Department of Natural Resources
MARYLAND GEOLOGICAL SURVEY
Emery T. Cleaves, Director

Monitoring for Land Subsidence in the Arnold, Broad Creek, and Crofton Meadows Well Fields of Anne Arundel County

Annual Report for 1994

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Prepared in cooperation with the
Anne Arundel County Department of Public Works
and the
Maryland State Highway Administration

1995

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INTRODUCTION

This report describes activities to monitor three Anne Arundel County well fields for land subsidence. It includes a report by the Maryland State Highway Administration (SHA) that describes its work in 1994 to establish bench marks in the well fields. The report by SHA also presents the results of its survey to those bench marks by precise leveling and the use of the Global Positioning System (GPS). Special efforts have been made to document, with maps and photos, the locations of the level lines, the well fields, and the bench marks because GPS is to be used annually to determine heights of the subsidence monitoring bench marks.

PURPOSE OF THE PROJECT

Demands for ground water in the coastal plain of Anne Arundel County have increased continuously in the past and are expected to rise in the future. As pumpage increases, ground-water levels can be expected to decline further in response to the greater hydraulic stresses imposed on the aquifer systems. Increased drawdown of ground-water levels in unconsolidated sediments has caused subsidence of the land surface in other areas. Case histories of subsidence in coastal plain settings have been published for Houston, Texas (Gabrysch, 1969); Baton Rouge, Louisiana (David and Rollo, 1969); and Franklin, Virginia (Davis, 1987). At least three specific sites in Anne Arundel County are expected to become major centers of ground-water pumpage in future years. These are the Arnold, Broad Creek, and Crofton Meadows well fields (figure 1). Pumpage at these sites is from the Patapsco and Patuxent aquifers of lower Cretaceous age.

In its earliest stages, subsidence of the land surface due to ground-water withdrawals would be very slight because the lower Cretaceous aquifers are "pre-stressed"; that is, they were subjected to greater overburden pressures in their geologic past, resulting in prior compaction. Increasing grain-to-grain loads due to declining water levels must exceed the pre-stress condition before significant land subsidence occurs. Davis (1987) suggests that a head loss of at least 65 feet is necessary before virgin compaction

begins in "typical" Atlantic Coastal Plain sediments. As a result, the onset of land subsidence may not be noticeable without a precise system to monitor small changes in the altitude of the land surface. For the case histories mentioned earlier, considerable damage had been done to sewer and water lines, buildings, and canals before it became apparent that the land surface was subsiding due to ground-water withdrawals.

Concern that future increases of withdrawals of ground water from the aquifers of Anne Arundel County could conceivably cause destructive land subsidence led to the design of an early detection system consisting of two elements:

1. The establishment of high integrity bench marks at sites considered to be most susceptible to land subsidence.
2. Monitoring of the heights of the bench marks on a periodic basis to detect changes that may occur.

ACCOMPLISHMENTS OF THE PROJECT IN 1994

The project was started in 1994. It entailed the following tasks, which were carried out with the cooperation of the State Highway Administration.

1. Selection of sites at which subsidence would be most likely to happen. The Arnold, Broad Creek, and Crofton Meadows well fields were selected because it is probable that deep cones of depression will eventually be developed around them by the withdrawal of large quantities of water.
2. The establishment of bench marks at each of the three well fields.
3. The determination of the heights of the bench marks by second order (class 1) leveling.

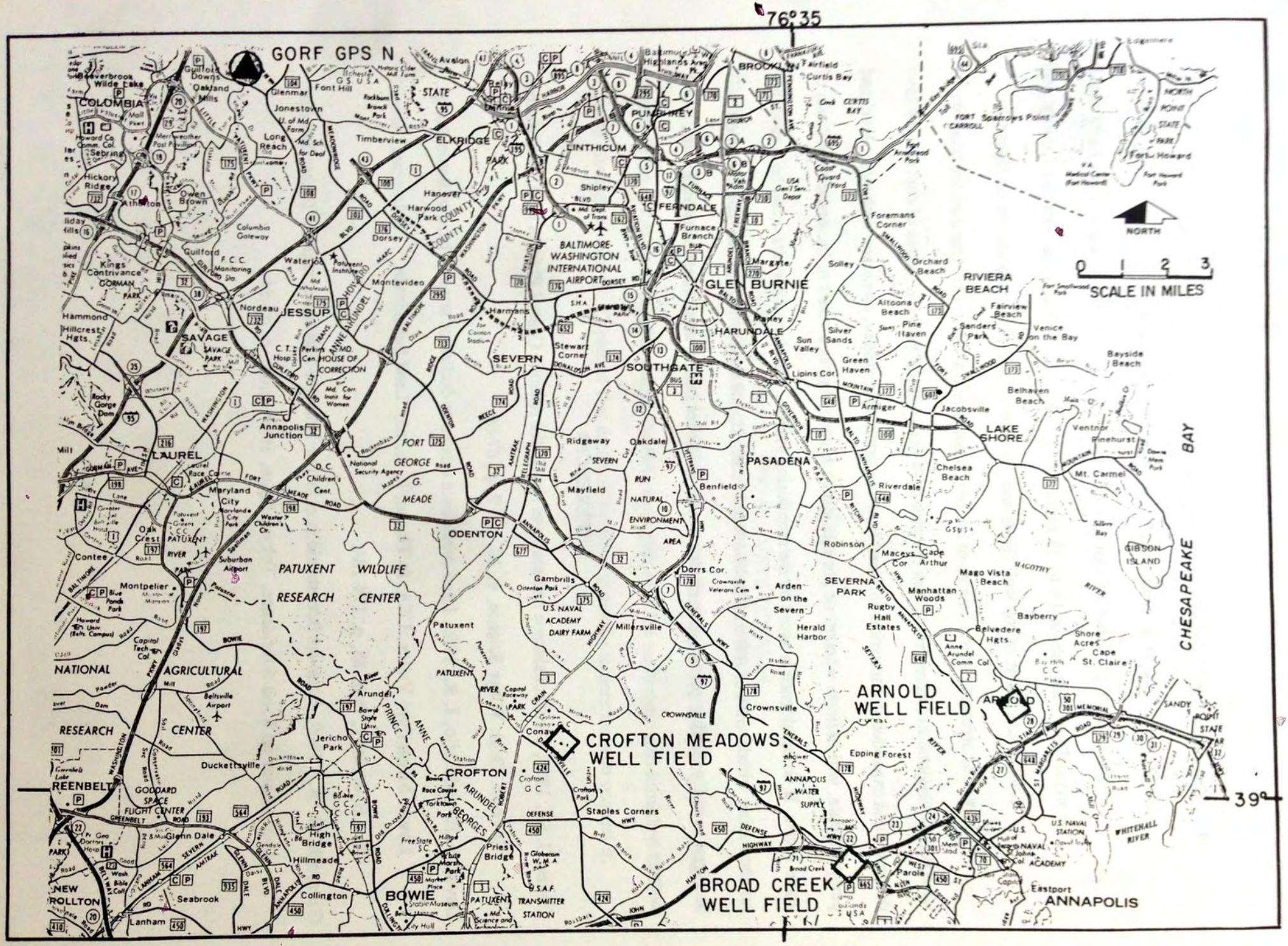

Figure 1. Locations of the three well fields monitored for subsidence in Anne Arundel County and the reference bench mark GORF GPS N, in Howard County.

4. The use of the Global Positioning System (GPS) to relate the heights of the bench marks in each well field to a bench mark designated GORF GPS N, located in the Piedmont physiographic province in Howard County. That bench mark is located on more stable crystalline rock, about 13 to 18 miles to the northwest of the Anne Arundel County well fields. Locations of the well fields and the GORF GPS N site are shown on figure 1.

Early measurements of the heights of the bench marks will serve as base line data for comparison with values obtained in future years when the ground-water pressure surfaces (cones of depression) have deepened and expanded. Information obtained from the monitoring system, combined with water-level and pumpage data, will indicate whether or not subsidence is occurring as a result of increased drawdown of water levels. If no subsidence is noted by the monitoring system, granting of permits could be considered for increasing withdrawals of water. If subsidence is noted by the monitoring system, consideration will be given to redistributing pumpage to alternate well-field sites before there is any significant structural damage.

REFERENCES

Davis, G. H., 1987, Land subsidence and sea level rise on the Atlantic Coastal Plain of the United States: Environ. Geol. Water Science, v. 10, no. 2, p. 67-80.

Davis, G. H. and Rollo, J. R., 1969, Land subsidence related to decline of artesian head at Baton Rouge, Lower Mississippi Valley, USA: *in* Tinson, L. J., ed., Land Subsidence, v. 1, Internat. Assoc. Sci. Hydrology, Pub. 88, p. 174-184.

Gabrysch, R. K., 1969, Land-surface subsidence in the Houston-Galveston region, Texas: Internat. Symposium on Land Subsidence, Tokyo, Japan, 1969, Proc., p. 43-54..

REPORT BY PLATS AND SURVEYS DIVISION OF THE MARYLAND STATE HIGHWAY ADMINISTRATION

The SHA summarized the results of its work on this project on the following three pages. Printouts of the extensive notes taken during the field work phases of the study were also furnished to the Maryland Geological Survey. Copies of that data will be made available to persons who request it.

PROJECT REPORT FOR ANNE ARUNDEL COUNTY WELLS PROJECT

I. LOCATION

THE PROJECT WAS CONDUCTED AT THREE ANNE ARUNDEL COUNTY WELL SITES. THE CROFTON MEADOWS FACILITY, THE BROAD CREEK FACILITY AND THE ARNOLD FACILITY.

II. SCOPE

A. PURPOSE

TO ESTABLISH A DIFFERENCE OF ELEVATION AT EACH WELL SITE FROM A STABLE LOCATION IN HOWARD COUNTY, THAT LOCATION BEING THE HIGH ACCURACY REFERENCE NETWORK STATION GORF GPS N AND TO RUN 2ND ORDER CLASS 1 PRECISE LEVELS AT EACH WELL SITE.

B. MONUMENTATION

THE STATE HIGHWAY ADMINISTRATION SET FIVE NEW BENCH MARKS. THE NATIONAL GEODETIC SURVEY SET THREE NEW BENCH MARKS.

THE STATE HIGHWAY ADMINISTRATION SET STATION ARNOLD-1 AND ARNOLD-2 AT THE ARNOLD FACILITY AND THE NATIONAL GEODETIC SURVEY SET STATION ARNOLD W.T. AT THAT FACILITY.

AT THE BROAD CREEK FACILITY THE STATE HIGHWAY ADMINISTRATION SET STATION BROAD-1 AND BROAD-2 AND THE NATIONAL GEODETIC SURVEY SET STATION BROAD CREEK W.T.

AT THE CROFTON FACILITY THE STATE HIGHWAY ADMINISTRATION SET STATION CROFTON-1 AND THE NATIONAL GEODETIC SURVEY SET STATION C.M. PUMP-1.

C. EXISTING CONTROL STATIONS

1. GORF GPS N
2. E 125
3. K 125
4. SHA 125
5. SHA 126
6. P 84
7. X 84
8. MATT (MATAPEAKE)

III. GPS

THERE WERE THREE GPS SESSIONS FOR THIS PROJECT. DURING THE FIRST SESSION FOUR POINTS WERE OCCUPIED (GORF GPS N, BROAD-1, CROFTON-1 AND ARNOLD-1). DURING THE SECOND SESSION GORF GPS N, ARNOLD-1 AND MATT WERE OCCUPIED. DURING THE THIRD SESSIONS GORF GPS N AND BROAD-1 WERE OCCUPIED.

STATION MATT WAS OCCUPIED FOR A HORIZONTAL CHECK AND ADJUSTMENT ON THE STATIONS AT THE WELL SITES. IT IS A PART OF THE MARYLAND HIGH ACCURACY REFERENCE NETWORK

SESSION 1 GPS ELEVATION DIFFERENCES (5-13-94)

GORF GPS N TO BROAD-1	-128.538 METERS (M)
GORF GPS N TO CROFTON-1	-116.258 M
GORF GPS N TO ARNOLD-1	-119.722 M

SESSION 2 (5-25-94)

GORF GPS N TO ARNOLD-1	-119.678 M

SESSION 3 (8-15-94)

GORF GPS N TO BROAD-1	-129.617 M

IV. PRECISE LEVELS

THE PRECISE LEVELS TO THE ARNOLD FACILITY WERE RUN FROM EXISTING STATIONS K-125 AND E-125 THROUGH THE STATIONS SET AT THE ARNOLD FACILITY AND BACK TO E-125. THE ELEVATIONS AT THE ARNOLD FACILITY ARE AS FOLLOWS

1.	ARNOLD-1	38.21 METERS (M)
2.	ARNOLD-2	39.22 M
3.	ARNOLD W. T.	43.71 M
4.	TOP OF WELL CASING	37.64 M

THE PRECISE LEVELS TO THE BROAD CREEK FACILITY WERE RUN FROM EXISTING STATIONS SHA-125 AND SHA-126, THESE STATIONS HAVE NOT BEEN ADJUSTED BY THE NATIONAL GEODETIC SURVEY AS OF THIS DATE. THE FOLLOWING ELEVATIONS ARE UNADJUSTED, BUT ARE PROBABLY WITHIN A CENTIMETER ACCURACY

1.	BROAD-1	28.32 METERS (M)
2.	BROAD-2	22.66 M
3.	BROAD CREEK W.T.	29.91 M

THE PRECISE LEVELS TO THE CROFTON FACILITY WERE RUN FROM EXISTING STATION X 84 AND P 84. THE ELEVATIONS AT THE CROFTON FACILITY ARE AS FOLLOWS

1.	CROFTON-1	41.24 METERS (M)
2.	C.M. PUMP-1	35.26 M

THESE ELEVATIONS ARE PLUS OR MINUS A CENTIMETER

V. INSTRUMENTATION

THE FOLLOWING INSTRUMENTS WERE USED FOR THIS PROJECT

ITEM	MANUFACTURER	SERIAL	OWNER
1. DATA COLLECTOR RHC44	PARAVANT	485.202	MDSHA
2. AUTOMATIC LEVEL N12	ZEISS	33244	NGS
3. MICROMETER	ZEISS	NONE	MDHSA
4. 0.5 CM LEVEL ROD	KERN	121176	NGS
5. 0.5 CM LEVEL ROD	KERN	132181	NGS
6. TURNING PLATES	NGS	NON	NGS
7. GPS RECEIVER 4000SST	TRIMBLE	3030A00987	MDSHA
8. GPS RECEIVER 4000SST	TRIMBLE	3030A00988	MDSHA
9. GPS RECEIVER 4000ST	TRIMBLE	3030A00979	MDSHA
10.GPS RECEIVER 4000SE	TRIMBLE	3151A00344	MDSHA
11.TOTAL STATION GTS 3	TOPCON	H90779	MDSHA

DOCUMENTATION OF DATA BY WELL FIELD

Specific information for individual well fields is presented in the following section of this report. Included here are maps of locations of level lines run from control points to the new bench marks, maps of the well fields showing locations of wells and bench marks; photos of the bench marks and their surroundings, written descriptions of the bench marks, and tables of individual wells in each well field.

BENCH MARK AND WELL DATA FOR THE ARNOLD WELL FIELD

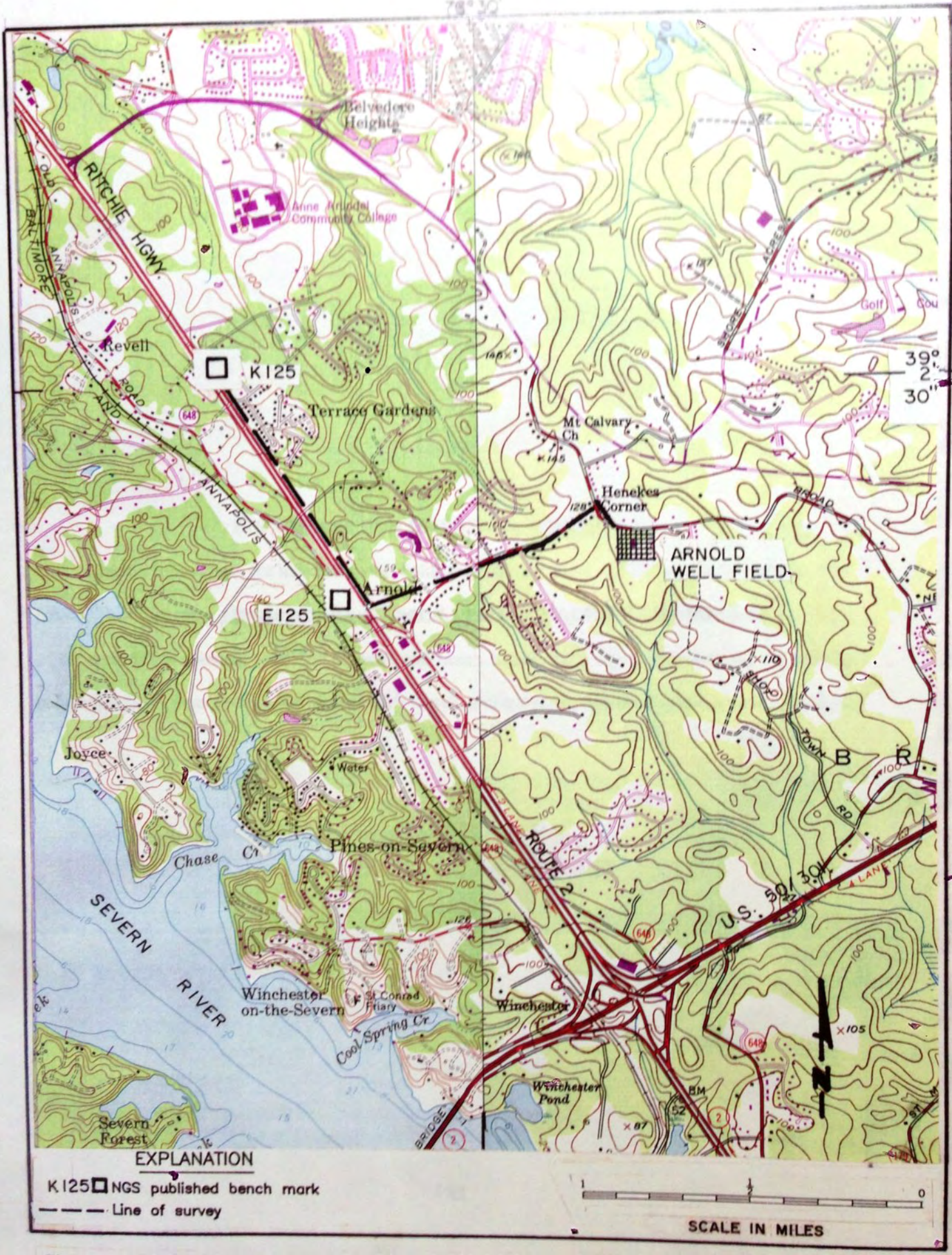

Figure 2. Locations of the control bench marks and the line of leveling to the subsidence bench marks in the Arnold well field.

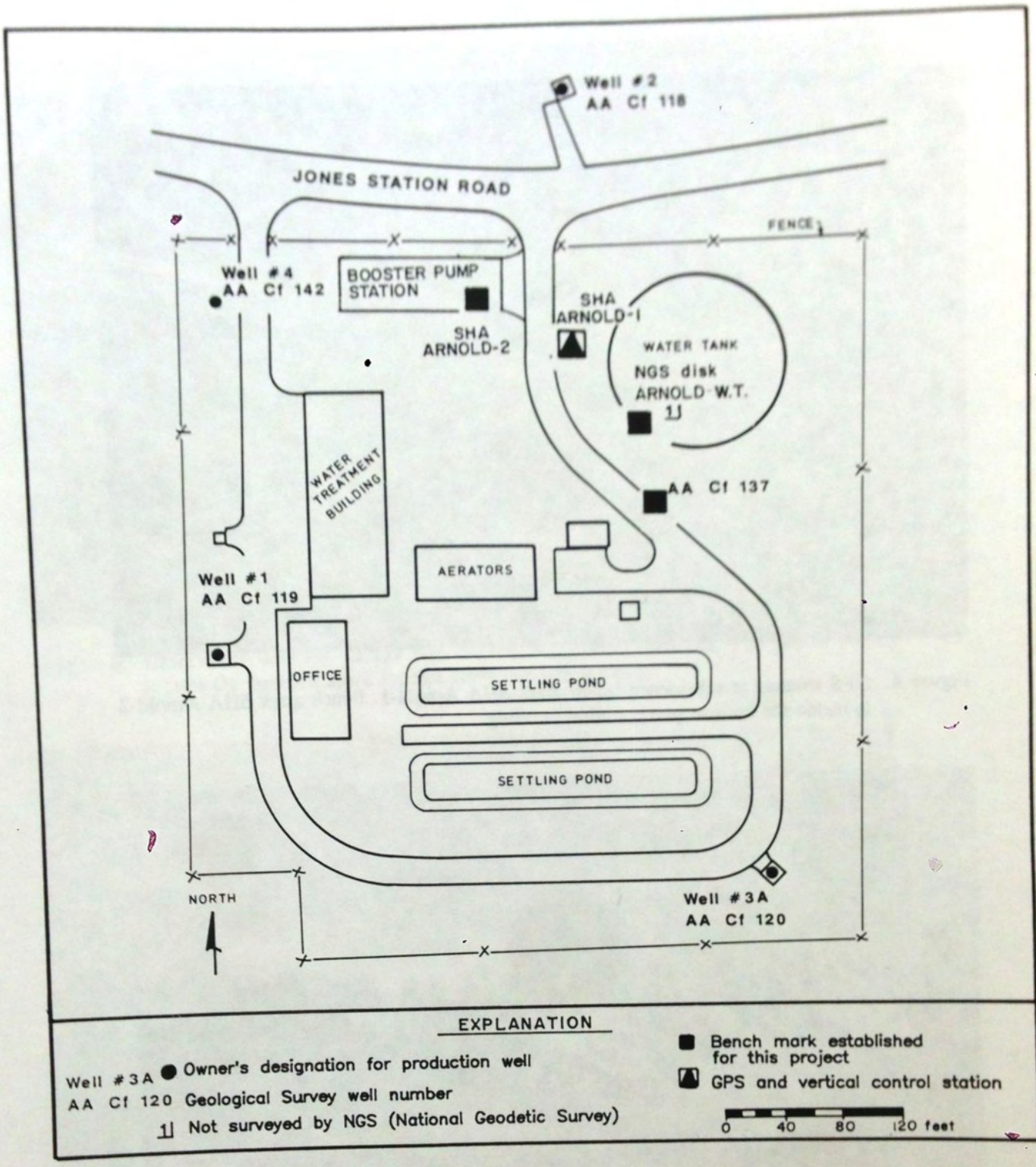

Figure 3. Locations of bench marks and wells at the Arnold well field.

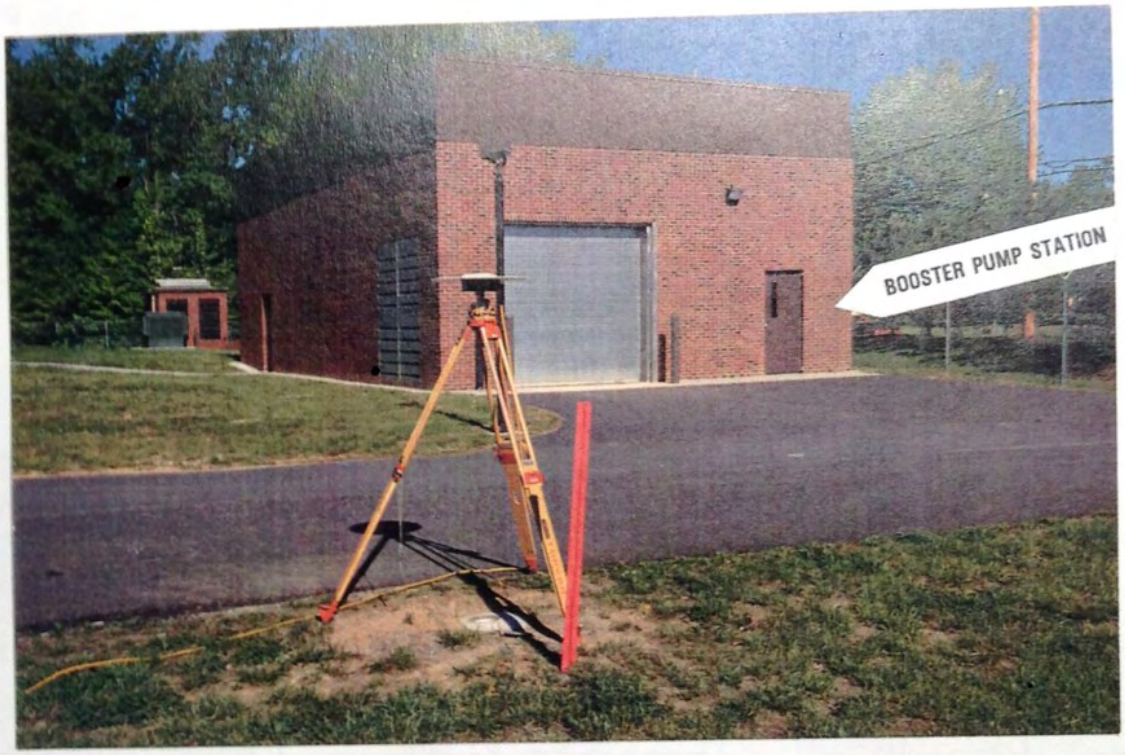

Figure 4. GPS antenna at subsidence bench mark SHA Arnold-1. Bench mark SHA Arnold-2 is inside the booster pump station building.

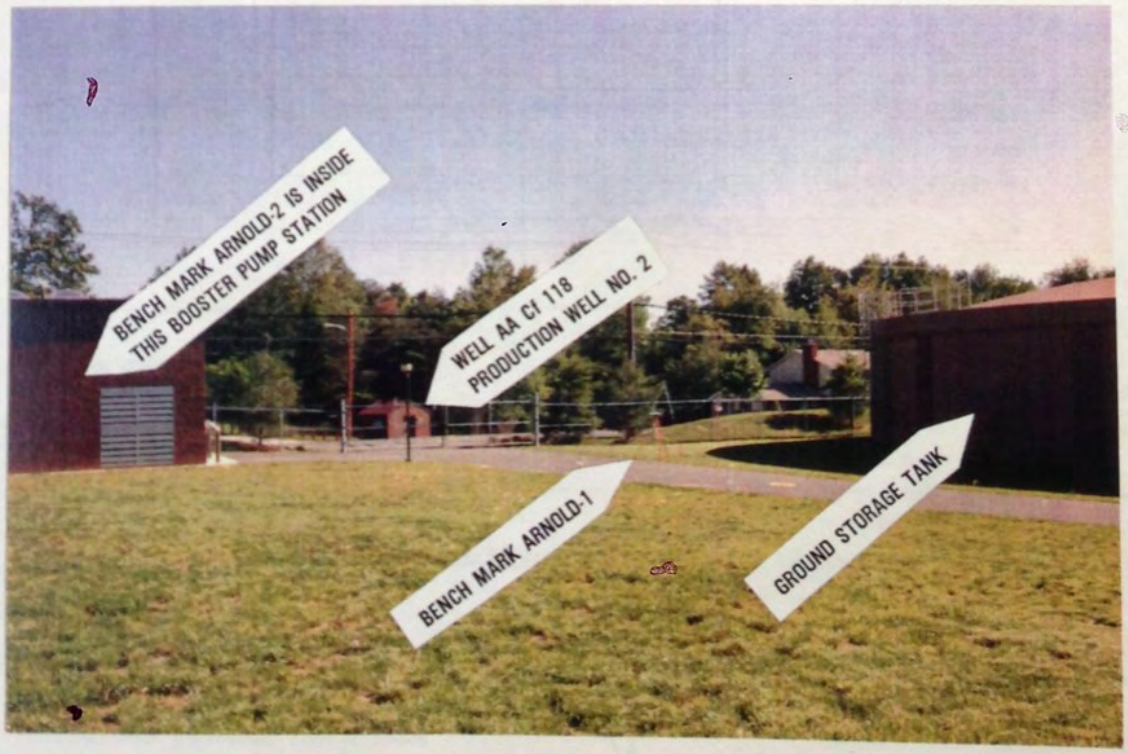

Figure 5. Ground storage tank, booster pump station building, well house for well AA Cf 118, and the GPS antenna at bench mark SHA Arnold-1.

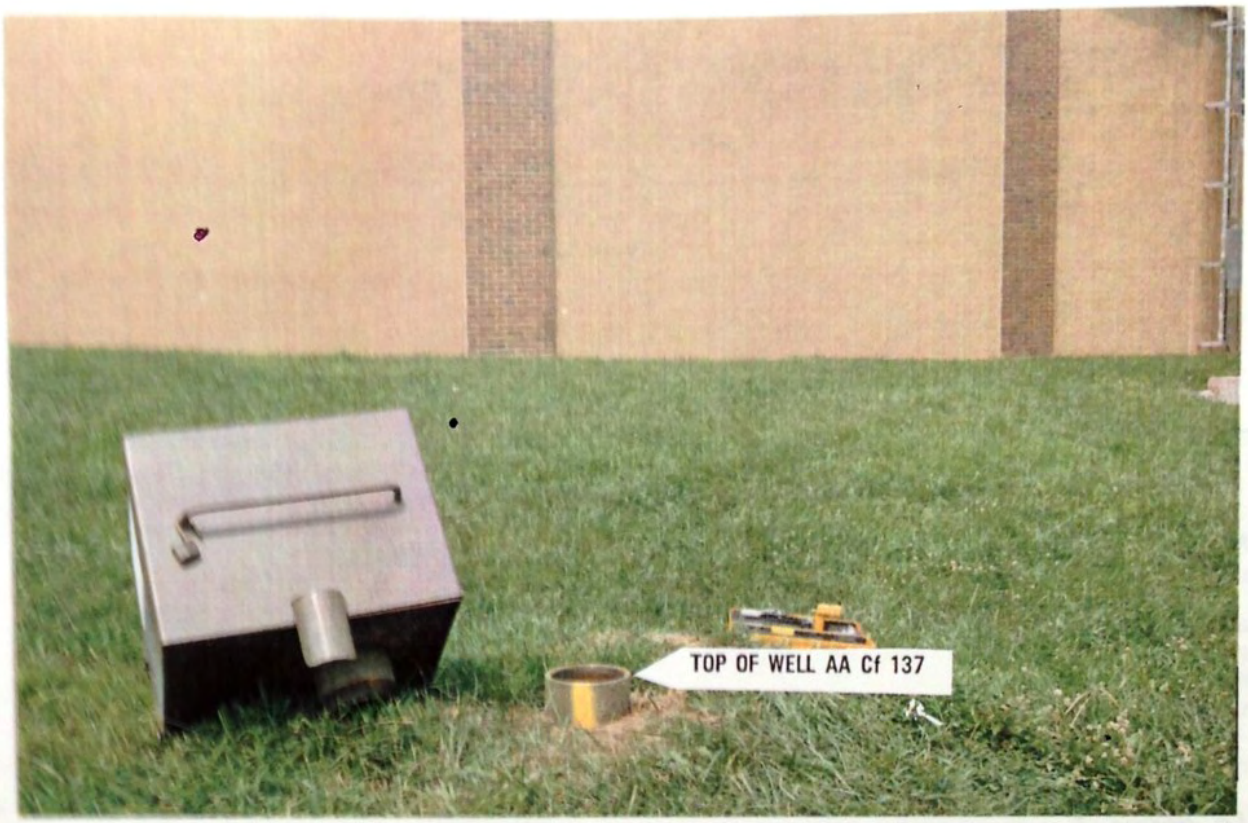

Figure 6. Observation well AA Cf 137 with the recorder shelter removed. The yellow paint locates the punched mark for this reference bench mark.

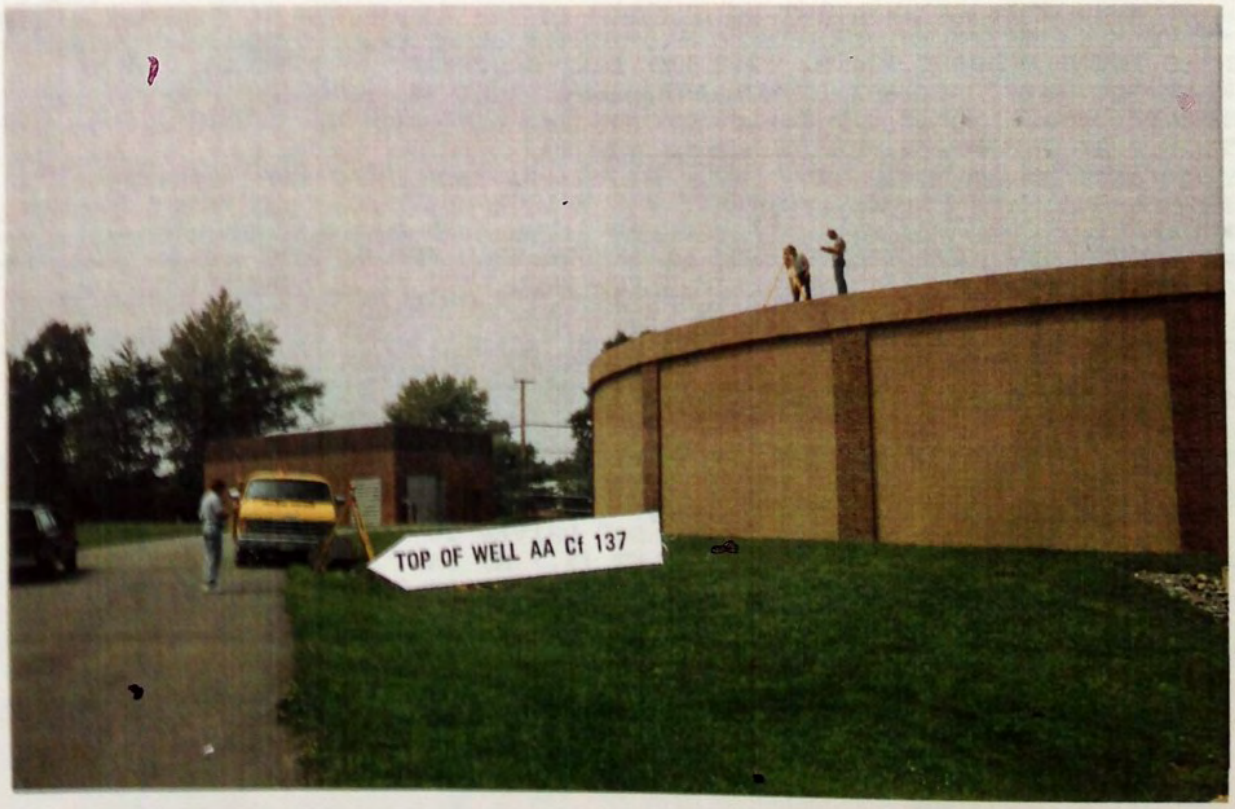

Figure 7. Triangulation to determine the difference in altitude between the mark on well AA Cf 137 and the NGS mark (Arnold W.T.) on the top of the water storage tank.

start

DESCRIPTION OF ARNOLD SUBSIDENCE BENCH MARK
ARNOLD-1

******* O R I G I N A L D E S C R I P T I O N *******

SSN: 0100
Designation: ARNOLD 1

PID:

Latitude: 390205N
Longitude: 0762926W
Elevation: 38.21M
Stamping: ARNOLD 1

State: MD
County: ANNE ARUNDEL
Disk From: MD DNR MD SHA

Surface Mark-
Type: Flange-encased Rod
Magnetic code: I
Setting: DRIVEN INTO THE GROUND

****Mark is suitable for GPS

Set by MD SHA in 1994, Chief of party NLE.

THE MARKER IS LOCATED ABOUT 1.4 MI (2.3 KM) EAST-SOUTHEAST OF ARNOLD, 2.8 MI (4.5 KM) WEST-SOUTHWEST OF CAPE ST. CLAIRE, AND 3.7 MI (6.0 KM) NORTH-NORTHEAST OF ANNAPOLIS. IT IS LOCATED ON THE ANNE ARUNDEL COUNTY DEPARTMENT OF PUBLIC WORKS PROPERTY.

TO REACH FROM A POINT WHERE STATE HIGHWAY 2 CONVERGES WITH U.S. HIGHWAY 50/301 NORTH OF ANNAPOLIS, GO NORTH ON STATE HIGHWAY 2 FOR 1.25 MI (2.01 KM) TO ARNOLD ROAD. TURN RIGHT AND GO EASTERLY ON ARNOLD ROAD FOR 0.05 MI (0.08 KM) TO A CROSSROADS WITH BALTIMORE ANNAPOLIS BLVD. TURN LEFT AND GO NORTHERLY ON BALTIMORE ANNAPOLIS BLVD. FOR 0.05 MI (0.08 KM) TO CHURCH ROAD ON THE RIGHT. TURN RIGHT AND GO EASTERLY ON CHURCH ROAD FOR 0.8 MI (1.3 KM) TO A CROSSROADS WITH JONES STATION ROAD. TURN RIGHT AND GO SOUTHERLY ON JONES STATION ROAD FOR 0.15 MI (0.24 KM) TO THE MOST EASTERLY ONE OF TWO ENTRANCE GATES TO THE ANNE ARUNDEL COUNTY DEPARTMENT OF PUBLIC WORKS ARNOLD WATER TREATMENT FACILITY. TURN RIGHT AND GO SOUTH ON THE ENTRANCE ROAD FOR 100.0 FT (30.5 M) TO THE STATION ON THE LEFT.

THE POINT IS MARKED WITH A STAINLESS STEEL ROD DRIVEN TO REFUSAL AT A DEPTH OF 33.5 FT (10.2 M) PLUS OR MINUS. IT IS 12.0 FT (3.7 M) EAST OF THE CENTER OF THE MACADAM ENTRANCE ROAD, 52.5 FT (16.0 M) SOUTHEAST OF THE SOUTHEAST CORNER OF A 1.5 STORY BRICK WELLHEAD CONTAINMENT BULDING, 53.0 FT (16.2 M) SOUTH OF THE MOST EASTERLY ONE OF TWO GATE POSTS AT THE FACILITY ENTRANCE, AND 3.0 FT (0.9 M) WEST OF A CARSONITE WITNESS POST. IT IS ABOUT LEVEL WITH THE SURFACE OF THE GROUND.

DESCRIPTION OF ARNOLD SUBSIDENCE BENCH MARK
ARNOLD-2

******* O R I G I N A L D E S C R I P T I O N *******

SSN: 0101
Designation: ARNOLD 2

PID:

Latitude: 390205N
Longitude: 0762925W
Elevation: 39.22M
Stamping: ARNOLD 2

State: MD
County: ANNE ARUNDEL
Disk From: MD SHA

Surface Mark-
Type: Survey disk
Magnetic code: O
Setting: CONCRETE WELLHEAD

****Mark is suitable for GPS

Set by MD SHA in 1994, Chief of party NLE.

THE MARKER IS LOCATED ABOUT 1.4 MI (2.3 KM) EAST-SOUTHEAST OF ARNOLD, 2.8 MI (4.5 KM) WEST-SOUTHWEST OF CAPE ST. CLAIRE, AND 3.7 MI (6.0 KM) NORTH-NORTHEAST OF ANNAPOLIS. IT IS LOCATED ON THE ANNE ARUNDEL COUNTY DEPARTMENT OF PUBLIC WORKS PROPERTY.

TO REACH FROM A POINT WHERE STATE HIGHWAY 2 CONVERGES WITH U.S. HIGHWAY 50/301 NORTH OF ANNAPOLIS, GO NORTH ON STATE HIGHWAY 2 FOR 1.25 MI (2.01 KM) TO ARNOLD ROAD. TURN RIGHT AND GO EASTERLY ON ARNOLD ROAD FOR 0.05 MI (0.08 KM) TO A CROSSROADS WITH BALTIMORE ANNAPOLIS BLVD. TURN LEFT AND GO NORTHERLY ON BALTIMORE ANNAPOLIS BLVD. FOR 0.05 MI (0.08 KM) TO CHURCH ROAD ON THE RIGHT. TURN RIGHT AND GO EASTERLY ON CHURCH ROAD FOR 0.8 MI (1.3 KM) TO A CROSSROADS WITH JONES STATION ROAD. TURN RIGHT AND GO SOUTHERLY ON JONES STATION ROAD FOR 0.15 MI (0.24 KM) TO THE MOST EASTERLY ONE OF TWO ENTRANCE GATES TO THE ANNE ARUNDEL COUNTY DEPARTMENT OF PUBLIC WORKS ARNOLD WATER TREATMENT FACILITY. TURN RIGHT AND GO SOUTH ON THE ENTRANCE ROAD FOR 100.0 FT (30.5 M) TO THE STATION ON THE RIGHT, INSIDE THE 1.5 STORY BRICK WELLHEAD CONTAINMENT BUILDING.

THE POINT IS MARKED WITH A MARYLAND STATE HIGHWAY ADMINISTRATION SURVEY DISK CEMENTED IN A DRILL HOLE IN THE SOUTHEAST CORNER OF THE MOST EASTERLY ONE OF FIVE CONCRETE WELLHEADS. IT IS 2.0 FT (0.6 M) HIGHER THAN THE SURFACE OF THE FLOOR.

DESCRIPTION OF CONTROL STATION
E-125

National Geodetic Survey, Retrieval Date = OCTOBER 15, 1993

****

DESIGNATION - E 125
PID - JV0690
STATE/COUNTY - MD/ANNE ARUNDEL
USGS QUAD - ROUND BAY

HORZ DATUM - NAD 83
VERT DATUM - NAVD 88

POSITION	-	39 01 59.	(N)	076 30 26.	(W)	SCALED
83 minus 27	-	+00.		-01.		NADCON
HEIGHT	-	23.929	(meters)	78.51	(feet)	ADJUST
88 minus 29	-	-0.244				ADJUSTED

****

GEOID HEIGHT- -33.58 GEOID93
MODELED GRAV- 980,077.1 NAVD88

VERT ORDER - FIRST CLASS 2

The horizontal coordinates were scaled from a topographic map and have an estimated accuracy of +/- 6 seconds.

The orthometric height was determined by differential leveling and adjusted by the National Geodetic Survey in June 1991.

The geoid height was determined by GEOID93.

The modeled gravity was interpolated from observed gravity values.

STATION MARK IS A BENCH MARK DISK
WITH SETTING: SET IN A LIGHT STRUCTURE
THE MARK IS STAMPED: E 125 1971
STABILITY: MARK OF QUESTIONABLE OR UNKNOWN STABILITY

HISTORY	- Year Condition	Recov. By
HISTORY	- 1971 STATION MONUMENTED	NATIONAL GEODETIC SURVEY

STATION DESCRIPTION

DESCRIBED BY NATIONAL GEODETIC SURVEY 1971
ABOUT 1.6 MILES NORTHWEST ALONG STATE HIGHWAY 450 FROM THE NORTHEAST END OF THE HIGHWAY BRIDGE OVER THE SEVERN RIVER AT ANNAPOLIS, THENCE 1.7 MILES NORTHWEST ALONG STATE HIGHWAY 2, NEAR THE JUNCTION OF OLD ANNAPOLIS ROAD LEADING NORTHWEST, SET IN THE TOP OF THE EAST CORNER OF A 6- X 6- X 5-FOOT CONCRETE CATCH BASIN THAT IS AT THE SOUTHWEST END OF A 36-INCH METAL PIPE CULVERT UNDER OLD ANNAPOLIS ROAD, 116 FEET SOUTHWEST AND ACROSS THE ROAD FROM THE CENTER LINE OF THE SOUTHWEST LANES OF THE HIGHWAY, 59 YARDS WEST OF THE CENTER OF THE JUNCTION OF THE HIGHWAY AND THE ROAD, AND ABOUT 1 FOOT BELOW THE LEVEL OF THE HIGHWAY.

National Geodetic Survey, Retrieval Date = OCTOBER 15, 1993

DESCRIPTION OF CONTROL STATION
K-125

National Geodetic Survey, Retrieval Date = OCTOBER 15, 1993

****

DESIGNATION - K 125
PID - JV0691
STATE/COUNTY- MD/ANNE ARUNDEL
USGS QUAD - ROUND BAY

HORZ DATUM - NAD 83
VERT DATUM - NAVD 88

POSITION -	39 02 37.	(N)	076 30 56.	(W)	SCALED
83 minus 27 -	+00.		-01.		NADCON
HEIGHT -	23.298	(meters)	76.44	(feet)	ADJUST
88 minus 29 -	-0.244				ADJUSTED

****

GEOID HEIGHT- -33.55 GEOID93
MODELED GRAV- 980,078.0 NAVD88

VERT ORDER - FIRST CLASS 2

The horizontal coordinates were scaled from a topographic map and have an estimated accuracy of +/- 6 seconds.

The orthometric height was determined by differential leveling and adjusted by the National Geodetic Survey in June 1991.

The geoid height was determined by GEOID93.

The modeled gravity was interpolated from observed gravity values.

STATION MARK IS A BENCH MARK DISK
WITH SETTING: COPPER-CLAD STEEL ROD W/O SLEEVE (10 FT.+)
THE MARK IS STAMPED: K 125 1971
STABILITY: PROBABLY HOLD POSITION/ELEVATION WELL

HISTORY	- Year Condition	Recov. By
HISTORY	- 1971 STATION MONUMENTED	NATIONAL GEODETIC SURVEY

STATION DESCRIPTION

DESCRIBED BY NATIONAL GEODETIC SURVEY 1971
ABOUT 1.6 MILES NORTHWEST ALONG STATE HIGHWAY 450 FROM THE NORTHEAST END OF THE HIGHWAY BRIDGE OVER THE SEVERN RIVER AT ANNAPOLIS, THENCE 2.55 MILES NORTHWEST ALONG STATE HIGHWAY 2, ALONG THE SOUTHWEST METAL FENCE AROUND THE DOGWOOD MOBILE HOME COURT, 40 1/2 FEET NORTHEAST OF THE CENTER LINE OF THE NORTHEAST LANES OF THE HIGHWAY, 110 FEET SOUTH OF THE SOUTH CORNER OF A COBBLESTONE HOUSE WHICH IS OWNED BY THE COURT MANAGER (FORMER C AND GS EMPLOYEE), 3 FEET WEST OF THE WEST CORNER OF A 5- X 5-FOOT CONCRETE SLAB THAT IS INSIDE THE FENCE LINE, 4 FEET SOUTHEAST OF POWER POLE NUMBER 169329, 3 1/2 FEET NORTHWEST OF A METAL WITNESS POST, AND ON THE TOP OF A COPPER COATED ROD THAT IS LEVEL WITH THE SURFACE OF THE GROUND AND IS PROTECTED BY A 4-INCH TILE THAT PROJECTS 1 INCH. THE ROD WAS DRIVEN TO REFUSAL AT A DEPTH OF 22 1/2 FEET.

Table 1. Data for wells in the Arnold well field

Well number			Aquifer	Approximate altitude of land surface (feet)	Casing diameter (inches)	Screen		Depth reached by drilling (feet)	Use of the well
Cooperative program AA-Cf	State permit AA-	Owner				Diameter (inches)	Position (feet below sea level)		
118	73-5564	Arnold PW 2	Upper Patapsco	121	18	12	283-303 307-322 329-344 349-374 381-401 405-420	610	Water supply
119	73-5562	Arnold PW 1	do.	131	18	12	305-337 343-377 385-423	600	do.
120	73-5563	Arnold PW 3A	do.	126	18	12	324-372 388-422	560	do.
136	86-0027	Patuxent test well	Patuxent	122	6	4	1,170-1,185 1,217-1,227 1,244-1,259 1,357-1,397 1,421-1,431	1,603	Test. This well was abandoned and filled to make space for the ground-storage tank.
137	86-0401	Lower Patapsco test well	Lower Patapsco	124	6	4	667-692 702-732 752-772 792-842	1,030	do.
142	88-3644	Arnold PW 4	do.	127	18	18	659-675 683-743 753-773 781-838	996	Water supply

BENCH MARK AND WELL DATA FOR THE BROAD CREEK WELL FIELD

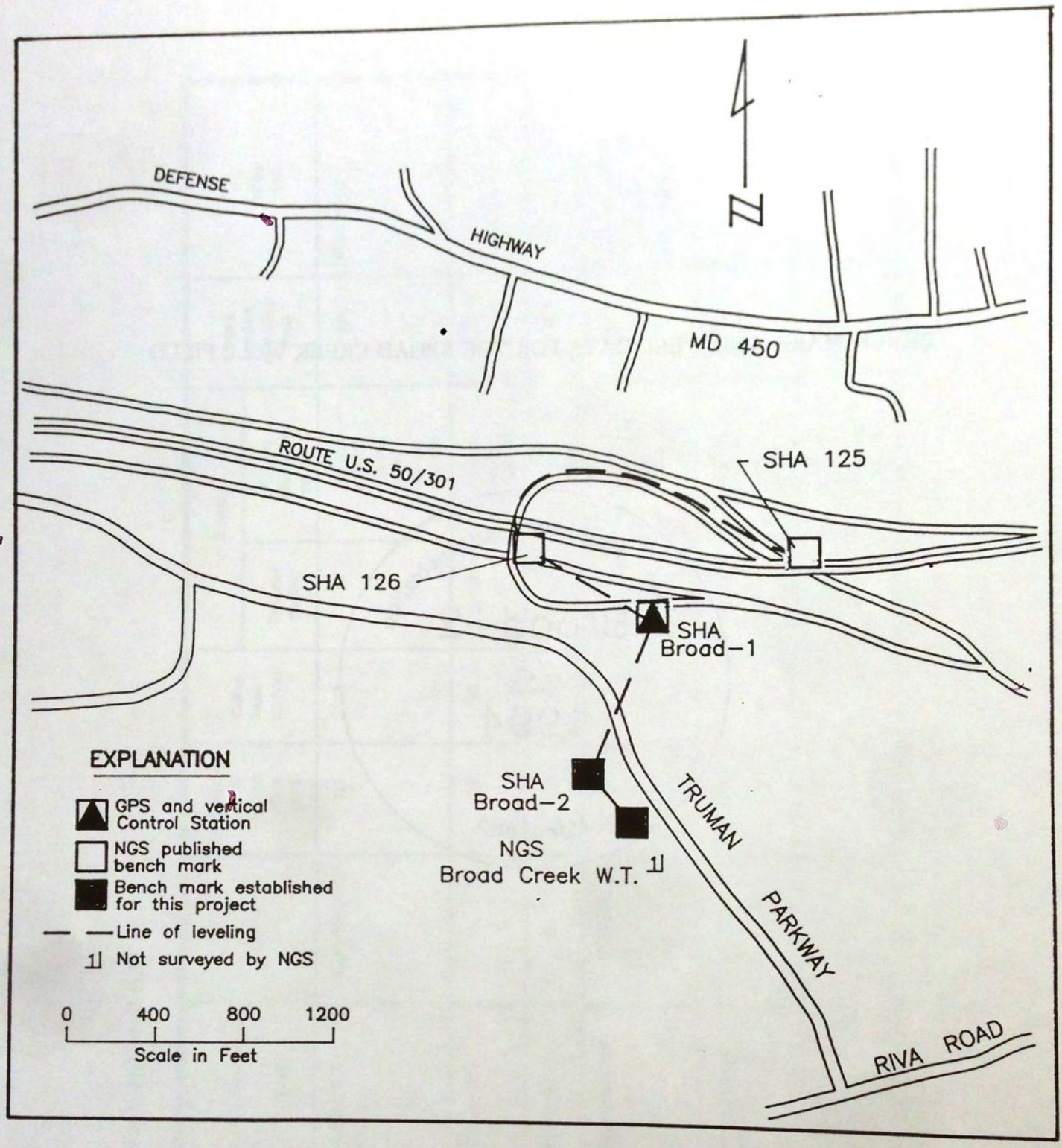

Figure 8. Locations of the control bench marks and line of leveling to the Broad Creek bench marks: SHA Broad-1, SHA Broad-2, and NGS Broad Creek W.T.

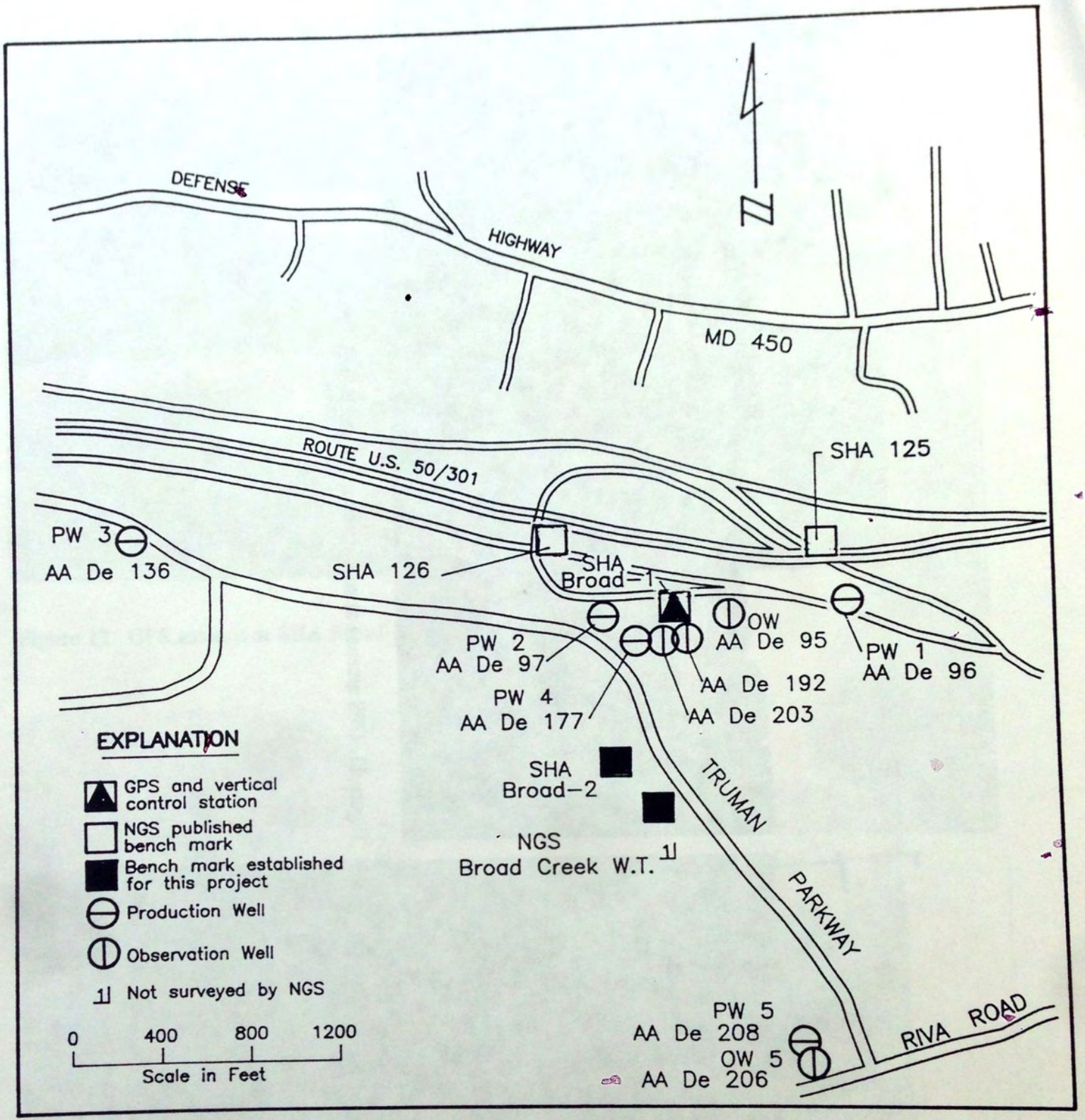

Figure 9. Locations of bench marks and wells in the Broad Creek well field.

Figure 10. Logo cap for subsidence bench mark SHA Broad-1 at Broad Creek I. US 50-301 is in the background.

Figure 11. GPS antenna at subsidence bench mark SHA Broad-1.

Figure 12. GPS antenna at SHA Broad-1.

Figure 13. Witness sign for SHA Broad-1.

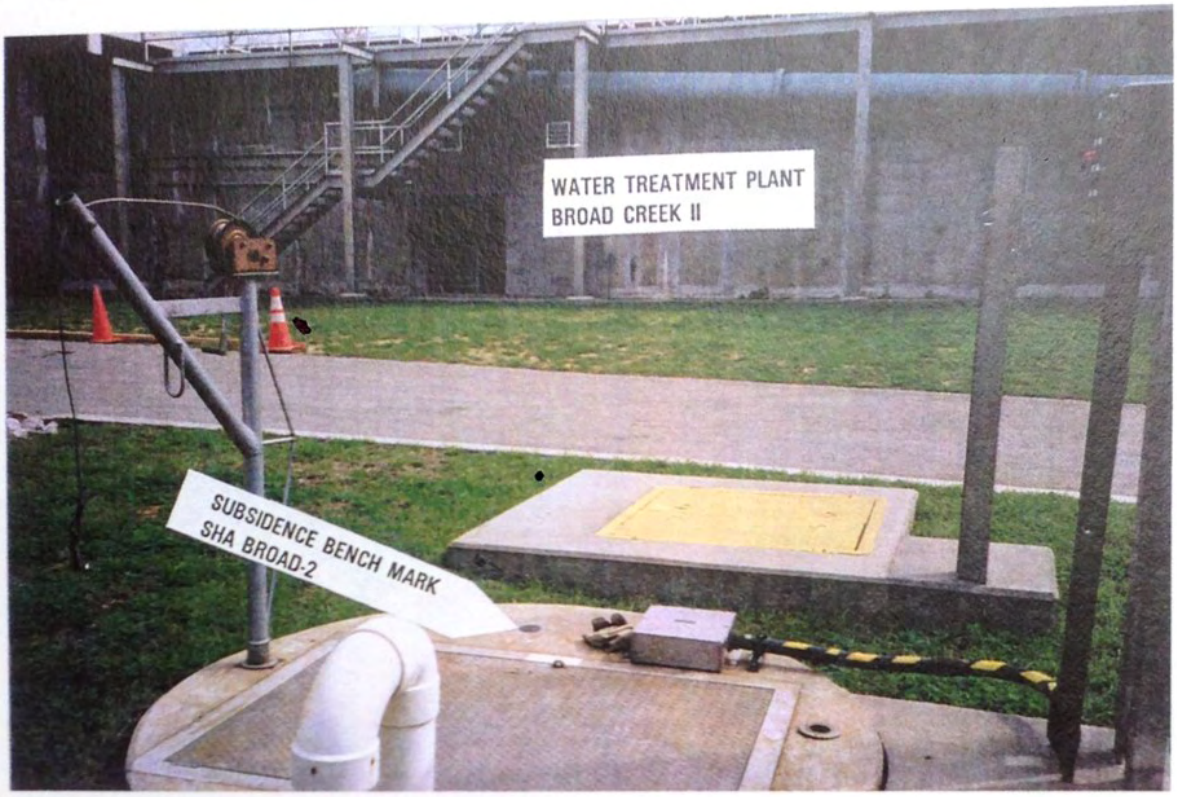

Figure 14. Subsidence bench mark SHA Broad-2, cemented into the top of the sludge lift station at Broad Creek II water treatment plant. This view is toward the east-southeast.

Figure 15. Subsidence bench mark SHA Broad-2 viewed toward the southeast.

DESCRIPTION OF BROAD CREEK SUBSIDENCE BENCH MARK
BROAD-1

******* O R I G I N A L D E S C R I P T I O N *******

SSN: 0102
Designation: BROAD 1

PID:

Latitude: 385854N
Longitude: 0763331W
Elevation: 28.32M
Stamping: BROAD 1

State: MD
County: ANNE ARUNDEL
Disk From: MD DNR MD SHA

Surface Mark-
Type: Flange-encased Rod
Magnetic code: O
Setting: DRIVEN INTO THE GROUND

****Mark is suitable for GPS

Set by MD SHA in 1994, Chief of party NLE.

THE MARKER IS LOCATED ABOUT 1.9 MI (3.1 KM) NORTH-NORTHEAST OF RIVA, 3.8 MI (6.1 KM) SOUTHEAST OF CROWNSVILLE, AND 4.1 MI (6.6 KM) WEST OF ANNAPOLIS. IT IS LOCATED ON THE ANNE ARUNDEL COUNTY DEPARTMENT OF PUBLIC WORKS PROPERTY.

TO REACH FROM A POINT WHERE STATE HIGHWAY 665, ARIS T. ALLEN BLVD., PASSES OVER RIVA ROAD NEAR PAROLE, GO SOUTHWEST ON RIVA ROAD FOR 0.4 MI (0.6 KM) TO HARRY S. TRUMAN PARKWAY. TURN RIGHT AND GO NORTHWESTERLY ON HARRY S. TRUMAN PARKWAY FOR 0.3 MI (0.5 KM) TO THE ENTRANCE TO THE ANNE ARUNDEL COUNTY DEPARTMENT OF PUBLIC WORKS BROAD CREEK WATER TREATMENT FACILITY ON THE LEFT. CONTINUE NORTHERLY ON HARRY S. TRUMAN PARKWAY FOR 100.0 FT (30.5 M) TO THE ENTRANCE TO A WELL SITE ON THE RIGHT. TURN RIGHT ON THE ENTRANCE ROAD AND GO EAST-NORTHEAST FOR 200.0 FT (61.0 M) TO A 6.0 FT (1.8 M) HIGH CHAIN LINK FENCE GATE. PASS THROUGH GATE AND FOLLOW THE MACADAM ROAD TO THE RIGHT, TO THE EASTERN SIDE OF A ONE STORY BRICK WELLHEAD CONTAINMENT BUILDING AND THE MARKER ON THE RIGHT.

THE POINT IS MARKED WITH A STAINLESS STEEL ROD DRIVEN TO REFUSAL AT A DEPTH OF 13.0 FT (4.0 M) ,PLUS OR MINUS. IT IS 69.0 FT (21.0 M) EAST-NORTHEAST OF THE SOUTHEAST CORNER OF A ONE STORY BRICK WELLHEAD CONTAINMENT BUILDING, 47.0 FT (14.3 M) WEST OF THE NORTHEAST CORNER OF A 6.0 FT (1.8 M) HIGH CHAIN LINK FENCE SURROUNDING THE TREATMENT FACILITY, 13.0 FT (4.0 M) SOUTH OF THE NORTHERN SIDE OF THE CHAIN LINK FENCE, 14.5 FT (4.4 M) NORTH OF THE NORTH EDGE OF THE MACADAM PAVEMENT AT THE WEST SIDE OF A LARGE SLUDGE HOLDING TANK, AND 3.0 FT (0.9 M) SOUTH OF A CARSONITE WITNESS POST. IT IS ABOUT LEVEL WITH THE SURFACE OF THE GROUND.

DESCRIPTION OF BROAD CREEK SUBSIDENCE BENCH MARK
BROAD-2

******* O R I G I N A L D E S C R I P T I O N *******

SSN: 0103
Designation: BROAD 2

PID:

Latitude: 385854N
Longitude: 0763331W
Elevation: 22.66M
Stamping: BROAD 2

State: MD
County: ANNE ARUNDEL
Disk From: MD SHA

Surface Mark-
Type: Survey disk
Magnetic code: O
Setting: CONCRETE SLUDGE WASTING TANK

****Mark is suitable for GPS

Set by MD SHA in 1994, Chief of party NLE.

THE MARKER IS LOCATED ABOUT 1.9 MI (3.1 KM) NORTH-NORTHEAST OF RIVA, 3.8 MI (6.1 KM) SOUTHEAST OF CROWNSVILLE, AND 4.1 MI (6.6 KM) WEST OF ANNAPOLIS. IT IS LOCATED ON THE ANNE ARUNDEL COUNTY DEPARTMENT OF PUBLIC WORKS PROPERTY.

TO REACH FROM A POINT WHERE STATE HIGHWAY 665, ARIS T. ALLEN BLVD., PASSES OVER RIVA ROAD NEAR PAROLE, GO SOUTHWEST ON RIVA ROAD FOR 0.4 MI (0.6 KM) TO HARRY S. TRUMAN PARKWAY. TURN RIGHT AND GO NORTHWESTERLY ON HARRY S. TRUMAN PARKWAY FOR 0.3 MI (0.5 KM) TO THE ENTRANCE TO THE ANNE ARUNDEL COUNTY DEPARTMENT OF PUBLIC WORKS BROAD CREEK WATER TREATMENT FACILITY ON THE LEFT. TURN LEFT ON ENTRANCE ROAD TO FACILITY AND GO SOUTHERLY ON THE MACADAM ROAD BETWEEN A MASSIVE CONCRETE ROUND ABOVE GROUND WATER STORAGE TANK AND A 1.5 STORY BRICK WATER TREATMENT FILTRATION BUILDING FOR 0.1 MI (0.2 KM) TO THE MARKER ON THE RIGHT.

THE POINT IS MARKED WITH A MARYLAND STATE HIGHWAY ADMINISTRATION SURVEY DISK, CEMENTED IN A DRILL HOLE IN THE EAST EDGE OF A 7.0 FT (2.1 M) DIAMETER ROUND CONCRETE SLUDGE WASTING TANK. IT IS 19.0 FT (5.8 M) WEST OF THE CENTER OF THE MACADAM ROAD AND ABOUT 0.5 FT (0.2 M) HIGHER THAN THE SURFACE OF THE GROUND.

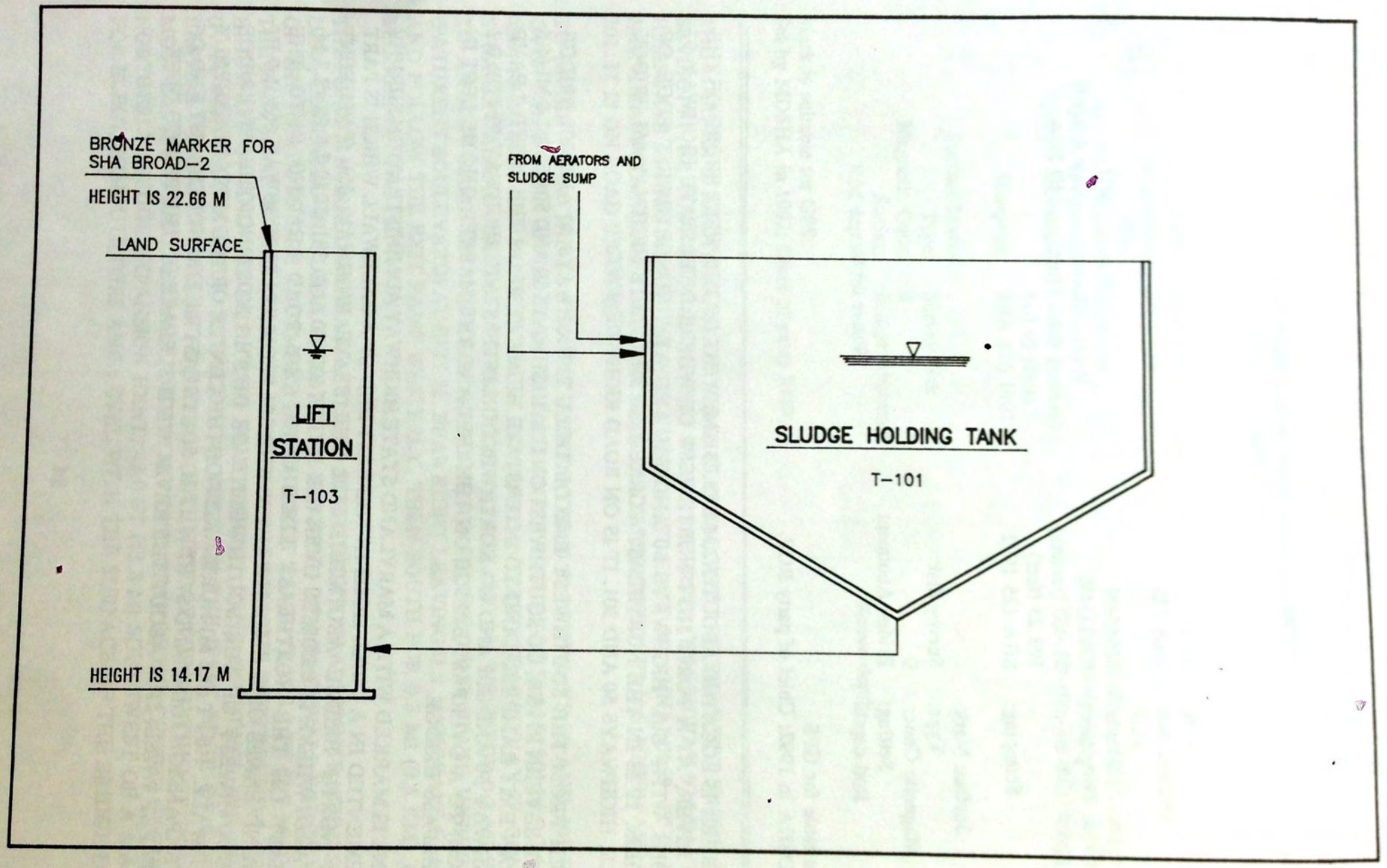

Figure 16. Sectional view showing that bench mark, SHA Broad-2, is at the top of the 29-foot deep concrete lift station.

DESCRIPTION OF CONTROL STATION
SHA-125

SSN:	0016		
Designation:	SHA 125		
PID:			
Approx. Latitude:	385856N	State:	MD
Approx. Longitude:	0763324W	County:	Anne Arundel
Approx. Elevation:	31.465 (meters)	Disk From:	MD SHA
	103.23 (feet)		
Stamping:	SHA 125 1992		
Surface Mark-			
Type:	Survey disk		
Magnetic Code:	0		
Setting:	Bridge Abutment		
Rod depth:		Sleeve depth:	

Mark is suitable for GPS
Set by MDSHA in 1992; Chief of party RGP.

THE MARKER IS LOCATED ABOUT 3.25 MI (5.23 KM) WEST OF THE WEST SHORE OF THE SEVERN RIVER, AT A POINT JUST NORTHWEST OF WHERE INTERSTATE HIGHWAY 97 JUNCTIONS WITH U.S. HIGHWAYS 50 AND 301 AND AT THE NORTHWEST EDGE OF ANNAPOLIS. IT IS IN THE NORTHEAST CORNER OF THE STATE HIGHWAY 665 BRIDGE OVER U.S. HIGHWAYS 50 AND 301. IT IS ON ROAD RIGHT-OF-WAY.

TO REACH FROM THE SOUTHWEST END OF THE U.S. HIGHWAYS 50 AND 301 BRIDGE OVER THE SEVERN RIVER, GO SOUTHWEST ON U.S. HIGHWAYS 50 AND 301 FOR 2.8 MI (4.5 KM) TO AN EXIT RAMP LEADING TO INTERSTATE HIGHWAY 97 ON THE RIGHT. LEAVE U.S. HIGHWAY 50 AND 301 AND GO NORTHWEST ON INTERSTATE HIGHWAY 97 FOR 0.3 MI (0.5 KM) TO A OVERPASS BRIDGE ON THE LEFT AND THE MARKER ON THE LEFT IN THE OVERPASS BRIDGE.

THE POINT IS MARKED WITH A MARYLAND STATE HIGHWAY ADMINISTRATION SURVEY DISK, CEMENTED IN A DRILL HOLE IN THE EAST END OF A BACKWALL WHICH IS PART OF THE NORTH BRIDGE ABUTMENT FOR THE STATE HIGHWAY 665 (PATUXENT BOULEVARD) WHERE IT CROSSES OVER U.S. HIGHWAYS 50 AND 301. IT IS 7.5 FT (2.3 M) NORTHEAST OF THE NORTHEAST EDGE OF A EXIT ROAD LEADING ONTO THE WESTBOUND LANES OF U.S. HIGHWAYS 50 AND 301 FROM STATE HIGHWAY 665, 1.9 FT (0.6 M) SOUTHWEST OF THE SOUTHWEST BASE OF THE MOST NORTHEAST BRIDGE PARAPET WALL, 1.8 FT (0.5 M) NORTHWEST OF THE CENTER OF THE MOST NORTHERLY BRIDGE EXPANSION JOINT AND 37 FT (11.3 M) SOUTHEAST OF THE NORTHWEST END OF THE PARAPET WALL. IT IS ABOUT THE LEVEL WITH SURFACE OF THE BRIDGE DECK.

DESCRIPTION OF CONTROL STATION
SHA-126

SSN:	0017		
Designation:	SHA 126		
PID:			
Approx. Latitude:	385858N	State:	MD
Approx. Longitude:	0763337W	County:	Anne Arundel
Approx. Elevation:	33.817 (meters)	Disk From:	MDSHA
	110.95 (feet)		
Stamping:	SHA 126 1992		
Surface Mark-			
Type:	Survey disk		
Magnetic Code:	0		
Setting:	Bridge Abutment		
Rod depth:		Sleeve depth:	

Mark is suitable for GPS
Set by MDSHA in 1992; Chief of party RGP.

THE MARKER IS LOCATED ABOUT 3.25 MI (5.23 KM) WEST OF THE WEST SHORE OF THE SEVERN RIVER, JUST WEST OF A POINT WHERE INTERSTATE HIGHWAY 97 LEAVES U.S. HIGHWAYS 50 AND 301 AND AT THE NORTHWEST EDGE OF ANNAPOLIS. IT IS IN THE NORTHEAST CORNER OF THE STATE HIGHWAY 665 BRIDGE OVER U.S. HIGHWAYS 50 AND 301. IT IS ON ROAD RIGHT-OF-WAY.

TO REACH FROM THE SOUTHWEST END OF THE U.S. HIGHWAYS 50 AND 301 BRIDGE OVER THE SEVERN RIVER, GO SOUTHWEST ON U.S. HIGHWAYS 50 AND 301 FOR 2.6 MI (4.2 KM) TO AN EXIT RAMP ON THE ROAD LEADING TO INTERSTATE HIGHWAY 97. CONTINUE STRAIGHT AHEAD AND FOLLOW U.S. HIGHWAYS 50 AND 301 WEST FOR 0.3 MI (0.5 KM) TO AN EXIT RAMP ON THE RIGHT LEADING TO SOUTHBOUND STATE HIGHWAY 665 (PATUXENT BOULEVARD) AT EXIT 22. BEAR RIGHT LEAVING U.S. HIGHWAYS 50 AND 301 AND FOLLOW THE EXIT RAMP WESTERLY, THEN SOUTH FOR 0.3 MI (0.5 KM) TO THE MARKER ON THE LEFT.

THE POINT IS MARKED WITH A MARYLAND STATE HIGHWAY ADMINISTRATION SURVEY DISK, CEMENTED IN A DRILL HOLE IN THE EAST END OF A BACKWALL WHICH IS PART OF THE NORTH BRIDGE ABUTMENT FOR THE EXIT RAMP. IT IS 8.7 FT (2.7 M) EAST OF THE EAST EDGE OF THE TRAFFIC LANE LEADING FROM THE WESTBOUND LANES U.S. HIGHWAYS 50 AND 301 ONTO THE SOUTHBOUND LANE OF STATE HIGHWAY 665 (PATUXENT BOULEVARD), 2.2 FT (0.7 M) WEST OF THE WEST EDGE OF THE MOST EASTERLY PARAPET WALL, 35 FT (10.7 M) SOUTHWEST OF THE NORTHEAST END OF THE MOST EASTERLY PARAPET WALL, 0.8 FT (24.4 CM) NORTH OF THE CENTER OF THE MOST NORTHERLY BRIDGE EXPANSION JOINT, 42.0 FT (12.8 M) SOUTHWEST OF A MANHOLE FOR ELECTRICAL UTILITIES AND LEVEL WITH THE SURFACE OF THE BRIDGE DECK.

Table 2. Data for wells in the Broad Creek well field

Well number			Aquifer	Approximate altitude of land surface (feet)	Casing diameter (inches)	Screen		Depth reached by drilling (feet)	Use of the well
Cooperative program AA-De	State permit AA-	Owner				Diameter (inches)	Position (feet below sea level)		
95	68-0175	Observation well	Upper Patapsco	76	6	6	393-408	612	Observation of water levels
96	68-0188	Broad Creek PW 1	Upper Patapsco	65	12	10	382-427	492	Water supply
97	68-0189	Broad Creek PW 2	Upper Patapsco	90	12	10	355-405	563	do.
136	81-2588	Broad Creek PW 3	Upper Patapsco	80 ?	18	12	320-402	600	do.
177	81-9213	Broad Creek PW 4	Lower Patapsco	94	18	12	742-774 780-800 824-870	974	do.
192	81-7171	TXH-1	Patuxent	93	3	3	1,483-1,498 1,503-1,573 1,540-1,565	1,583	Observation of water levels
203	81-7170	Patuxent test PW	Patuxent	94	8 6	6	1,458-1,488 1,508-1,520 1,530-1,550	1,552	do.
206	88-9908	Observation well	Lower Patapsco	80	4 2	2	695-933	1,024	do.
208	88-9909	Broad Creek PW 5	Lower Patapsco	80	24	12	680-710 740-767 795-826 846-872 888-925 931-937	1,033	Water supply

BENCH MARK AND WELL DATA FOR THE CROFTON MEADOWS WELL FIELD

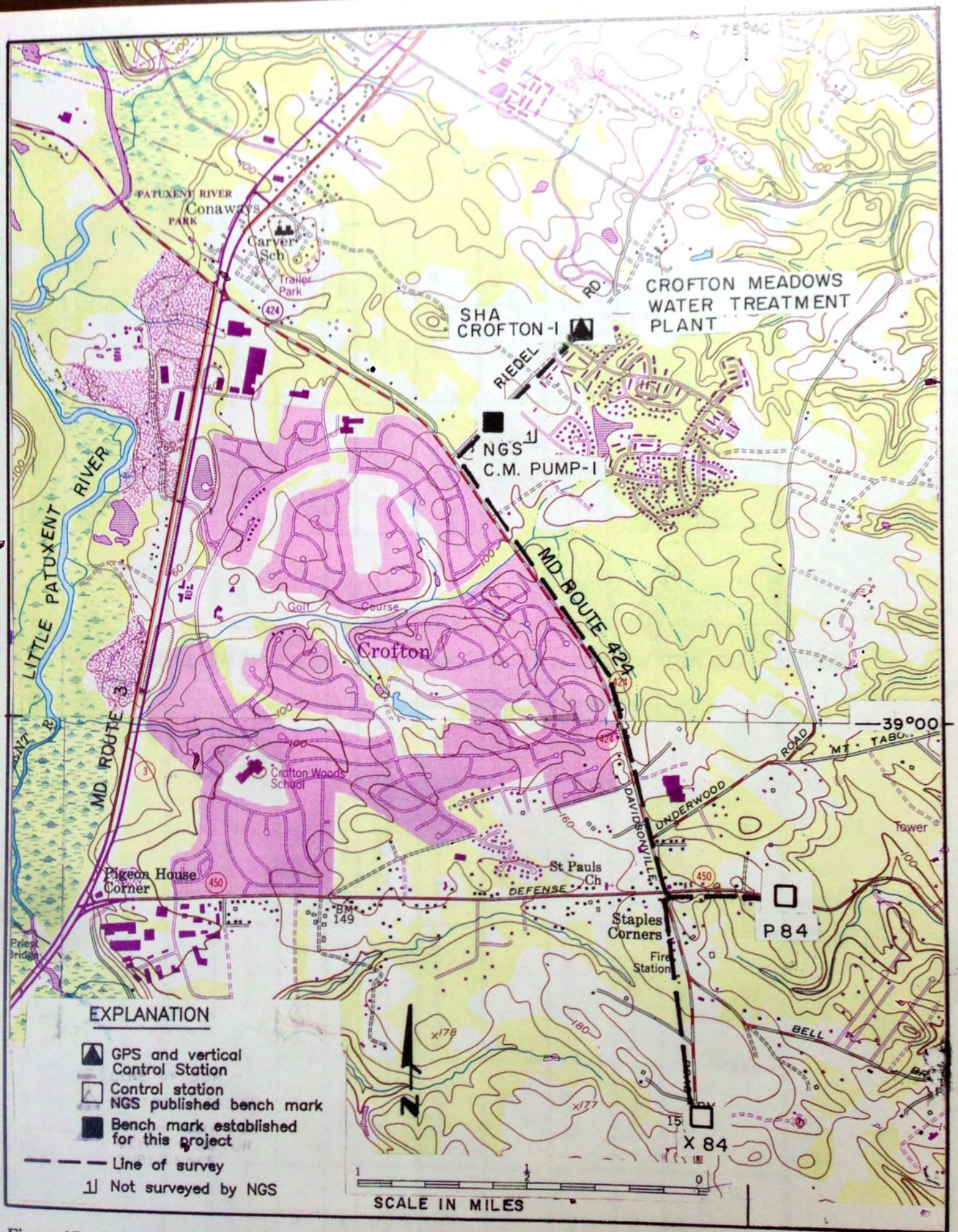

Figure 17. Locations of the control bench marks and the line of leveling to the subsidence bench marks in the Crofton Meadows well field.

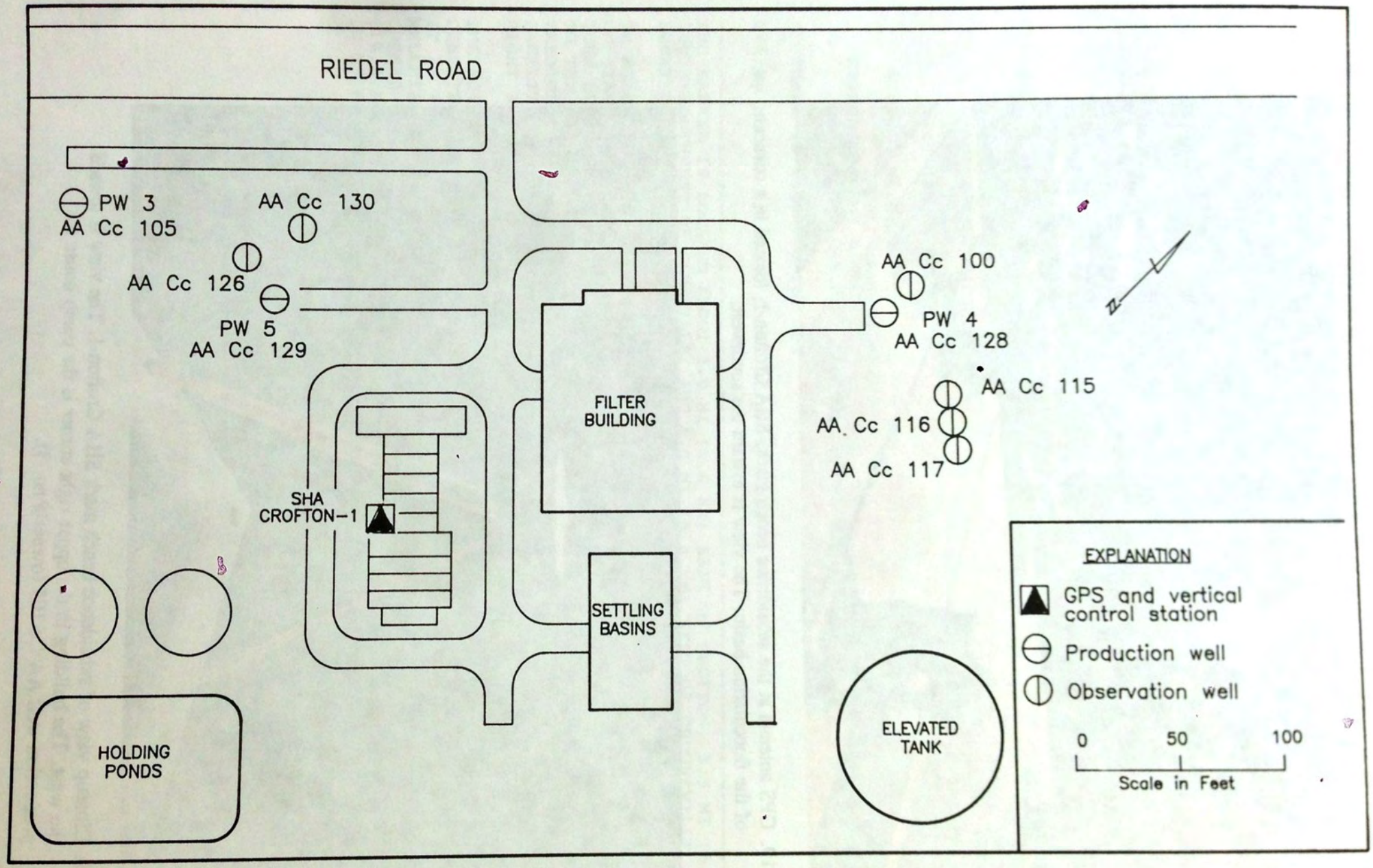

Figure 18. Locations of bench mark SHA Crofton-1 and wells at the Crofton Meadows water treatment plant.

Figure 19. GPS antenna at the subsidence bench mark, SHA Crofton-1, located in a corner of the flocculation basin. The view is toward the southwest.

Figure 20. Closeup view of subsidence bench mark SHA Crofton-1. The view is toward the west. The building in the upper right corner is the pump house for production well AA Cc 105 (owner's no. 3).

DESCRIPTION OF CROFTON MEADOWS SUBSIDENCE BENCH MARK
CROFTON-1

******* O R I G I N A L D E S C R I P T I O N *******

SSN: 0104
Designation: CROFTON 1

PID:

Latitude: 390102N
Longitude: 0764028W
Elevation: 41.24M
Stamping: CROFTON 1

State: MD
County: ANNE ARUNDEL
Disk From: MD SHA

Surface Mark-
Type: Survey disk
Magnetic code: O
Setting: CONCRETE FLOCCULATOR BASIN

****Mark is suitable for GPS

Set by MD SHA in 1994, Chief of party NLE.

THE MARKER IS LOCATED ABOUT 1.0 MI (1.6 KM) EAST OF CROFTON, 3.5 MI (5.6 KM) SOUTH-SOUTHWEST OF GAMBRILLS, AND 4.0 MI (6.4 KM) WEST OF CROWNSVILLE. IT IS LOCATED ON THE ANNE ARUNDEL COUNTY DEPARTMENT OF PUBLIC WORKS PROPERTY.

TO REACH FROM THE INTERSECTION OF STATE HIGHWAYS 3 AND 424 AT CROFTON, GO SOUTH ON STATE HIGHWAY 424 FOR 0.8 MI (1.3 KM) TO THE INTERSECTION WITH REIDEL ROAD. TURN LEFT AND GO NORTHEAST ON REIDEL ROAD FOR 0.5 MI (0.8 KM) TO THE ENTRANCE TO THE ANNE ARUNDEL COUNTY DEPARTMENT OF PUBLIC WORKS CROFTON MEADOWS WATER TREATMENT FACILITY ON THE RIGHT. TURN RIGHT ON THE ENTRANCE ROAD INTO THE FACILITY GROUNDS AND GO EASTERLY FOR 200.0 FT (61.0 M) TO THE STATION ON THE RIGHT ALONG THE SOUTH SIDE OF THE FLOCCULATOR BASIN.

THE POINT IS MARKED WITH A MARYLAND STATE HIGHWAY ADMINISTRATION SURVEY DISK, CEMENTED IN A DRILL HOLE IN THE WEST CORNER OF A CONCRETE FLOCCULATOR BASIN. IT IS 100.0 FT (30.5 M) SOUTH OF THE SOUTHWEST CORNER OF A ONE STORY BRICK WELLHEAD CONTAINMENT BUILDING, 105.0 FT (32.0 M) SOUTHEAST OF THE SOUTHEAST CORNER OF A 14.0 FT (4.3 M) BY 14.0 FT (4.3 M) BRICK WELLHOUSE, AND 60.0 FT (18.3 M) SOUTHWEST OF THE CENTER OF THE MACADAM ENTRANCE ROAD IN THE FACILITY. IT IS ABOUT 1.0 HIGHER THAN THE SURFACE OF THE GROUND.

DESCRIPTION OF CONTROL STATION
P-84

```
DESIGNATION -  P 84
PID         -  HV1172
STATE/COUNTY-  MD/ANNE ARUNDEL
USGS QUAD   -  BOWIE

HORZ DATUM  -  NAD 83
VERT DATUM  -  NAVD 88

POSITION    -  38 59 33.      (N)    076 39 51.      (W)     SCALED
83 minus 27 -       +00.                 -01.              NADCON

HEIGHT      -       47.913  (meters)     157.19   (feet)   ADJUST
88 minus 29 -       -0.239                                 ADJUSTED
```

```
GEOID HEIGHT-       -33.23                                 GEOID93
MODELED GRAV-   980,078.6                                  NAVD88

VERT ORDER  -  SECOND     CLASS 0
```

The horizontal coordinates were scaled from a topographic map and have an estimated accuracy of +/- 6 seconds.

The orthometric height was determined by differential leveling and adjusted by the National Geodetic Survey in June 1991.

The geoid height was determined by GEOID93.

The modeled gravity was interpolated from observed gravity values.

STATION MARK IS A BENCH MARK DISK
WITH SETTING: SET IN TOP OF CONCRETE MONUMENT (ROUND)
THE MARK IS STAMPED: P 84 1942
STABILITY: MAY HOLD, BUT OF TYPE COMMONLY SUBJECT TO SURFACE
STABILITY: MOTION - E.G. FROST HEAVE, ETC

HISTORY	- Year	Condition	Recov. By
HISTORY	- 1942	STATION MONUMENTED	COAST AND GEODETIC SURVEY

STATION DESCRIPTION

DESCRIBED BY COAST AND GEODETIC SURVEY 1942
IN ANNE ARUNDEL COUNTY, ABOUT 5.8 MILES EAST ALONG U.S. HIGHWAY 50 FROM THE BRIDGE OVER THE PENNSYLVANIA RAILROAD AT COLLINGTON, PRINCE GEORGES COUNTY, ABOUT 0.3 MILE EAST OF THE JUNCTION OF STATE HIGHWAY 424, ABOUT 65 YARDS EAST OF MILEAGE MARKER 94, AT A FARM ROAD LEADING NORTH ALONG THE EAST SIDE OF A CULTIVATED FIELD, 9 FEET WEST OF THE CENTER LINE OF THE FARM ROAD, 24 FEET NORTH OF THE CENTER LINE OF THE HIGHWAY, JUST EAST OF A SMALL FRAME FRUIT STAND, AND 6.5 FEET NORTHEAST OF THE J.C. HOAGLAND MAIL BOX. A STANDARD DISK, STAMPED P 84 1942 AND SET IN THE TOP OF A CONCRETE POST.

DESCRIPTION OF CONTROL STATION
X-84

National Geodetic Survey, Retrieval Date = OCTOBER 15, 1993

****

DESIGNATION - X 84
PID - HV1162
STATE/COUNTY- MD/ANNE ARUNDEL
USGS QUAD - BOWIE

HORZ DATUM - NAD 83
VERT DATUM - NAVD 88

POSITION -	38 58 59.	(N)	076 40 08.	(W)	SCALED
83 minus 27 -	+00.		-01.		NADCON
HEIGHT -	47.146	(meters)	154.68	(feet)	ADJUST
88 minus 29 -	-0.240				ADJUSTED

****

GEOID HEIGHT- -33.23 GEOID93
MODELED GRAV- 980,078.3 NAVD88

VERT ORDER - SECOND CLASS 0

The horizontal coordinates were scaled from a topographic map and have an estimated accuracy of +/- 6 seconds.

The orthometric height was determined by differential leveling and adjusted by the National Geodetic Survey in June 1991.

The geoid height was determined by GEOID93.

The modeled gravity was interpolated from observed gravity values.

STATION MARK IS A BENCH MARK DISK
WITH SETTING: SET IN A MASSIVE STRUCTURE
THE MARK IS STAMPED: X 84 1942
STABILITY: PROBABLY HOLD POSITION/ELEVATION WELL

HISTORY -	Year Condition	Recov. By
HISTORY -	1942 STATION MONUMENTED	COAST AND GEODETIC SURVEY

STATION DESCRIPTION

DESCRIBED BY COAST AND GEODETIC SURVEY 1942
5.3 MILES NORTH ALONG STATE HIGHWAY 424 FROM THE CROSSROADS AT DAVIDSONVILLE, ANNE ARUNDEL COUNTY, ABOUT 0.7 MILE SOUTH OF THE JUNCTION OF U.S. HIGHWAY 50, AT A SMALL CONCRETE BRIDGE OVER A STREAM, IN THE TOP OF THE WEST WALL, 1-1/2 FEET FROM THE SOUTH END, AND ABOUT 2-1/2 FEET HIGHER THAN THE PAVEMENT. A STANDARD DISK, STAMPED X 84 1942.

Table 3. Data for wells in the Crofton Meadows well field

Well number			Aquifer	Approximate altitude of land surface (feet)	Casing diameter (inches)	Screen		Depth reached by drilling (feet)	Use of the well
Cooperative program AA-Cc	State permit AA-	Owner				Diameter (inches)	Position (feet below sea level)		
100	81-7130	T-4	Lower Patapsco	134	6	4	526-536 543-554 572-583	740	Observation well
103	73-0086	Crofton Meadows PW 2	Patuxent	125	20 to 1,026'; 10 below 1,026'	10	905-1,005	1,197	Water supply
105	73---87	Crofton Meadows PW 3	do.	130	20	10	910-960 980-985 1,040-1,060	1,242	do.
107	73-2802	Crofton Meadows PW 1	do.	120	20	10	912-942 972-1,007 1,016-1,061	1,281	do.
115	73-9755	Observation well	Lower Patapsco	134	4	4	526-536	723	Observation well
116	73-9756	do.	do.	134	4	4	338-348	495	do.
117	73-9757	do.	Magothy	134	4	4	2-12	155	do.
126	81-7131	0-5	Lower Patapsco	132	2	2	418-428 435-445	600	do.
128	81-7313	PW 4	do.	134	18	10	516-554 564-592	728	Water supply
129	81-7314	PW 5	do.	134	18	10	389-407 420-430 437-447	590	do.
130	81-7132	T-5	do.	132	6	4	418-429 435-445	600	Observation well

DATA FOR CONTROL MONUMENT GORF GPS N

The control station GORF GPS N was selected to serve as the reference mark for monitoring the altitudes of bench marks in the three Anne Arundel County well fields because it is located in the Piedmont physiographic province on what is considered to be stable crystalline rock. It is unlikely that the withdrawal of ground water in Anne Arundel County would have an effect on the altitude of the land surface at this site.

The GORF GPS N station is located in a grass strip between Howard High School and Md. Route 108. The high school is located about 1.6 miles southeast of the interchange of Md. 108 with U.S. Highway 29 on the northeast side of Md. 108.

More detailed information regarding the GORF GPS N station is given on the following pages.

Figure 21. GPS antenna at control station GORF GPS N, in Howard County. The view is toward the northeast. Howard High School is in the background.

Figure 22. GPS antenna at control station GORF GPS N.

Figure 23. GPS antenna at control station GORF GPS N. View facing southwest. The traffic light is at Md. Rt. 108.

DESCRIPTION OF CONTROL STATION
GORF GPS N

DEPARTMENT OF COMMERCE
NOAA - NOS - C&GS
NATIONAL GEODETIC SURVEY

PUBLICATION DATE: NOVEMBER 13, 1991
USGS QUAD SHEET: SAVAGE

GORF GPS N

PID: JV6895

HORIZONTAL DATUM: NAD 83 (1991)
VERTICAL DATUM: NGVD 29

STATE: MARYLAND
COUNTY: HOWARD

LATITUDE:	39° 13' 34.24168" N	±0.00020	SECONDS
LONGITUDE:	076° 48' 50.46404" W	±0.00030	SECONDS
ORTHOMETRIC HEIGHT:	157.1		METERS
	515.		FEET
DEFLECTIONS:	ξ= -1.54 η= 4.43		SECONDS
LAPLACE CORRECTION:	-3.62		SECONDS
GEOID HEIGHT:	-32.473		METERS
ELLIPSOIDAL HEIGHT:	124.593	±0.077	METERS
X:	1128606.438		METERS
Y:	-4817138.973		METERS
Z:	4011878.533		METERS

HORIZONTAL NETWORK ORDER: B

THE HORIZONTAL COORDINATES WERE ESTABLISHED BY GPS OBSERVATIONS
AND ADJUSTED BY THE NATIONAL GEODETIC SURVEY IN OCTOBER 1991
THE ORTHOMETRIC HEIGHT WAS DETERMINED BY GPS OBSERVATIONS.

HORIZONTAL DATUM SHIFT	LATITUDE	LONGITUDE	
NAD83 minus NAD27	+00.4	-01.1	(Based on Nadcon Interpolation)

PLANE COORDINATES

GRID	ZONE	NORTHING METERS	EASTING METERS	POINT SCALE FACTOR	CONVERGENCE DEG MIN SEC
SPC	MD	173,131.313	416,059.035	0.99996850	- 0 07 00.2
UTM	18	4,343,444.127	343,417.043	0.99990189	- 1 08 50.6

STATION MARK IS A .... METAL ROD
WITH SETTING ..... STAINLESS STEEL ROD IN SLEEVE (10 FT.+)
THE MARK IS STAMPED ... GORF GPS N MAY 1990

STATION MARK HISTORY

YEAR MONUMENTED OR RECOVERED	CONDITION OF MARK	RECOVERED OR DESCRIBED BY
1990	STATION MONUMENTED	NATIONAL GEODETIC SURVEY
1991	GOOD	HOWARD COUNTY MARYLAND

(Continued on Next Page)

DEPARTMENT OF COMMERCE
NOAA - NOS - C&GS
NATIONAL GEODETIC SURVEY

PUBLICATION DATE: NOVEMBER 13, 1991
USGS QUAD SHEET: SAVAGE

GORF GPS N

PID: JV6895

STATION DESCRIPTION

DESCRIBED BY HOWARD COUNTY MARYLAND 1991
STATION IS LOCATED ABOUT 12 KM (7.5 MI) SOUTHWEST OF THE BALTIMORE BELTWAY (INTERSTATE HIGHWAY 695), ABOUT MIDWAY BETWEEN COLUMBIA, ELLICOTT CITY AND CATONSVILLE, AND AT THE HOWARD HIGH SCHOOL, IN A GRASS STRIP BETWEEN THE EXIT ROAD AND A PARKING LOT.
OWNERSHIP--COUNTY BOARD OF EDUCATION. CONTACT JIM HILLEN (301-313-2867) IN ADVANCE SO SECURITY CAN BE NOTIFIED. TO REACH FROM THE JUNCTION OF INTERSTATE HIGHWAY 95 AND STATE HIGHWAY 175 (EXIT 41), ABOUT 12 KM (7.5 MI) SOUTHWEST OF THE BALTIMORE BELTWAY, GO NORTHWEST ON HIGHWAY 175 FOR 0.88 KM (0.55 MI) TO STATE HIGHWAY 108 ON THE RIGHT. BEAR RIGHT, NORTHERLY ON HIGHWAY 108 FOR 4.68 KM (2.91 MI) TO ITS JUNCTION WITH STATE HIGHWAY 104. TURN LEFT, NORTHWEST, ON HIGHWAY 108 FOR 0.50 KM (0.31 MI) TO THE SCHOOL ENTRANCE ROAD ON THE RIGHT. TURN RIGHT ON ROAD FOR 0.11 KM (0.07 MI) TO A ROAD LEFT IN FRONT OF THE SCHOOL. TURN LEFT FOR 0.23 KM (0.14 MI) TO THE EXIT ROAD ON THE LEFT. TURN LEFT FOR ABOUT 30 M (98.4 FT) TO THE STATION ON THE LEFT. STATION MARK IS A PUNCH HOLE IN THE TOP OF A STEEL ROD ENCASED IN PCV PIPE WITH AN ALUMINUM LOGO CAP ATTACHED THAT PROJECTS 1 CM. IT IS 4.2 M (13.8 FT) SOUTHEAST OF THE EXIT ROAD CURB, 13.8 M (45.3 FT) NORTHEAST OF PARKING LOT EXIT CURB, 3.7 M (12.1 FT) SOUTHEAST OF THE CENTER OF A MANHOLE COVER IN THE SIDEWALK, 15.2 M (49.9 FT) WEST-SOUTHWEST OF A METAL LIGHT POLE, 10.5 M (34.4 FT) NORTH-NORTHWEST OF A FIBERGLASS WITNESS POST IN A TALL HEDGE, AND 9.0 M (29.5 FT) NORTH-NORTHWEST OF TRIANGULATION STATION SENIOR RESET.
DESCRIBED BY G.R.HEID.

Table 4. Bench marks for subsidence monitoring.

Well field	Identifying marks	Description
Arnold	SHA Arnold-1	Stainless steel rod driven to refusal
	SHA Arnold-2	Bronze disk cemented into concrete base for pump located inside building for booster pump station
	NGS Arnold W.T.	Bronze disk cemented into concrete top of 3 million gallon ground-storage tank
	Well AA Cf 137	Punched mark in top of casing coupling
Broad Creek	SHA Broad-1	Stainless steel rod driven to refusal at Broad Creek I
	SHA Broad-2	Bronze disk cemented into top of concrete sludge lift station
	NGS Broad Creek W.T.	Bronze disk cemented into concrete roof of water treatment building of Broad Creek II
Crofton Meadows	SHA Crofton-1	Bronze disk cemented into the west corner of the flocculation and settling basin
	NGS C.M. Pump-1	Stainless steel rod driven to refusal behind pump house for production well No. 1, AA Cc 107.

NGS National Geodetic Survey
SHA Maryland State Highway Administration