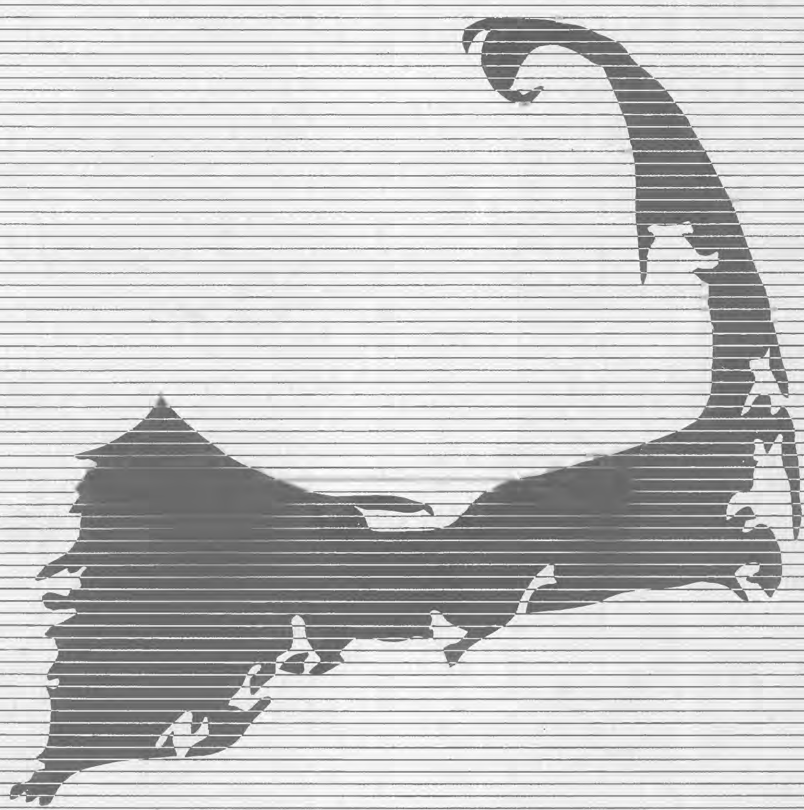
WATER-RESOURCES INVESTIGATIONS
83-4112

ESTIMATING HIGHEST GROUND-WATER LEVELS FOR CONSTRUCTION AND LAND USE PLANNING–
A CAPE COD, MASSACHUSETTS, EXAMPLE



PREPARED BY
UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Falmouth Enterprise 8/25/81

Reducing Guesswork In Ground Water Study

The U.S. Geological Survey (USGS) has removed a lot of the guesswork for determining ground water levels before installation of septic systems.

A new formula has been devised by USGS scientists to predict with up to 90 percent accuracy how much the ground water level will fluctuate anywhere on Cape Cod.

"The idea is based on the concept that what is happening to the water table in one place is happening in other places as well," USGS sub-district chief Michael H. Frimpter told a gathering of some 40 engineers and other professionals at a workshop yesterday at Cape Cod Community College.

"If we know what is happening (to the water level) in our observation well, we know what happens at another site where there is no well and where we're going to put in a septic system," Mr. Frimpter explained.

The information can be vital because the state Sanitary Code, Title Five, requires that septic system leaching fields be at least four feet above maximum ground water level.

The scientists proved out their theory with considerable observations taken at 13 "index" observation wells the USGS has maintained at various locations on the Cape for the last several years in addition to "more than four thousand observations taken at 149 additional, short-term wells," Mr. Frimpter said.

Money From USGS

Money for the additional wells was provided by the Survey, and the study was carried out by the USGS scientists with the cooperation of the state Department of Environmental Quality Engineering (DEQE) and the Cape Cod Planning and Economic Development Commission.

Also present with Mr. Frimpter at the workshop were Ivan C. James II, New England district chief of the USGS; Scott Horsley, the planning commission's water resources coordinator, and the commission's water resources planner, Mark Fouhy.

Each contributed to the discussion and the question and answer period that followed.

Mr. Fouhy said charts and data for each of the Cape's 15 towns have been sent to the health agents in those towns. "They have the information," he said, "But they're waiting for the engineers to use it."

Mr. Frimpter said the Cape's ground water level fluctuates. In areas near the coast, he said, "the change is small, from zero to two feet, but in the central part of the Cape, the fluctuation can be as much as five feet."

This would seem to indicate that the four feet requirement of Title Five is too stringent in some areas, but Mr. Frimpter said that DEQE has not indicated any intention of backing down on the limit yet.

He said he had talked to DEQE regional engineer Paul T. Anderson. "we discussed our system at some length," Mr. Frimpter said, "and he said 'Go ahead and use it.'"

When Level Is Highest

Mr. Frimpter said extensive observations made at wells by the scientists disclosed that the Cape's water table is at its highest level—closest to the ground surface—in the spring and winter.

"But this is not caused because it rains more in the spring and winter. It's caused by the plants using up all the water supply in the summer," he said, when the Cape's level is at its lowest.

On a master chart, the scientists broke the Cape down to five different zones, of varying ground water levels.

Each zone has an observation well from which data relative to the ground water level fluctuations apply to any site within that zone at any time of the year.

Thus, a resident planning to dig a septic system can find out by asking the local health agent what the maximum ground water level is at the location to assure that the system is four feet above that level and will function properly.

Mr. Frimpter confessed early in the workshop that the idea for the study was given to him by the planning commission's former water resources coordinator Paula Magnuson.

"Paula asked me one day, 'Why can't you do something to predict water levels?' and that's how it all began," Mr. Frimpter said.

ESTIMATING HIGHEST GROUND-WATER LEVELS FOR CONSTRUCTION AND LAND USE PLANNING—A CAPE COD, MASSACHUSETTS, EXAMPLE

BY

MICHAEL H. FRIMPTER AND MARTHA N. FISHER

U.S. GEOLOGICAL SURVEY
WATER-RESOURCES INVESTIGATIONS 83-4112

September 1983

UNITED STATES DEPARTMENT OF THE INTERIOR

JAMES G. WATT, *SECRETARY*

GEOLOGICAL SURVEY

Dallas L. Peck, *Director*

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U.S. Geological Survey
150 Causeway Street, Suite 1001
Boston, MA 02114

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ILLUSTRATIONS

(Plates are in pocket)

TABLES

METRIC CONVERSION FACTORS

The following factors may be used to convert inch-pounds to the International System of Units (SI).

Multiply	By	To obtain
inch (in)	2.540	centimeter (cm)
	0.254	decimeter (dm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)

ESTIMATING HIGHEST GROUND-WATER LEVELS FOR CONSTRUCTION AND LAND USE PLANNING–A CAPE COD, MASSACHUSETTS, EXAMPLE

BY
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ABSTRACT

High ground-water level is one major cause of septic-system failures, wet basements, and other serious problems for suburban and rural residents. A technique for estimating the level to which ground water can rise as a consequence of weather and seasonal factors has been developed to assist the homebuilding industry and health officials who design, construct, or regulate septic systems. Water-level records from about 160 sites were used to make four maps of annual water-level ranges: 0-2 feet, 2-3 feet, 3-4 feet, 4-5 feet, and 5-6 feet. Nine observation wells with 16 or more years of record were used to index water-level fluctuations throughout Cape Cod. To estimate high water levels, measurements of the current depth to water at test sites are cross referenced with current depth to water in the index wells.

This report uses septic-system regulations on Cape Cod, Massachusetts, as an example. The technique can also be used at potential building construction sites and other places where estimates of highest ground-water levels are needed.

The technique assumes good correlations between water-level fluctuations at septic-system sites and the index wells. Eighty-seven percent of the correlation coefficients determined from correlating water-level fluctuations from 146 sites with water-level fluctuations in the index wells were greater than 0.8.

INTRODUCTION

Problems with High Ground-Water Levels

High ground-water levels are a major cause of septic-system failures, wet basements, and other problems for suburban and rural residents. For example, unexpectedly high ground-water levels may flood septic system, causing sewage to back up in the system, break out at land surface, produce obnoxious odors, and devalue property (fig. 1). Persons who come in contact with untreated sewage may be exposed to bacterial and viral diseases such as infectious hepatitis, dysentery, and diarrhea.

This report presents an estimating technique that could be employed, with certain adaptations, almost anywhere that high ground-water levels in sedimentary deposits may present construction planning problems such as design and safe use of septic tank drain fields, and design of foundations, basements, and roadways. Conditions leading to these problems could be anticipated during design phases of construction. The guide can be used during any season of the year, thus eliminating the need to restrict water-level measurements to the spring. It can thereby relieve builders, construction engineers, and health officials of seasonal restrictions on site testing in many situations. Transfer of the technique to other areas of relatively uniform climate, weather, and hydrologic conditions may only require analysis of available data from geologic maps and observation well networks.

Although the report uses septic-system design as an example, the technique also applies to potential building sites and other places where estimates of highest ground-water levels are needed. To avoid septic-system failure caused by high ground-water levels, the U.S. Public Health Service (1969) and the Massachusetts Department of Environmental Quality Engineering (1977) have recommended that the bottoms of domestic septic systems be at least 4 feet above the maximum elevation of the water table. The aerated soil between the bottom of the septic system and the water table acts as a safety zone against flooding and also provides physical, chemical, and microbial treatment of the sewage to convert the constituents into less noxious forms. Accurate estimates of high ground-water levels are, therefore, necessary for the design of effective septic systems.

Photograph courtesy of Soil Conservation Service,
U.S. Department of Agriculture

Septic test regs disgruntle some

Yarmouth builders wait for 'high time'

By Fran Gilpin

Yarmouth is not the strictest town on the Cape when regulating groundwater testing for installation of subsurface septic systems. But the recurrence of dissatisfied pleas heard around the community from building contractors, engineers and real estate agents about the town's amendments to Title V of the state sanitary code would almost make one think otherwise.

"I'm totally unaware of any specific complaints," said Ralph Cipolla, who headed ... e selectmen's health bo... s created last fa... ntil a new independe... rumor, a ... but you ...

building industry was generally favorable to Title V in the beginning since it brought a semblance of uniformity to town government building codes. When each town began going off in six different directions from Sunday, however, the tradesmen lost their enthusiasm for Title V.

"The uniformity was gone," said Johnson, "and that's when I had to object to what the Yarmouth Board of Health was doing. I also thought D... (Karnes, the then-health officer) was rushing it. We... Title V, stan... ...itself, would...

"The Register" 5/28/81

Figure 1. Septic system breakout and newspaper article.

Ground-Water Levels Vary with Time and Location

Ground-water levels can fluctuate several feet in response to weather and the changing seasons. A single water-level measurement, while easily obtained, will rarely represent the extreme ground-water levels. During the warm months of summer when evaporation and transpiration rates are high, water levels decline, reaching their lowest levels in late fall (fig. 2). During the winter months, water levels rise and commonly reach their peaks following the melting of snow and ice in March and April. Recognizing this seasonal variation in water levels, some public health agencies have decided to only accept water levels measured during winter and spring for septic-system permit applications.

Other factors cause fluctuations in water level as well. A drought, such as that experienced during the mid-1960s may cause water levels to drop several feet below normally observed levels. Above-average precipitation, such as occurred in the early 1970s, may cause water levels to rise higher than usual.

Hydrologic location also affects water-level range. Generally, the range is smallest near the ocean, and its bays, estuaries, or salt marshes. For example, observation well SDW 252, 0.3 miles from Cape Cod Bay, showed a range of only 2.6 feet; while well SDW 253, 6 miles from Cape Cod Bay, showed a range of 9.3 feet over the same 13-year period (fig. 3).

Explanation of the Technique

Weather and climate, which control ground-water recharge and evapotranspiration, are relatively uniform over all of Cape Cod. Also, most of Cape Cod consists of sandy deposits that have relatively uniform hydrologic properties, and water levels on the Cape are expected to respond similarly to similar hydrologic stresses. Because of these conditions, water-level changes at one location can be used to estimate water-level changes at other locations on Cape Cod.

The technique depends on maps of the annual range of water levels and is based on the assumption that water-level fluctuations at a septic system test site may be referenced to water-level fluctuations in index wells (fig. 4). Five zones of annual ranges of water levels (0-2 feet, 2-3 feet, 3-4 feet, 4-5 feet, and 5-6 feet) are mapped in color on the basis of water-level records from about 160 sites (plates 1-4). Periods of record for these 160 sites varied but the water-level range at a particular site, for the site's period of record, was within the annual range of the zone mapped. Areas where water levels best correlate with each of nine index wells are delineated on the maps by dashed-line boundaries (plates 1-4). The close similarity of water levels shown for two locations almost 30 miles apart on opposite sides of Cape Cod Bay is evidence of good correlation. Water levels from 146 wells correlate well with levels from the nine index wells; 87 percent of the correlation coefficients were greater than 0.8 out of a possible 1.0. Water levels from the nine index wells with 16 to 28 years of record were also used to develop tables of potential water-level rise for each index well (tables 1-9). The tables are matrices of water-level-adjustment values to be applied to water-level measurements from the test sites. Because the periods of record for the index wells generally exceed those for wells used to map the zones of annual ranges of ground-water level, values of potential water-level rise shown in the tables may exceed the ranges of the zones.

Because the water-level records for the index wells span the period of the highest (1972) and lowest (1965) annual precipitation recorded at Hyannis on Cape Cod over an 86-year period, the adjustment tables are considered representative of the ground-water level extremes during that 86-year period. Also, a test of the technique for 49 sites showed that over a 5-year period water levels exceeded the estimated high water level at only 8 percent of the sites, and the errors were less than 0.75 foot.

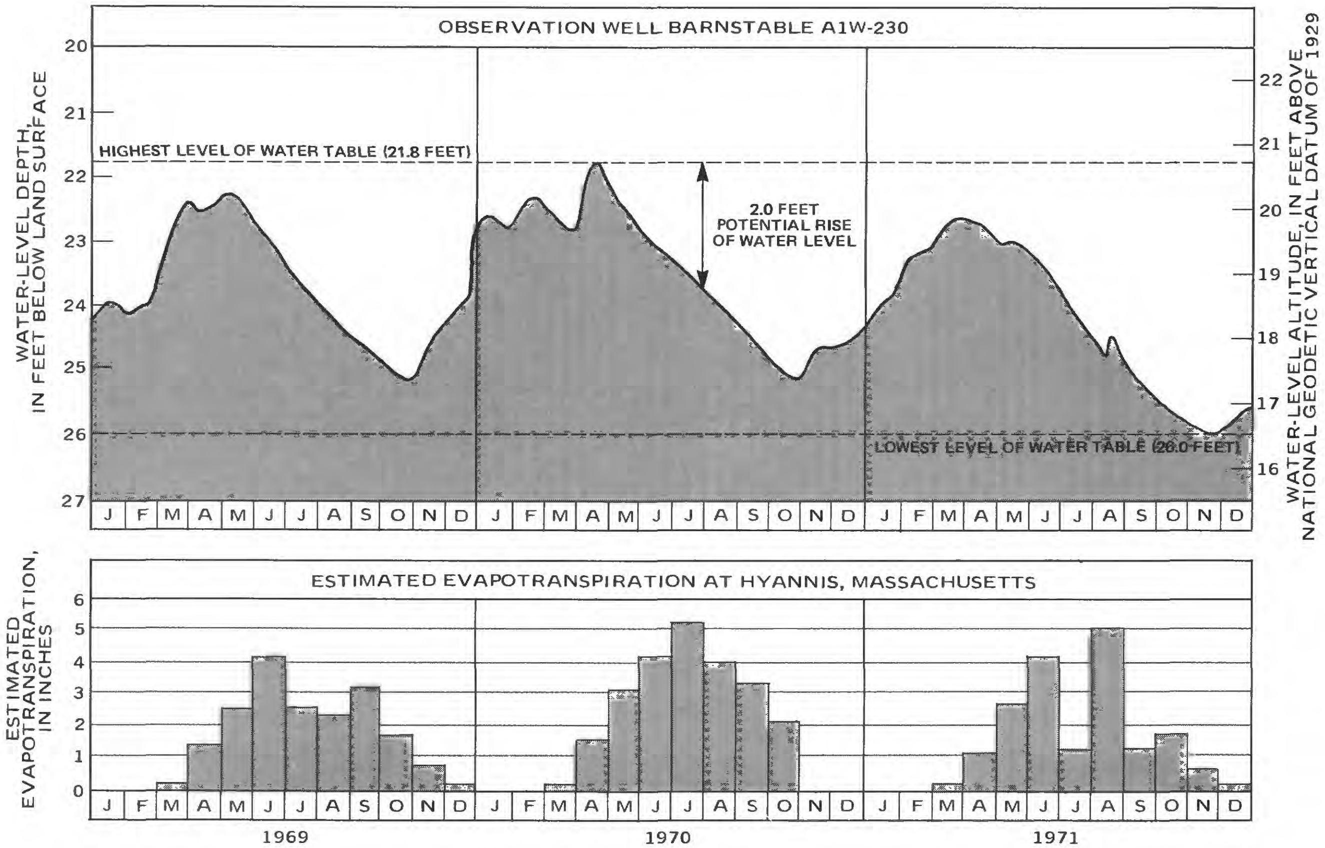


Figure 2. Seasonal water-level fluctuations and potential water-level rise.

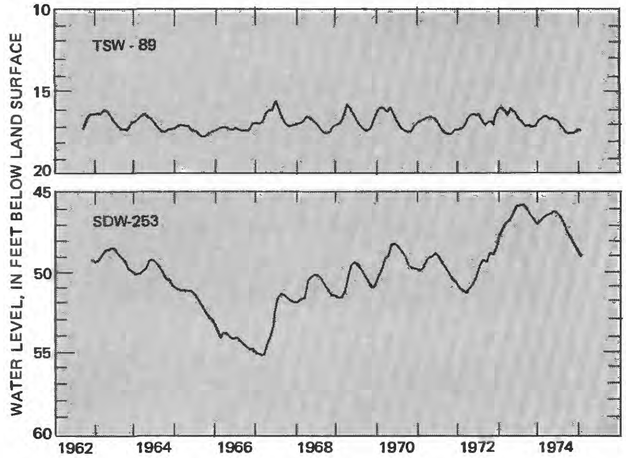


Figure 3. Water-level fluctuations in wells at 0.3 miles (TSW-89) and 6 miles (SDW-253) from Cape Cod Bay.

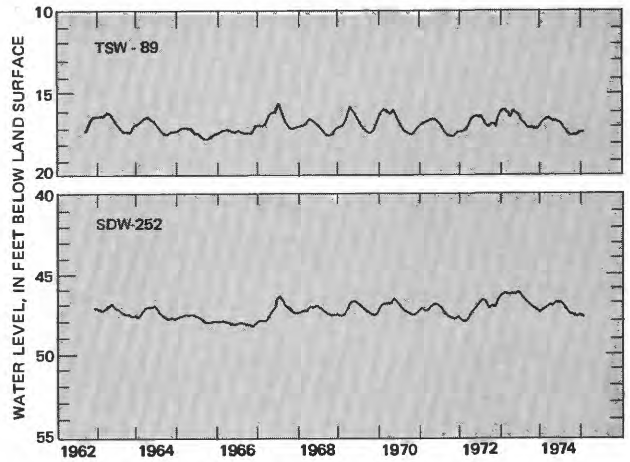


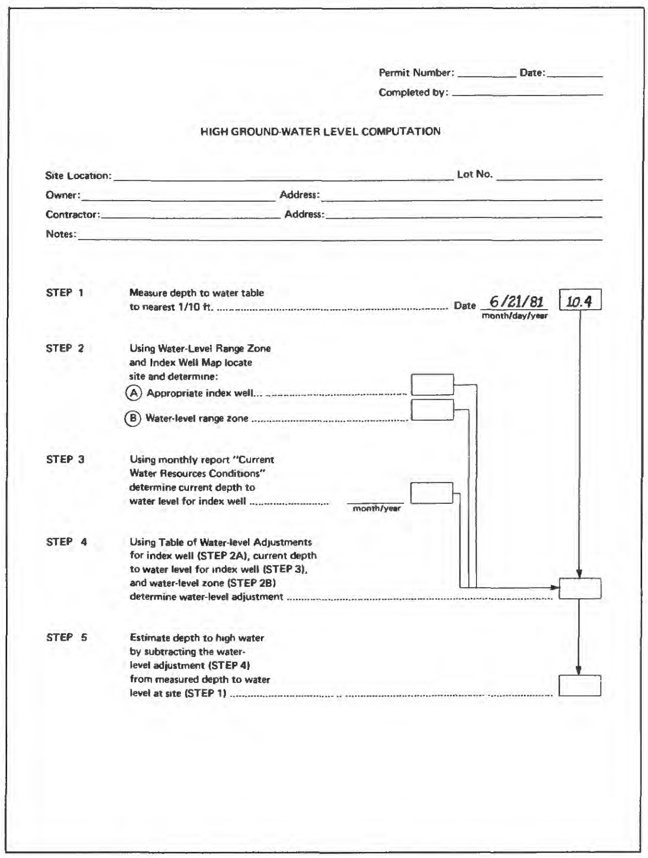
Figure 4. Similarity of water-level fluctuations in two wells about 28 miles apart but close to cape Cod Bay.

HOW TO ESTIMATE HIGH GROUND-WATER LEVELS

Step 1. Measure Depth to Water at the Test Site

Measure the depth to water below the land surface and record on computation form (fig. 5.) Make measurement to the nearest one-tenth of a foot (fig. 6). Take note of soil conditions. Sites should be inspected for layers of silt, clay, or till prior to attempting to estimate water levels. This technique is valid only in sand and gravel.

On June 21, 1981, the depth to water was 10.4 feet.


Permit Number: ______ Date: ______
Completed by: ______

HIGH GROUND-WATER LEVEL COMPUTATION

Site Location: ______ Lot No. ______
Owner: ______ Address: ______
Contractor: ______ Address: ______
Notes: ______

STEP 1 Measure depth to water table to nearest 1/10 ft. .... Date 6/21/81 (month/day/year) [10.4]

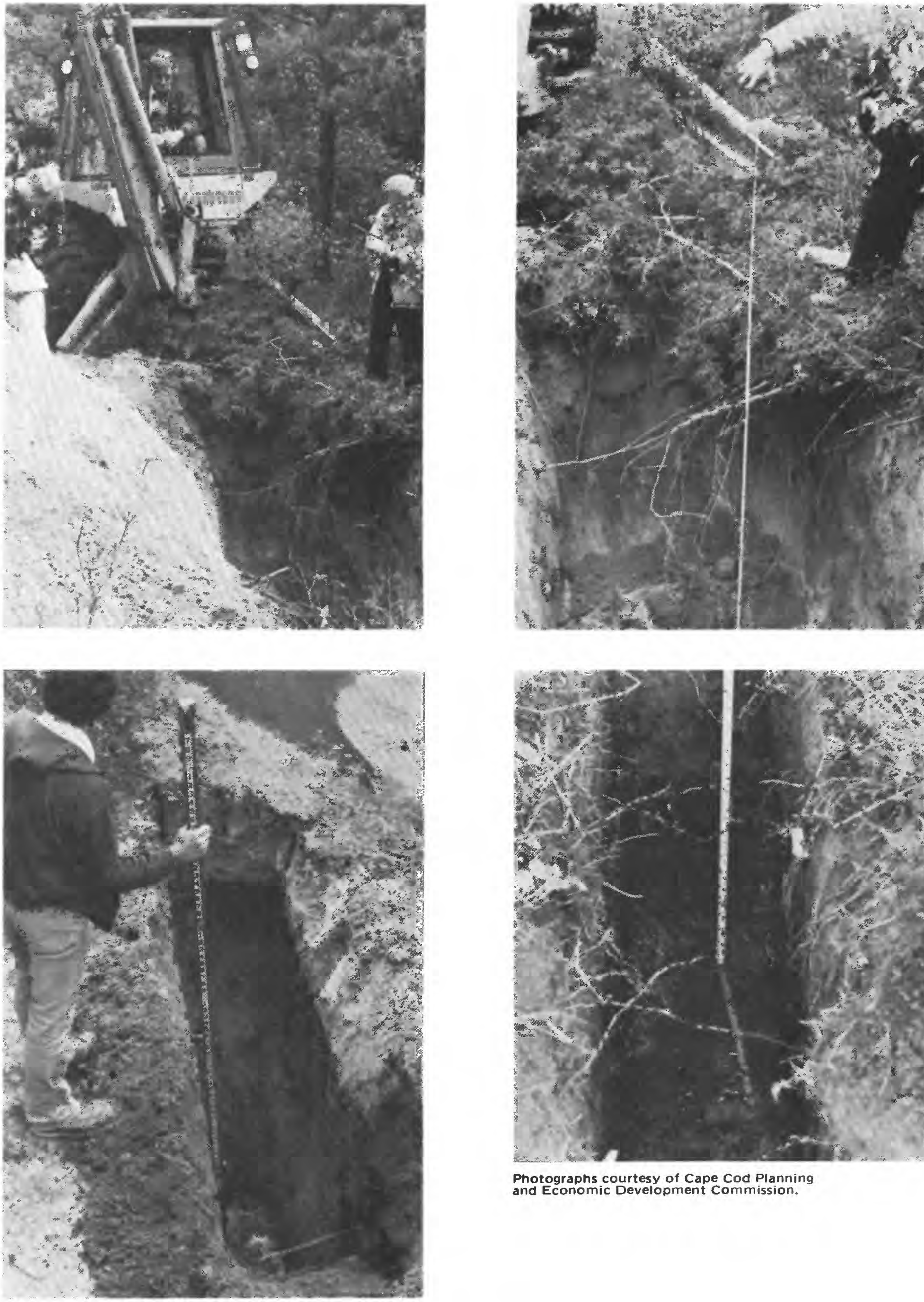
STEP 2 Using Water-Level Range Zone and Index Well Map locate site and determine:
(A) Appropriate index well........
(B) Water-level range zone........

STEP 3 Using monthly report "Current Water Resources Conditions" determine current depth to water level for index well .... month/year

STEP 4 Using Table of Water-level Adjustments for index well (STEP 2A), current depth to water level for index well (STEP 3), and water-level zone (STEP 2B) determine water-level adjustment ....

STEP 5 Estimate depth to high water by subtracting the water-level adjustment (STEP 4) from measured depth to water level at site (STEP 1) ....

Figure 5. Computation form, step 1.



Photographs courtesy of Cape Cod Planning and Economic Development Commission.

Figure 6. Measuring depth to water.

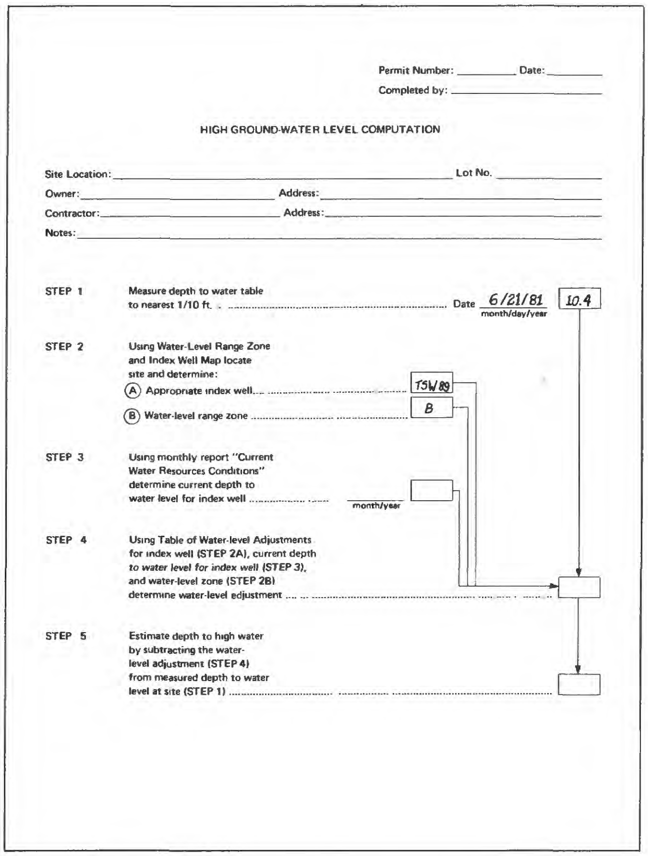
Step 2. Identify the Representative Index Well and Annual Water-Level Range for the Test Site

Locate the test site on the "Annual Ranges of Ground-Water Level and Index-Well Areas for Cape Cod" maps (plates 1-4) accompanying this report. Figure 8 shows an example of locating a site on a plate. (In some areas of Cape Cod, this estimation procedure cannot be used owing to unsuitable soil such as silt and clay or till. These areas are not colored on the maps of this report.)

Step 2A. Determine the Appropriate Index Well for the Site (as in fig. 8) and enter the well number on computation form (fig. 7)

Step 2B. Determine the Annual Water-Level Range Zone in Which the Site is Located (fig. 8) and Enter the Zone Letter on Computation Form (fig.7)

Figure 8 shows that the (example) test site is in the area indexed to well TSW-89 and is in zone B.


Permit Number: ________ Date: ________
Completed by: ________

HIGH GROUND-WATER LEVEL COMPUTATION

Site Location: ________ Lot No. ________
Owner: ________ Address: ________
Contractor: ________ Address: ________
Notes: ________

STEP 1 Measure depth to water table to nearest 1/10 ft. .... Date 6/21/81 (month/day/year) [10.4]

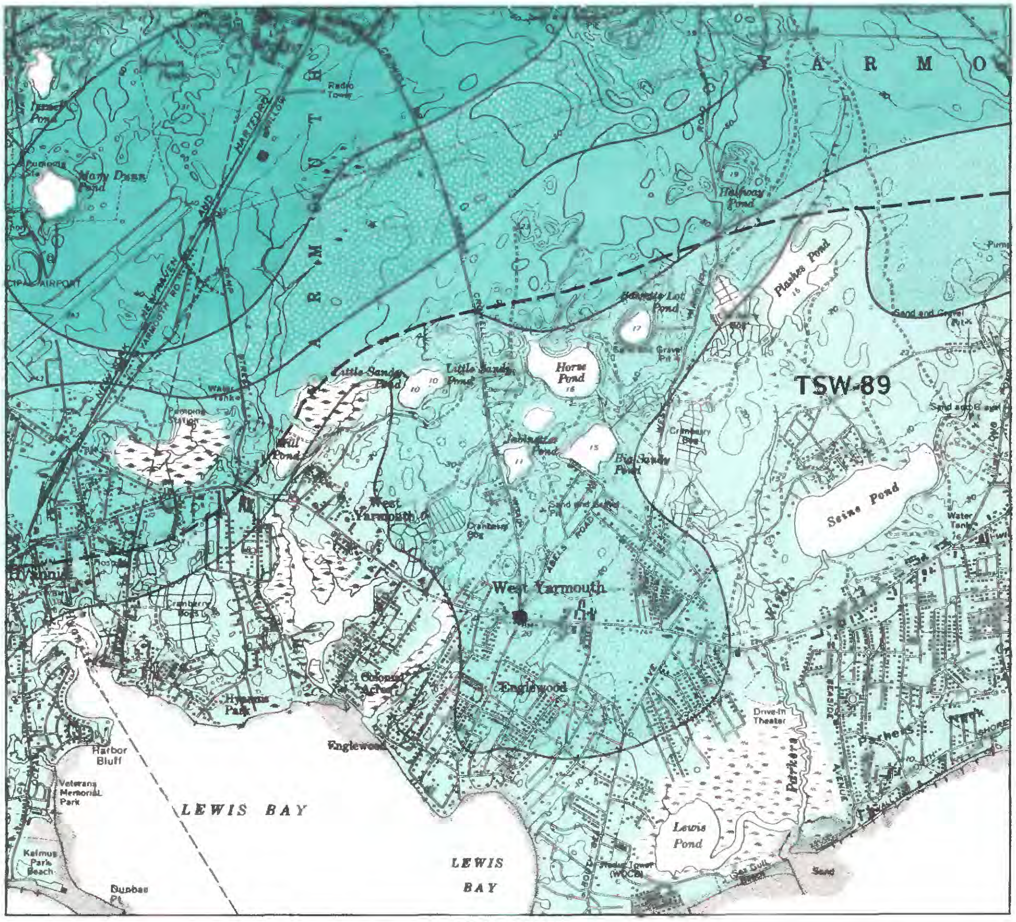
STEP 2 Using Water-Level Range Zone and Index Well Map locate site and determine:
(A) Appropriate index well........ [TSW 89]
(B) Water-level range zone .... [B]

STEP 3 Using monthly report "Current Water Resources Conditions" determine current depth to water level for index well .... ____ (month/year) [ ]

STEP 4 Using Table of Water-level Adjustments for index well (STEP 2A), current depth to water level for index well (STEP 3), and water-level zone (STEP 2B) determine water-level adjustment .... [ ]

STEP 5 Estimate depth to high water by subtracting the water-level adjustment (STEP 4) from measured depth to water level at site (STEP 1) .... [ ]

Figure 7. Computation form, step 2.



SCALE 1:48,000

0 1 2 3 MILES

0 1 2 3 4 KILOMETERS

CONTOUR INTERVAL 10 FEET
DATUM IS SEA LEVEL

EXPLANATION

Annual range of ground-water level, in feet

Zone	
A	0 - 2
B	2 - 3
C	3 - 4
D	4 - 5
E	5 - 6

TSW-89 **Index observation well to be used for area delineated by dashed line.**

● **Test site**

Figure 8. Example of map with site indicated.

Step 3. Determine Current Depth to Water Level for Index Well

The current depth to water level for the index well can be obtained from the U.S. Geological Survey report, "Current Water Resources Conditions in Central New England", which is issued each month by the U.S. Geological Survey [1]. Record the month and year and (index well) water level for the current depth to water in the index well on the computations form (fig. 9). Using the "Summary of Ground-Water Levels" table from that report (fig. 10), determine the depth to water in the appropriate index well that was recorded in STEP 2 for the month in which depth to water was measured at the test site. Figure 10 shows that in June 1981 the water level in well TSW-89, the index well for this area, was 12.20 feet below land surface.

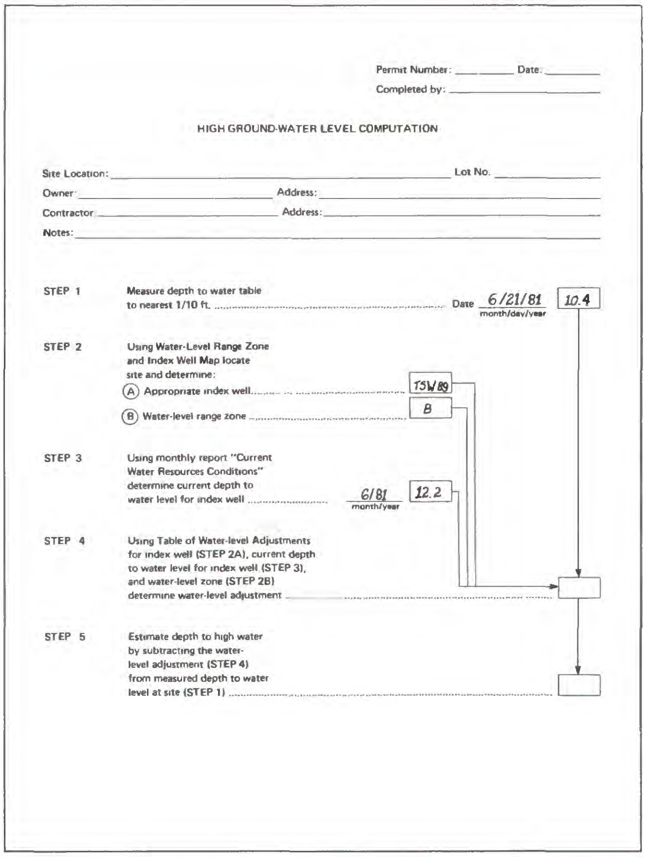


Figure 9. Computation form, step 3.

SUMMARY OF GROUND-WATER LEVELS. JUNE 1981 PROVISIONAL ***********

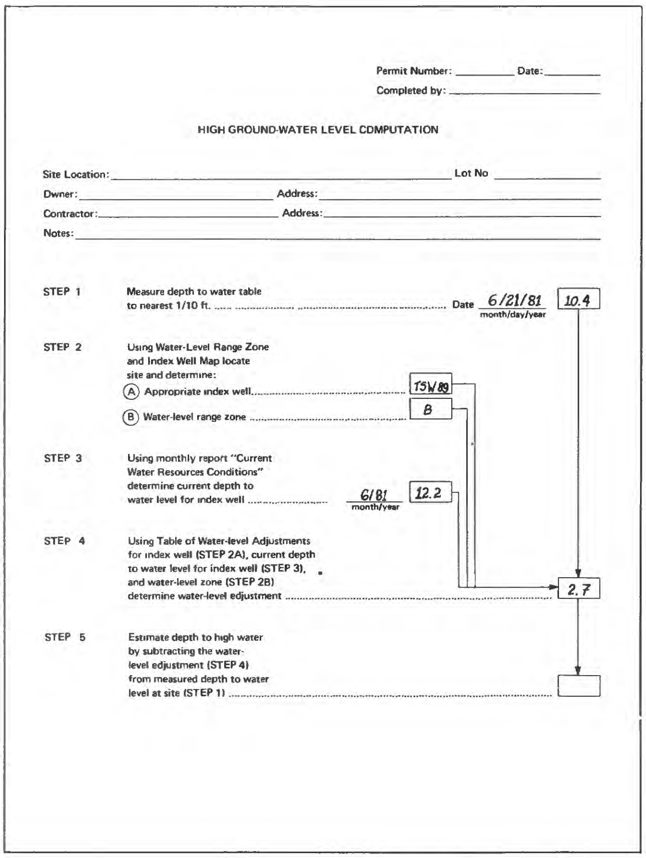
WELL	START OF RECORD	NET CHANGE IN MONTH (FEET)	NET CHANGE IN ONE YEAR (FEET)	DEPARTURE FROM JUNE AVERAGE (FEET)	WATER LEVEL BELOW LAND-SURFACE DATUM (FEET)
MASSACHUSETTS					
ACTON 158	1965	- 0.40	- 1.04	- 1.33	19.62
BARNSTABLE 230	1957	+ 0.18	- 0.61	- 1.06	24.26
BARNSTABLE 247	1962	- 0.16	- 1.59	- 2.19	26.04
BOURNE 198	1962	- 0.38	- 0.71	- 0.98	33.79
BREWSTER 21	1962	+ 0.01	- 2.39	- 2.64	11.99
CHATHAM 138	1962	+ 0.09	- 0.80	- 1.55	24.83 ##
DEDHAM 231	1965	- 2.47	- 0.45	- 1.22	8.97
DOVER 10	1965	- 0.24	- 0.93	- 1.38	33.84 ##
EAST BRIDGEWATER 30	1958	- 1.85	- 1.03	- 1.60	10.68
FREETOWN 23	1964	+ 0.03	- 1.42	- 1.53	14.47
GRANVILLE 5	1965	- 0.17	- 2.01	- 1.01	33.29
GREAT BARRINGTON 2	1951	- 2.88	+ 0.75	- 0.45	11.86
HAVERHILL 23	1960	- 0.79	+ 0.26	- 0.30	12.12
LOWELL 14	1939	- 1.39	- 0.81	- 0.96	13.03
MONTAGUE 5	1942	- 1.28	- 1.60	- 1.01	4.61
NORTHBOROUGH 38	1962	- 0.68	+ 0.35	+ 0.18	6.04
NORTHBRIDGE 1	1965	- 0.30	- 0.13	- 0.22	3.13
PITTSFIELD 51	1963	- 1.34	0.0	- 0.77	16.17
PLYMOUTH 22	1956	0.0	- 1.83	- 2.95	26.36
SANDWICH 252	1962	- 0.09	- 0.15	- 0.51	47.55
SANDWICH 253	1962	- 0.16	- 1.39	- 1.97	51.13
STERLING 1	1947	+ 0.53	+ 2.78	+ 2.17	3.10 #
TRURO 89	1962	- 0.09	+ 0.14	- 0.24	12.20
WELLFLEET 17	1962	- 0.22	- 0.28	- 1.36	11.10
WENHAM 76	1965	- 0.63	- 0.20	- 0.16	3.25
WEST BROOKFIELD 10	1970	- 2.06	+ 1.79	+ 0.77	5.96
WEYMOUTH 2	1965	- 2.71	- 1.99	- 3.58	15.28 ##
WILMINGTON 78	1951	- 0.40	+ 0.19	- 0.03	8.05
WINCHENDON 13	1939	- 1.71	+ 1.97	+ 0.96	5.33
WINCHESTER 14	1940	- 1.68	- 0.68	- 0.76	11.93

Figure 10. Sample table from "Current Water Resources Conditions in Central NewEngland".

[1] The U.S. Geological Survey report, "Current Water Resources Conditions in Central New England" is available from: U.S. Geological Survey, 150 Causeway St., Suite 1001, Boston, MA 02114, and from Cape Cod Planning and Economic Development Commission, Barnstable County Courthouse, Barnstable, MA 02630.

Step 4. Determine Water-Level Adjustment

Refer to the water-level-adjustment table, "Potential Water-Level Rise, in feet, for Use With Index Well...", (tables 1-9) in the back of this report for the appropriate index well (recorded in STEP 2A). Record the water-level adjustment value on the computation form (fig. 11). To determine the correct water-level adjustment, locate the current water level for the index well in the left-hand column of the water-level adjustment table (fig. 12). Then read from left to right on the same horizontal row to the column of adjustment values for the zone recorded in STEP 2B. Figure 12 shows the water-level adjustment for the (sample) test site is 2.7 feet.



Permit Number: ________ Date: ________
Completed by: ________

HIGH GROUND-WATER LEVEL COMPUTATION

Site Location: ________ Lot No ________
Owner: ________ Address: ________
Contractor: ________ Address: ________
Notes: ________

STEP 1 Measure depth to water table to nearest 1/10 ft. .... Date 6/21/81 (month/day/year) [10.4]

STEP 2 Using Water-Level Range Zone and Index Well Map locate site and determine:
(A) Appropriate index well .... [TSW89]
(B) Water-level range zone .... [B]

STEP 3 Using monthly report "Current Water Resources Conditions" determine current depth to water level for index well .... 6/81 (month/year) [12.2]

STEP 4 Using Table of Water-level Adjustments for index well (STEP 2A), current depth to water level for index well (STEP 3), and water-level zone (STEP 2B) determine water-level adjustment .... [2.7]

STEP 5 Estimate depth to high water by subtracting the water-level adjustment (STEP 4) from measured depth to water level at site (STEP 1) .... [ ]

Figure 11. Computation form, step 4.

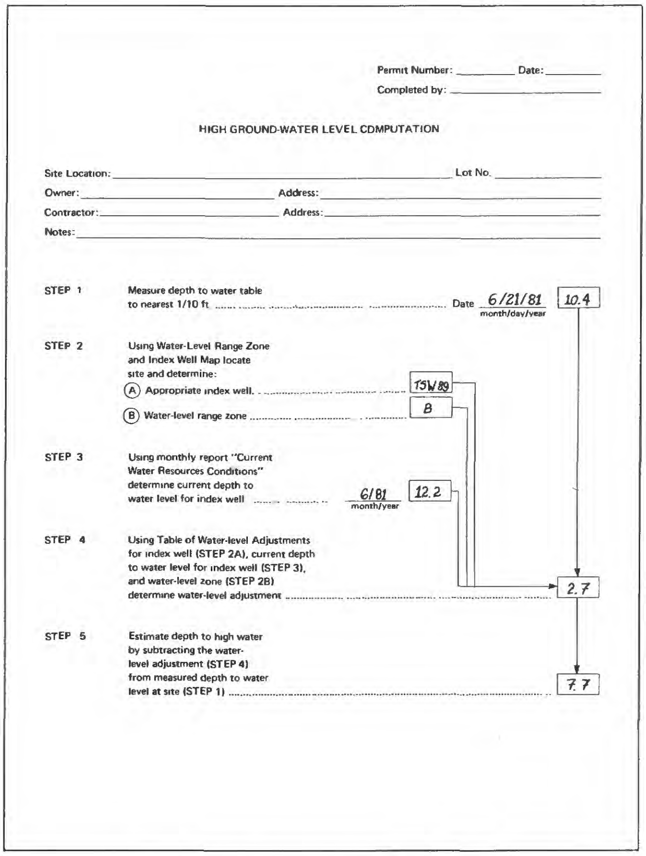
Potential water-level rise, in feet,
for use with index well Truro TSW-89

Water level in well (in feet below land surface)	Zone A	Zone B	Zone C
10.4	0.0	0.0	0.0
10.5	.1	.1	.2
10.6	.2	.3	.4
10.7	.3	.4	.6
10.8	.4	.6	.8
10.9	.5	.7	1.0
11.0	.6	.9	1.2
11.1	.7	1.0	1.4
11.2	.8	1.2	1.6
11.3	.9	1.3	1.8
11.4	1.0	1.5	2.0
11.5	1.1	1.6	2.2
11.6	1.2	1.8	2.4
11.7	1.3	1.9	2.6
11.8	1.4	2.1	2.8
11.9	1.5	2.2	3.0
12.0	1.6	2.4	3.2
12.1	1.7	2.5	3.4
12.2	1.8	2.7	3.6
12.3	1.9	2.8	3.8
12.4	2.0	3.0	4.0
12.5	2.1	3.1	4.2
12.6	2.2	3.3	4.4
12.7	2.3	3.4	4.6
12.8	2.4	3.6	4.8
12.9	2.5	3.7	5.0
13.0	2.6	3.9	5.2

Figure 12. Example of water-level adjustment table.

Step 5. Estimate Depth to High Water Level at Site

Using the computation form (fig. 14), subtract the water-level-adjustment value determined in STEP 4 from the measured depth to water at the site recorded in STEP 1 to obtain the estimate of depth to high water level and record on the computation form (fig. 13). Figure 13 shows the estimated depth to high water level at the (sample) test site is 7.7 feet below the land surface.


Permit Number: ________ Date: ________
Completed by: ________________

HIGH GROUND-WATER LEVEL COMPUTATION

Site Location: ______________________ Lot No. ________
Owner: ______________ Address: ______________
Contractor: ______________ Address: ______________
Notes: ______________________________

STEP 1 Measure depth to water table to nearest 1/10 ft .... Date 6/21/81 (month/day/year) [10.4]

STEP 2 Using Water-Level Range Zone and Index Well Map locate site and determine:
(A) Appropriate index well. .... [T5W 89]
(B) Water-level range zone .... [B]

STEP 3 Using monthly report "Current Water Resources Conditions" determine current depth to water level for index well .... 6/81 (month/year) [12.2]

STEP 4 Using Table of Water-level Adjustments for index well (STEP 2A), current depth to water level for index well (STEP 3), and water-level zone (STEP 2B) determine water-level adjustment .... [2.7]

STEP 5 Estimate depth to high water by subtracting the water-level adjustment (STEP 4) from measured depth to water level at site (STEP 1) .... [7.7]

Figure 13. Computation form, step 5.

Permit Number: __________ Date: __________

Completed by: ______________________________

HIGH GROUND-WATER LEVEL COMPUTATION

Site Location: ______________________________ Lot No. __________

Owner: ______________________ Address: ______________________________

Contractor: ______________________ Address: ______________________________

Notes: ____

STEP 1 — Measure depth to water table to nearest 1/10 ft. .... Date __________ (month/day/year) [ ]

STEP 2 — Using Water-Level Range Zone and Index Well Map locate site and determine:

- (A) Appropriate index well .... [ ]
- (B) Water-level range zone .... [ ]

STEP 3 — Using monthly report "Current Water Resources Conditions" determine current depth to water level for index well .... __________ (month/year) [ ]

STEP 4 — Using Table of Water-level Adjustments for index well (STEP 2A), current depth to water level for index well (STEP 3), and water-level zone (STEP 2B) determine water-level adjustment .... [ ]

STEP 5 — Estimate depth to high water by subtracting the water-level adjustment (STEP 4) from measured depth to water level at site (STEP 1) .... [ ]

Figure 14. Suggested computation form.

SUMMARY

Ground-water levels can be estimated for sand and gravel areas of Cape Cod using the procedure outlined in this report. An estimate can be made based upon a water-level measurement taken at any season of the year. This method should not be applied in areas where layers of silt and clay or till are present.

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Table 1. Potential water-level rise, in feet, for use with index well Barnstable A1W-230.

Water level in well (in feet below land surface)	Zone A	Zone B	Zone C	Zone D	Zone E
21.1	0.0	0.0	0.0	0.0	0.0
21.2	.0	.1	.1	.1	.1
21.3	.1	.1	.2	.2	.3
21.4	.1	.2	.3	.4	.4
21.5	.2	.3	.4	.5	.6
21.6	.2	.4	.5	.6	.7
21.7	.3	.4	.6	.7	.9
21.8	.3	.5	.7	.9	1.0
21.9	.4	.6	.8	1.0	1.2
22.0	.4	.7	.9	1.1	1.3
22.1	.5	.7	1.0	1.2	1.5
22.2	.5	.8	1.1	1.4	1.6
22.3	.6	.9	1.2	1.5	1.8
22.4	.6	1.0	1.3	1.6	1.9
22.5	.7	1.0	1.4	1.7	2.1
22.6	.7	1.1	1.5	1.9	2.2
22.7	.8	1.2	1.6	2.0	2.4
22.8	.8	1.3	1.7	2.1	2.5
22.9	.9	1.3	1.8	2.2	2.7
23.0	.9	1.4	1.9	2.4	2.8
23.1	1.0	1.5	2.0	2.5	3.0
23.2	1.0	1.6	2.1	2.6	3.1
23.3	1.1	1.6	2.2	2.7	3.3
23.4	1.1	1.7	2.3	2.9	3.4
23.5	1.2	1.8	2.4	3.0	3.6
23.6	1.2	1.9	2.5	3.1	3.7
23.7	1.3	1.9	2.6	3.2	3.9
23.8	1.3	2.0	2.7	3.4	4.0
23.9	1.4	2.1	2.8	3.5	4.2
24.0	1.4	2.2	2.9	3.6	4.3
24.1	1.5	2.2	3.0	3.7	4.5
24.2	1.5	2.3	3.1	3.9	4.6
24.3	1.6	2.4	3.2	4.0	4.8
24.4	1.6	2.5	3.3	4.1	4.9
24.5	1.7	2.5	3.4	4.2	5.1
24.6	1.7	2.6	3.5	4.4	5.2
24.7	1.8	2.7	3.6	4.5	5.4
24.8	1.8	2.8	3.7	4.6	5.5
24.9	1.9	2.8	3.8	4.7	5.7
25.0	1.9	2.9	3.9	4.9	5.8
25.1	2.0	3.0	4.0	5.0	6.0
25.2	2.0	3.1	4.1	5.1	6.1
25.3	2.1	3.1	4.2	5.2	6.3
25.4	2.1	3.2	4.3	5.4	6.4
25.5	2.2	3.3	4.4	5.5	6.6
25.6	2.2	3.4	4.5	5.6	6.7
25.7	2.3	3.4	4.6	5.7	6.9
25.8	2.3	3.5	4.7	5.9	7.0
25.9	2.4	3.6	4.8	6.0	7.2
26.0	2.4	3.7	4.9	6.1	7.3
26.1	2.5	3.7	5.0	6.2	7.5
26.2	2.5	3.8	5.1	6.4	7.6
26.3	2.6	3.9	5.2	6.5	7.8
26.4	2.6	4.0	5.3	6.6	7.9
26.5	2.7	4.0	5.4	6.7	8.1
26.6	2.7	4.1	5.5	6.9	8.2
26.7	2.8	4.2	5.6	7.0	8.4

Table 2. Potential water-level rise, in feet, for use with index well Barnstable A1W-247.

Water level in well (in feet below land surface)	Zone A	Zone B	Zone C	Zone D
21.0	0.0	0.0	0.0	0.0
21.1	.1	.1	.1	.2
21.2	.1	.2	.3	.3
21.3	.2	.3	.4	.5
21.4	.3	.4	.5	.7
21.5	.3	.5	.7	.8
21.6	.4	.6	.8	1.0
21.7	.5	.7	.9	1.2
21.8	.5	.8	1.1	1.3
21.9	.6	.9	1.2	1.5
22.0	.7	1.0	1.3	1.7
22.1	.7	1.1	1.5	1.8
22.2	.8	1.2	1.6	2.0
22.3	.9	1.3	1.7	2.2
22.4	.9	1.4	1.9	2.3
22.5	1.0	1.5	2.0	2.5
22.6	1.1	1.6	2.1	2.7
22.7	1.1	1.7	2.3	2.8
22.8	1.2	1.8	2.4	3.0
22.9	1.3	1.9	2.5	3.2
23.0	1.3	2.0	2.7	3.3
23.1	1.4	2.1	2.8	3.5
23.2	1.5	2.2	2.9	3.7
23.3	1.5	2.3	3.1	3.8
23.4	1.6	2.4	3.2	4.0
23.5	1.7	2.5	3.3	4.2
23.6	1.7	2.6	3.5	4.3
23.7	1.8	2.7	3.6	4.5
23.8	1.9	2.8	3.7	4.7
23.9	1.9	2.9	3.9	4.8
24.0	2.0	3.0	4.0	5.0
24.1	2.1	3.1	4.1	5.2
24.2	2.1	3.2	4.3	5.3
24.3	2.2	3.3	4.4	5.5
24.4	2.3	3.4	4.5	5.7
24.5	2.3	3.5	4.7	5.8
24.6	2.4	3.6	4.8	6.0
24.7	2.5	3.7	4.9	6.2
24.8	2.5	3.8	5.1	6.3
24.9	2.6	3.9	5.2	6.5
25.0	2.7	4.0	5.3	6.7
25.1	2.7	4.1	5.5	6.8
25.2	2.8	4.2	5.6	7.0
25.3	2.9	4.3	5.7	7.2
25.4	2.9	4.4	5.9	7.3
25.5	3.0	4.5	6.0	7.5
25.6	3.1	4.6	6.1	7.7
25.7	3.1	4.7	6.3	7.8
25.8	3.2	4.8	6.4	8.0
25.9	3.3	4.9	6.5	8.2
26.0	3.3	5.0	6.6	8.3
26.1	3.4	5.1	6.8	8.5
26.2	3.5	5.2	6.9	8.7
26.3	3.6	5.3	7.0	8.9

Table 3. Potential water-level rise, in feet, for use with index well Bourne BHW-198.

Water level in well (in feet below land surface)	Zone A	Zone B	Zone C	Water level in well (in feet below land surface)	Zone A	Zone B	Zone C
30.4	0.0	0.0	0.0	33.4	2.0	3.0	4.0
30.5	.1	.1	.1	33.5	2.1	3.1	4.1
30.6	.1	.2	.3	33.6	2.1	3.2	4.3
30.7	.2	.3	.4	33.7	2.2	3.3	4.4
30.8	.3	.4	.5	33.8	2.3	3.4	4.5
30.9	.3	.5	.7	33.9	2.3	3.5	4.7
31.0	.4	.6	.8	34.0	2.4	3.6	4.8
31.1	.5	.7	.9	34.1	2.5	3.7	4.9
31.2	.5	.8	1.1	34.2	2.5	3.8	5.1
31.3	.6	.9	1.2	34.3	2.6	3.9	5.2
31.4	.7	1.0	1.3	34.4	2.7	4.0	5.3
31.5	.7	1.1	1.5	34.5	2.7	4.1	5.5
31.6	.8	1.2	1.6	34.6	2.8	4.2	5.6
31.7	.9	1.3	1.7	34.7	2.9	4.3	5.7
31.8	.9	1.4	1.9	34.8	2.9	4.4	5.9
31.9	1.0	1.5	2.0	34.9	3.0	4.5	6.0
32.0	1.1	1.6	2.1	35.0	3.1	4.6	6.1
32.1	1.1	1.7	2.3	35.1	3.1	4.7	6.3
32.2	1.2	1.8	2.4	35.2	3.2	4.8	6.4
32.3	1.3	1.9	2.5	35.3	3.3	4.9	6.5
32.4	1.3	2.0	2.7	35.4	3.3	5.0	6.6
32.5	1.4	2.1	2.8	35.5	3.4	5.1	6.8
32.6	1.5	2.2	2.9	35.6	3.5	5.2	6.9
32.7	1.5	2.3	3.1	35.7	3.6	5.3	7.0
32.8	1.6	2.4	3.2	35.8	3.6	5.4	7.2
32.9	1.7	2.5	3.3	35.9	3.7	5.5	7.3
33.0	1.7	2.6	3.5	36.0	3.8	5.6	7.4
33.1	1.8	2.7	3.6	36.1	3.8	5.7	7.6
33.2	1.9	2.8	3.7	36.2	3.9	5.8	7.7
33.3	1.9	2.9	3.9				

Table 4. Potential water-level rise, in feet, for use with index well Brewster BMW-21.

Water level in well (in feet below land surface)	Zone A	Zone B	Water level in well (in feet below land surface)	Zone A	Zone B
6.9	0.0	0.0	10.1	2.1	3.2
7.0	.1	.1	10.2	2.2	3.3
7.1	.1	.2	10.3	2.3	3.4
7.2	.2	.3	10.4	2.3	3.5
7.3	.3	.4	10.5	2.4	3.6
7.4	.3	.5	10.6	2.5	3.7
7.5	.4	.6	10.7	2.5	3.8
7.6	.5	.7	10.8	2.6	3.9
7.7	.5	.8	10.9	2.7	4.0
7.8	.6	.9	11.0	2.7	4.1
7.9	.7	1.0	11.1	2.8	4.2
8.0	.7	1.1	11.2	2.9	4.3
8.1	.8	1.2	11.3	2.9	4.4
8.2	.9	1.3	11.4	3.0	4.5
8.3	.9	1.4	11.5	3.1	4.6
8.4	1.0	1.5	11.6	3.1	4.7
8.5	1.1	1.6	11.7	3.2	4.8
8.6	1.1	1.7	11.8	3.3	4.9
8.7	1.2	1.8	11.9	3.3	5.0
8.8	1.3	1.9	12.0	3.4	5.1
8.9	1.3	2.0	12.1	3.5	5.2
9.0	1.4	2.1	12.2	3.6	5.3
9.1	1.5	2.2	12.3	3.6	5.4
9.2	1.5	2.3	12.4	3.7	5.5
9.3	1.6	2.4	12.5	3.8	5.6
9.4	1.7	2.5	12.6	3.8	5.7
9.5	1.7	2.6	12.7	3.9	5.8
9.6	1.8	2.7	12.8	4.0	5.9
9.7	1.9	2.8	12.9	4.0	6.0
9.8	1.9	2.9	13.0	4.1	6.1
9.9	2.0	3.0	13.1	4.2	6.2
10.0	2.1	3.1	13.2	4.2	6.3
			13.3	4.3	6.4

Table 5. Potential water-level rise, in feet, for use with index well Chatham CGW-138.

Water level in well (in feet below land surface)	Zone A	Zone B	Zone C	Zone D
21.1	0.0	0.0	0.0	0.0
21.2	.1	.1	.1	.2
21.3	.1	.2	.3	.3
21.4	.2	.3	.4	.5
21.5	.3	.4	.5	.7
21.6	.3	.5	.7	.8
21.7	.4	.6	.8	1.0
21.8	.5	.7	.9	1.2
21.9	.5	.8	1.1	1.3
22.0	.6	.9	1.2	1.5
22.1	.7	1.0	1.3	1.7
22.2	.7	1.1	1.5	1.8
22.3	.8	1.2	1.6	2.0
22.4	.9	1.3	1.7	2.2
22.5	.9	1.4	1.9	2.3
22.6	1.0	1.5	2.0	2.5
22.7	1.1	1.6	2.1	2.7
22.8	1.1	1.7	2.3	2.8
22.9	1.2	1.8	2.4	3.0
23.0	1.3	1.9	2.5	3.2
23.1	1.3	2.0	2.7	3.3
23.2	1.4	2.1	2.8	3.5
23.3	1.5	2.2	2.9	3.7
23.4	1.5	2.3	3.1	3.8
23.5	1.6	2.4	3.2	4.0
23.6	1.7	2.5	3.3	4.2
23.7	1.7	2.6	3.5	4.3
23.8	1.8	2.7	3.6	4.5
23.9	1.9	2.8	3.7	4.7
24.0	1.9	2.9	3.9	4.8
24.1	2.0	3.0	4.0	5.0
24.2	2.1	3.1	4.1	5.2
24.3	2.1	3.2	4.3	5.3
24.4	2.2	3.3	4.4	5.5
24.5	2.3	3.4	4.5	5.7
24.6	2.3	3.5	4.7	5.8
24.7	2.4	3.6	4.8	6.0
24.8	2.5	3.7	4.9	6.2
24.9	2.5	3.8	5.1	6.3
25.0	2.6	3.9	5.2	6.5
25.1	2.7	4.0	5.3	6.7
25.2	2.7	4.1	5.5	6.8
25.3	2.8	4.2	5.6	7.0
25.4	2.9	4.3	5.7	7.2
25.5	2.9	4.4	5.9	7.3
25.6	3.0	4.5	6.0	7.5
25.7	3.1	4.6	6.1	7.7
25.8	3.1	4.7	6.3	7.8
25.9	3.2	4.8	6.4	8.0
26.0	3.3	4.9	6.5	8.2
26.1	3.3	5.0	6.6	8.3
26.2	3.4	5.1	6.8	8.5

Table 6. Potential water-level rise, in feet, for use with index well Sandwich SDW-252.

Water level in well (in feet below land surface)	Zone A	Zone B	Water Level in well (in feet below land surface)	Zone A	Zone B
46.0	0.0	0.0	47.2	1.2	1.8
46.1	.1	.1	47.3	1.3	1.9
46.2	.2	.3	47.4	1.4	2.1
46.3	.3	.4	47.5	1.5	2.2
46.4	.4	.6	47.6	1.6	2.4
46.5	.5	.7	47.7	1.7	2.5
46.6	.6	.9	47.8	1.8	2.7
46.7	.7	1.0	47.9	1.9	2.8
46.8	.8	1.2	48.0	2.0	3.0
46.9	.9	1.3	48.1	2.1	3.1
47.0	1.0	1.5	48.2	2.2	3.3
47.1	1.1	1.6			

Table 7. Potential water-level rise, in feet, for use with index well Sandwich SDW-253.

Water level in well (in feet below land surface)	Zone A	Zone B	Zone C	Water level in well (in feet below land surface)	Zone A	Zone B	Zone C
45.8	0.0	0.0	0.0	50.5	3.2	4.7	6.2
45.9	.1	.1	.1	50.6	3.2	4.8	6.4
46.0	.1	.2	.3	50.7	3.3	4.9	6.5
46.1	.2	.3	.4	50.8	3.4	5.0	6.6
46.2	.3	.4	.5	50.9	3.4	5.1	6.8
46.3	.3	.5	.7	51.0	3.5	5.2	6.9
46.4	.4	.6	.8	51.1	3.6	5.3	7.0
46.5	.5	.7	.9	51.2	3.6	5.4	7.2
46.6	.5	.8	1.1	51.3	3.7	5.5	7.3
46.7	.6	.9	1.2	51.4	3.8	5.6	7.4
46.8	.7	1.0	1.3	51.5	3.8	5.7	7.6
46.9	.7	1.1	1.5	51.6	3.9	5.8	7.7
47.0	.8	1.2	1.6	51.7	4.0	5.9	7.8
47.1	.9	1.3	1.7	51.8	4.0	6.0	7.9
47.2	.9	1.4	1.9	51.9	4.1	6.1	8.1
47.3	1.0	1.5	2.0	52.0	4.2	6.2	8.2
47.4	1.1	1.6	2.1	52.1	4.3	6.3	8.3
47.5	1.1	1.7	2.3	52.2	4.3	6.4	8.5
47.6	1.2	1.8	2.4	52.3	4.4	6.5	8.6
47.7	1.3	1.9	2.5	52.4	4.5	6.6	8.7
47.8	1.3	2.0	2.6	52.5	4.5	6.7	8.9
47.9	1.4	2.1	2.8	52.6	4.6	6.8	9.0
48.0	1.5	2.2	2.9	52.7	4.7	6.9	9.1
48.1	1.6	2.3	3.0	52.8	4.7	7.0	9.3
48.2	1.6	2.4	3.2	52.9	4.8	7.1	9.4
48.3	1.7	2.5	3.3	53.0	4.9	7.2	9.5
48.4	1.8	2.6	3.4	53.1	4.9	7.3	9.7
48.5	1.8	2.7	3.6	53.2	5.0	7.4	9.8
48.6	1.9	2.8	3.7	53.3	5.1	7.5	9.9
48.7	2.0	2.9	3.8	53.4	5.1	7.6	10.1
48.8	2.0	3.0	4.0	53.5	5.2	7.7	10.2
48.9	2.1	3.1	4.1	53.6	5.3	7.8	10.3
49.0	2.2	3.2	4.2	53.7	5.3	7.9	10.5
49.1	2.2	3.3	4.4	53.8	5.4	8.0	10.6
49.2	2.3	3.4	4.5	53.9	5.5	8.1	10.7
49.3	2.4	3.5	4.6	54.0	5.5	8.2	10.9
49.4	2.4	3.6	4.8	54.1	5.6	8.3	11.0
49.5	2.5	3.7	4.9	54.2	5.7	8.4	11.1
49.6	2.6	3.8	5.0	54.3	5.7	8.5	11.3
49.7	2.6	3.9	5.2	54.4	5.8	8.6	11.4
49.8	2.7	4.0	5.3	54.5	5.9	8.7	11.5
49.9	2.8	4.1	5.4	54.6	5.9	8.8	11.7
50.0	2.8	4.2	5.6	54.7	6.0	8.9	11.8
50.1	2.9	4.3	5.7	54.8	6.1	9.0	11.9
50.2	3.0	4.4	5.8	54.9	6.1	9.1	12.1
50.3	3.0	4.5	6.0	55.0	6.2	9.2	12.2
50.4	3.1	4.6	6.1	55.1	6.3	9.3	12.3

Table 8. Potential water-level rise, in feet, for use with index well Truro TSW-89.

Water level in well (in feet below land surface)	Zone A	Zone B	Zone C	Water level in well (in feet below land surface)	Zone A	Zone B	Zone C
10.4	0.0	0.0	0.0	11.8	1.4	2.1	2.8
10.5	.1	.1	.2	11.9	1.5	2.2	3.0
10.6	.2	.3	.4	12.0	1.6	2.4	3.2
10.7	.3	.4	.6	12.1	1.7	2.5	3.4
10.8	.4	.6	.8	12.2	1.8	2.7	3.6
10.9	.5	.7	1.0	12.3	1.9	2.8	3.8
11.0	.6	.9	1.2	12.4	2.0	3.0	4.0
11.1	.7	1.0	1.4	12.5	2.1	3.1	4.2
11.2	.8	1.2	1.6	12.6	2.2	3.3	4.4
11.3	.9	1.3	1.8	12.7	2.3	3.4	4.6
11.4	1.0	1.5	2.0	12.8	2.4	3.6	4.8
11.5	1.1	1.6	2.2	12.9	2.5	3.7	5.0
11.6	1.2	1.8	2.4	13.0	2.6	3.9	5.2
11.7	1.3	1.9	2.6				

Table 9. Potential water-level rise, in feet, for use with index well Wellfleet WNW-17.

Water level in well (in feet below land surface)	Zone A	Zone B	Zone C	Water level in well (in feet below land surface)	Zone A	Zone B	Zone C
7.3	0.0	0.0	0.0	10.1	1.4	2.1	2.8
7.4	.0	.1	.1	10.2	1.4	2.2	2.9
7.5	.1	.1	.2	10.3	1.5	2.2	3.0
7.6	.1	.2	.3	10.4	1.5	2.3	3.1
7.7	.2	.3	.4	10.5	1.6	2.4	3.2
7.8	.2	.4	.5	10.6	1.6	2.5	3.3
7.9	.3	.4	.6	10.7	1.7	2.5	3.4
8.0	.3	.5	.7	10.8	1.7	2.6	3.5
8.1	.4	.6	.8	10.9	1.8	2.7	3.6
8.2	.4	.7	.9	11.0	1.8	2.8	3.7
8.3	.5	.7	1.0	11.1	1.9	2.8	3.8
8.4	.5	.8	1.1	11.2	1.9	2.9	3.9
8.5	.6	.9	1.2	11.3	2.0	3.0	4.0
8.6	.6	1.0	1.3	11.4	2.0	3.1	4.1
8.7	.7	1.0	1.4	11.5	2.1	3.1	4.2
8.8	.7	1.1	1.5	11.6	2.1	3.2	4.3
8.9	.8	1.2	1.6	11.7	2.2	3.3	4.4
9.0	.8	1.3	1.7	11.8	2.2	3.4	4.5
9.1	.9	1.3	1.8	11.9	2.3	3.4	4.6
9.2	.9	1.4	1.9	12.0	2.3	3.5	4.7
9.3	1.0	1.5	2.0	12.1	2.4	3.6	4.8
9.4	1.0	1.6	2.1	12.2	2.4	3.7	4.9
9.5	1.1	1.6	2.2	12.3	2.5	3.7	5.0
9.6	1.1	1.7	2.3	12.4	2.5	3.8	5.1
9.7	1.2	1.8	2.4	12.5	2.6	3.9	5.2
9.8	1.2	1.9	2.5	12.6	2.6	4.0	5.3
9.9	1.3	1.9	2.6	12.7	2.7	4.0	5.4
10.0	1.3	2.0	2.7	12.8	2.7	4.1	5.5