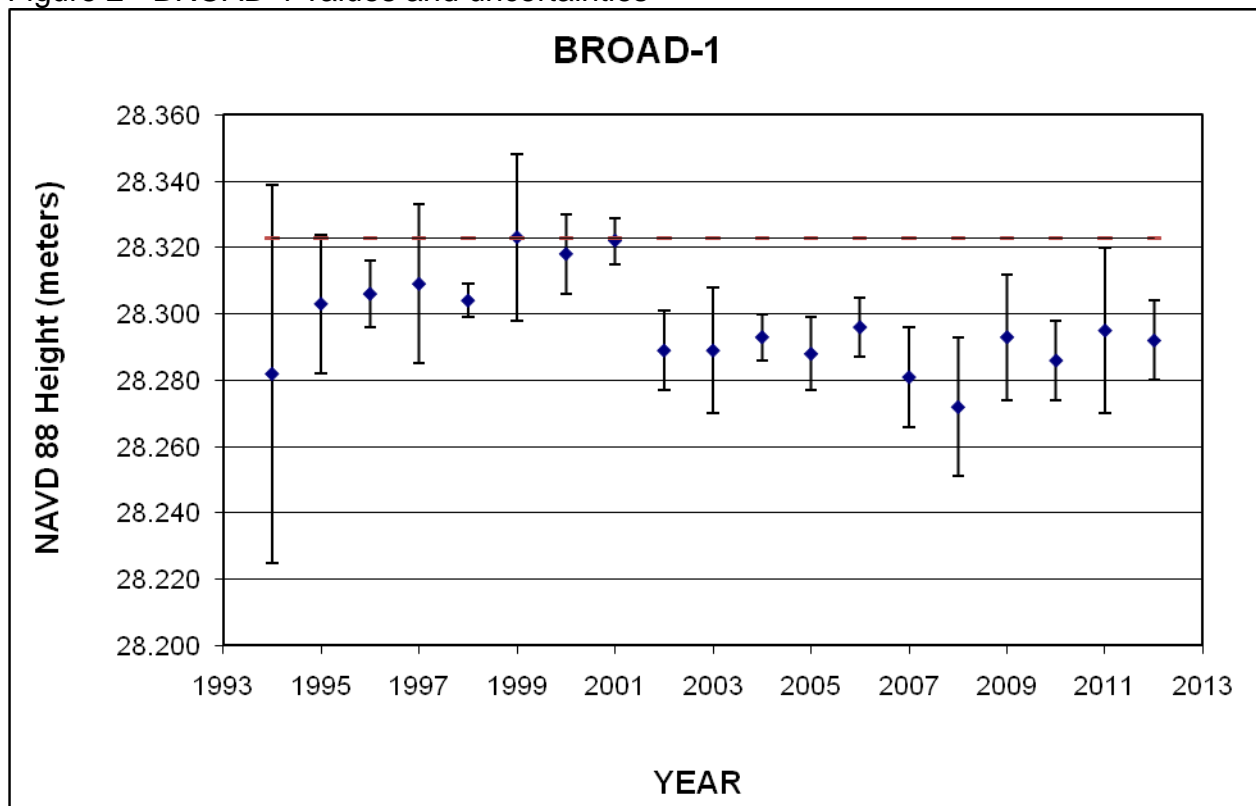
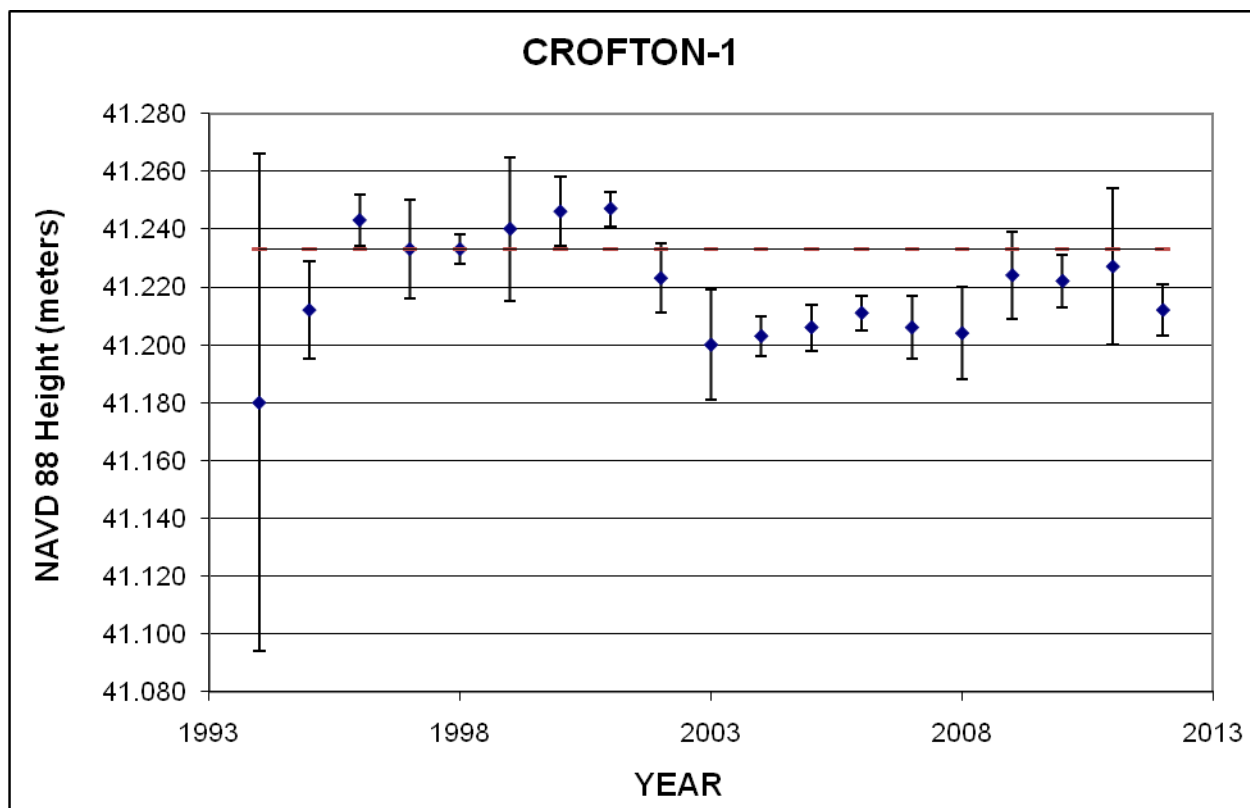


Figure 2 - BROAD-1 values and uncertainties



**Figure 3 - CROFTON-1 values and uncertainties**



**Table 5 - NAVD 88 heights in meters derived from different techniques.**

Station	Leveling 1994(L)	GPS-derived 2012(G)	Difference (L-G)
ARNOLD-1	38.214	38.182	+0.032
BROAD-1	28.323	28.292	+0.031
CROFTON-1	41.233	41.212	+0.021

The discrepancy between the height determinations could be due to deficiencies in the geoid model, limitations of GPS as a system for determining heights and possible errors in the network of benchmarks.

**Table 6 - Geoid Heights for project monuments**

Station	Geoid 2003 Height (meters)
ARNOLD-1	-33.208
BROAD-1	-33.140
CROFTON-1	-32.791
GORF GPS N	-32.212

## ***June 2012 Observation Schedule***

All monuments were occupied for a minimum of 5.5 hours. CORS operate continuously (24/7).

DOY: 156      Date: 4 June 2012

Station	Start time UTC	End time UTC
ARNOLD-1	15:28	21:00
BROAD-1	15:22	21:00
CROFTON-1	15:21	21:00
GORF GPS N	15:25	21:00
Annapolis CORS site	00:00	23:59
NASA Goddard CORS	00:00	23:59
US Naval Observatory CORS	00:00	23:59

DOY: 157      Date: 5 June 2012

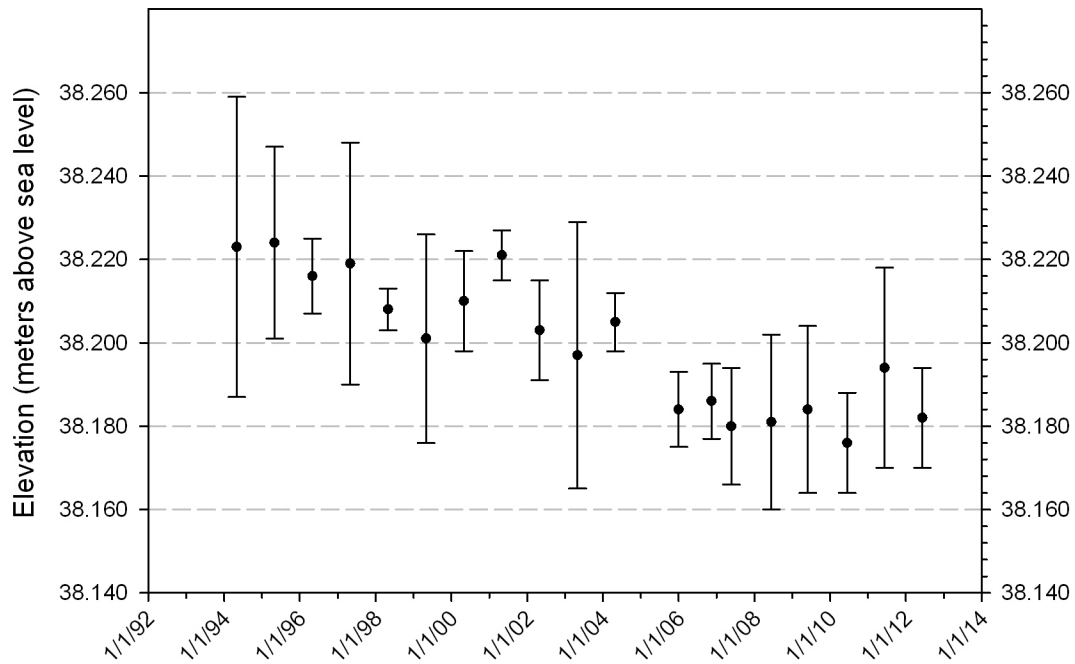
Station	Start time UTC	End time UTC
ARNOLD-1	11:31	17:00
BROAD-1	11:34	17:02
CROFTON-1	11:25	17:00
GORF GPS N	11:25	17:02
Annapolis CORS site	00:00	23:59
NASA Goddard CORS	00:00	23:59
US Naval Observatory CORS	00:00	23:59

DOY: 158      Date: 6 June 2012

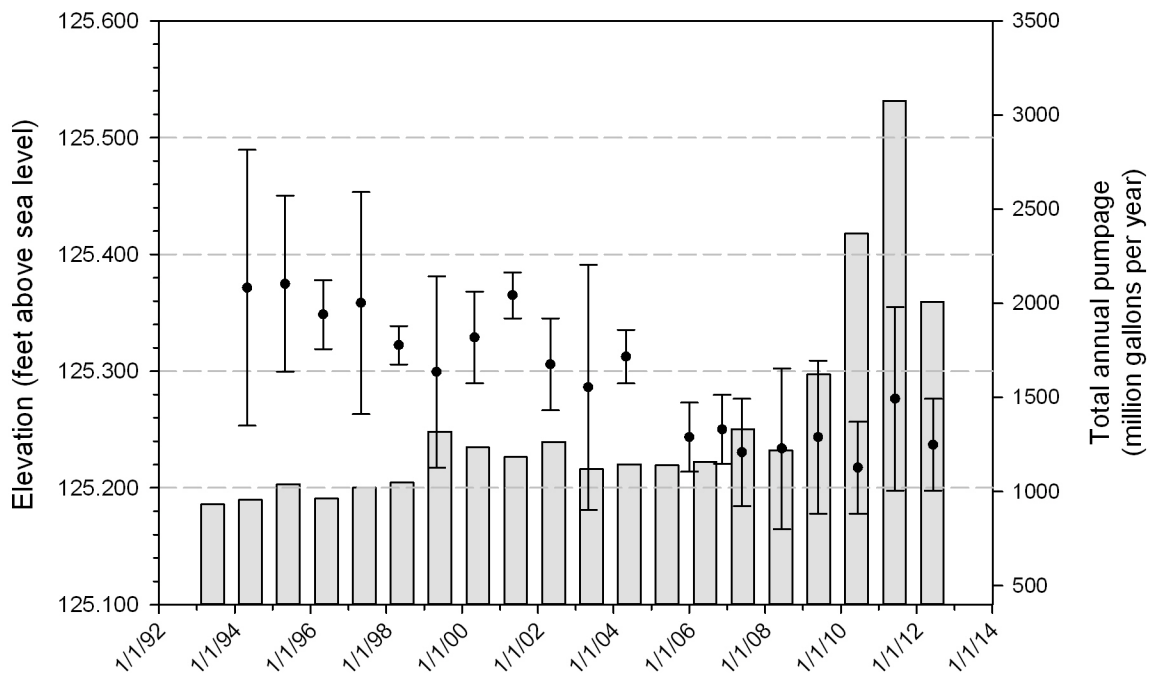
Station	Start time UTC	End time UTC
ARNOLD-1	11:28	17:10
BROAD-1	11:31	17:10
CROFTON-1	11:24	17:10
GORF GPS N	11:39	17:13
Annapolis CORS site	00:00	23:59
NASA Goddard CORS	00:00	23:59
US Naval Observatory CORS	00:00	23:59



Arnold wellfield elevation survey (meters)

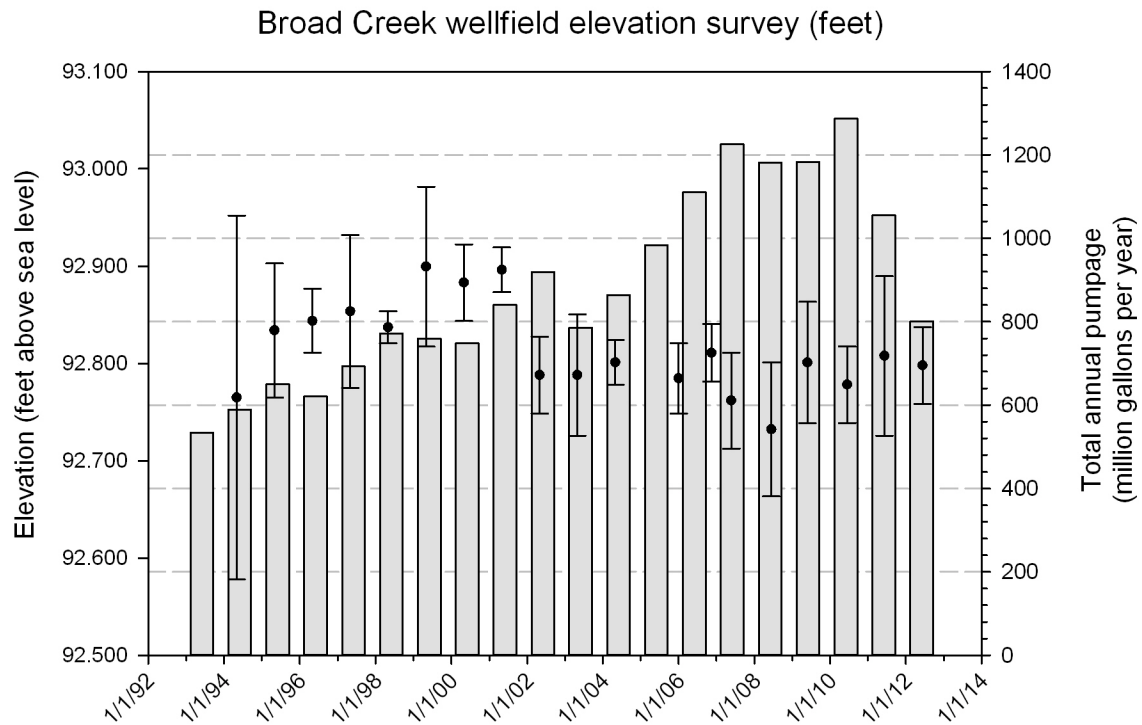
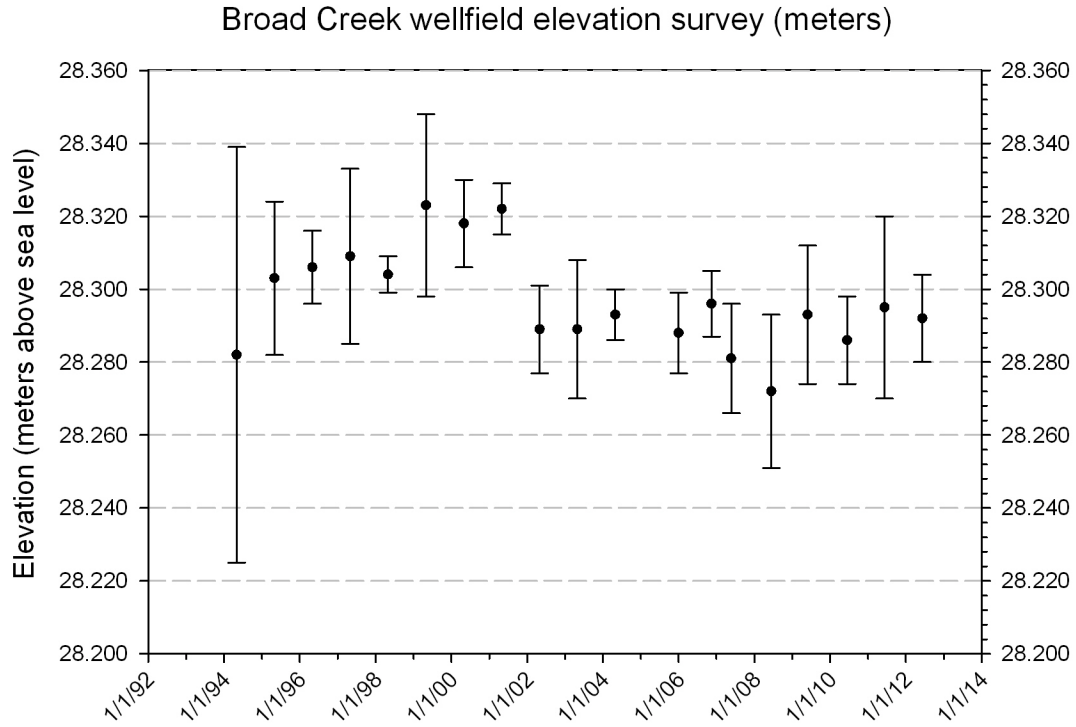


Arnold wellfield elevation survey (feet)



Plots on this page prepared by David Bolton, MGS

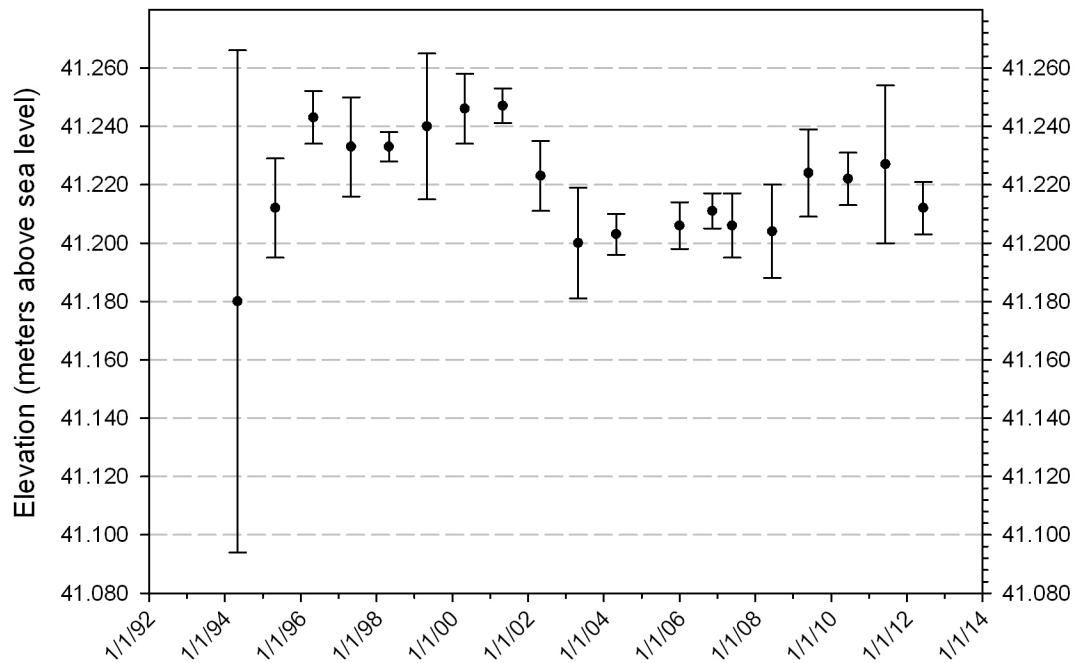
November 2012



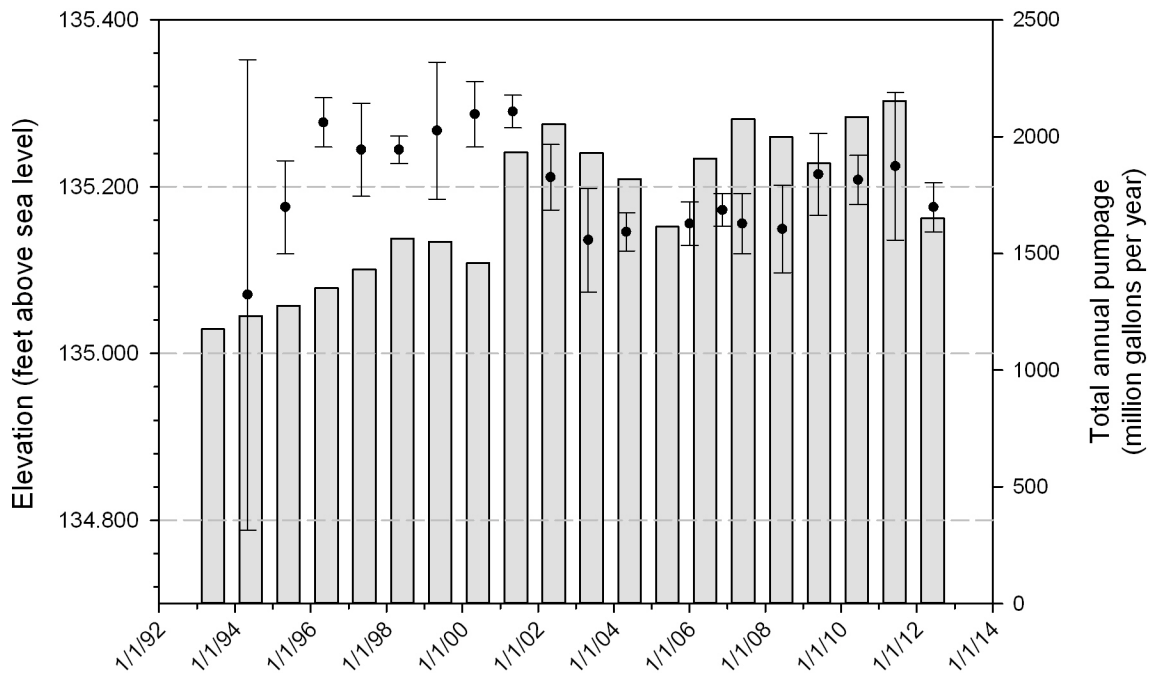
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November 2012

Crofton Meadows wellfield elevation survey (meters)



Crofton Meadows wellfield elevation survey (feet)



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November 2012