

UNITED STATES
DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

AERIAL PROFILING OF TERRAIN SYSTEM (APTS)
APPLICATIONS TEST REPORT--CHARLES RIVER PROJECT

By William H. Chapman

Open-File Report 85-302

Reston, Virginia
1985

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AERIAL PROFILING OF TERRAIN SYSTEM (APTS)
APPLICATIONS TEST REPORT--CHARLES RIVER PROJECT

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INTRODUCTION

The Aerial Profiling of Terrain System (APTS), developed under a contract with the Charles Stark Draper Laboratory (CSDL), is being tested to determine its effectiveness and efficiency as an earth-science data collection tool. The APTS is an airborne inertial surveying system consisting of an inertial platform, laser tracker, and a laser profiler. Performance evaluation tests have demonstrated that the system can perform terrain mapping tasks to an accuracy of ± 15 cm vertically and ± 60 cm horizontally.

The Charles River Project was the first of a series of projects to be completed during a 15.5-month period of applications testing. Mr. David J. Lang, Water Resources Division, U.S. Geological Survey, proposed the Charles River Project and assisted in the selection of retroreflector sites. The Charles River meanders just west and south of Boston, Massachusetts. The project extends from Medfield to Needham and includes the surveying of 11 well sites and water surface elevations along a 28-mile stretch of the river (fig. 1). Each well is located near the river, and the ground water level in each well is measured at various times during the year. The level of the ground water in the aquifer is compared to the level of the nearby river to determine the direction of flow. When the level of the river is higher than that of the ground water, the flow will be from the river into the aquifer; when the level of the river is lower, the flow will be in the opposite direction. This information is necessary to predict the dispersion of pollutants from septic tanks and to determine the effects on the water table from drilling new wells. The possibility of salt water intrusion into the aquifer is a major concern in this area.

FLIGHT OPERATIONS AND RESULTS

Preliminary work in the Charles River Project consisted of measuring the position and elevation of four control points that encompassed the project area. The positions were measured by translocation techniques using Magnavox 1502 satellite receivers and were referenced to the North American Datum of 1927. Elevations were established by fly levels that originated at bench marks of the National Geodetic Vertical Datum of 1929. A description, which includes precise latitude and longitude values, and elevation for each control point (Red Cross, Wheelock School, Morses Pond, and Dedham) are given in Appendix B.

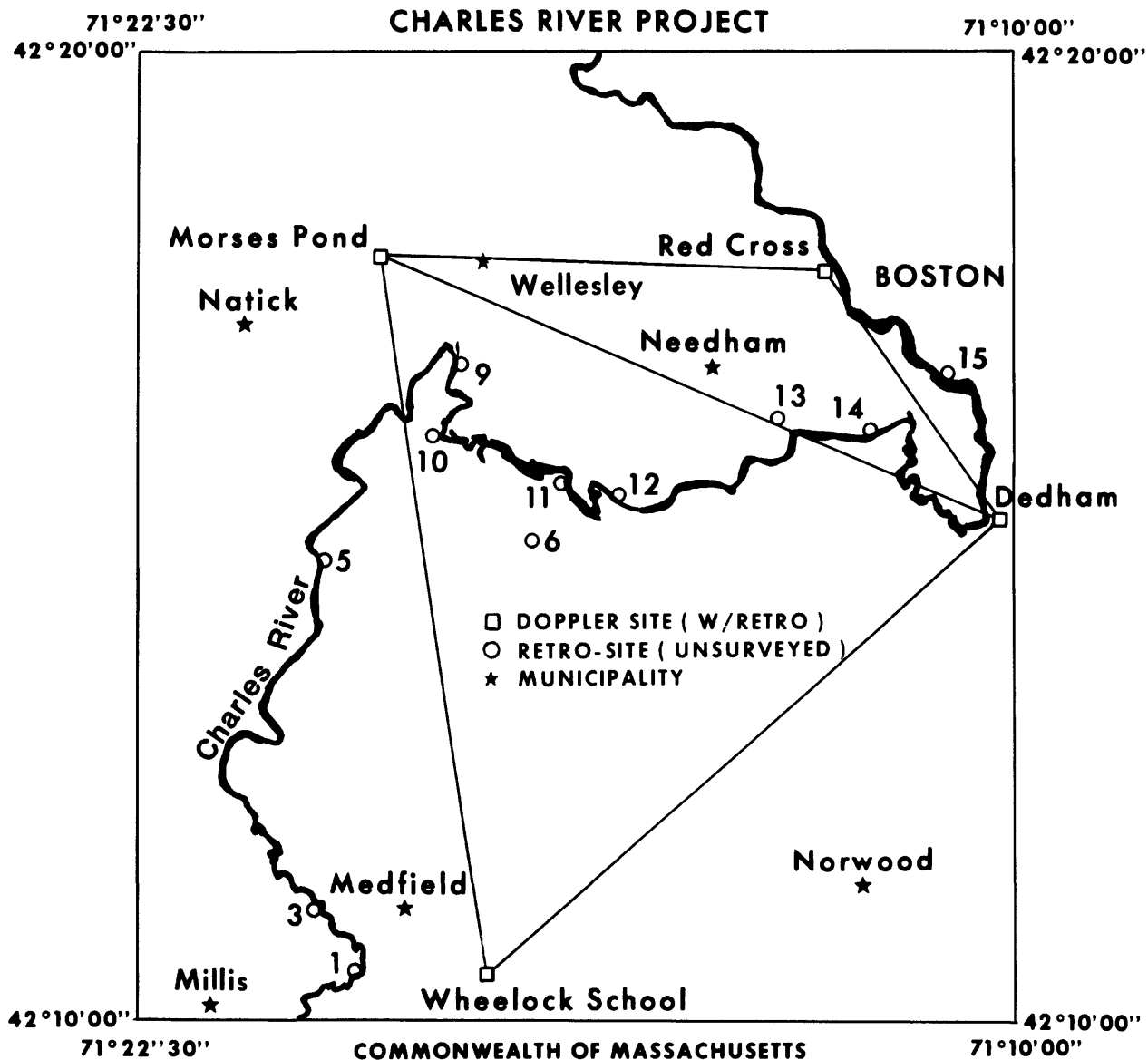


Figure 1.--Charles River Project - APTS applications testing.

At the time of the APTS flights, retroreflectors were centered over each control point and over the 11 well sites. The flight mission consisted of a series of passes over the project, each beginning and ending with a tracker lock on a control point. In between the control point locks, one or more well site retroreflectors were overflown and tracker locks obtained. The profiler and video camera were in operation during the mission, and later, the river crossing times were selected from the video image so that profile elevations could be computed for the river surface at many places.

The initial flights of the APTS on the Charles River Project followed the original flight plan given in the Applications Test Plan. Two problems were encountered:

- Local obstruction of site 6 required an east-west pass for a clear view.
- Sites 1 and 3 were too close together for the sequential tracker locks.

A new flight plan was developed and is shown in figure 2. Two hours of flight time were required to complete this path with a forward and reverse run. A total of 13 flights were made over the Charles River Project. Most of these flights were plagued by problems in the system's operations and weak signal returns from some of the retroreflectors. The source of the latter problem was discovered after the project was completed (see memorandum by C.R. Henkle, Appendix A). Although all 13 flights produced useful data, the data from the May 5, 1984, flight were selected for well site coordinates (table 1). The description of each well site and preliminary coordinates are given in Appendix B.

The source of river surface elevations are two flights made on March 28 and May 7, 1984. These elevations are listed in tables 2 and 3; plots of these points are shown in figures 3 and 4. Note that at the time of both of these flights, the river was at near flood stage.

CONCLUSIONS

Although the requested data were obtained, we believe that the full capability and accuracy of the APTS were not demonstrated. The Charles River Project survey was reflown using a better flight plan during November 1984 with acceptable retroreflectors at all sites. These new results will be made available in a separate report.

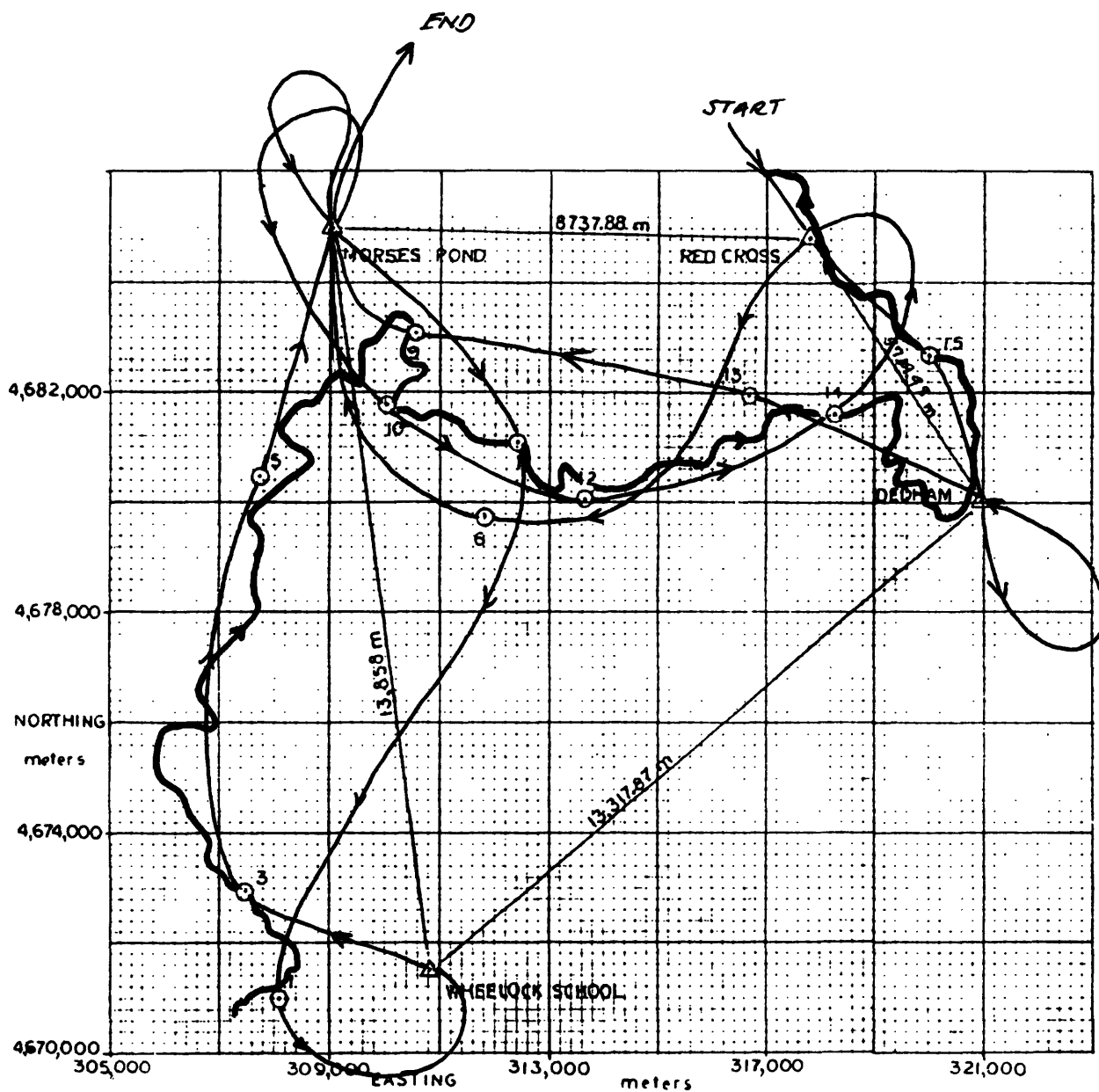


Figure 2.--Revised flight plan for Charles River Project - APTS applications testing.

Table 1.--APTS Charles River Project retroreflector coordinates
(May 7, 1984, flight)

| <u>Name</u> | <u>Latitude</u> | <u>Retroreflector Longitude</u> | <u>Elevation (m)</u> | <u>Station Mark Elevation (m)</u> |
|-------------|-----------------|-------------------------------------|----------------------|-------------------------------------------|
| 1 | 42° 10' 20.398" | 71° 19' 03.750" | 38.19 | 36.61 |
| 3 | 42° 11' 11.057" | 71° 19' 54.451" | 39.21 | 38.18 |
| 5 | 42° 14' 45.364" | 71° 19' 46.006" | 41.28 | 38.27 |
| 6 | 42° 14' 58.454" | 71° 16' 52.190" | 42.47 | 40.91 |
| 9 | 42° 16' 42.104" | 71° 17' 50.800" | 43.82 | 43.81 |
| 10 | 42° 16' 00.493" | 71° 18' 12.433" | 37.19 | 35.94 |
| 11 | 42° 15' 34.775" | 71° 16' 25.143" | 35.61 | 34.30 |
| 12 | 42° 15' 24.790" | 71° 15' 32.539" | 30.70 | 29.22 |
| 13 | 42° 16' 13.649" | 71° 13' 19.392" | 38.54 | 30.10 |
| 14 | 42° 16' 02.694" | 71° 12' 13.036" | 34.81 | 33.37 |
| 15 | 42° 16' 39.268" | 71° 10' 58.390" | 30.29 | 29.96 |

Table 2.--Charles River surface elevations from APTS flight #43281,
March 28, 1984.

| | <u>UTM Zone 19</u> | | <u>Elevation (m)</u> |
|-----|---------------------|--------------------|----------------------|
| | <u>Northing (m)</u> | <u>Easting (m)</u> | |
| 1. | 4671224.982 | 308504.463 | 36.2 |
| 2. | 4672361.054 | 307819.126 | 36.1 |
| 3. | 4673095.647 | 307145.868 | 36.1 |
| 4. | 4673359.641 | 306965.986 | 36.1 |
| 5. | 4674721.973 | 306457.872 | 36.1 |
| 6. | 4675873.191 | 306649.273 | 36.0 |
| 7. | 4676310.626 | 306786.228 | 36.0 |
| 8. | 4677053.436 | 307060.544 | 35.65 |
| 9. | 4677509.218 | 307184.994 | 35.75 |
| 10. | 4678666.016 | 307575.620 | 35.8 |
| 11. | 4680418.297 | 308250.556 | 35.45 |
| 12. | 4681090.827 | 308423.923 | 34.8 |
| 13. | 4691757.262 | 308417.057 | 34.9 |
| 14. | 4682840.478 | 309562.960 | 31.7 |
| 15. | 4682905.779 | 309699.788 | 31.1 |
| 16. | 4683111.543 | 309968.487 | 32.3 |
| 17. | 4681819.324 | 310179.399 | 31.25 |
| 18. | 4682154.069 | 310303.554 | 30.8 |
| 19. | 4682249.950 | 310456.220 | 32.2 |
| 20. | 4681667.971 | 310741.488 | 32.1 |
| 21. | 4681634.766 | 310748.587 | 30.8 |
| 22. | 4681642.382 | 310762.799 | 31.8 |
| 23. | 4681466.009 | 310921.058 | 30.8 |
| 24. | 4681338.240 | 310947.591 | 32.2 |
| 25. | 4681111.073 | 312493.981 | 31.4 |
| 26. | 4680940.153 | 312672.396 | 31.4 |
| 27. | 4680337.428 | 312948.096 | 31.8 |
| 28. | 4680287.961 | 313074.796 | 31.85 |
| 29. | 4680410.528 | 313129.152 | 31.7 |
| 30. | 4680524.283 | 313470.374 | 28.8 |

Table 2.--Charles River surface elevations from APTS flight #43281,
March 28, 1984--continued

| | <u>UTM Zone 19</u> | | |
|-----|---------------------|--------------------|----------------------|
| | <u>Northing (m)</u> | <u>Easting (m)</u> | <u>Elevation (m)</u> |
| 31. | 4680448.827 | 313596.367 | 29.0 |
| 32. | 4680718.496 | 314641.093 | 28.65 |
| 33. | 4680778.749 | 314889.825 | 28.6 |
| 34. | 4681137.704 | 315961.991 | 27.9 |
| 35. | 4681033.435 | 316007.170 | 28.4 |
| 36. | 4681113.943 | 316026.368 | 27.7 |
| 37. | 4681196.661 | 316478.786 | 27.65 |
| 38. | 4681142.103 | 316535.323 | 28.2 |
| 39. | 4681288.840 | 316914.456 | 28.1 |
| 40. | 4681553.809 | 317948.050 | 27.4 |
| 41. | 4681608.510 | 318400.706 | 27.1 |
| 42. | 4681661.455 | 318587.216 | 27.1 |
| 43. | 4681663.182 | 318597.267 | 27.2 |
| 44. | 4681748.257 | 318742.636 | 27.1 |
| 45. | 4681720.388 | 319362.107 | 26.4 |
| 46. | 4680137.499 | 319814.198 | 26.9 |
| 47. | 4680076.421 | 320734.877 | 26.75 |
| 48. | 4680679.096 | 320718.272 | 26.6 |
| 49. | 4681118.057 | 320652.193 | 26.6 |
| 50. | 4682474.691 | 320132.920 | 26.6 |
| 51. | 4682908.283 | 319749.578 | 26.6 |
| 52. | 4683353.560 | 319304.531 | 26.5 |
| 53. | 4683696.044 | 318960.724 | 26.45 |
| 54. | 4683904.838 | 318383.192 | 26.4 |
| 55. | 4683901.357 | 318364.091 | 26.3 |
| 56. | 4684269.462 | 318108.013 | 26.4 |
| 57. | 4684287.781 | 318096.508 | 26.3 |
| 58. | 4684536.406 | 317893.198 | 27.2 |
| 59. | 4684615.874 | 317840.342 | 27.2 |
| 60. | 4684829.323 | 318047.227 | 27.1 |

Table 3.--Charles River surface elevations from APTS flight #45071,
May 7, 1984.

| | <u>UTM Zone 19</u> | | <u>Elevation (m)</u> |
|-----|---------------------|--------------------|----------------------|
| | <u>Northing (m)</u> | <u>Easting (m)</u> | |
| 1. | 4670958.457 | 307270.753 | 35.1 |
| 2. | 4672732.034 | 307641.156 | 35.35 |
| 3. | 4672906.244 | 307488.841 | 35.8 |
| 4. | 4679408.976 | 307770.911 | 34.9 |
| 5. | 4679941.737 | 307860.443 | 36.0 |
| 6. | 4680891.695 | 308646.586 | 34.2 |
| 7. | 4681802.020 | 308463.292 | 33.85 |
| 8. | 4681854.746 | 308657.799 | 34.25 |
| 9. | 4681992.822 | 308840.624 | 34.1 |
| 10. | 4682852.412 | 309602.299 | 32.3 |
| 11. | 4682814.017 | 309616.260 | 34.1 |
| 12. | 4683094.583 | 309930.011 | 32.9 |
| 13. | 4683322.816 | 310108.288 | 31.3 |
| 14. | 4682864.616 | 310329.901 | 31.4 |
| 15. | 4682888.776 | 310434.597 | 32.6 |
| 16. | 4682392.550 | 310436.093 | 32.4 |
| 17. | 4681145.874 | 312060.766 | 31.4 |
| 18. | 4681137.469 | 312626.749 | 31.5 |
| 19. | 4680763.362 | 312625.567 | 31.5 |
| 20. | 4680388.062 | 312925.465 | 31.0 |
| 21. | 4680351.796 | 312971.495 | 31.0 |
| 22. | 4680321.848 | 313042.707 | 30.9 |
| 23. | 4680442.305 | 313101.006 | 31.4 |
| 24. | 4680564.113 | 313440.447 | 27.3 |
| 25. | 4680502.386 | 313539.804 | 27.4 |
| 26. | 4680338.579 | 313824.451 | 28.5 |
| 27. | 4680337.561 | 314192.560 | 28.8 |
| 28. | 4680392.261 | 314241.067 | 26.65 |
| 29. | 4681267.198 | 316092.563 | 27.0 |
| 30. | 4681277.185 | 316276.903 | 27.3 |
| 31. | 4681428.535 | 316964.277 | 26.4 |
| 32. | 4681578.200 | 317566.573 | 26.8 |

Table 3.--Charles River surface elevations from APTS flight #45071,
May 7, 1984--continued

| | <u>UTM Zone 19</u> | | <u>Elevation (m)</u> |
|-----|---------------------|--------------------|----------------------|
| | <u>Northing (m)</u> | <u>Easting (m)</u> | |
| 33. | 4681596.744 | 318061.261 | 26.4 |
| 34. | 4681577.455 | 318328.835 | 26.35 |
| 35. | 4681709.185 | 318634.533 | 26.4 |
| 36. | 4681779.117 | 318711.464 | 27.5 |
| 37. | 4681798.408 | 319252.190 | 28.1 |
| 38. | 4680910.405 | 319129.978 | 27.0 |
| 39. | 4681442.328 | 319360.539 | 27.15 |
| 40. | 4680573.075 | 320607.345 | 26.4 |
| 41. | 4680197.437 | 320699.157 | 26.5 |
| 42. | 4680193.303 | 320704.046 | 26.6 |
| 43. | 4681253.087 | 320799.922 | 26.5 |
| 44. | 4681392.926 | 320807.731 | 26.6 |
| 45. | 4682403.598 | 319914.905 | 26.3 |
| 46. | 4682604.316 | 320148.454 | 26.6 |
| 47. | 4683016.498 | 319559.453 | 26.4 |
| 48. | 4683141.223 | 319350.770 | 25.9 |
| 49. | 4683420.407 | 319274.339 | 26.3 |
| 50. | 4683612.172 | 319285.562 | 25.95 |
| 51. | 4683625.712 | 319265.923 | 26.2 |
| 52. | 4684542.306 | 318117.442 | 26.2 |
| 53. | 4684586.522 | 318036.615 | 26.15 |
| 54. | 4684683.513 | 318038.256 | 26.0 |
| 55. | 4685127.741 | 317705.221 | 26.0 |

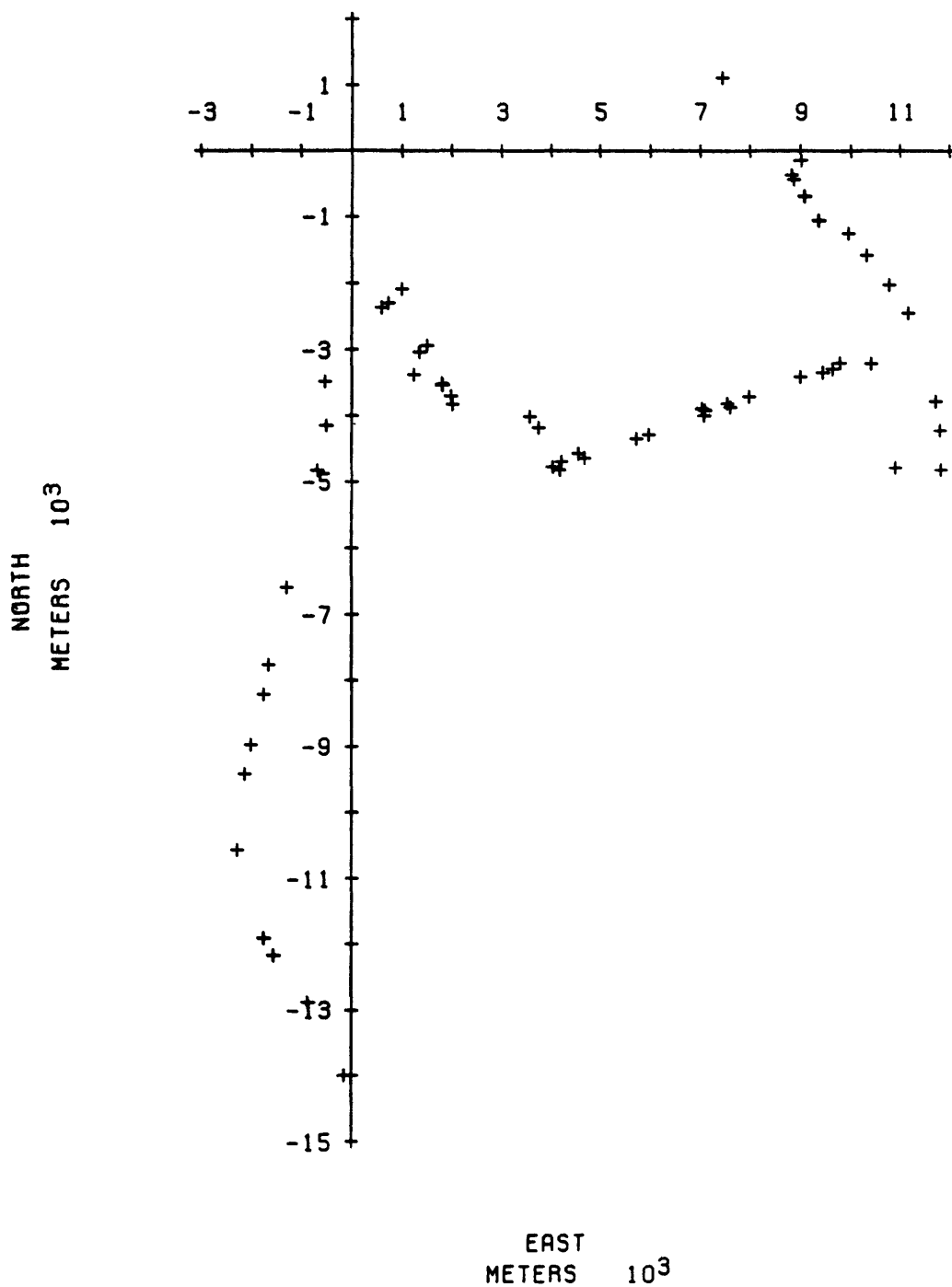
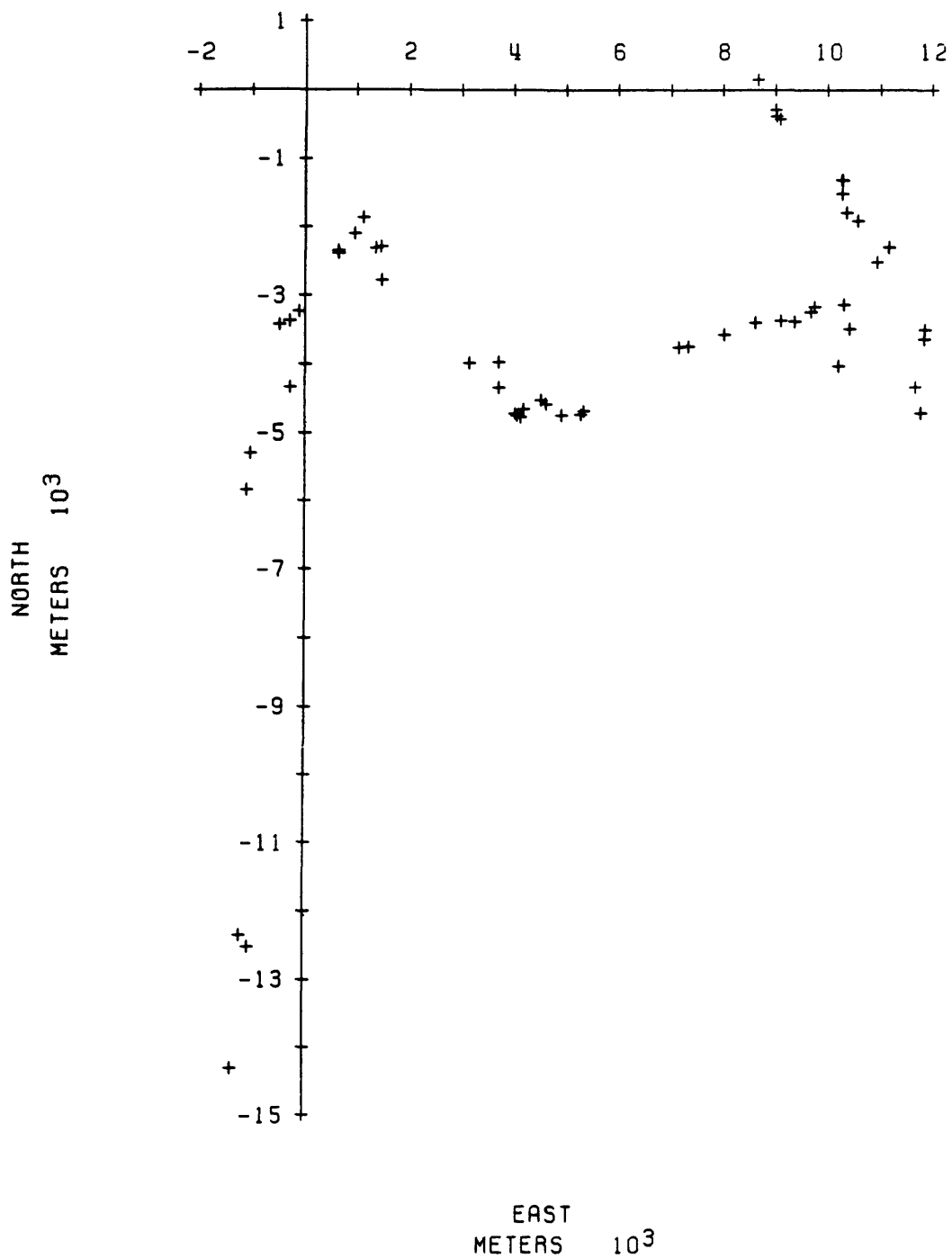


Figure 3.--Charles River profile crossings in flight F43281 - APTS applications testing.



SELECTED REFERENCES

- Donna, J.I., 1984, Aerial profiling of terrain system application test report Charles River project results: Cambridge, Mass., The Charles Stark Draper Laboratory, Inc., Report CSDL-R-1727, 82 p.
- Mamon, G.A., 1984, Aerial profiling of terrain system applications test report Charles River project operations: Cambridge, Mass., The Charles Stark Draper Laboratory, Inc., Report CSDL-R-1728, 7 p.
- U.S. Geological Survey, 1984, Applications test plan - Charles River Project: National Mapping Division internal report, March 1984, 33 p.

ADDITIONAL REFERENCE

- Cyran, E.J., and Chapman, W.H., 1984, Flight testing the Aerial Profiling of Terrain System: U.S. Geological Survey Open-File Report 84-881, 18 p.

APPENDIXES



APPENDIX A.--Report of APTS Retroreflector Study

United States Department of the Interior

GEOLOGICAL SURVEY
RESTON, VA. 22092

In Reply Refer To:
WGS-Mail Stop 538

September 17, 1984

Memorandum

To: William H. Chapman
From: Charles R. Henkle
Subject: APTS retroreflectors

In reviewing the CSDL Report R-1727-P on the Charles River Project, it became apparent that tracker lock was difficult to obtain at some sites. It was noticed that the retroreflectors at these sites were of low quality with divergence angles of 40" and 45". The percentage of successful locks on a retroreflector appears to depend somewhat on its quality.

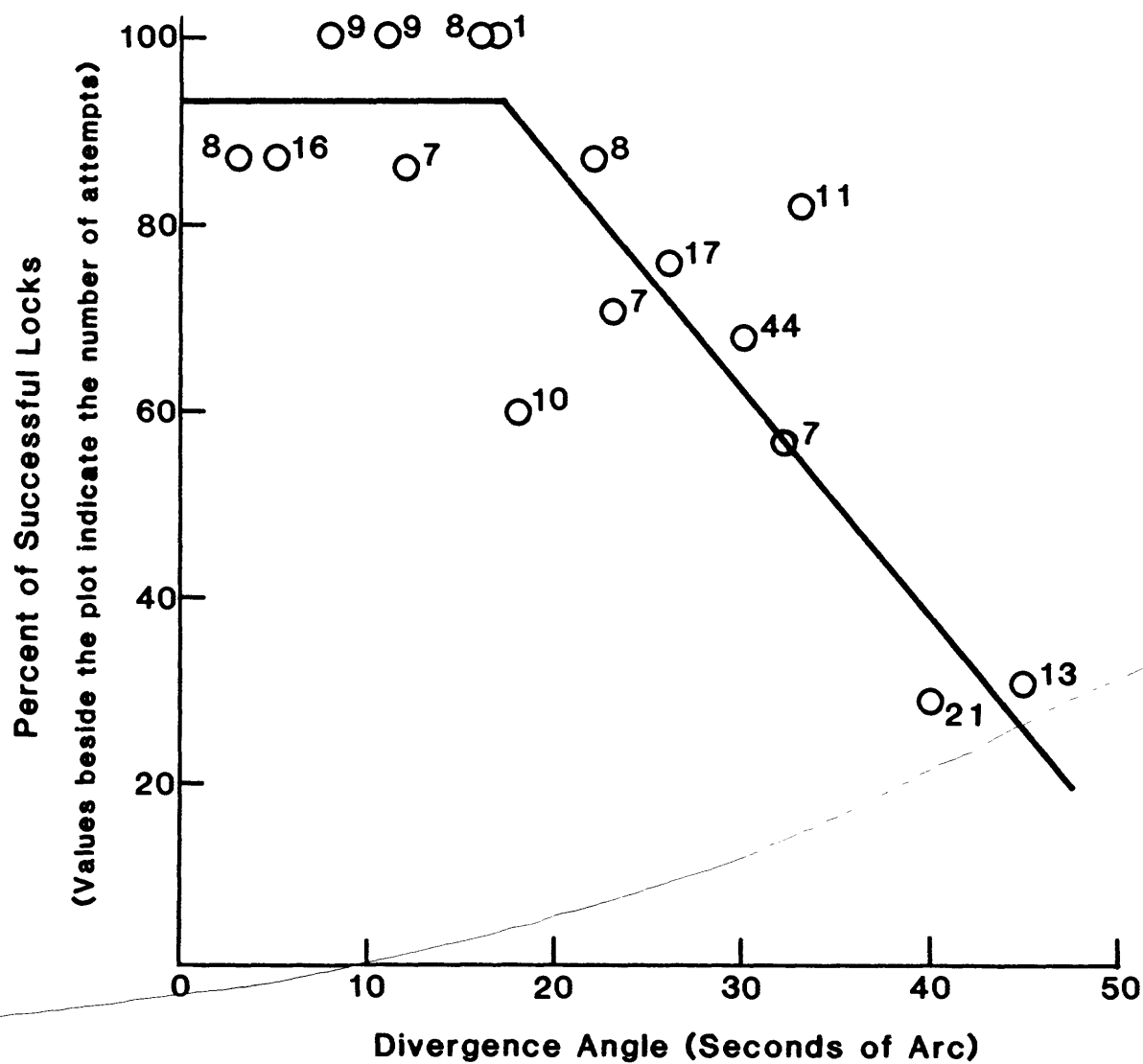
To test this theory, the percentage of locks (ignoring those caused by other problems) was plotted against the quality of the retroreflector using the Charles River Project data. The attached graph shows a strong correlation between the percentage of locks and retroreflector quality. The chance of a successful lock drops drastically when the divergence angle increases beyond 20". The results suggest we use only the better quality retroreflectors for the remaining application test projects.

Our present inventory of retroreflectors, as shown on the attached retro history listing, shows only 11 of our present 19 are of the quality needed to ensure successful locks. To continue with the planned application flights, we will need additional retroreflectors with divergence angles of 20" or less to be constructed as soon as possible.

Charles R. Henkle
Charles R. Henkle

2 Attachments

CHARLES RIVER PROJECT RETROREFLECTOR PERFORMANCE



APPENDIX A.--Report of APTS Retroreflector Study--continued

RETRO HISTORY LISTING

CORRECT AS OF 9-17-84

| | |
|--------------------|-------------|
| | PROJ ABBREV |
| CALIBRATION RANGE | (CAL) |
| CHARLES RIVER | (CR) |
| KETTLE POND | (KP) |
| LEBANON PLUTON, VT | (LEB) |
| FARMINGTON RIV, CT | (FR) |

| | |
|-----------------------|--------------|
| | OTHER ABBREV |
| DAY OF FLIGHT | (DOF) |
| MEAN DIVERGENCE ANGLE | (DA) |
| LOST | (MIA) |

| ID | DA | STATION ID | PROJ | DATE SET | DATE REMOVED | REMARKS |
|----|----|---------------------------------------------|-------------------------|--------------------------------------|---------------------------|---------------------------|
| A | 3 | ASHLAND SITE 6 PLYMOUTH AP | CAL CR KP | 5-31-83 DOF 5-10-84 | 2-13-84 DOF 6-14-84 | 3-28, 4-26, 4-27, 5-07-84 |
| B | 5 | ACTON DEDHAM | CAL CR | 8-23-83 | 8-24-83 5-11-84 | |
| C | 8 | POST SITE 11 | CAL CR | 6-11-83 3-28-84 | 2-13-84 5-10-84 | |
| D | 10 | NAGOG | CAL | 5-03-83 | | |
| E | 11 | ACTON SITE 15 MOHAWK | CAL CR CAL | 11-10-83 2-15-84 6-12-84 | 2-13-84 5-10-84 | |
| F | 12 | SITE 3 NASHOBA | CR CAL | 3-28-84 5-11-84 | 5-10-84 5-11-84 | RETRO TEST |
| G | 13 | SUDBURY FRAMINGHAM WHEELLOCK ACTON | CAL CAL CR CAL | 5-04-83 8-23-83 DOF 5-08-84 | 4- -84 DOF 5-31-84 | 4-13-84 |
| H | 14 | INDIAN | CAL | 6-11-83 | MIA | |
| I | 14 | FRAMINGHAM | CAL | 6-01-83 | MIA | |
| J | 16 | HAYSTACK DCP3 SITE 9 ONSET | CAL CR KP | 6-02-83 2-15-84 6-05-84 | 2-13-84 5-11-84 | |

APPENDIX A.--Report of APTS Retroreflector Study--continued

| ID | DA | STATION ID | PROJ | DATE SET | DATE REMOVED | REMARKS |
|----|----|-----------------------------------------------|-----------------------|-----------------------------------|----------------------------------|--------------------------------------|
| K | 17 | LAKE WHEELLOCK | CAL CR | 6-02-83 2-15-84 | 2-13-84 MIA | 4-12-84 |
| L | 18 | LAB SITE 12 | CAL CR | 5-02-83 DOF | 2-13-84 DOF | 4-26, 4-27, 5-07-84 |
| M | 19 | NAT RED CROSS | CAL CR | 6-01-83 2-15-84 | 2-13-84 | |
| O | 23 | ABBOT SITE 1 | CAL CR | 5-31-84 DOF | 2-13-84 DOF | 4-26, 4-27, 5-07-84 |
| P | 26 | SUDBURY WHEELLOCK SITE 1 PLYMOUTH CC | CAL CR CR KP | 11-10-83 DOF DOF 5-10-84 | 2-13-84 DOF DOF 6-14-84 | 4-26, 4-27, 5-07-84 4-12, 4-13-84 |
| R | 30 | LITTLETON MORSES POND | CAL CR | 5-19-83 | 2-13-84 5-10-84 | |
| T | 33 | MOHAWK | CAL | 5-17-83 | 6-12-84 | |
| U | 37 | ACTON | CAL | 5-17-83 | MIA | 7-04-83 |
| V | 40 | WATER SITE 5 | CAL CR | 6-02-83 2-15-84 | 2-84 5-11-84 | SITE NOT USED |
| W | 46 | INDIAN SITE 13 | CAL CR | 11-10-83 2-15-84 | 2-13-84 5-10-84 | |
| 10 | 32 | SITE 10 ONSET ACTON | CR KP CAL | DOF 5-10-84 DOF | DOF 6-04-84 DOF | 3-28, 4-26, 4-27, 5-07-84 6-15-84 |
| 11 | 22 | SITE 14 NASHOBA ABBOT | CR CAL CAL | DOF DOF 9-13-84 | DOF DOF | 4-26, 4-27, 5-07-84 6-15-84 |
| 12 | 28 | NAT | CAL | 5-08-84 | 6-11-84 | |
| 13 | 2 | | | | | 2 1/2" PRISMS |
| 14 | 2 | | | | | |

APPENDIX B.--Retroreflector Site Description

Site #1

Medfield, intersection of State Routes 27 and 109, 0.1 mi. SW. on 109, thence 1.0 mi. SW. on Causeway St. to bridge over Stop River and station, in NW. on bridge abutment, "ch. sq.".

Sta. Mk: ch. sq.

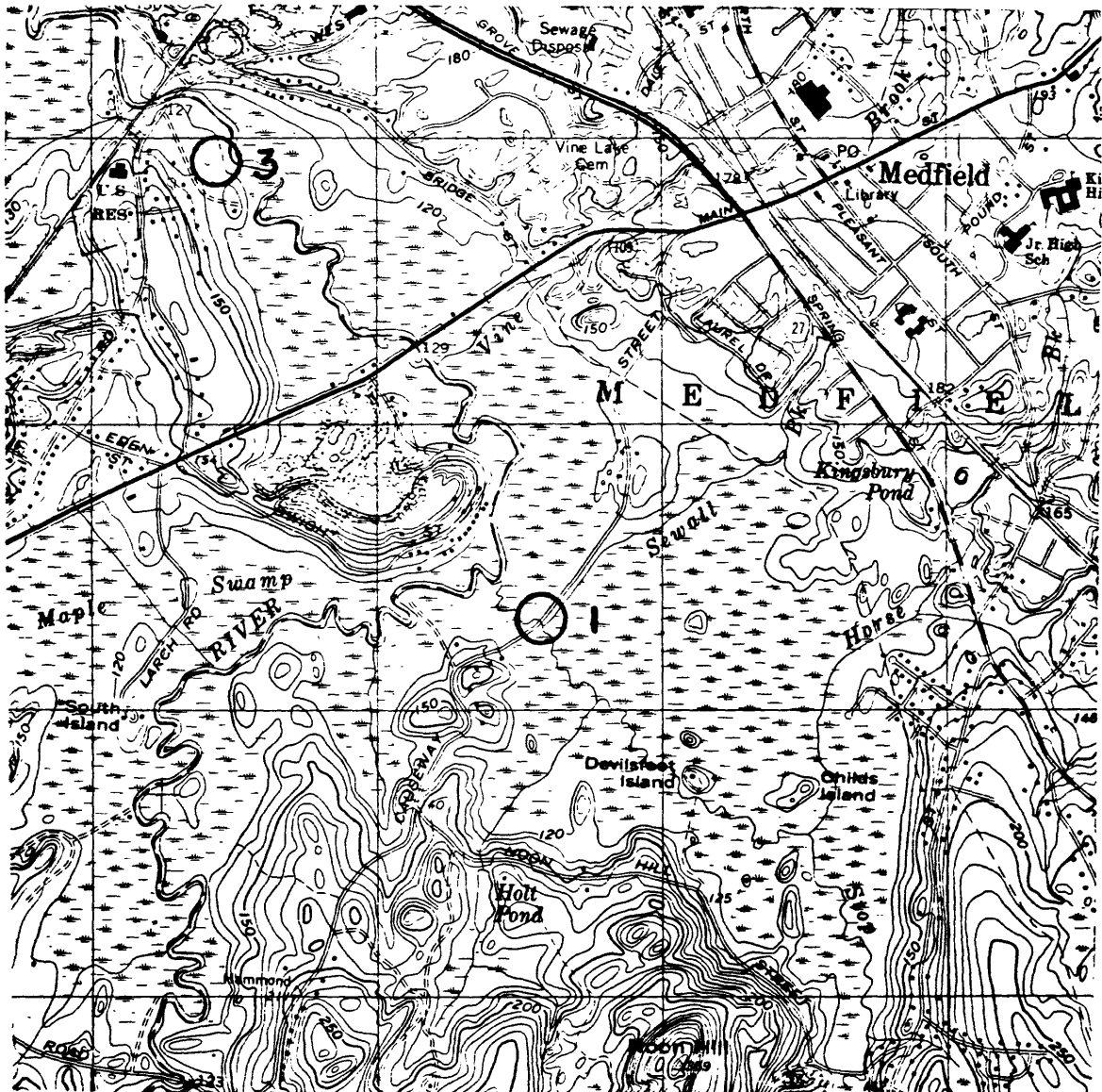
Scaled Coords: N. 42 10 20.9 W. 71 19 02.3

Scaled Elev: 115 ft. 35 m

H.I.: 1.53 m (3/28/84) 1.545 m (4/12/84) 1.54 m (4/13/84) 1.53 m (4/26/84)
1.59 m (4/27/84) 1.58 m (5/7/84)

Retro: "P" (4/12-13/84) "O" (4/26-27/84, 5/7/84)

Contact: None



APPENDIX B.--Retroreflector Site Description--continued

Site #3

Medfield, intersection of State Routes 27 and 109, 0.9 mi. N. along 109, thence 0.55 mi. SW. along West St., thence 0.15 mi. S. on private drive, thence 0.1 mi. E. to well site.
(If wet, last 0.1 mi. must be walked. Area has red flagging marking way.)

Sta. Mk: center of well head

Scaled Coords: N. 42 11 12.4 W. 71 19 55.3

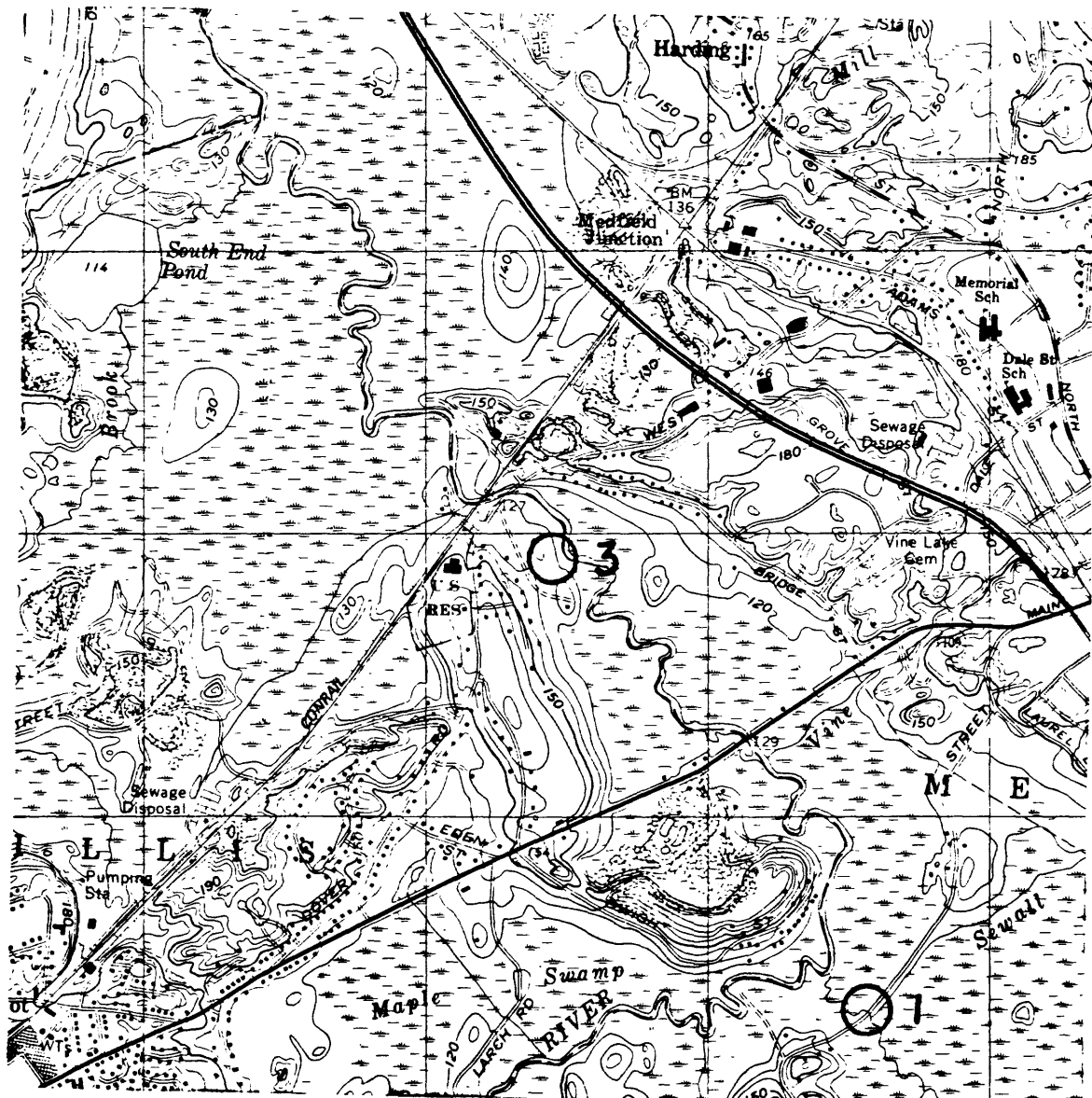
Scaled Elev: 125 ft. 38 m

H.I.: 1.03 m (3/28)

Scaled Elev. of Retro:

Retro: "F"

Contact: Mr. John Horgan 617-359-8331 (home), 617-359-8597 (work)

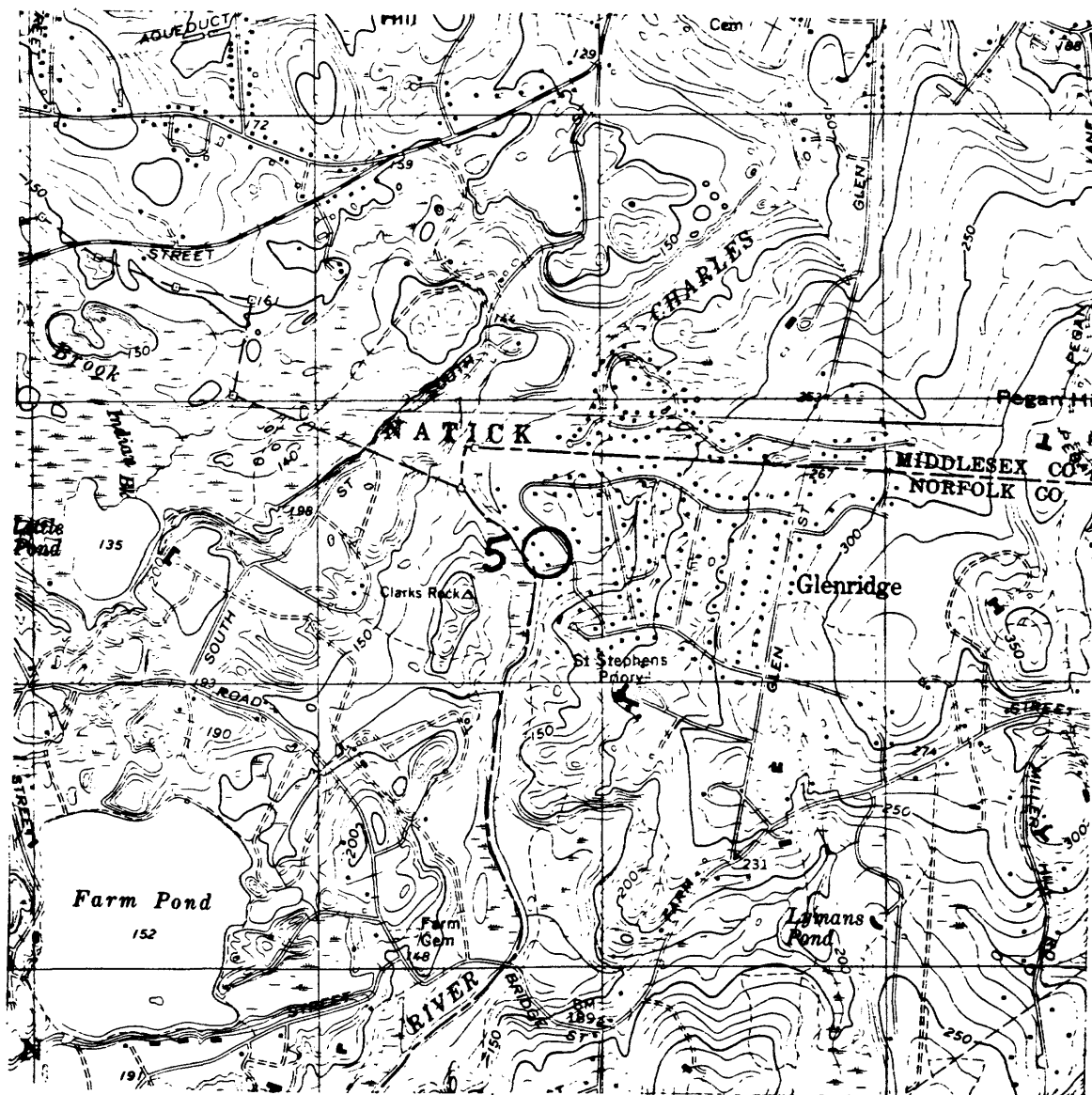


APPENDIX B.--Retroreflector Site Description--continued
Site #5

Glenridge, in the town of Dover, intersection of Glen St. and Greystone Rd., 0.3 mi. W. along Greystone Rd., thence 0.2 mi. N. on Yorkshire Rd. to 49 Yorkshire Rd. and station on left at tennis courts in front of the Jack Sheppard residence.

Sta. Mk: Third wooden post N. of drive on fence around tennis courts
Scaled Coords: N. 42 14 45.5 W. 71 19 46.0
Scaled Elev: 125 ft. 38 m
H.I.: 9.87 ft. 3
Scaled Elev. of Retro: 41 m
Retro: "V"

Contact: Mr. Jack Sheppard



APPENDIX B.--Retroreflector Site Description--continued

Site #6

Dover, intersection of Centre and Haven Sts. 0.1 mi. W. along Haven St. to the residence of Ms. Justine Kent and station on N. side of road at W. end of house.

Sta. Mk: Nail in driveway W. of house

Flight Line: E-W

Scaled Coords: N. 42 14 57.7 W. 71 16 52.2

Scaled Elev: 135 ft. 41 m

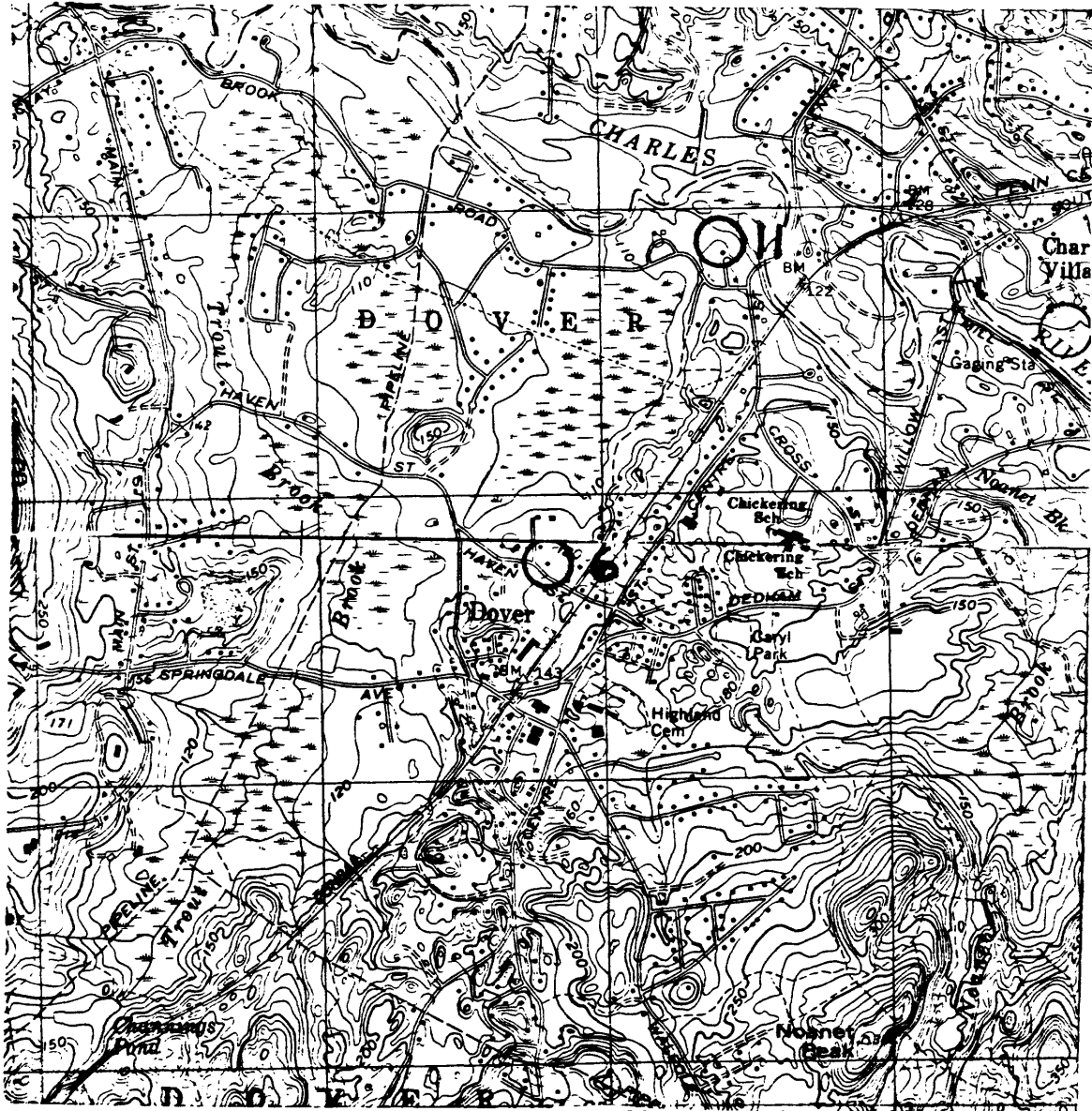
H.I.: 1.52 m (3/28/84) 1.61 m (4/26/84) 1.60 m (4/27/84) 1.56 m (5/7/84)

Scaled Elev. of Retro:

Retro: "A"

Contact: Ms. Justine Kent - private residence

NOTE: Flight line E-W



APPENDIX B.--Retroreflector Site Description--continued

Site #9

South Natick, intersection of State Route 16 and Pleasant St., 0.4 mi. S. along Pleasant St., thence 0.75 mi. E. along Dover Rd., thence 0.85 mi. N. along Winding River Rd. to private residence W. of road.

Sta. Mk: On top of chimney on N. end of house, cut "X"

Scaled Coords: N. 42 16 42.2 W. 71 17 50.7

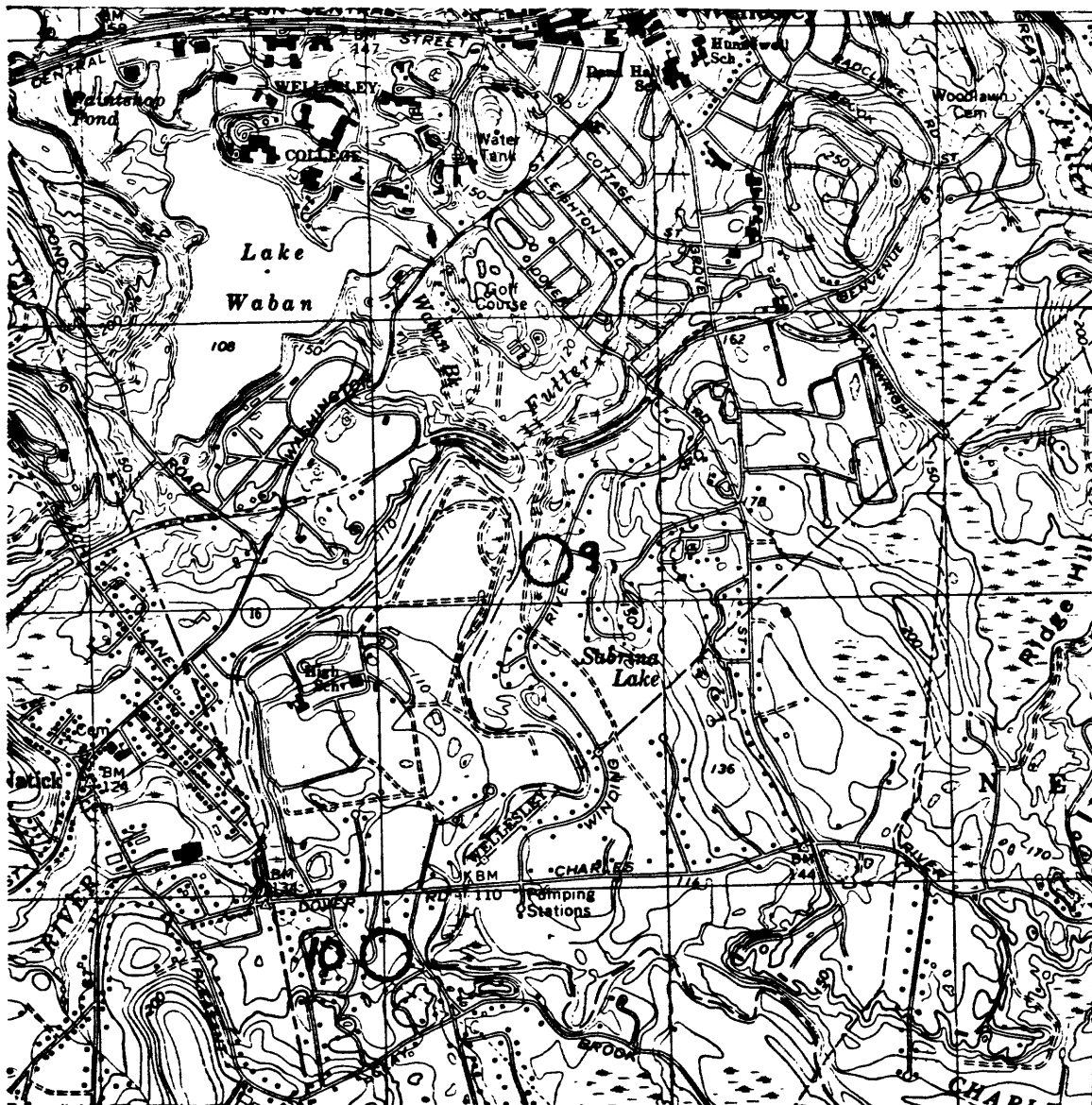
Scaled Elev: 140 ft. 43 m

H.I.: 0.01 m + 3.0 m for chimney 3

Scaled Elev. of Retro: 46 m

Retro: "J"

Contact: Mr. Bennett



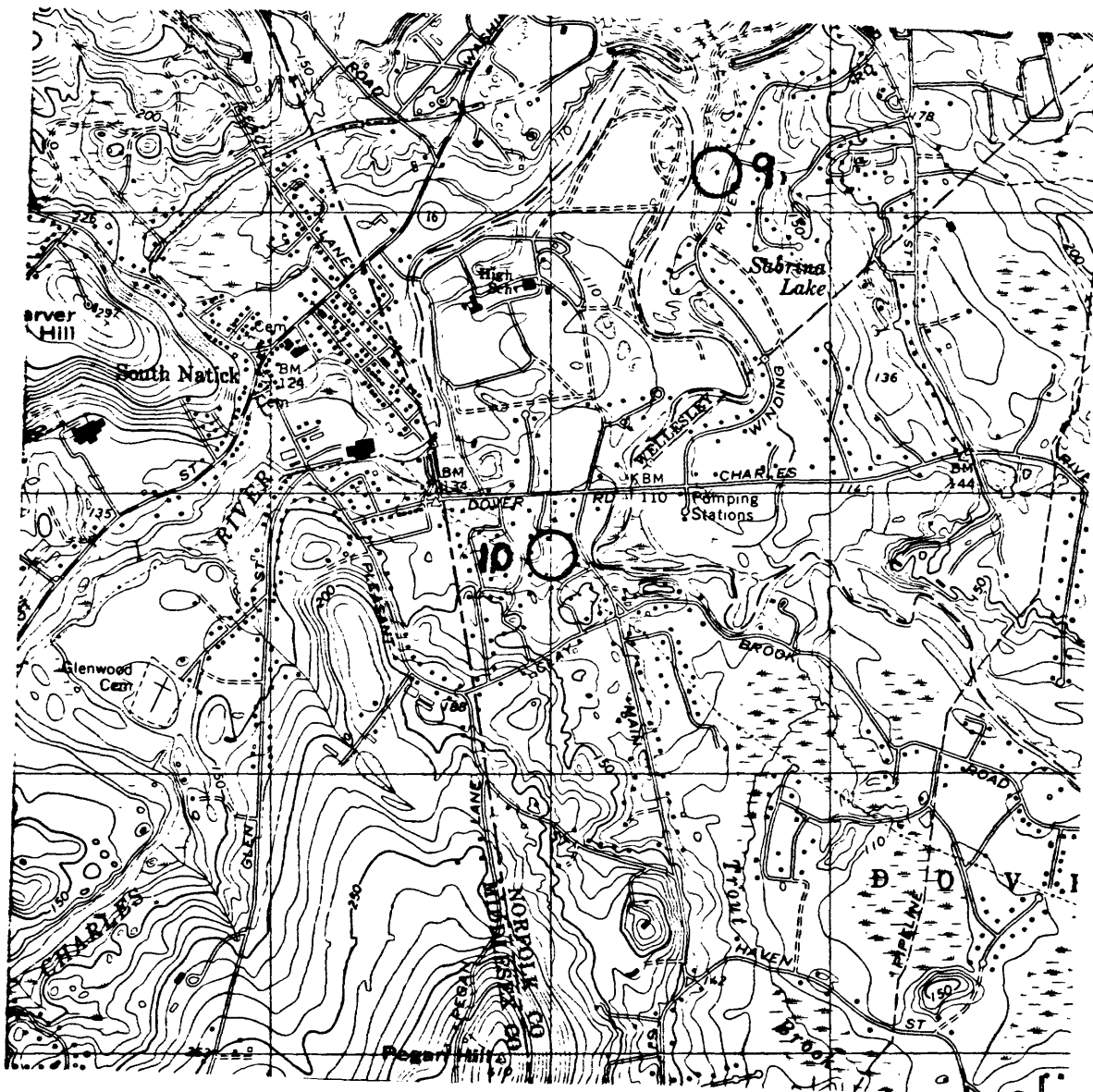
APPENDIX B.--Retroreflector Site Description--continued

Site #10

South Natick, intersection of State Route 16 and Pleasant St., 0.4 mi. S. along Pleasant St., thence 0.40 mi. E. along Dover Rd., thence 0.15 mi. S. to pumping station E. of road. Park and walk approx. 200 ft. E. to station. Area flagged.

Sta. Mk: Concrete post (steel post driven for securing Retro)
Scaled Coords: N. 42 16 00.530 W. 71 18 12.305 (4/13/84)
Scaled Elev: 125 ft. 38 m
H.I.: 1.16 m (3/28/84) 1.37 m (4/26/84) 1.36 m (4/27/84) 1.25 m (5/7/84)
Scaled Elev. of Retro:
Retro: "10"

Contact: None



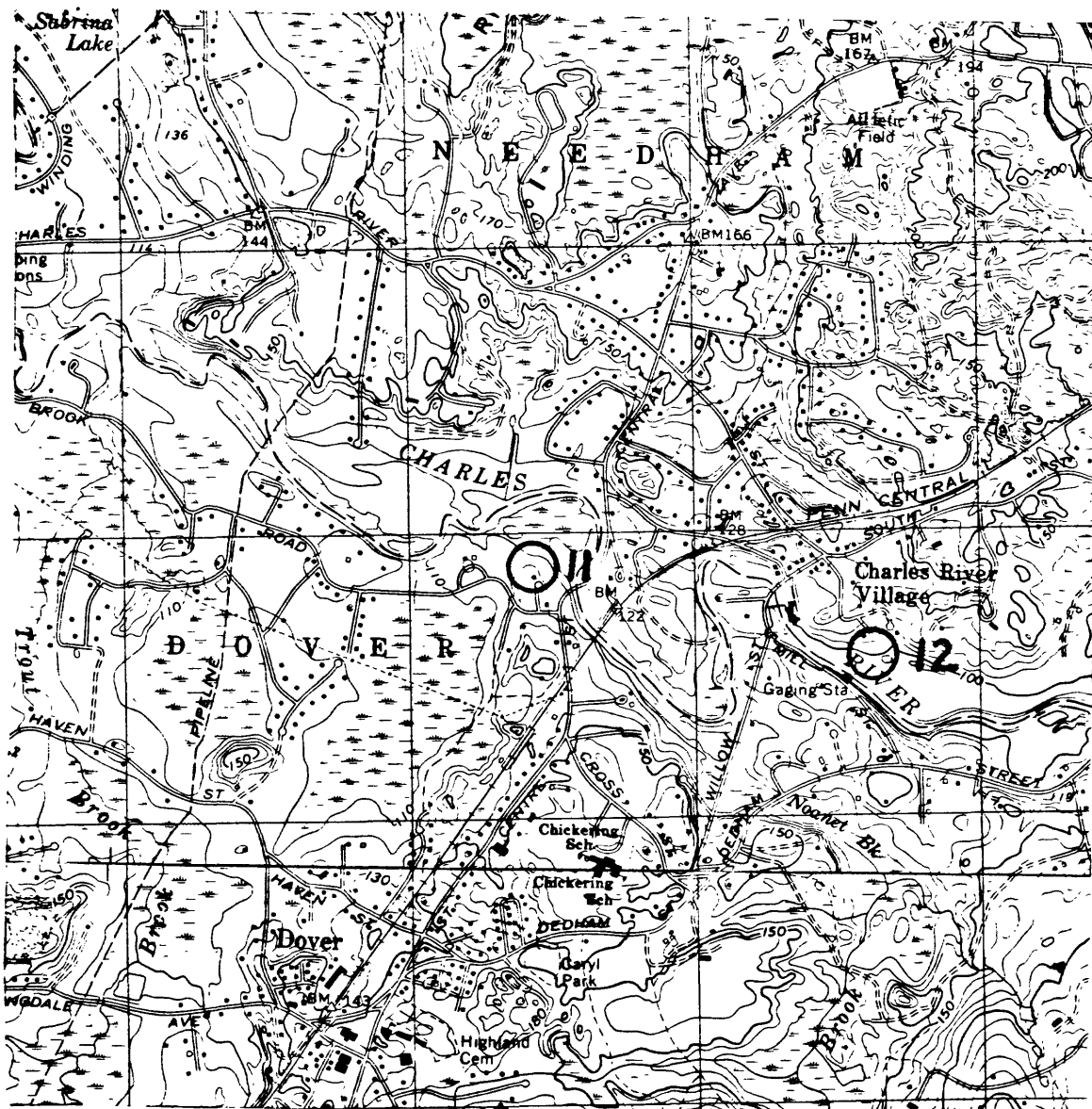
APPENDIX B.--Retroreflector Site Description--continued

Site #11

South Natick, intersection of State Route 16 and Pleasant St., 0.8 mi. S. along Pleasant St., thence 1.85 mi. to private drive on left, thence 0.05 mi. E. along drive to the residence of Mr. John Leach. Station located approx. 200 ft. NNW of house. Area flagged.

Sta. Mk: Steel pipe in small clump of bushes
Scaled Coords: N. 42 15 34.6 W. 71 16 25.8
Scaled Elev: 120 ft. 37 m
H.I.: 1.31 m
Scaled Elev. of Retro:
Retro: "C"

Contact: Mr. John Leach



APPENDIX B.--Retroreflector Site Description--continued

Site #12

Charles River Village in town of Needham, intersection of Charles River St., South St., and private lane, 0.15 mi. S. along private lane to first house on right, thence approx. 350 ft. SE. along field road to station. Area flagged.

Sta. Mk: 1/2-inch steel pipe

Scaled Coords: N. 42 15 24.6 W. 71 15 33.0

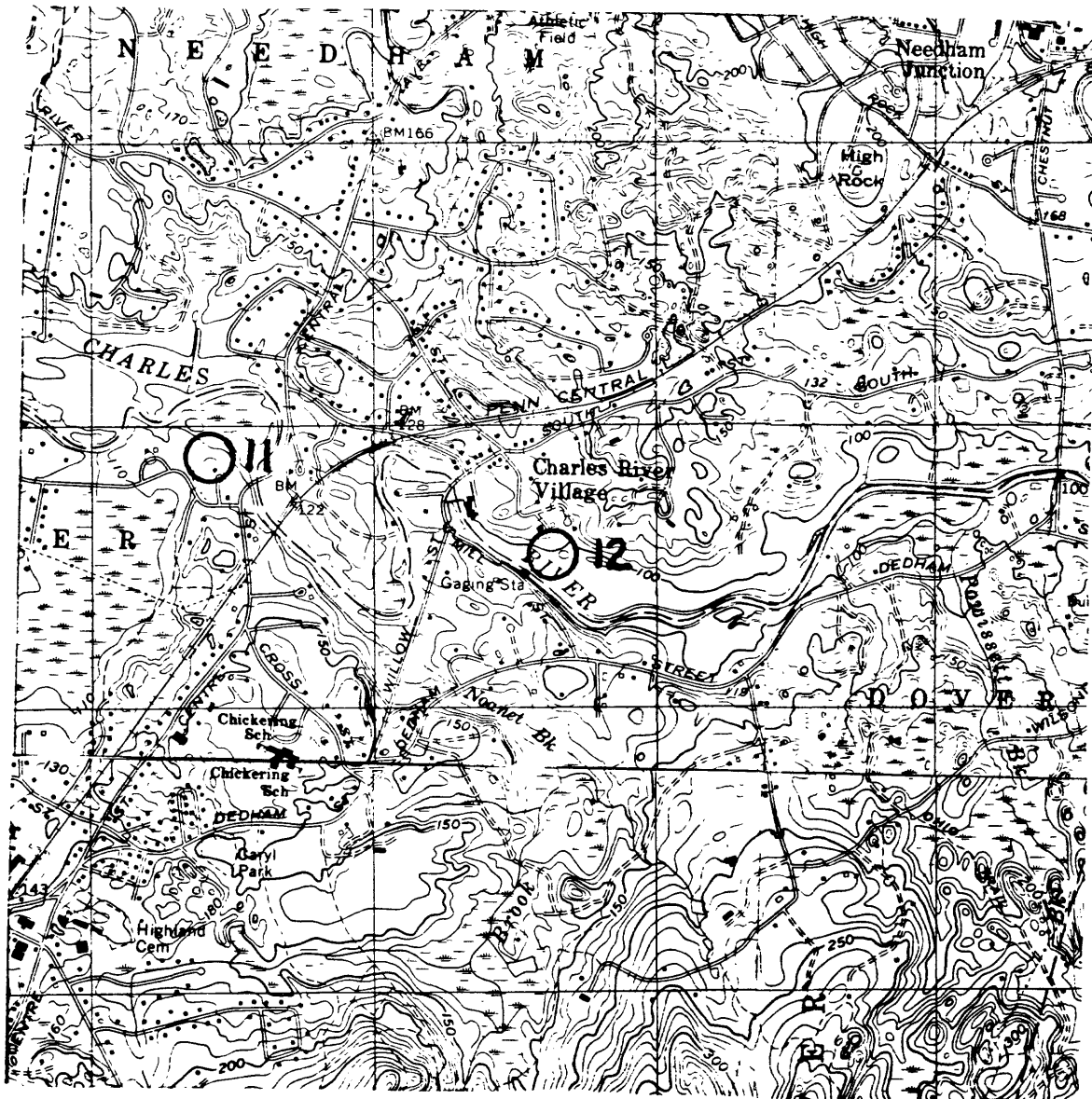
Scaled Elev: 100 ft. 30 m

H.I.: 1.34 m (3/28/84) 1.40 m (4/26/84) 1.41 m (4/27/84) 1.48 m (5/7/84)

Scaled Elev. of Retro:

Retro: "L"

Contact: Michael Craig (617-542-9300)



APPENDIX B.--Retroreflector Site Description--continued

Site #13

Dedham, intersection of State Routes 128 and 135, 0.9 mi. NW. along 135 to Needham Department of Public Works and station on NE. corner of building; access is through garage area and inside ladder.

Ground Mk: Copper nail and washer 15.71 ft. NW. of SE. corner of (elev. only) building, 0.22 E. of wall at entrance to building.

Sta. Mk: Top of antenna (6") at NE. corner of building (painted red)

Scaled Coords: N. 42 16 13.4 W. 71 13 19.5

Scaled Elev: 100 + 25.24 ft. = 125.24 ft. 38.17 m

H.I.: 0.745 m 0.745

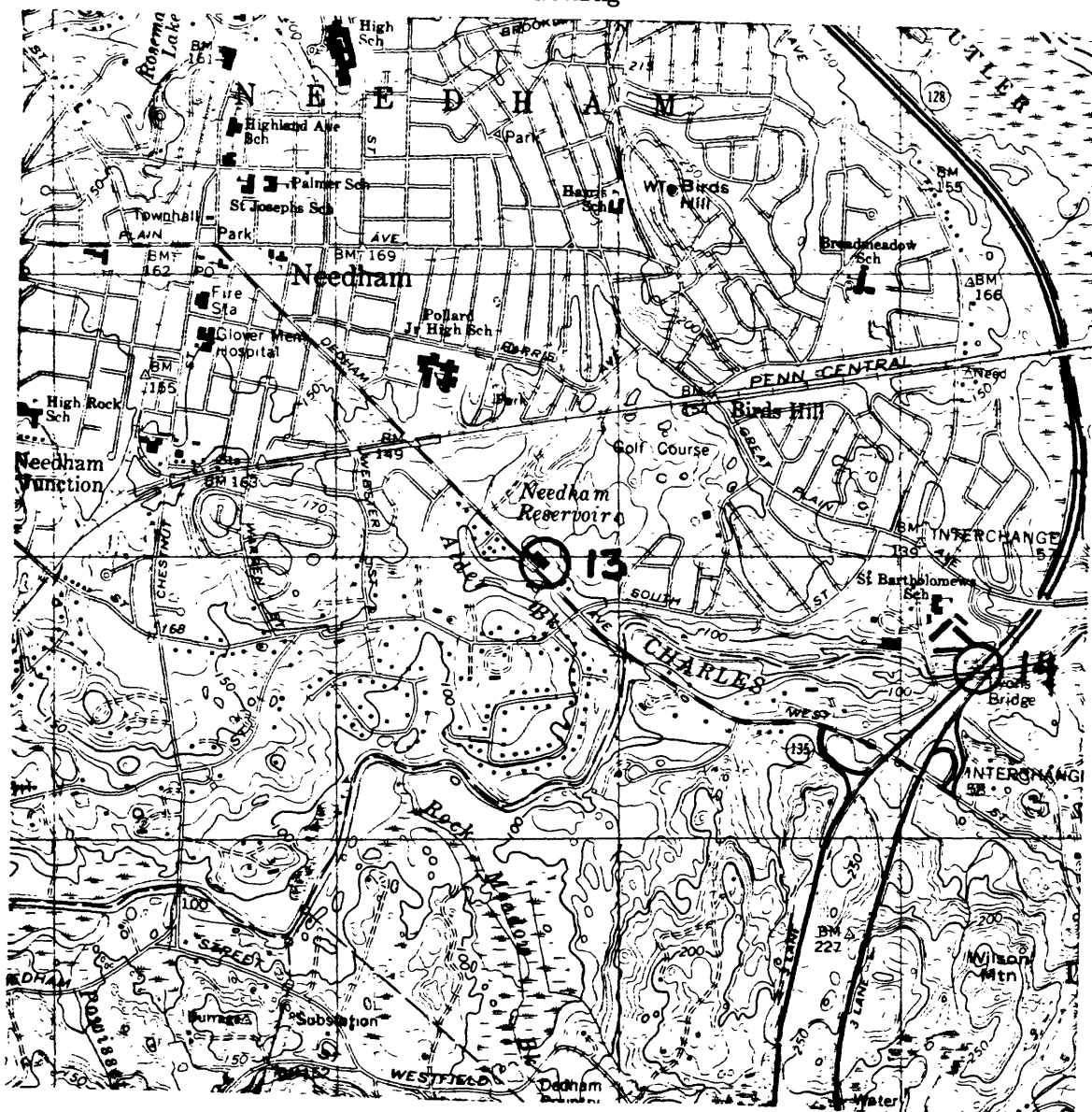
Scaled Elev. of Retro: 38.915 m

Retro: "W"

Ground Mk: -25.24 ft. (-7.693 m) from Doppler station

Contact: Mr. Walter Beliski, Building Supt., office in garage area

N. Line: Red paint mark on roof flashing



Site #14

Contact: None



APPENDIX B.--Retroreflector Site Description--continued

Site #15

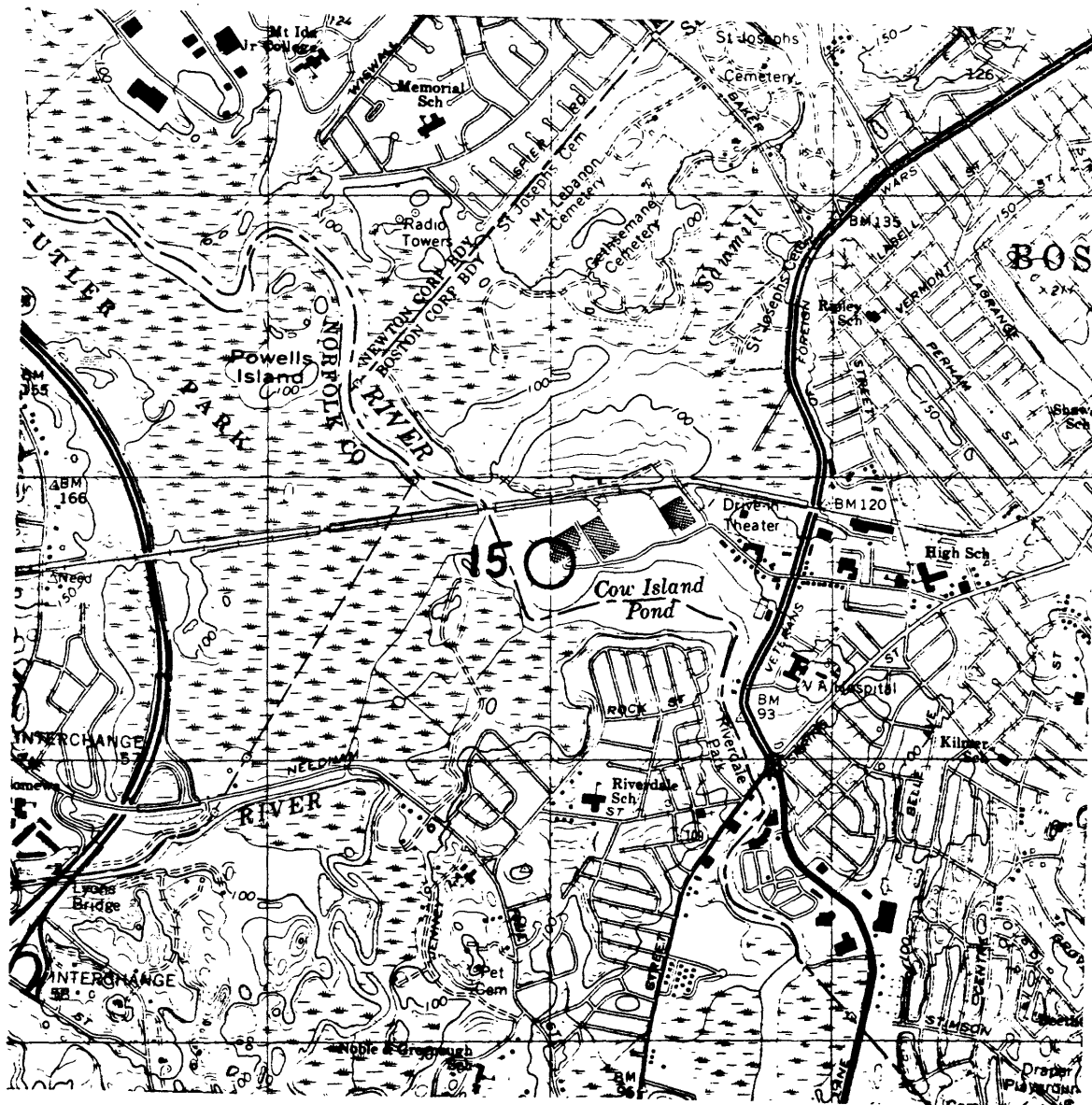
Boston, intersection of U.S. 1 and State Route 109, 0.45 mi. N. along U.S. 1, thence 0.2 mi. NW. along Charles Park Rd., thence 0.3 mi. W. along Rivermoor St. to the Barnstead Corp. and station site at SW. corner of building.

Sta. Mk.: Vent pipe on well site at SW. corner of Barnstead Bldg. Red paint mark on highest point.

Scaled Coords: N. 42 16 39.3 W. 71 10 58.3
Scaled Elev: 93 ft. 28 m
H.I.: 0.33 m 0.33
Scaled Elev. of Retro: 28.33 m
Retro: "E"

N. Line: Red paint mark on window frame.

Contact: Mr. Donald J. Keans 617-327-1600
Mr. Pete Kelly, Facility Mgr. - See Pete for access



APPENDIX B.--Retroreflector Site Description--continued

Red Cross (Doppler #69650)

Needham, Kendrick St. bridge over State Route 128, 0.4 mi. E. along Kendrick St. to Red Cross Building on right. Access is through inside ladder.

Sta. Mk.: Paint mark on drain cover

Ground Mk.: Paint mark on E. end of concrete pad at entrance to building,
W. most one of two on N. side.

Ground Elev.: 97.66 ft.

Coords: N. 42 17 46.3053 W. 71 12 38.0802

Elev: 122.78 ft. 37.42 m

H.I.: 0.84

Elev. of Retro: 38.26 m

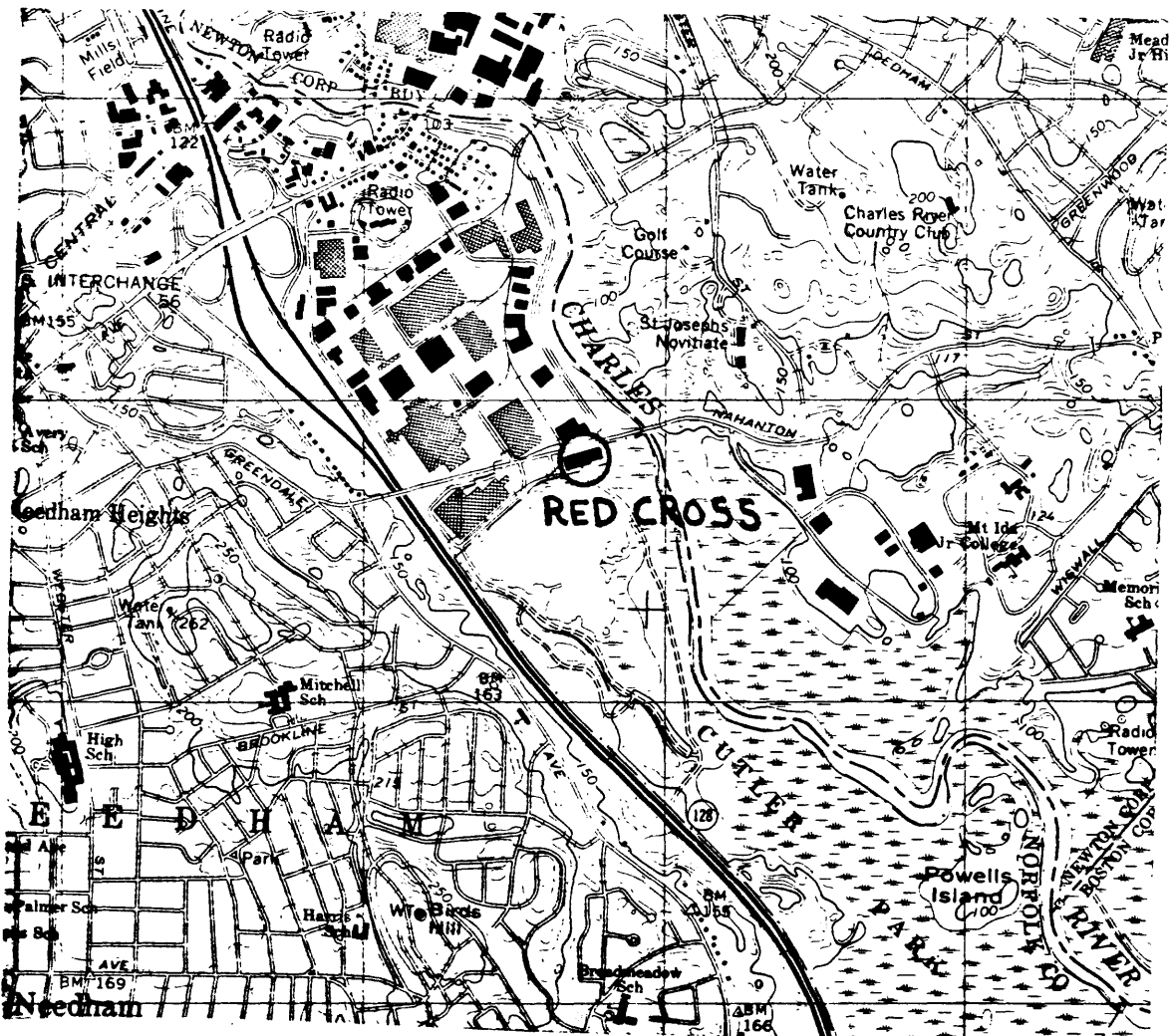
Retro: "M"

N. Line: Paint mark on edge of roof

Contact: Mr. Bob Phetteplace, Maint. Engineer 617-449-0773

Mr. Tim O'Connors

Work hours - 8:00 a.m.-4:00 p.m.



APPENDIX B.--Retroreflector Site Description--continued

Morses Pond (Doppler #69652)

Wellesley, intersection of State Routes 16 and 135, 0.5 mi. W. along 135, thence 0.5 mi. NW. along Weston St., thence 0.7 mi. SW. along Turner Rd. to end of pavement and Morses Pond pumping station.

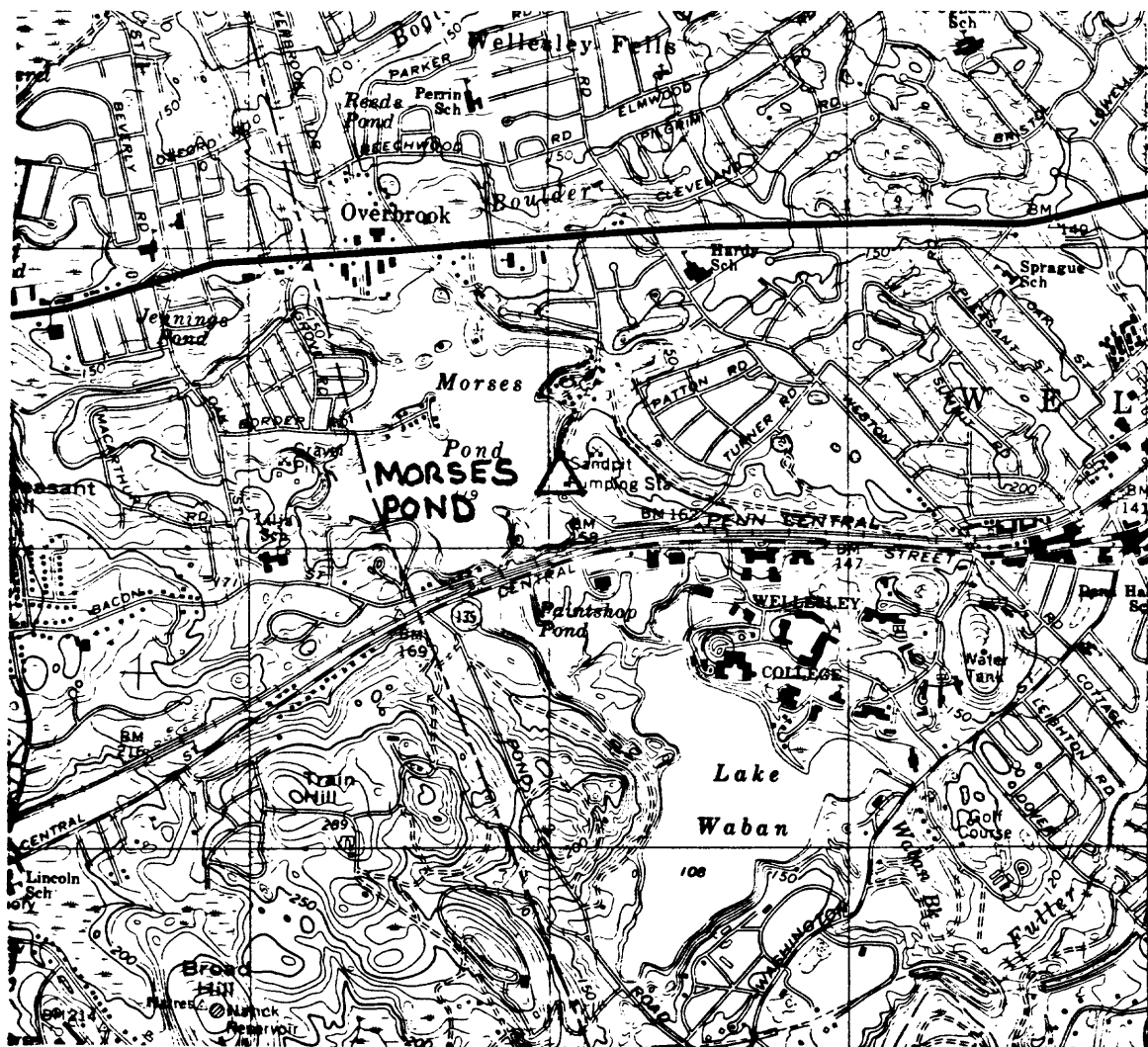
Sta. Mk.: 1/2-inch steel pipe (set 3/22/84)

Coords: N. 42 17 51.8353 W. 71 18 59.4481
Elev: 127.51 ft. 38.865 m
H.I.: 1.38 m
Elev. of Retro: 40.205
Retro: "R"

N. Line: Metal fence post - first one right of cedar

Contact: Mr. Joe Duggin, Wellesley Public Works Dept., 617-235-7600

NOTE: We have key to gate. Must return to Public Works Dept.



APPENDIX B.--Retroreflector Site Description--continued

Dedham (Doppler #69651)

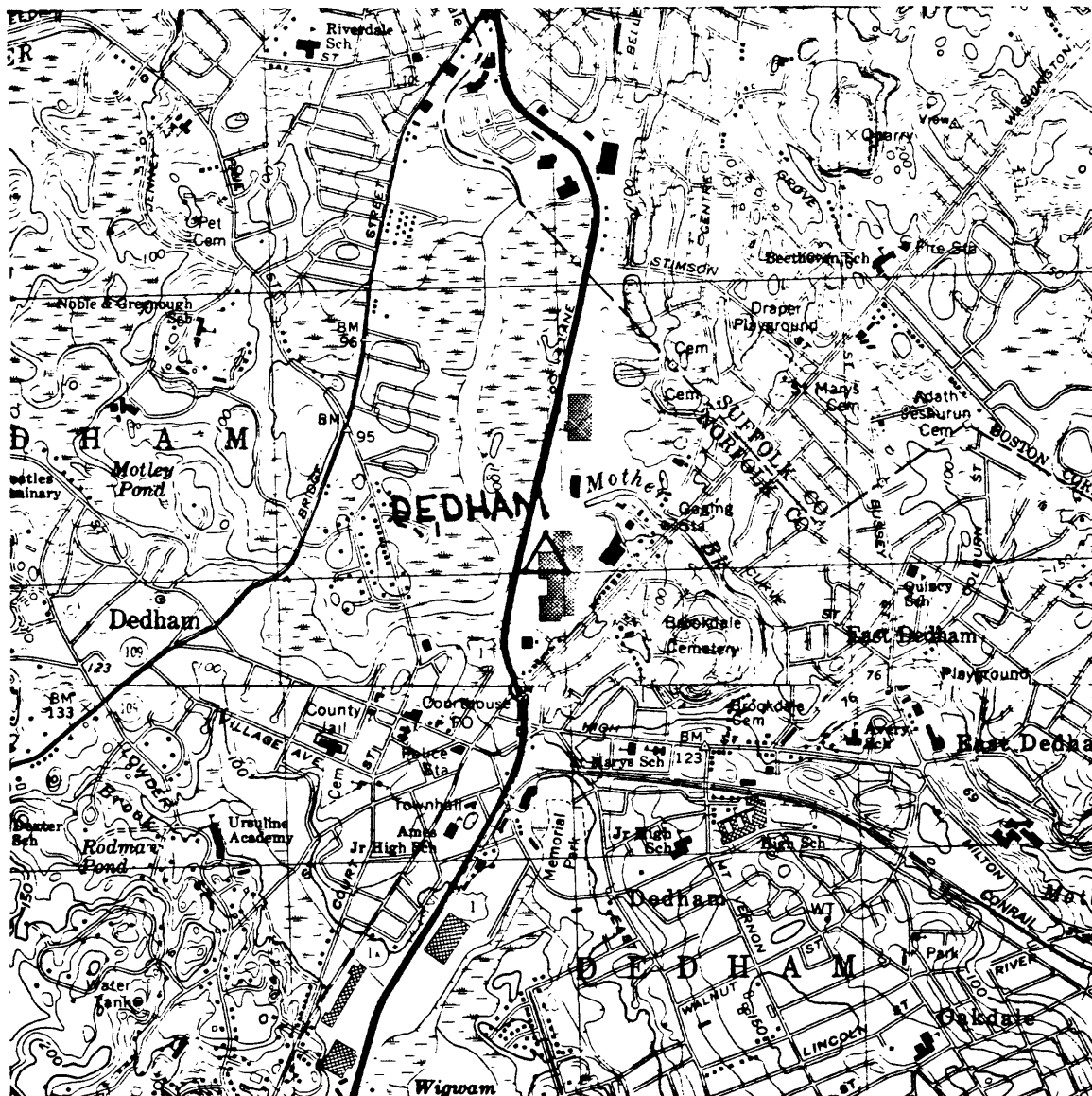
Station is located on the highest part of Dedham Shopping Center at NW. corner. Access is through offices located on 2nd floor of mall.

Sta. Mk.: Scraped "X", painted red, on SE. end of S. steel beam used to support air conditioning unit. 0.28 m W. of E. end of rail.

Coords: N. 42 15 14.9495 W. 71 10 13.1964
Elev: 131.47 ft. 40.072 m
H.I.: 0.03 m
Elev. of Retro: 40.098 m
Retro: "B"

N. Line: 3-inch vent pipe at N. edge of roof

Contact: Mr. Bill Porter, Flatly Company, offices on the 2nd floor of shopping center. 617-329-1210



APPENDIX B.--Retroreflector Site Description--continued

Wheelock School (Doppler #69653)

Medfield, intersection of State Routes 27 and 109, 0.25 mi. NE. along 109, thence 0.9 mi. S. along South St., thence 0.3 mi. E. along Elm St. to Wheelock Elem. School on right. Access to the roof is by inside ladder.

Sta. Mk.: Paint mark on drain cover approx. 20 ft. SW. of access ladder.
Ground Mk.: Copper nail and washer
Elev. 174.96 ft.

Coords: N. 42 10 27.9759 W. 71 17 26.8981
Elev: 197.28 ft. 60.13 m
H.I.: 0.85 m (original) 0.035 (4/13/84) (4/26/84)
(4/27/84)
Elev. of Retro: 60.48 m
Retro: "G" (4/13/84) "P" (4/26-27/84)

N. Line: Paint mark on edge of roof

Contact: Mr. Hogan, Supt. of Grounds 617-359-2302
Check with building custodian for key to roof access (Vinie)

NOTE: Only need to contact Mr. Hogan as a courtesy to let him know someone will be working at the school. His office is on Dale St. in Medfield at town school office complex.

