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SWSA 6 Interim Corrective Measures Environmental Monitoring: FY 1991 Results

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DISCLAIMER

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ACRONYMS

DOE	U.S. Department of Energy
ESD	Environmental Sciences Division
HDPE	high-density polyethylene
ICM	interim corrective measure
LLW	low-level waste
ORNL	Oak Ridge National Laboratory
RCRA	Resource Conservation and Recovery Act
SWSA	Solid Waste Storage Area

EXECUTIVE SUMMARY

In 1988, interim corrective measures (ICMs) were implemented at Solid Waste Storage Area (SWSA) 6 at Oak Ridge National Laboratory. The SWSA 6 site was regulated under the Resource Conservation and Recovery Act (RCRA). The ICMs consist of eight large high-density polyethylene sheets placed as temporary caps to cover trenches known to contain RCRA-regulated materials. Environmental monitoring for FY 1991 consisted of collecting water levels at 13 groundwater wells outside the capped areas and 44 wells in or near the capped areas in order to identify any significant loss of hydrologic isolation of the wastes. Past annual reports show that the caps are only partially effective in keeping the waste trenches dry and that many trenches consistently or intermittently contain water.

Monitoring during FY 1991 showed that the patterns, both in time and in space, of trenches with measurable water were similar to patterns previously observed. There was no indication of failure of the any of the caps with respect to hydrologic isolation as compared to their performance in previous years. Results from the past year of water level monitoring reinforce conclusions made in earlier annual reports. Hydrologic isolation of buried wastes by means of impermeable caps cannot be assured unless the entire area of recharge is covered. Analysis suggests that perched water in trenches beneath caps 1, 2, 6, and the uphill slope of cap 5 are caused by lateral subsurface flow above the water table; however, the deep trenches beneath cap 8 and probably the trenches in the lower portion of cap 5 exhibit saturated conditions as a result of inflow of groundwater from the water table aquifer. At cap 8, water levels in trenches are related to the elevation of White Oak Lake, and this factor must be considered in plans for future remediation.

Based on well hydrographs, the ICM caps have improved the hydrologic isolation of the buried wastes at all cap sites because direct infiltration has been eliminated; however, hydrologic isolation by means of impermeable caps cannot be ensured unless the entire area of recharge is covered. Even if the stormflow is diverted or eliminated, wastes can be saturated by groundwater in low-lying places. Isolation of waste in trenches from groundwater may require wide-area suppression of recharge, artificial lowering of the water table by inducing drainage, and/or construction of a barrier to groundwater movement.

The SWSA 6 ICM environmental monitoring program for FY 1992 will be expanded to include the monitoring of surface water discharge and the sampling of water and suspended sediment during baseflow and storm conditions. The purpose of the expanded study is to further evaluate the effectiveness of the caps and to document baseline contaminant discharge levels so that the effectiveness of the final remediation can be evaluated in terms of the relative and absolute reduction of contaminants leaving SWSA 6.

1. INTRODUCTION

Solid Waste Storage Area (SWSA) 6 is the only operating low-level waste (LLW) disposal facility at Oak Ridge National Laboratory (ORNL). In 1986, SWSA 6 was closed for approximately two months when it was found that materials regulated by the Resource Conservation and Recovery Act (RCRA) were being disposed of there. Operations were resumed in July 1988 with new waste acceptance criteria and other improvements. Burial trenches in SWSA 6 that had received hazardous or mixed waste after November 8, 1980, were designated as RCRA-regulated units. Closure of those units had to be initiated before November 1988 under 40 CFR 265 Subpart G, but because final remediation was not a feasible alternative, interim corrective measures (ICMs) were implemented. Currently, it is the U.S. Department of Energy's (DOE's) position that the Federal Facilities Agreement, effective January 1, 1992, provides for the Tennessee Department of Environment and Conservation, the U.S. Environmental Protection Agency, and DOE to proceed with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 as the lead regulatory requirement and with RCRA as an applicable and relevant or appropriate requirement.

The ICMs at SWSA 6 consist of eight temporary caps of high-density polyethylene (HDPE) sheeting installed over burial trenches to reduce or eliminate infiltration of rainwater into the wastes and subsequent leaching and transport of contaminants. The caps cover ~4.2 ha (10.4 acres) or about 15% of the 26.7 ha (68 acres) within the fenced perimeter of SWSA 6. An ICM environmental monitoring program was initiated to evaluate the effectiveness of the caps. Two annual reports have been issued (Miller et al. 1989, Ashwood and Spalding 1990), and this report is the third. Because monitoring in 1991 was limited to measurements of water levels in 57 wells and no water sampling was done, this report is essentially a data summary. The main purpose is to review the observations and conclusions of the preceding reports with respect to the recently collected data and to determine whether or not those data conform to observations and conclusions regarding the hydrologic isolation of wastes beneath the temporary ICM caps. The narrative portion of the report is supported by Figs. 1 through 35, which follow Sect. 8.

2. BACKGROUND

During past waste operations, the disposal trenches in SWSA 6 were known to fill with water, especially following storms (Boegly 1984). There are three pathways by which water may have entered the trenches: by direct infiltration through the soil covers, by lateral shallow subsurface stormflow originating upgradient, and by groundwater inflow from the water table aquifer. The stormflow phenomenon described by Moore (1988, 1989) is considered a significant contributor to the frequent "bathtubbing" of trenches observed in various disposal areas at ORNL. Bathtubbing refers to the development of a temporary perched water table within the trench that occurs when water flows in faster than it can flow out. Subsurface stormflow moves predominately through the near-surface region (<2 m depth), roughly corresponding to the root zone where permeability is large relative to that of the partially weathered shale beneath it. The ICM temporary caps are intended to reduce saturation of the wastes and the subsequent mobilization of contaminants by eliminating infiltration into the buried waste. In locations where stormflow or groundwater inflow are the major cause of saturation within trenches, caps will not be effective.

The difference between saturation by stormflow and saturation by groundwater inflow can be important to the performance of an ICM cap and therefore to the choice of remediation. If stormflow is entering a trench, then it may be possible to extend the cap uphill to the surface divide to prevent the infiltration causing the stormflow. If groundwater inflow is the cause of trench saturation, then recharge control may require that the cap be extended beyond the top of the local hill where the trench is located all the way to the ridge line. Alternatively, the water table could be lowered by engineered drainage techniques. Of course, both stormflow and groundwater inflow can be operative at the same trench.

For any single trench beneath the ICMs at SWSA 6, the groundwater level information is limited, and it is not possible to draw flow nets to determine groundwater flow paths. If the aquifer water level measured in the groundwater well adjacent to a trench is consistently lower than the level of water in the trench, then stormflow is the likely cause of filling. If the water levels are similar, then it is difficult to judge whether the groundwater is flowing into the trench or draining a trench that is filled by stormflow. A frequent series of measurements may show whether the level of water in the trench is driving the water table level or vice versa.

In 1988, drivepoint wells were installed into waste trenches designated to be capped in order to monitor intratrench water levels. These levels were measured manually prior to, during, and after the construction of the caps. One round of sampling was taken from the intratrench wells to provide data on leachate quality and to assess the risk to workers monitoring and remediating SWSA 6 (Ashwood and Spalding 1991).

In the FY 1989 annual ICM environmental monitoring report, Miller et al. (1989) concluded that water levels in the SWSA 6 water table aquifer were unaffected by the capping. The report also contains radiological analyses of water and sediment samples. In the FY 1990 annual environmental monitoring report, Ashwood and Spalding (1991) summarized the preceding report and observed that further surface water and sediment sampling was not useful without concurrent discharge data, so sampling was discontinued. Their main conclusions follow.

1. Use of impermeable caps as ICMs are effective only where they act to eliminate all recharge, including shallow stormflow, in the area of effect.

2. Final closure of SWSA 6 must address stabilization of the burial trenches and the isolation of trenches from the influence of White Oak Lake.

3. Trench leachate data suggest that volatile contaminants (organics and tritium) are widespread in the capped burial trenches and that other RCRA-regulated contaminants are present in much greater concentrations than previously recognized.

In FY 199[illegible] no sampling was performed, but water levels were measured in both groundwater wells and intratrench wells.

3. METHODS

The SWSA 6 ICM monitoring activity for FY 1991 consisted of monitoring water levels at 13 groundwater wells outside of the cap areas (Fig. 1) once per month and 44 wells in the capped areas twice per month. The wells in the capped areas consist of 34 intratrench wells and 10 groundwater wells. Water levels were measured in accordance with Energy Systems Procedure ESP 302-1 (Kimbrough et al. 1990). Data were recorded in a field notebook; for the wells located away from the caps, the data were entered into the ORNL Environmental Restoration Program Numeric Data Base (Hook et al. 1990), whereas the data from the cap wells were entered into a spreadsheet.

Since the beginning of the ICM environmental monitoring program, measurements have been discontinued at three groundwater wells (649, 650A, 650B) and at 11 capped-area wells because they were damaged or covered with HDPE sheeting, as summarized in Table 1. Among the wells that were monitored are nine groundwater wells identified by CX numbers, and published information on these wells is incomplete. All of them were recently surveyed (Table 2), and four of them were either consistently dry or damaged; therefore, no water level data are reported for them. Two of them have alternative identification numbers (C2X3 = well 647 and C5X3 = well 347).

Trends in the water levels within the trenches were compared to the rainfall record. Rainfall for FY 1991 was collected at the Engineering Test Facility site in SWSA 6. The prior record was collected at the Tumulus facility (Ashwood and Spalding 1991); the sites are close by and no significant difference is expected. During FY 1991 precipitation was 1444 mm, an increase of approximately 10% over the 1304 mm of precipitation in FY 1990. During FY 1991 there were two relatively large storms. On December 22 and 23, 1990, there was 128 mm of rainfall, and on February 17 through 19, 1991, there was 152 mm. Water levels in the trenches seemed to react more to the second storm, probably because the soil was initially wetter in midwinter and because the storm duration was longer, allowing more water to infiltrate. In addition, a wet period in early summer (June 17–25, 1991) with 84 mm of rainfall caused some water levels to rise above the low levels expected at that time of year. The daily rainfall amounts are listed in Table A.4 in the Appendix.

Table 1. Summary of water level measurements at SWSA 6 ICM caps

Well ID	Well not in trench	Date of last measurement	Reason	Notes
CAP 1 AREA:				
T82		08/18/89	discountinued (1)	Water level rose 0.76 m over 3 months prior to discontinuation
T103		08/18/89	discountinued	consistently dry
T120		08/18/89	discountinued	consistently dry
T370		08/18/89	discountinued	consistently dry
T380		08/18/89	discountinued	consistently dry
T444		08/18/89	discountinued	Water was about 1.05 m deep continously after caps completed
S11	X			
640	X	05/07/90	damaged	
CAP 2 AREA:				
T69				intermittently dry
T84				consistently dry
T121		05/21/91	blocked	consistently dry following capping
T330				consistently dry
T363				intermittently dry
T397		01/30/90	blocked	consistently dry following capping
T408		10/04/90	damaged	consistently dry
T417		10/04/90	damaged	consistently dry (2)
C2-X1	X			never dry
C2-X2	X		blocked	no record
C2-X3	X			never dry
C2-X4	X			never dry
C2-X5	X			consistently dry
C2-X6	X			consistently dry after 4/3/90
CAP 5 AREA:				
T85				never dry
T92-1				occasionally dry (7 dry observations)
T92-2				never dry
T105				never dry
T110				consistently dry after 1/3/90
T112				never dry
T308				mostly dry
T318				almost never dry (observed dry 9/19/91)
C5-X1	X			never dry
C5-X2	X			never dry
C5-X3	X			never dry

Table 1 (continued)

Well ID	Well not in trench	Date of last measurement	Reason	Notes
CAP 6 AREA:				
T101				never dry
T315				almost always dry (water observed 10/3/89)
T329				almost never dry (observed dry 9/1-22/89)
T395				mostly dry (water observed 5 times after capping)
T413				consistently dry following capping
T414				consistently dry following capping
T426		05/14/91	blocked	consistently dry following capping
CAP 8 AREA:				
T44				intermittently dry
T57				consistently dry
T60				consistently dry
T63				intermittently dry
T162				consistently dry following capping
T180				consistently dry following capping
T225		01/12/90	blocked	consistently dry following capping
T237				consistently dry following capping
T241				consistently dry
T352				consistently dry following capping
T367				consistently dry following capping
T373				consistently dry following capping
T374				consistently dry
T422				consistently dry following capping
T424		08/06/90	blocked	consistently dry following capping
T453		10/04/90	blocked	consistently dry following capping
382	X			never dry

(1) discontinued due to elevated levels of radioactivity
(2) repaired; measurements resumed 4/19/91

Table 2. Coordinates and elevations of the CX well at the SWSA 6 ICM caps

Well	Also known as	ORNL North	ORNL East (m)	Top of casing (m)	Ground surface (m)	Stickup (m)	Bottom of well
C2X1		17193	24619	251.71	251.35	0.36	246.11
C2X2[a]		17159	24616	250.62			
C2X3	Well 647	17146	24749	250.07	249.28	0.79	238.11
C2X4		17024	24609	246.49	245.92	0.57	232.10
C2X5		17030	24600	246.59	246.14	0.45	241.73
C2X6		16985	24683	245.29	244.87	0.42	239.97
C5X1		16718	24608	240.35	239.83	0.51	231.27
C5X2		16716	24617	240.31	239.80	0.51	235.39
C5X3	Well 347	16545	24602	237.34	236.85	0.49	233.02

[a]Well stickup has been removed, and well access has been covered.

4. WATER LEVELS IN GROUNDWATER WELLS

Water levels in groundwater wells at most locations shown in Fig. 1 were monitored monthly. Data were collected to determine (1) the effect, if any, of the ICM caps on water levels beyond the individual caps and (2) reference levels that could be compared to water levels measured beneath the caps.

The well hydrographs for FY 1991 for 13 wells are shown in Figs. 2 through 13, and the data appear in Table A.1 in the Appendix. Not all of the wells that were monitored in earlier investigations (Miller et al. 1989, Ashwood and Spalding 1990) are included among the hydrographs. Wells 649 and 650 were blocked or damaged, and no data were collected. Well 649 was consistently dry, and well 318 had measurable water levels only twice during FY 1991.

All other wells show seasonal cycles of water levels from midwinter high levels to midautumn low levels that are similar to those seen in FY 1990. Water levels did respond more to individual storm events during FY 1991. Water levels tended to be high on December 20, which actually predated the large storm later that month, and after the storms in February and June.

The well hydrographs are shown in groups. Wells 276, 636, 642, and 654 are separated from the capped areas by a stream which presumably is a groundwater control. No effects are expected for these wells, and none are observed in the data. Well 656 is a deep well (~37 m) located at a topographically high point north of SWSA 6. The well hydrograph shows very little variability or response to rainfall.

Well 646 is topographically upgradient from cap 3 and distant from cap 1, and wells 345, 356, 645, and 655 are each topographically lower than one or more capped areas (Fig. 1). There are deviations from past trends in water level at these wells. Well 368 (Fig. 13) is located in cap 3. It is the only groundwater well located at a cap where there are no intratrench wells to provide a comparison between trench water levels and permanent water table elevations. The water table, as indicated by measurements at the well, is about 7.5 m below the surface and steady. Because trenches are shallower (usually about 3 to 3.5 m deep), the wastes are probably not being saturated by groundwater. Because there are no intratrench wells at cap 3, nothing can be concluded about the presence or absence of stormflow inputs to the trenchs.

In summary, there are no apparent trends in the water level data at these caps since the caps were constructed, with the exception of well 318, which went dry after cap construction and stayed dry through FY 1991 except for two occasions. Miller et al. (1989) and Ashwood and Spalding (1991) concluded that the caps had no apparent effects on groundwater levels, and data for FY 1991 are consistent with that observation. Again, well 318 was the exception, and it remained mostly dry.

5. WATER LEVELS IN CAPPED AREAS

A summary of the monitoring at all the cap wells is shown in Table 1. Based on water levels for all wells in trenches reported by Ashwood and Spalding (1991) and those reported here (Table A.2 in the Appendix), 12 trenches were consistently dry, both before and after the completion of the caps, 19 became dry or mostly dry after the caps were completed, 4 were intermittently wet after the caps were completed, and 9 were consistently wet. These numbers reflect, in part, the arbitrary choices of which trenches would be monitored, and there are complicating factors. For instance, drive points in trenches may not penetrate to the bottom of a trench; therefore, a trench that looks dry may actually be partially saturated. These numbers should be used cautiously as a grading system to rate the absolute effectiveness of the caps.

Hydrographs for the cap wells are presented in the ensuing sections, and the data are listed in Table A.2 in the Appendix. Only wells that were not consistently dry during FY 1991 are plotted. The complete record since mid-1988 is shown so that trends before and after the completion of the caps can be observed. The hyetograph is plotted with each hydrograph so that response, or lack thereof, to rainfall can be observed. The scale for the rainfall record is not given because it is the pattern of rainfall, rather than the amount, that is important to interpreting the hydrographs.

5.1 CAP AREA 1 (0.28 ha)

At the beginning of the monitoring program, wells in five trenches at cap area 1 (Fig. 14) were monitored, but monitoring was discontinued after August 11, 1989, as a result of radioactive contamination to the water-level probe. Hydrographs are not shown because no data were collected in FY 1991. As reported by Ashwood and Spalding (1991), three of the trench wells were consistently dry, and two had measurable water (T82 and T444). The source of the water in those trenches is not the water table in the aquifer. Groundwater well S11, which is located at cap area 1, provides a measure of the water table elevation (Fig. 15). The maximum measured elevation was 245.16 m, which is 4 m below the bottom of trench 82 (as judged by the depth of well T82) and 4.16 m below the bottom of trench 444. Because the cap cuts off vertical infiltration, the plausible source of water for these trenches is lateral shallow subsurface stormflow.

5.2 CAP AREA 2 (0.79 ha)

Of the eight trench wells in cap area 2 (Fig. 4), only wells T69 and T363 had measurable water after the cap was installed (Figs. 5 and 6). Ashwood and Spalding (1991) observed that cap construction led to reduced water levels in both wells and that only well T363 exhibited intermittent periods of wetness associated with storm events after cap completion. The cap straddles a small ridge that is drained to the east by a small gully and intermittent stream and to the west by a French drain (Fig. 1) designed to reduce water levels in the trench 49 area (further to the west of cap area 2). Ashwood and Spalding (1991) hypothesized that these drainage features act together with the cap to keep water levels low and stabilized. There is not much opportunity for recharge to the stormflow zone north of the cap because the roadway is expected to reduce infiltration and divert runoff away from cap area 2.

The water level in T69, which appeared to be suppressed in FY 1990, rose 55 cm during the wet winter conditions of FY 1991 and stayed at a constant elevation. The flat response of the well hydrograph (Fig. 17) suggests that the well may have penetrated the bottom of the trench to form a sump that filled to the level of the bottom of the trench and did not drain until spring.

The source of water is uncertain, but there is some evidence that the water table may rise and enter the trenches from below. Trenches 69 and 363 are located in the lower part of the cap where the water table is expected to be closer to the surface. The elevations at the bottoms of wells T69 (239.63 m) and T363 (240.65 m) are lower than that of T85 (242.96), the next deepest intratrench well.

There is no direct measure of the water table elevation, but the water level measured in groundwater well C2X4 is close to the bottom of the trenches (elevation mean 239.52 m and maximum 239.72 m). Well C2X4 is screened below the bottom of the trenches; therefore, it measures the groundwater head, not the water table elevation. (The bottom of C2X4 is about 8 m below the bottom of the trenches.) Calculations based on head measurements in groundwater wells C2X3 and C2X4 indicate a general downward flow component under cap 2 due to a consistent positive head gradient of about 0.10 m/m. A positive head gradient occurs where head measurements decrease with depth beneath the water table. The positive gradient implies that the actual water table at C2X4 was higher than the measured water levels at the well, further implying that it is possible that the water table has risen above the bottom of the trenches. The cause of the positive head gradient is the proximity of the French drain and the creek bed that bound the capped area. The elevation of the drain pipe in the French drain at a point along strike (probably the preferred direction of flow) is about 237.5 m (Davis and Stansfield 1984), well below the bottoms of the trenches beneath cap 2.

There are no apparent leaks in the cap, and there is a general downward movement of groundwater; therefore, there must be a lateral supply of water beneath the cap. Water could move laterally as perched stormflow or in the water table zone. For the Conasauga shales (the bedrock type at SWSA 6), it has recently been shown that there can be a high frequency of fracture-flow intervals near the water table (G. K. Moore, University of Tennessee, Knoxville, personal communication, 1992). These flow intervals could move water laterally. Stormflow is thought to move down the topographic gradient, but none of the upslope trenches have water. The evidence suggests that rises in the water table related to lateral groundwater flow are causing the water levels in trenches 69 and 363 to rise. The levels of saturation are significantly less than before the cap was installed; therefore, the cap has had a positive effect.

The difference in flow path may be significant to remediation design. Because stormflow is expected to move downslope, simple capping of the upslope area should essentially eliminate stormflow. Flow in the water table zone is less localized, and the recharge area is probably larger. Where fracture flow occurs near the water table, identification of the specific recharge area for remediation design may not be possible without extensive field investigations. One alternative to such investigations is to overestimate the recharge area and to design very large caps.

5.3 CAP AREA 5 (0.38 ha)

For cap area 5 (Fig. 21), water levels at all seven trenches and three groundwater wells were monitored (Figs. 22 through 28). The trends in water level data during FY 1991 were similar to those reported by Ashwood and Spalding (1991). Specifically, six of the seven trenches were consistently wet, and only well T110 in trench 110 located in the center of the cap area (Fig. 21) remained dry throughout the year.

The roles of stormflow and groundwater flow appear to vary between the trenches located at the upslope end of the cap, where trenches 92 and 308 are located, and trench 105 at the downhill end. At the uphill end, groundwater wells C5X1 and C5X2 provide a measure of the vertical head distribution beneath the cap. The bottom of well C5X1 is 4.12 m below that of C5X2, and the average head gradient between wells is about 0.03 m/m. The positive gradient (increasing head with increasing elevation) was almost consistent with only 5 observations of negative gradients in 53 observations. This implies a downward flow component beneath cap 5, at least at the uphill end in the vicinity of wells C5X1 and C5X2. Trench 92 exhibits frequent changes in water levels which are correlated with the groundwater levels in C5X2 (the shallow groundwater well) (Fig. 23). The data are not collected frequently enough to determine if water levels rise first in the trench or in the surrounding groundwater. Given the downward flow component in the area, it is probable that water enters trench 92 above the water table through fracture flow paths. The responsiveness of water in T92 to storms also suggests that a flow path above the permanent water table is operative.

Trenches 85 and 112 are located at about the same elevation midway down the slope. The mean water levels in the wells are similar (236.37 m for trench 85 and 235.97 m for trench 112), but the level for trench 85 is slightly higher and more variable (standard deviation is 0.44 m for trench 85 as compared with 0.20 m for trench 112). These data suggest that the subsurface water is entering from the west side between the French drain and the edge of cap 5. Of course, the relatively large variability of water level in trench 85 may be due to a relatively small drainable porosity rather than variable inflows.

At the downhill end of the cap, the water table is closest to the surface as seen at groundwater well C5X3 (Fig. 28), presumably because of the surface water drain to the south that acts as a nearly constant head for the local groundwater system. In trench 105, about 15 m uphill from well C5X3, the water levels are within the range of the water table elevations, and they lag the water table elevation by 1 observation period (about 2 weeks). The observations are connected by lines in Fig. 27 in order to show the continuity from observation to observation. At this lower end, it is highly likely that the water level in the trench is controlled by the local permanent water table elevation. For this situation, corrective actions designed to divert stormflow probably would not improve the hydrologic isolation of the buried waste, and the objective for corrective action should either be lowering the water table by lowering the head boundary (i.e., the stream below cap 5) or by isolating the groundwater (e.g., with slurry walls) to impede flow and contaminant transport.

5.4 CAP AREA 6 (0.61 ha)

For cap area 6 (Fig. 29) Ashwood and Spalding (1991) reported measurable water in four of the seven trenches that were monitored (Figs. 30 through 32). Two of those four wells dried out prior to FY 1991, and they remained dry throughout the year. Trench 101 exhibited intermittent wetting following storms (Fig. 30), whereas trench 329 (Fig. 31) has remained consistently wet since monitoring began in 1988. Trench 395 (Fig. 32) was dry except for one observation. All seven wells had measurable water prior to the completion of the caps; thus ICM cap 6 has been effective in reducing water levels in all but one case (trench 329).

5.5 CAP AREA 8 (0.93 ha)

Ashwood and Spalding (1991) observed that all but two trenches dried out after cap 8 (Fig. 33) and the adjacent cap 7 were installed. Trenches 44 and 63 (Figs. 34 and 35) tend to become wet when the level of White Oak Lake rises above the bottoms of the trenches. Maximum monthly stage of White Oak Lake is plotted and the correlation can be observed (Figs. 34 and 35). The stage data are listed in the Appendix, Table A.4. In addition, water table elevations measured in groundwater well 382 are also plotted. The rise and fall of the water table are matched by the water levels in the trenches. This is the most obvious case in all of the ICM monitoring wells where the groundwater, and not stormflow, is causing changes in water levels in the waste trenches.

The figures also show the high water in May 1991, when the floodgates were closed on White Oak Dam. At high water, more trenches will fill with water and more contaminants may be mobilized. The remediation plan for SWSA 6 must address this potential hazard by considering all projected water levels in White Oak Lake.

6. CONCLUSIONS AND DISCUSSION

Water levels in intratrench wells and in groundwater wells were collected during FY 1991. Results were very similar to those reported earlier. Trenches that were dry remained dry, and a few trenches that had a trace amount of water in FY 1990 were consistently dry in FY 1991. In the opposite direction, trench 69 beneath cap 2 did have some water during the winter of 1991 after it had appeared that the water level might have been suppressed. There was no indication of failure of any of the caps in hydrologic isolation as compared to their performance in earlier years.

The temporal pattern of rising and falling water levels in trenches that was observed in FY 1990 seemed to continue. The spatial pattern of wet and dry trenches remained essentially the same. Comparison of intratrench water levels to water table elevations measured in nearby groundwater wells provides an indication of whether or not the stormflow mechanism is the predominant method of filling a trench. For cap area 1, the groundwater is considerably below the bottom of the trenches; therefore, any accumulated water probably results from stormflow. At the other extreme, for the lower end of cap area 5, water levels lag behind the water table fluctuations, implying that groundwater elevation is the controlling factor. It is probable that water levels in the uphill end of cap 5 and at cap 2 are caused by inflows above the water table based on groundwater gradients beneath the caps. Information about the permanent water table at cap 6 is insufficient to make a determination, but the cap has reduced water levels in most of the trenches there. At cap 8 the entire area is cut off from recharge, and the mechanism of wetting is related to the rise in stage of White Oak Lake.

Results from the past year of water level monitoring reinforce earlier conclusions. The ICM caps have improved the hydrologic isolation of the buried waste at all cap sites because direct infiltration has been eliminated; however, hydrologic isolation of buried waste by means of impermeable caps cannot be assured unless the entire area of recharge is covered. Even if the stormflow is diverted or eliminated, wastes can be saturated by groundwater in low-lying places.

In FY 1992, the SWSA 6 ICM environmental monitoring program will continue to collect water levels in the intratrench wells and the groundwater wells, and the cap wells will be monitored intensively (about five times over 2 weeks) after a significant storm (weather permitting) in order to assess the changes in trench water levels versus those in the surrounding water table. The measurements of water levels at the outlying ten groundwater wells have not proved to be particularly informative, but they are easy to obtain and will be continued. Some measurements will be made at cap 1, where contamination problems have occurred, in order to assess if wastes in those trenches are wet.

The monitoring program will be expanded to include monitoring surface water discharge and water and suspended sediment sampling during storms and baseflow. Samples will be analyzed for fission products, which are known to be the most abundant contaminants being mobilized and transported. The purpose of the expanded study is to further evaluate the effectiveness of the caps and to document baseline contaminant discharge levels so that the effectiveness of the final closure can be evaluated in terms of the relative and the absolute reduction of contaminants leaving SWSA 6.

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I thank Tom Ashwood, who managed the data collection activities during the past year. Dennis Borders provided data on White Oak Lake elevations.

8. REFERENCES

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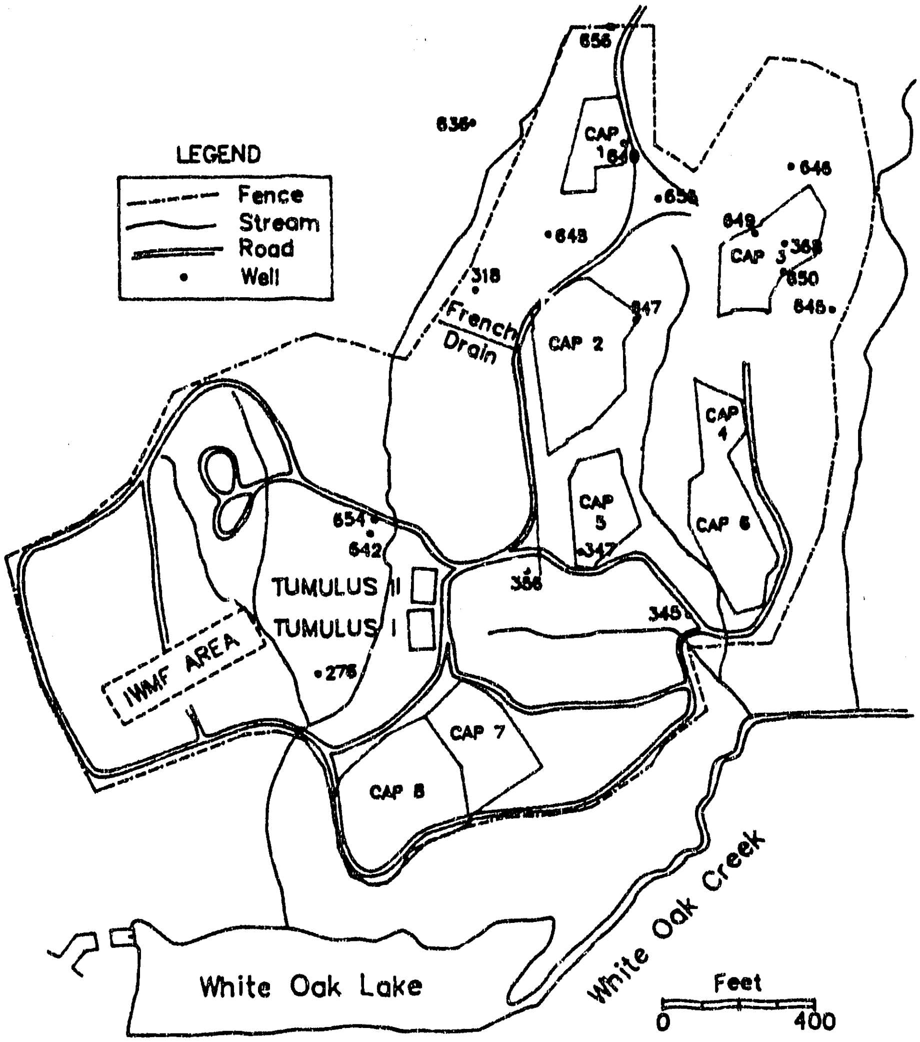

Fig. 1. Solid Waste Storage Area 6, showing interim corrective measures capped areas, French drain, monitoring wells outside burial trenches, and major areas of low-level waste disposal.

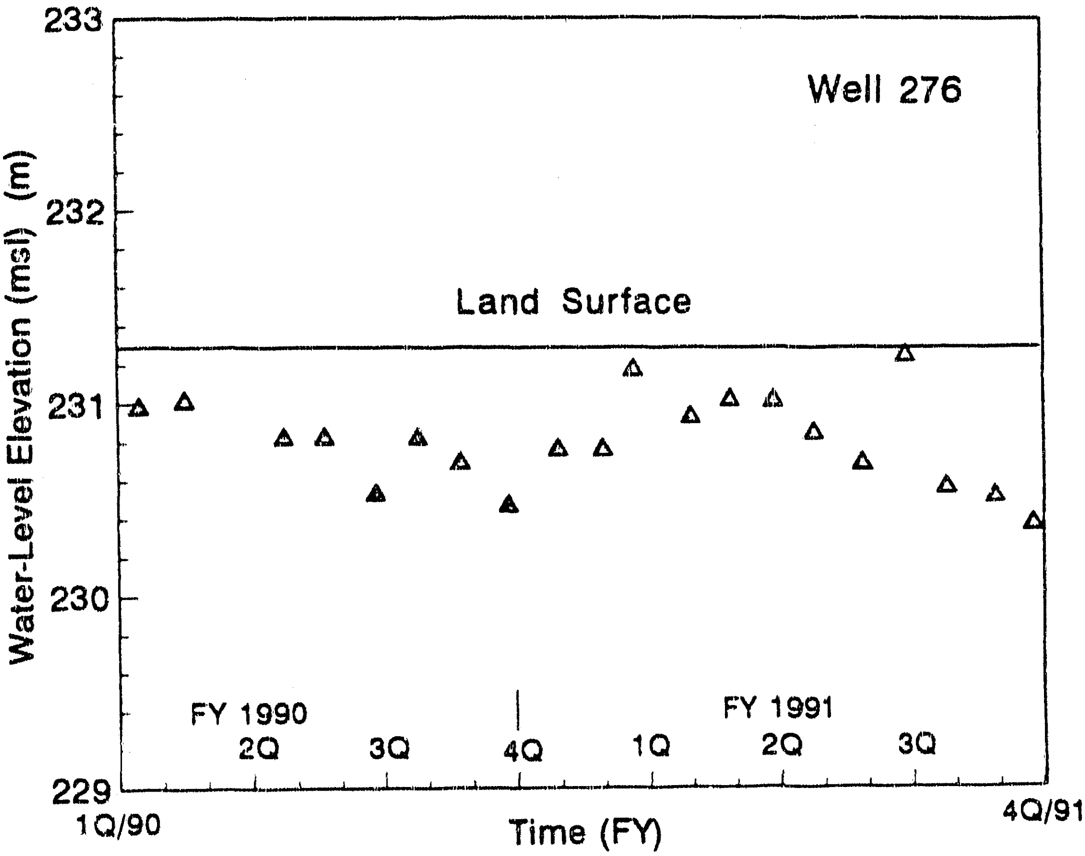

Fig. 2. Hydrograph and associated hyetograph for ICM monitoring well 276.

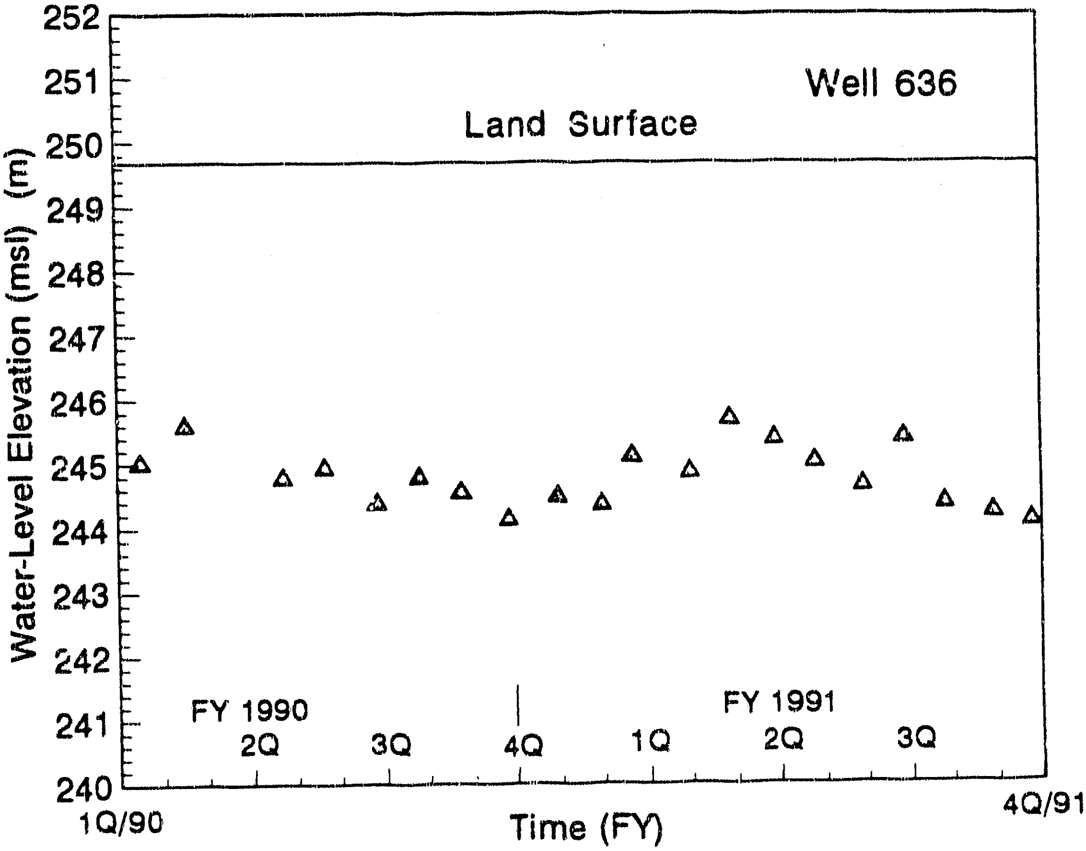

Fig. 3. Hydrograph and associated hyetograph for ICM monitoring well 636.

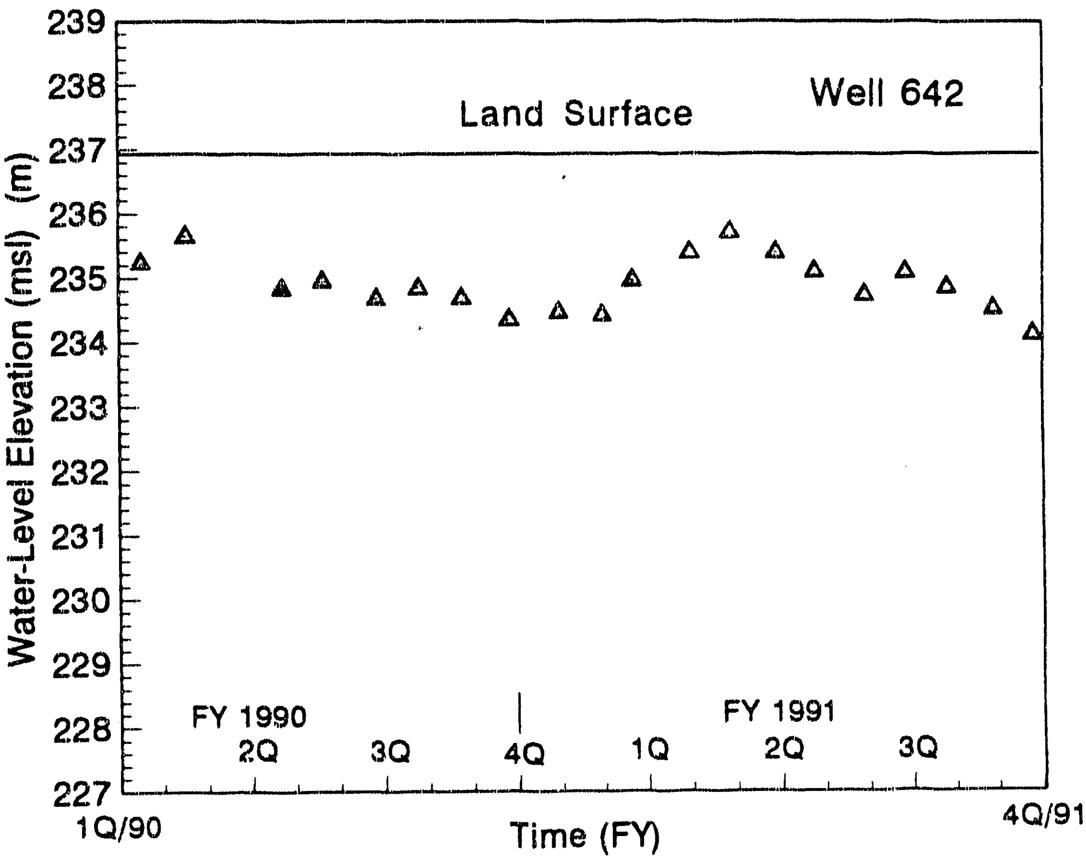

Fig. 4. Hydrograph and associated hyetograph for ICM monitoring well 642.

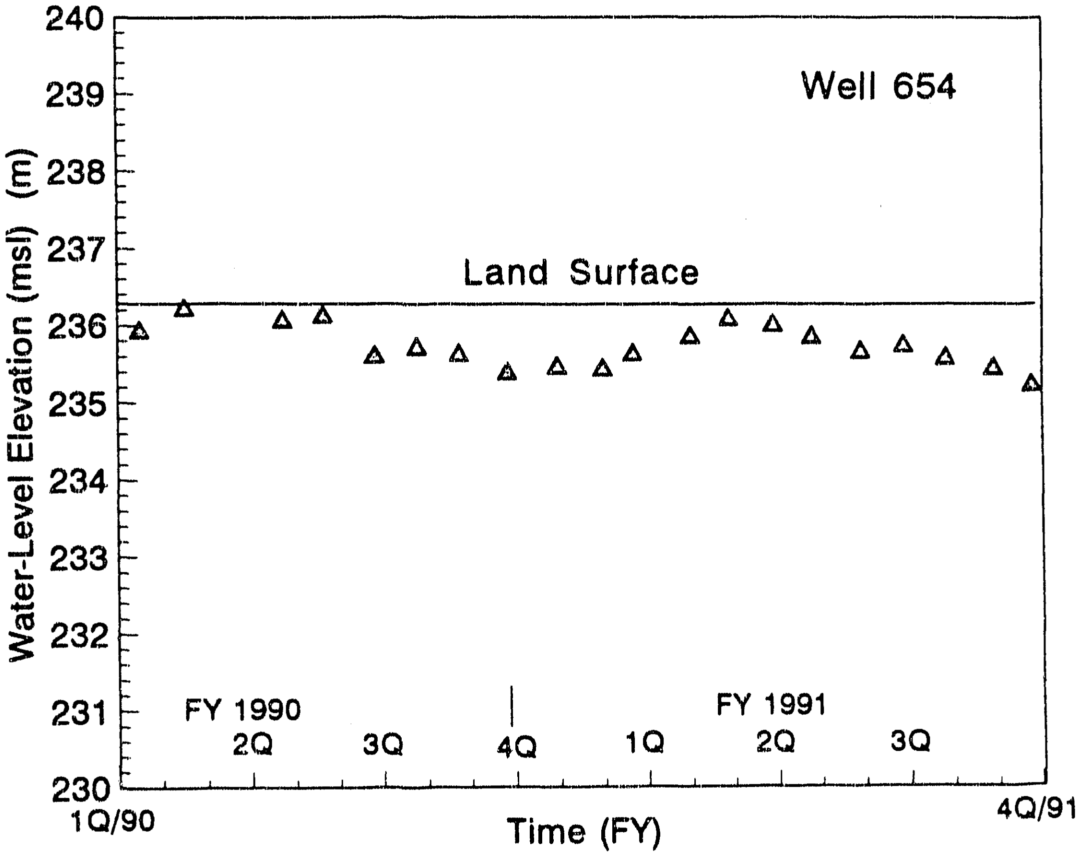

Fig. 5. Hydrograph and associated hyetograph for ICM monitoring well 654.

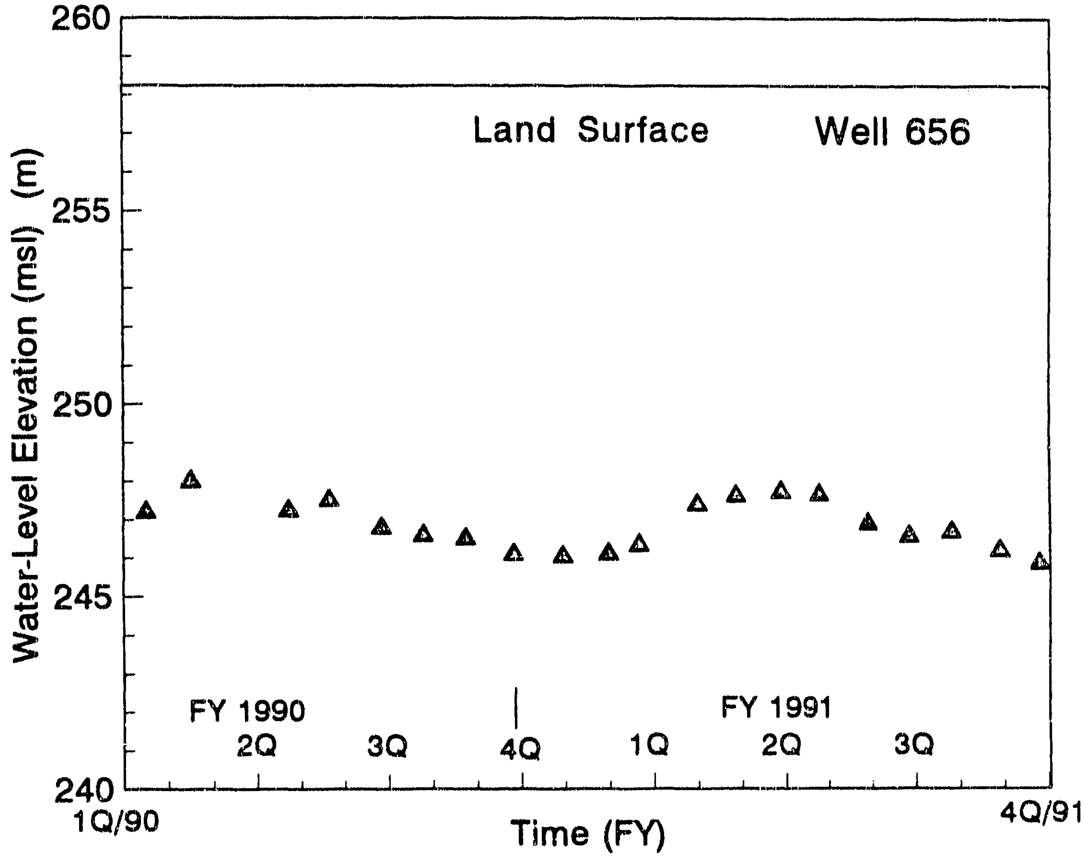

Fig. 6. Hydrograph and associated hyetograph for ICM monitoring well 656.

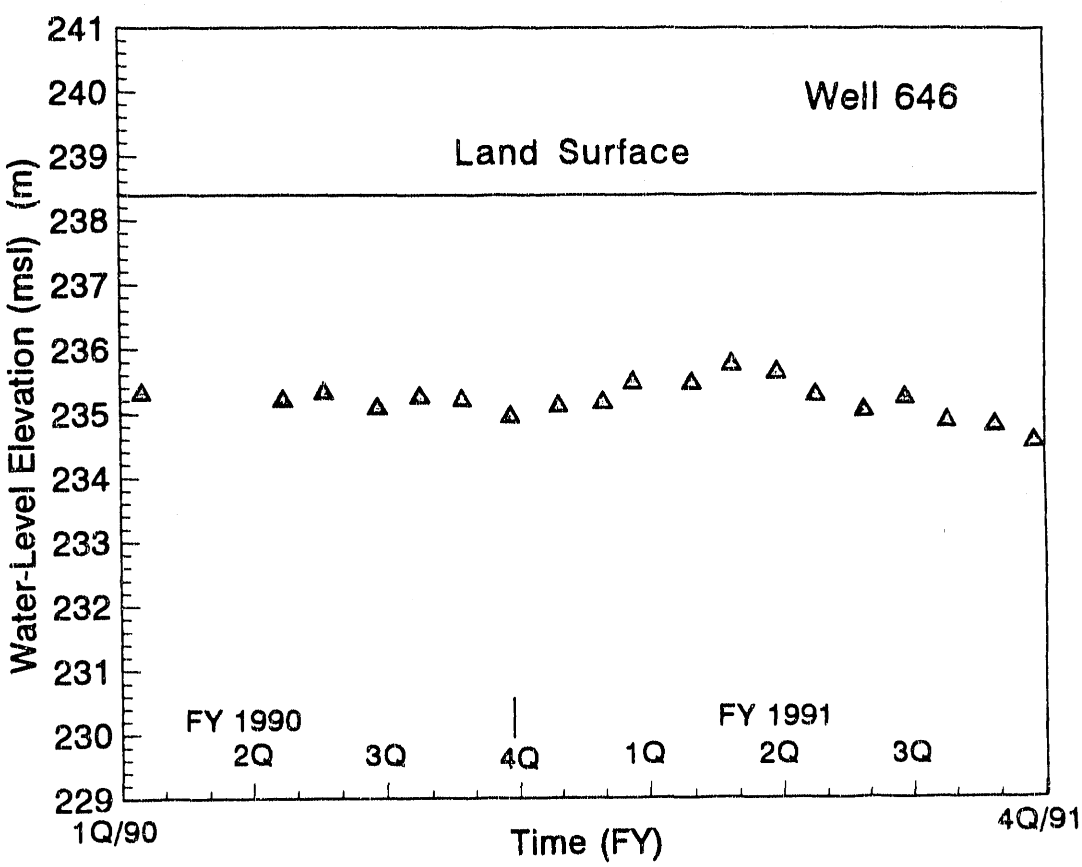

Fig. 7. Hydrograph and associated hyetograph for ICM monitoring well 646.

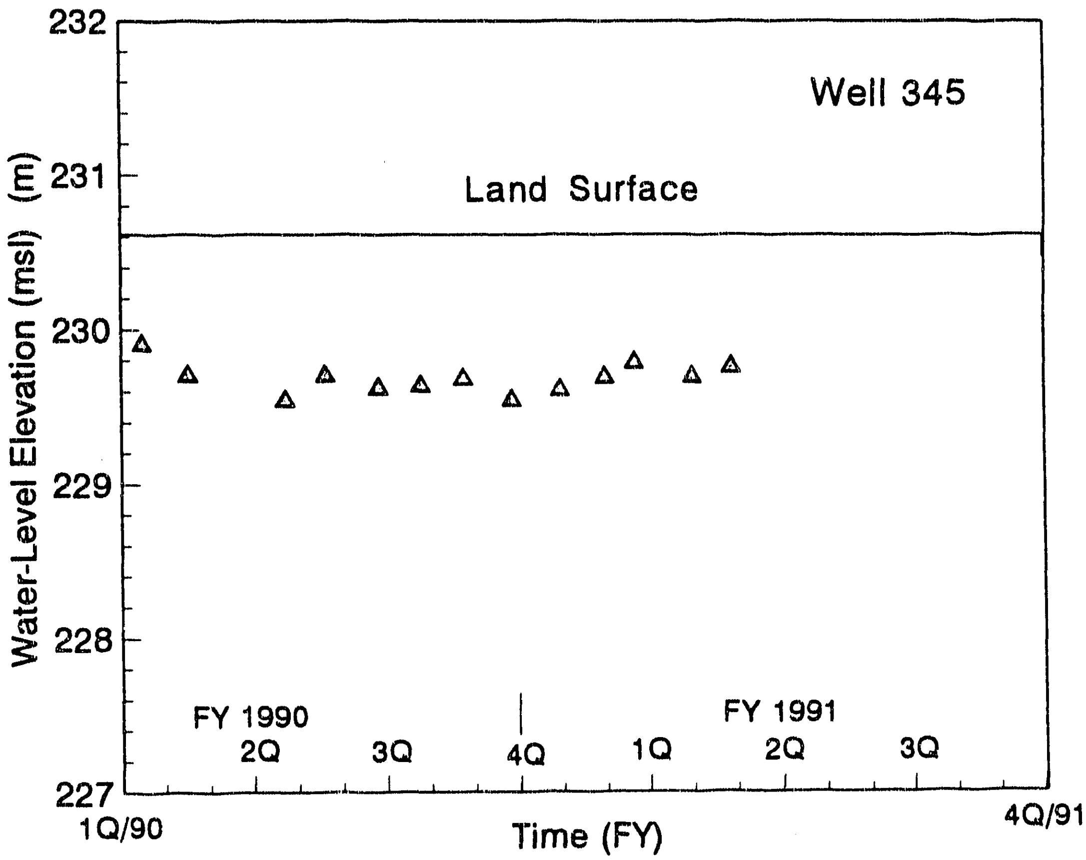

Fig. 8. Hydrograph and associated hyetograph for ICM monitoring well 345.

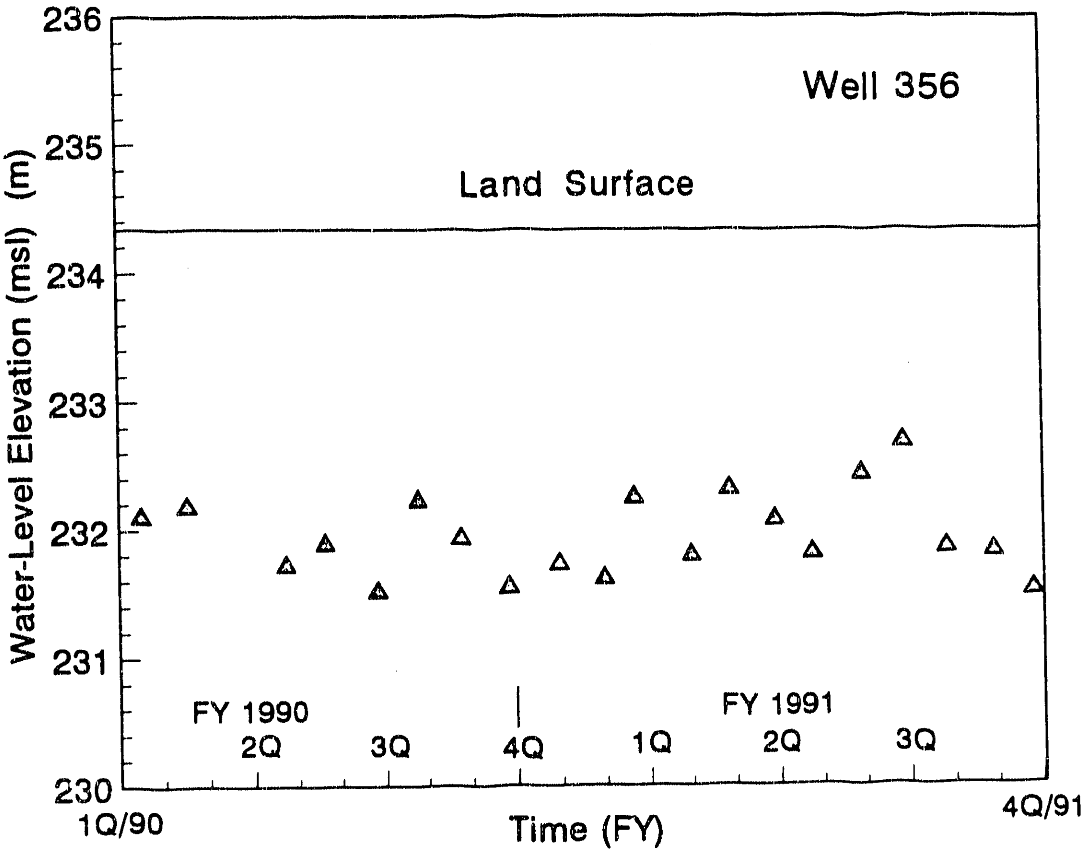

Fig. 9. Hydrograph and associated hyetograph for ICM monitoring well 356.

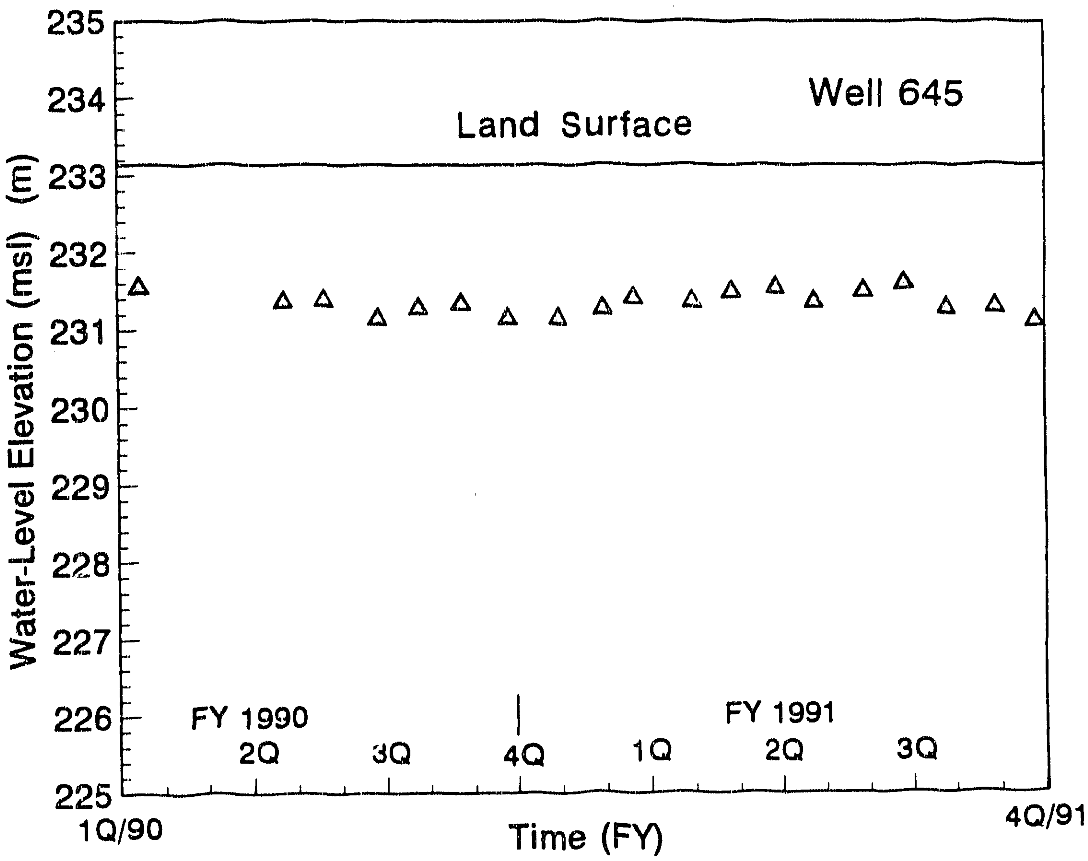

Fig. 10. Hydrograph and associated hyetograph for ICM monitoring well 645.

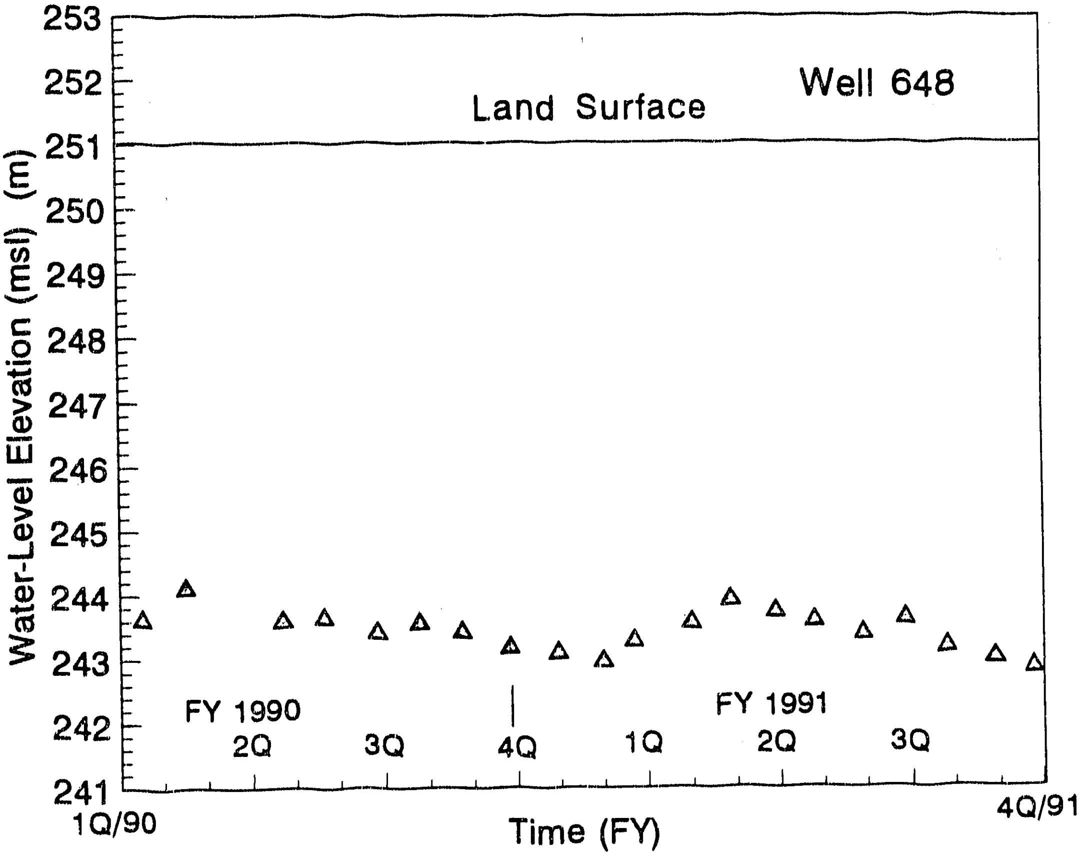

Fig. 11. Hydrograph and associated hyetograph for ICM monitoring well 648.

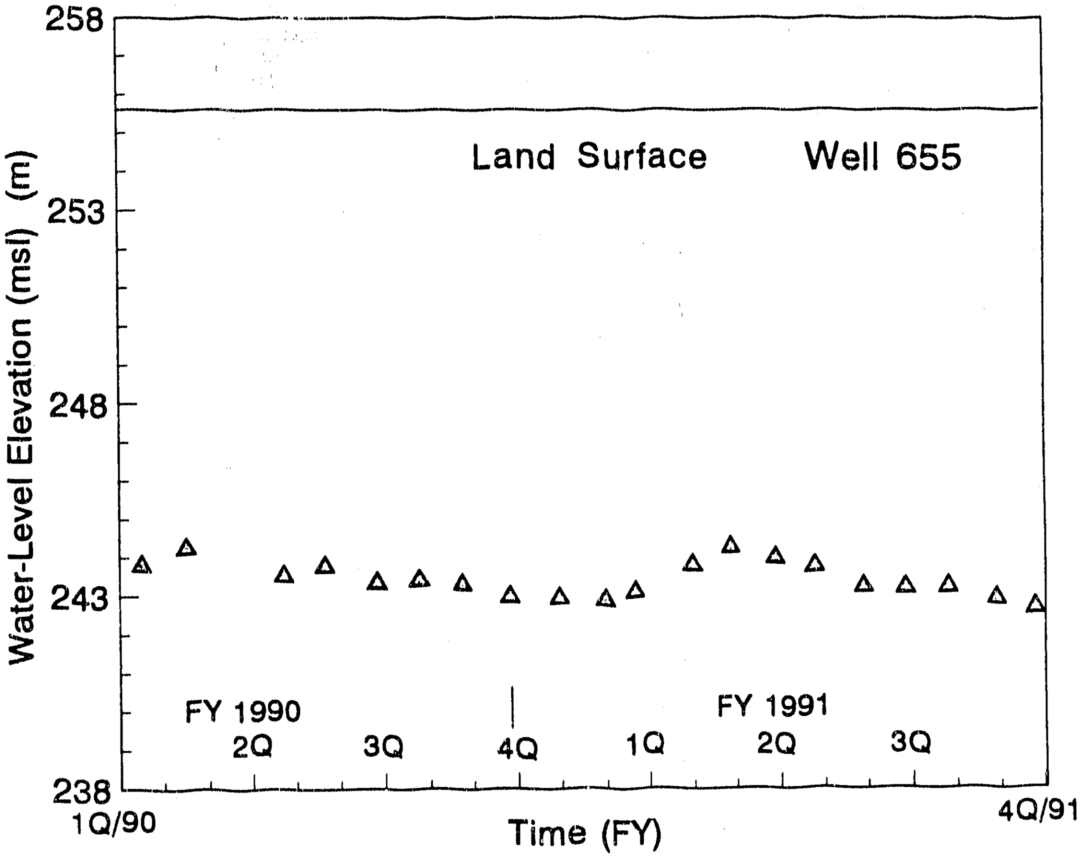

Fig. 12. Hydrograph and associated hyetograph for ICM monitoring well 655.

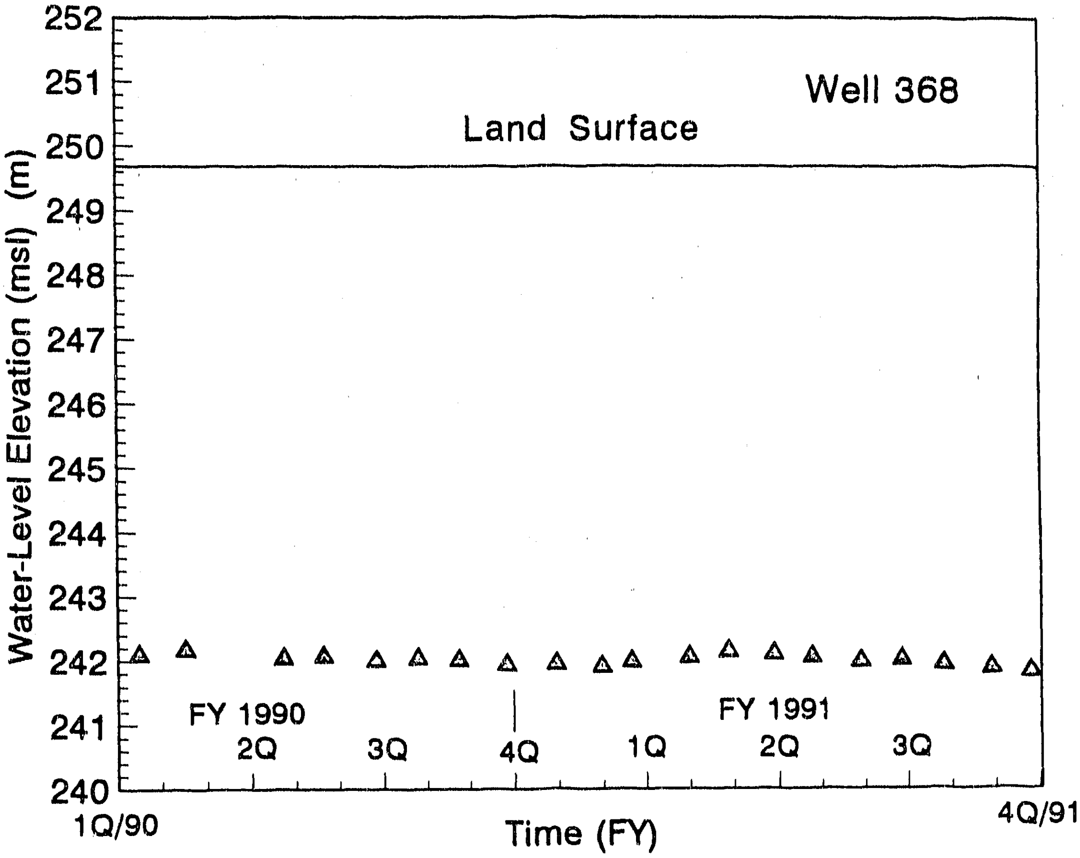

Fig. 13. Hydrograph and associated hyetograph for ICM monitoring well 368.

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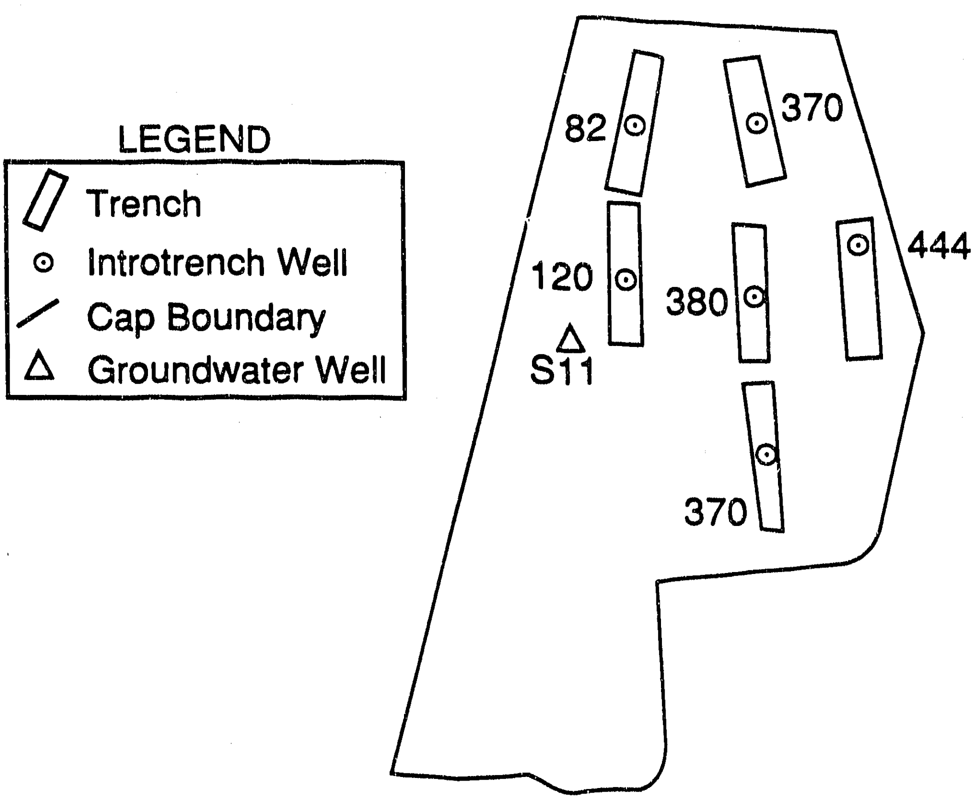

Fig. 14. Burial trench and well locations within cap area 1.

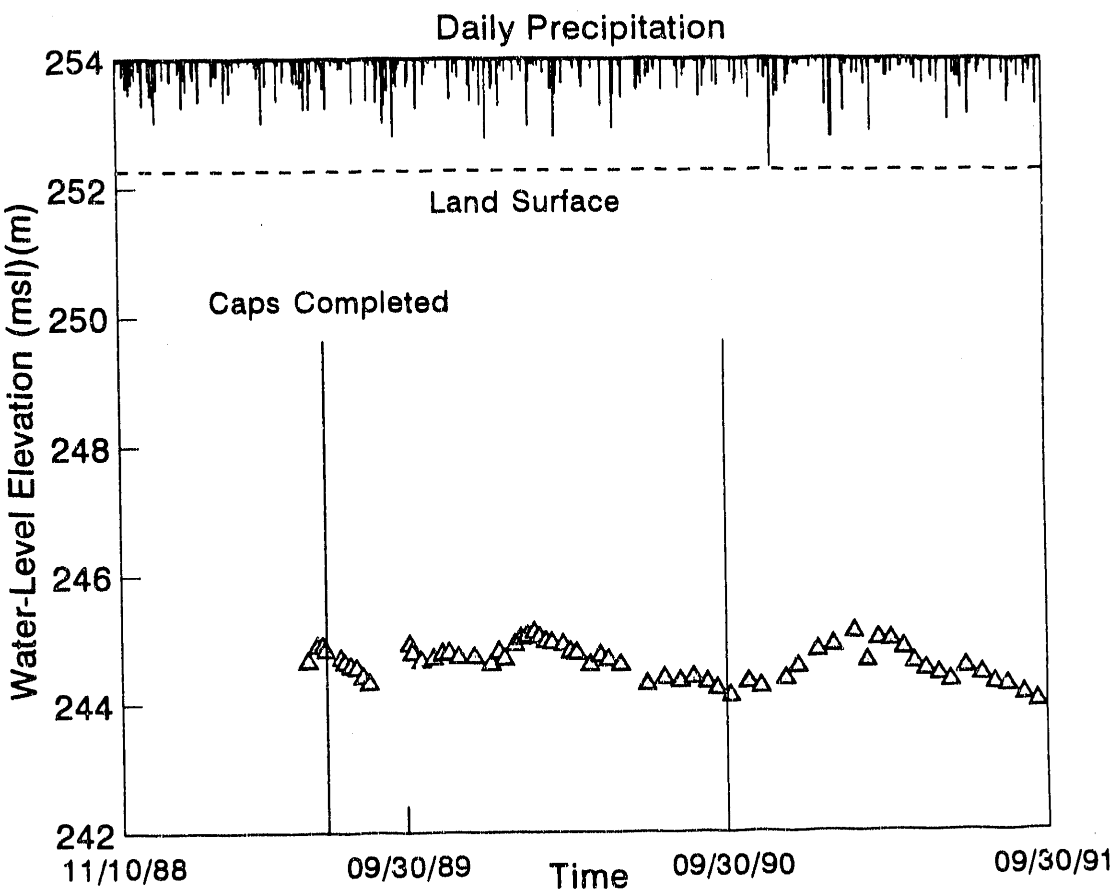

Fig. 15. Hydrograph and associated hyetograph for cap area 1 well S11.

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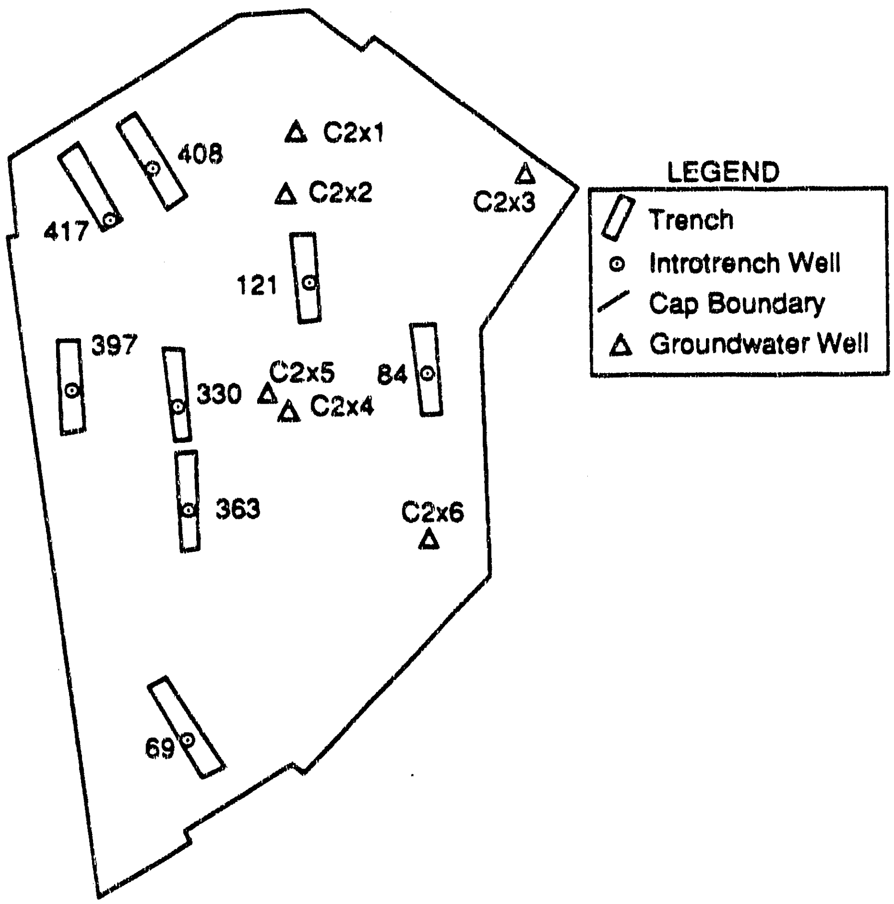

Fig. 16. Burial trench and well locations within cap area 2.

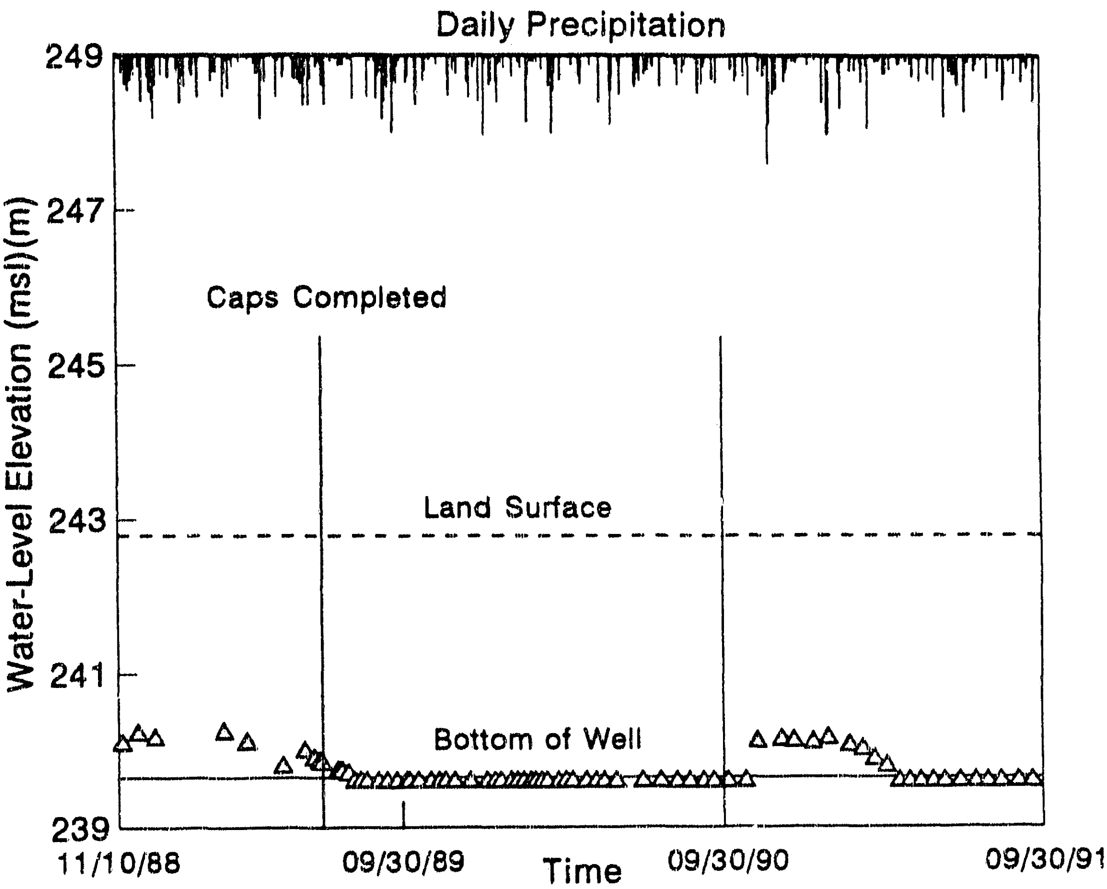

Fig. 17. Hydrograph and associated hyetograph for cap area 2 well T69.

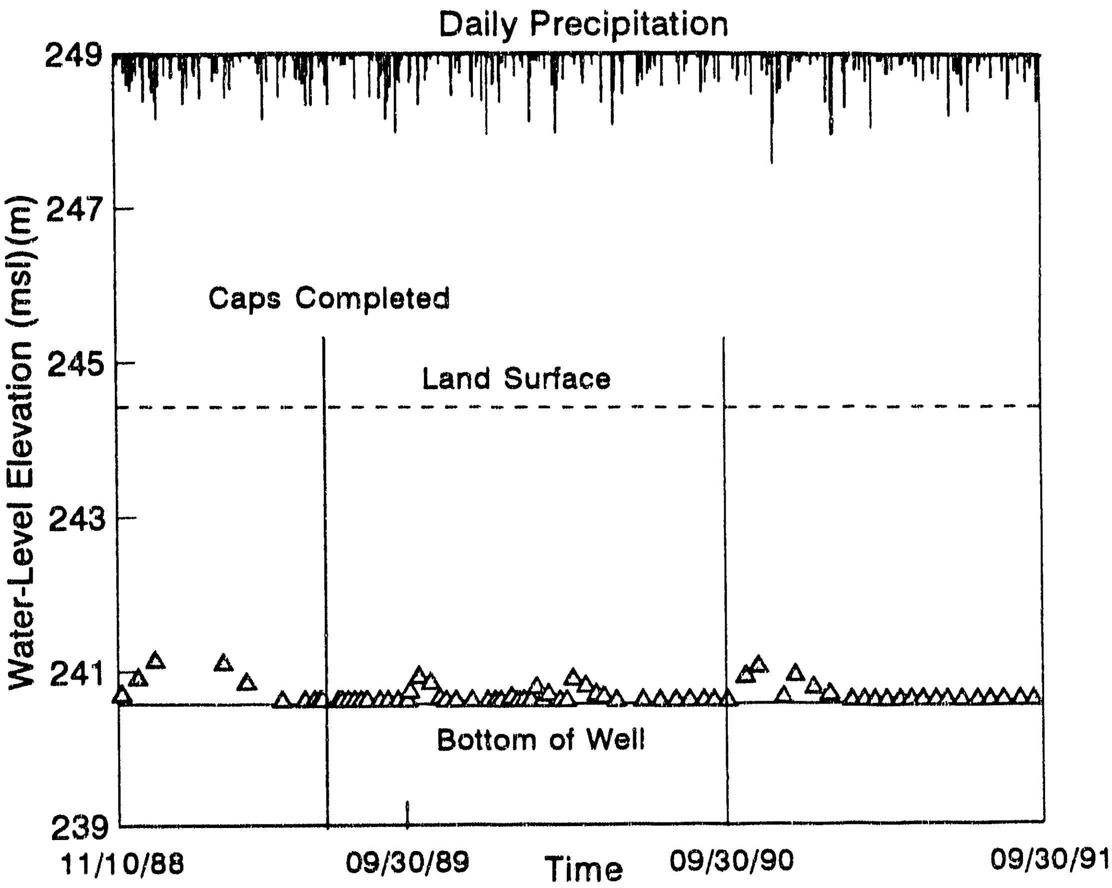

Fig. 18. Hydrograph and associated hyetograph for cap area 2 well T363.

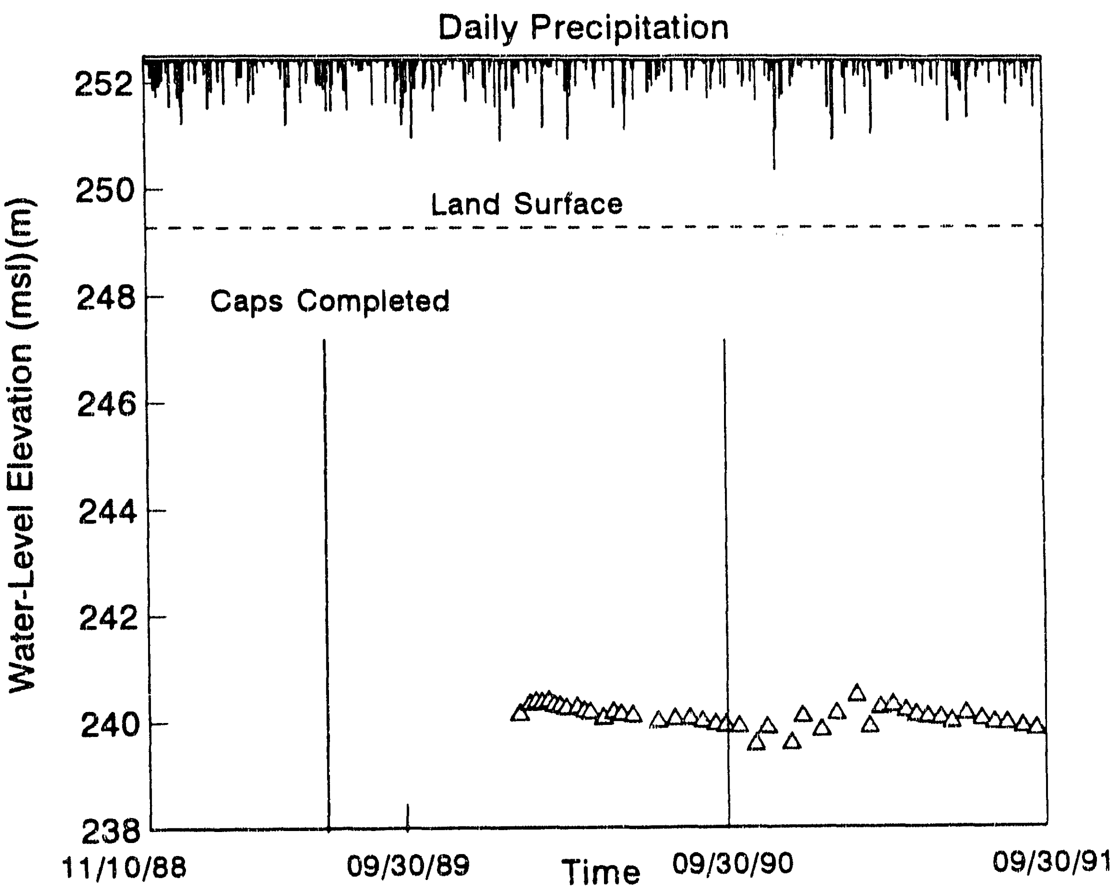

Fig. 19. Hydrograph and associated hyetograph for cap area 2 well C2X3.

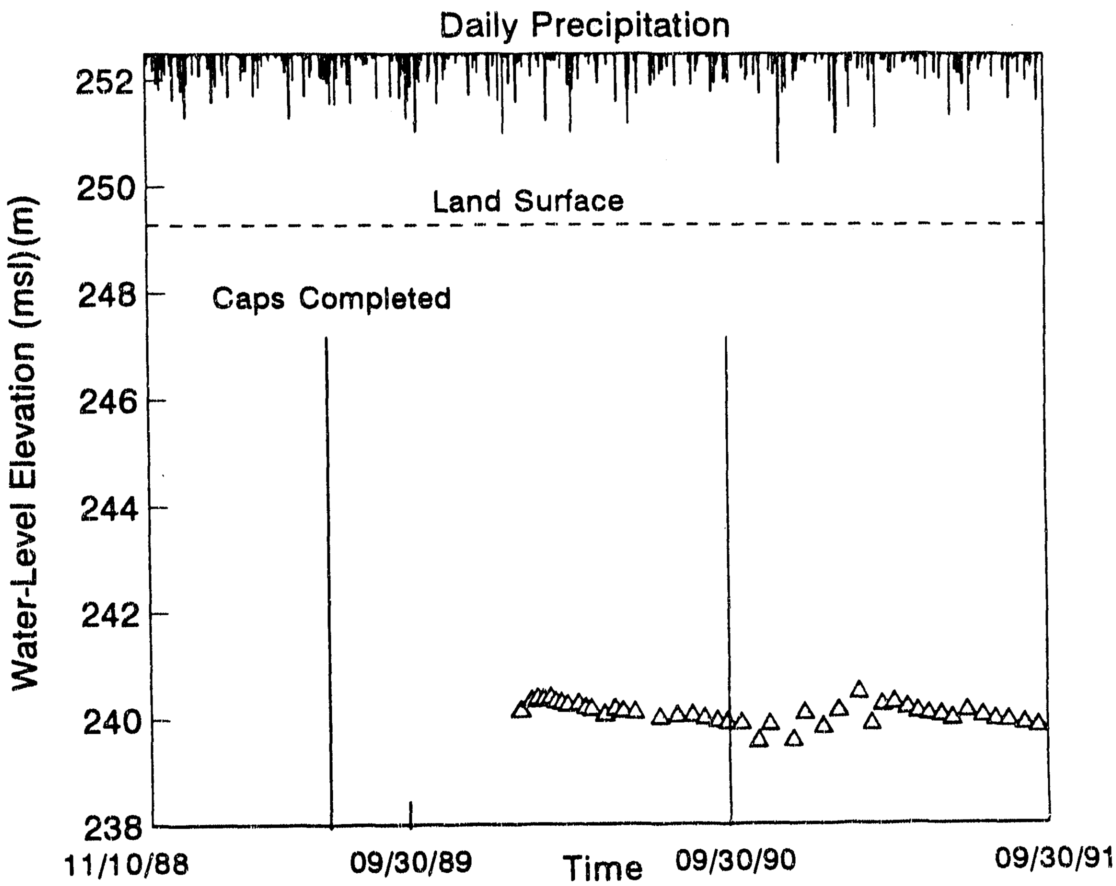

Fig. 20. Hydrograph and associated hyetograph for cap area 2 well C2X4.

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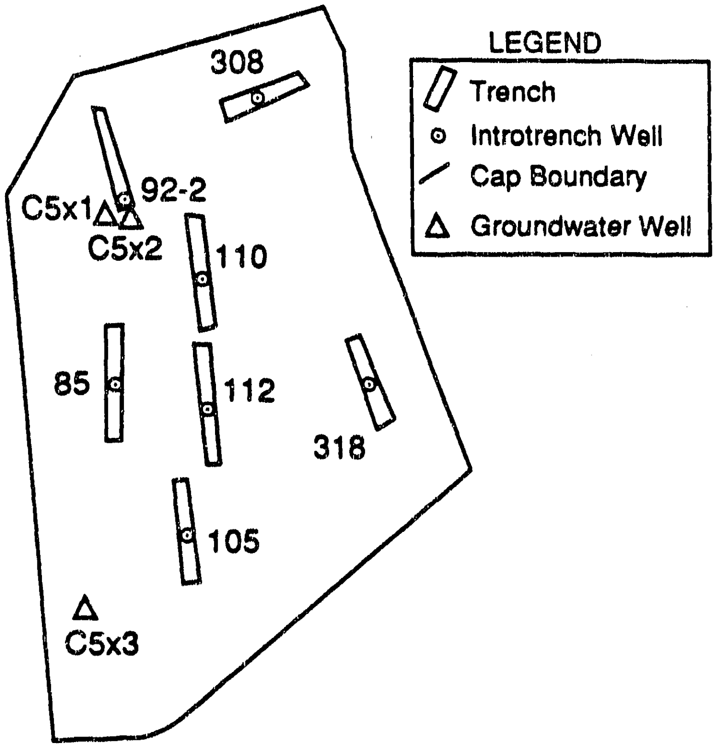

Fig. 21. Burial trench and well locations within cap area 5.

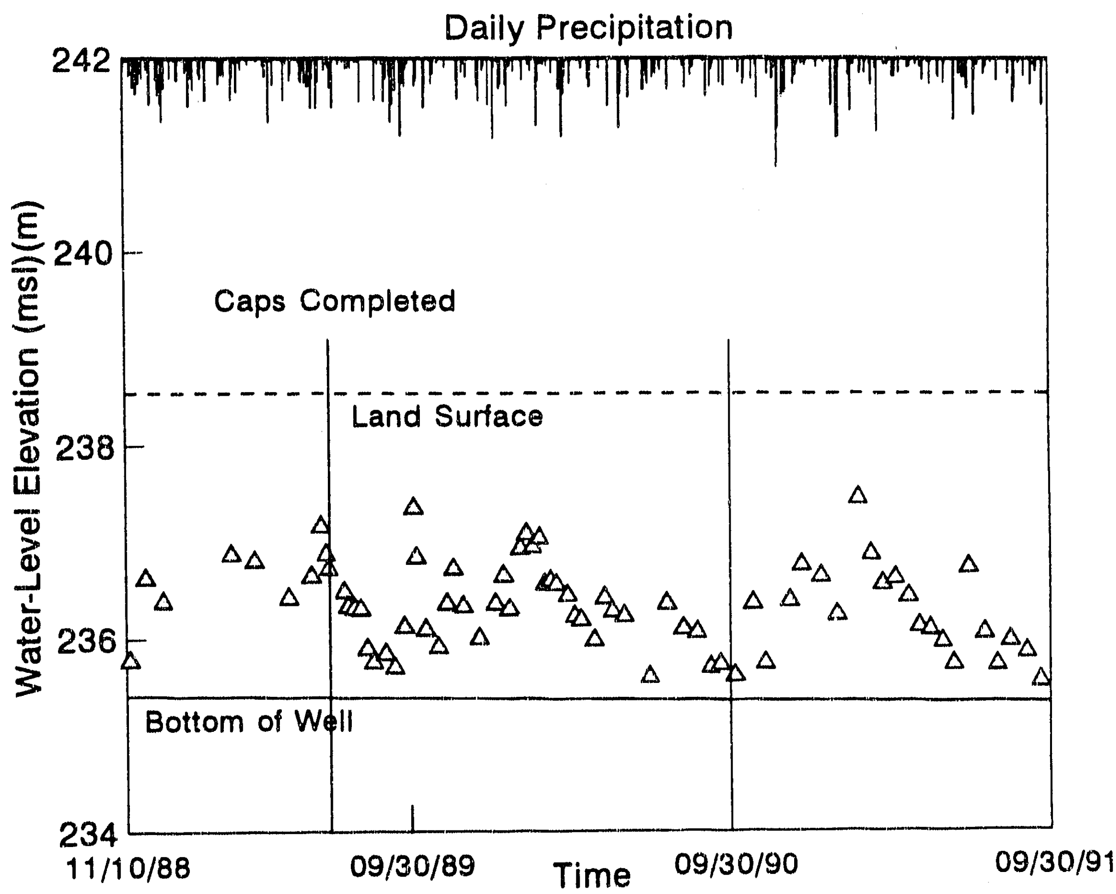

Fig. 22. Hydrograph and associated hyetograph for cap area 5 well T85.

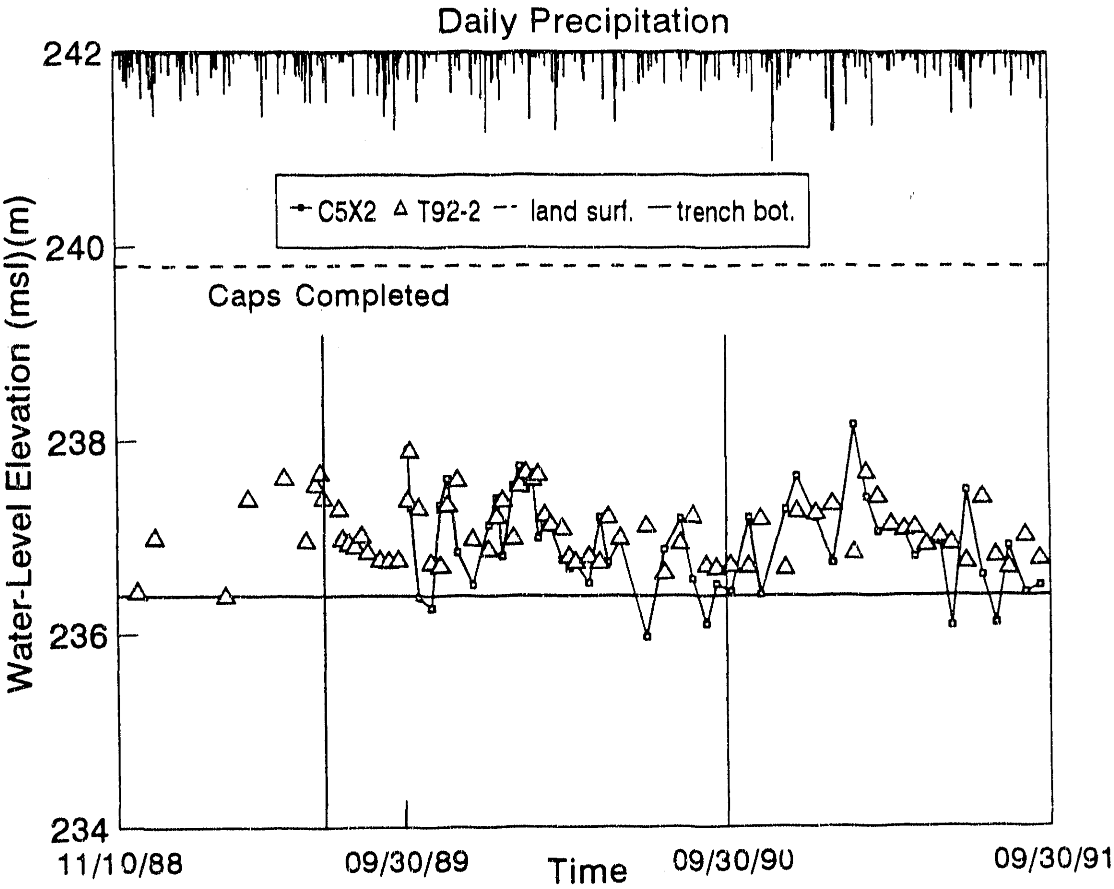

Fig. 23. Hydrograph and associated hyetograph for cap area 5 well T92-2 and groundwater well C5X2.

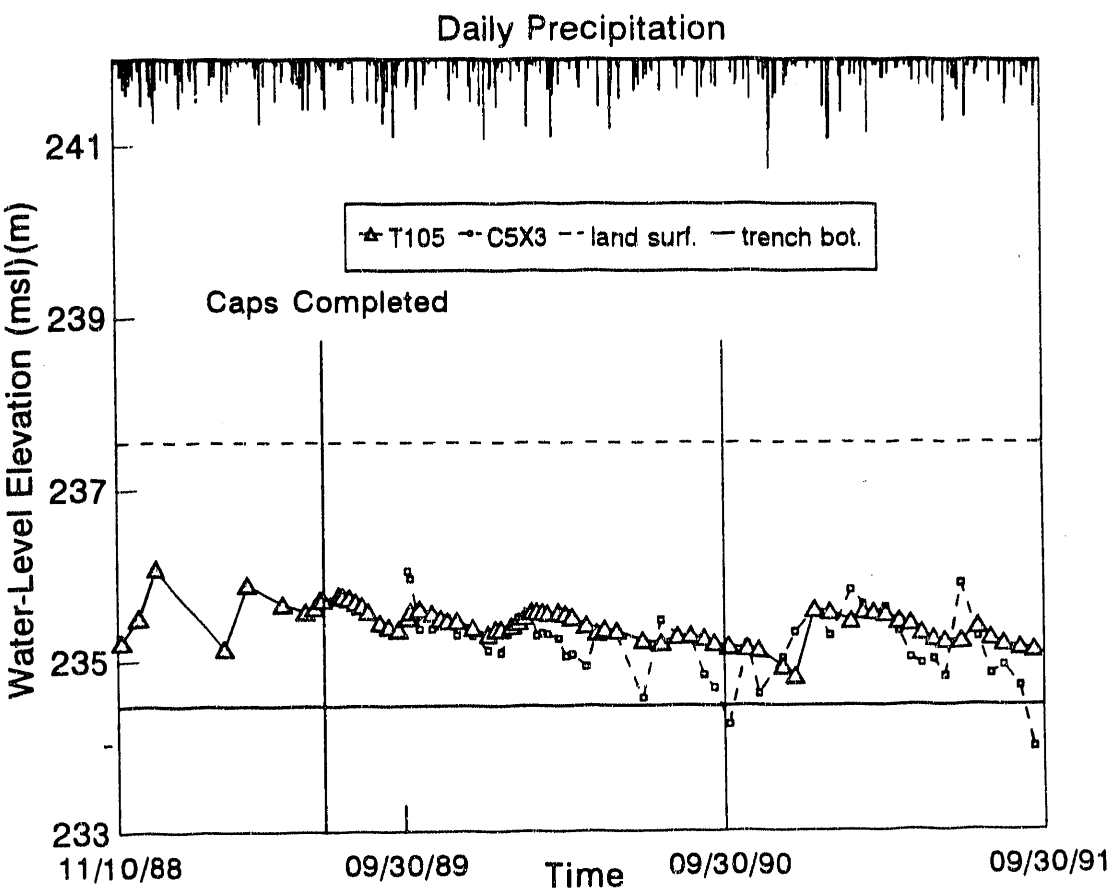

Fig. 24. Hydrograph and associated hyetograph for cap area 5 well T105 and groundwater well C5X3.

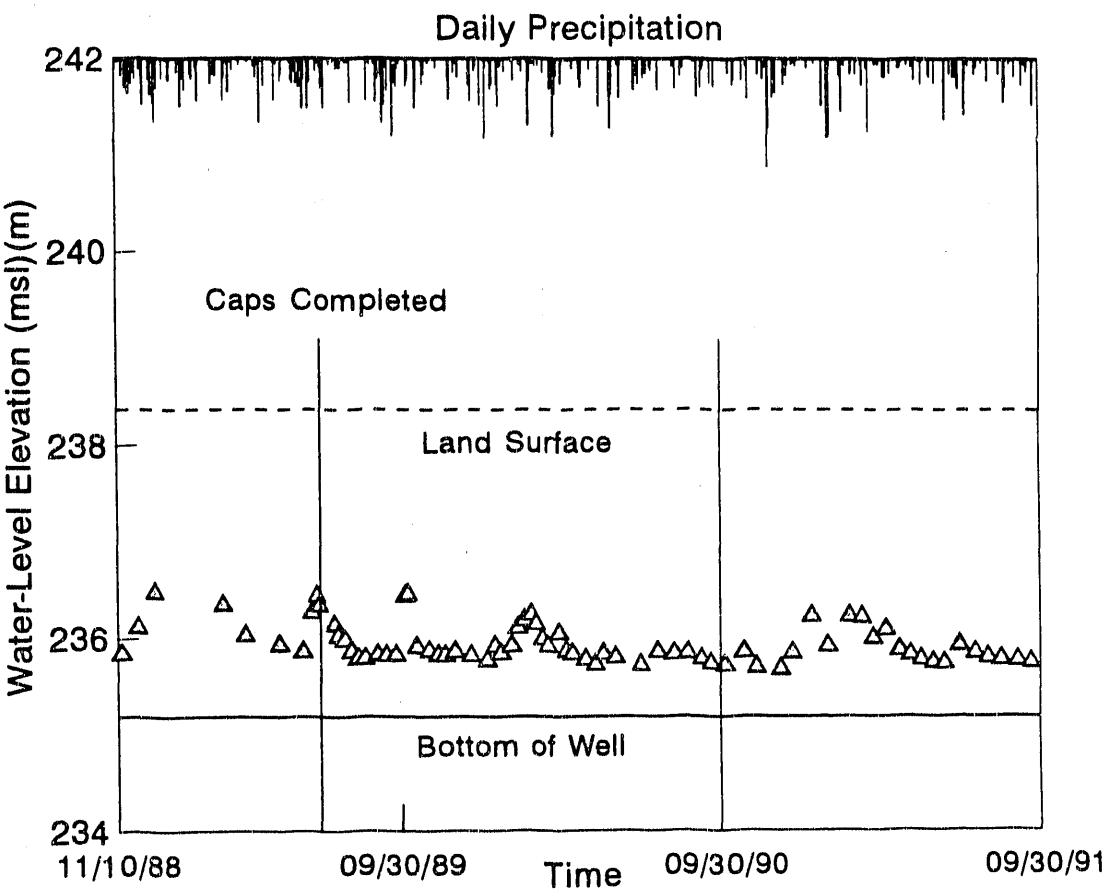

Fig. 25. Hydrograph and associated hyetograph for cap area 5 well T112.

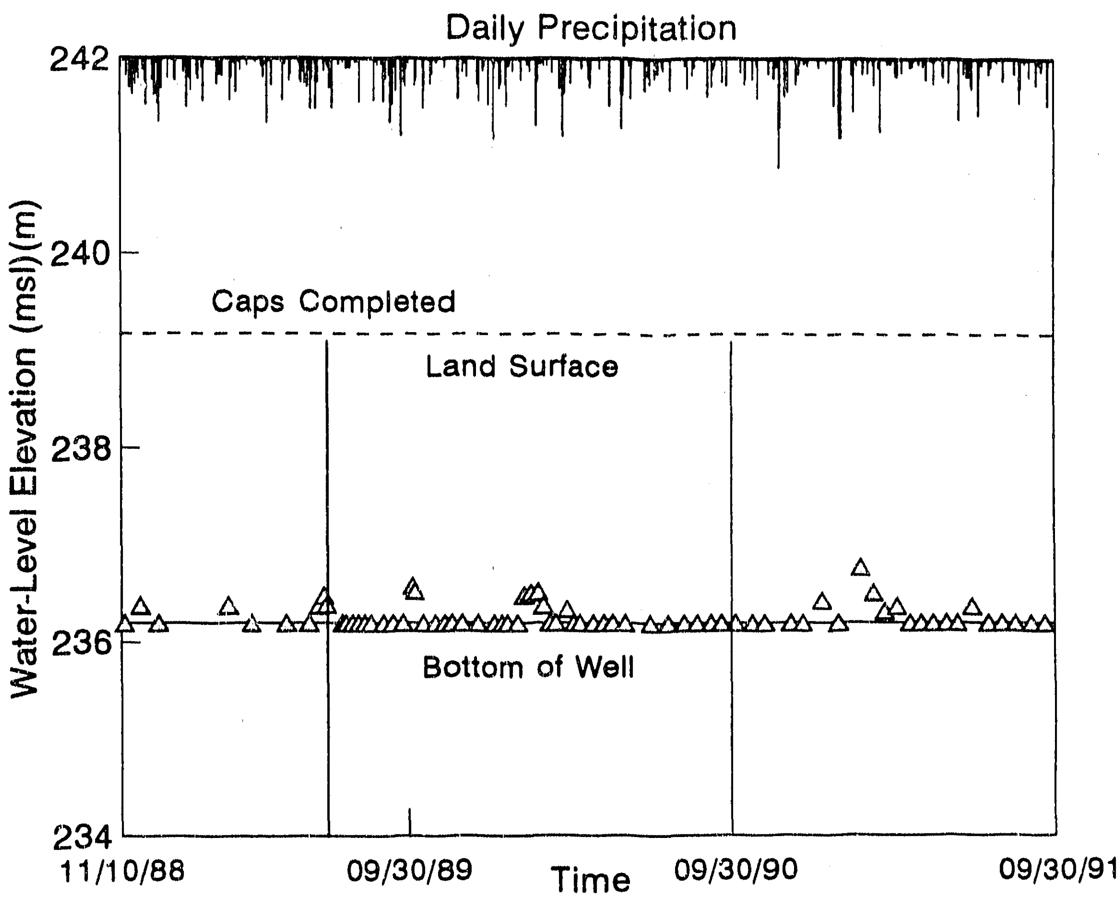

Fig. 26. Hydrograph and associated hyetograph for cap area 5 T308.

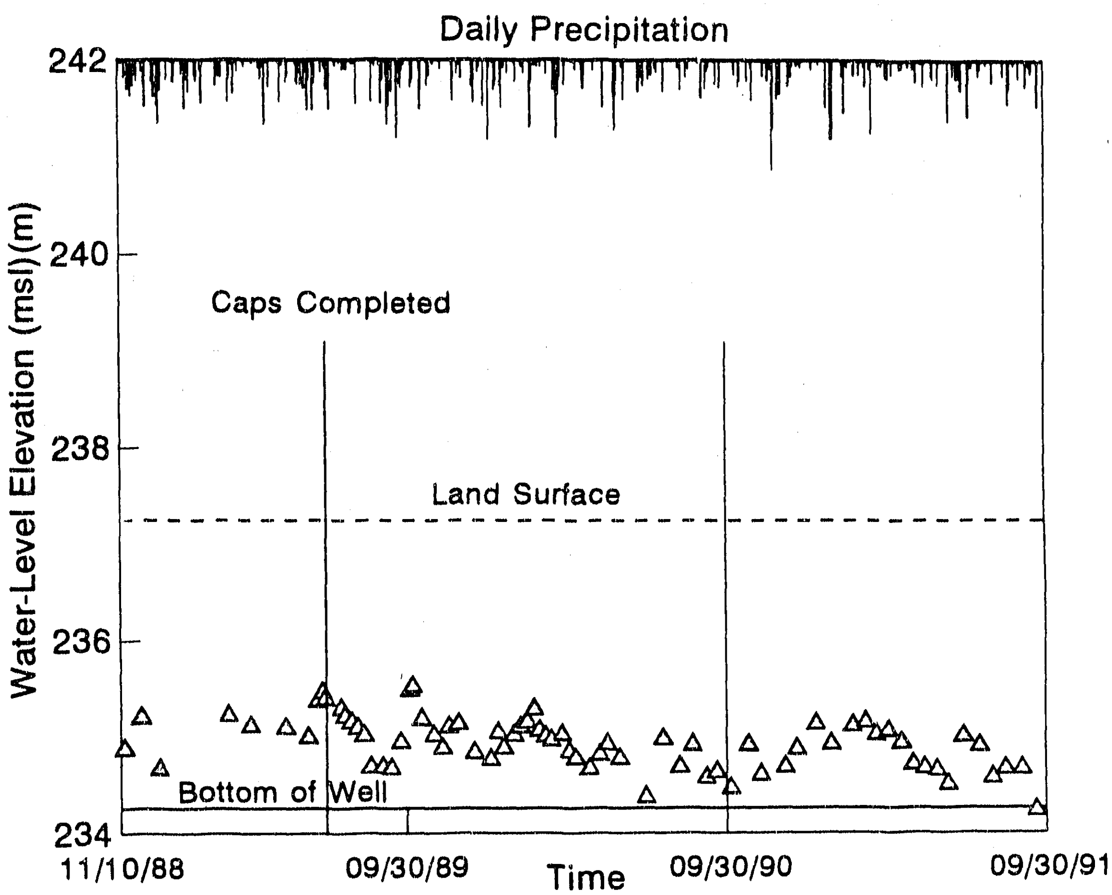

Fig. 27. Hydrograph and associated hyetograph for cap area 5 T318.

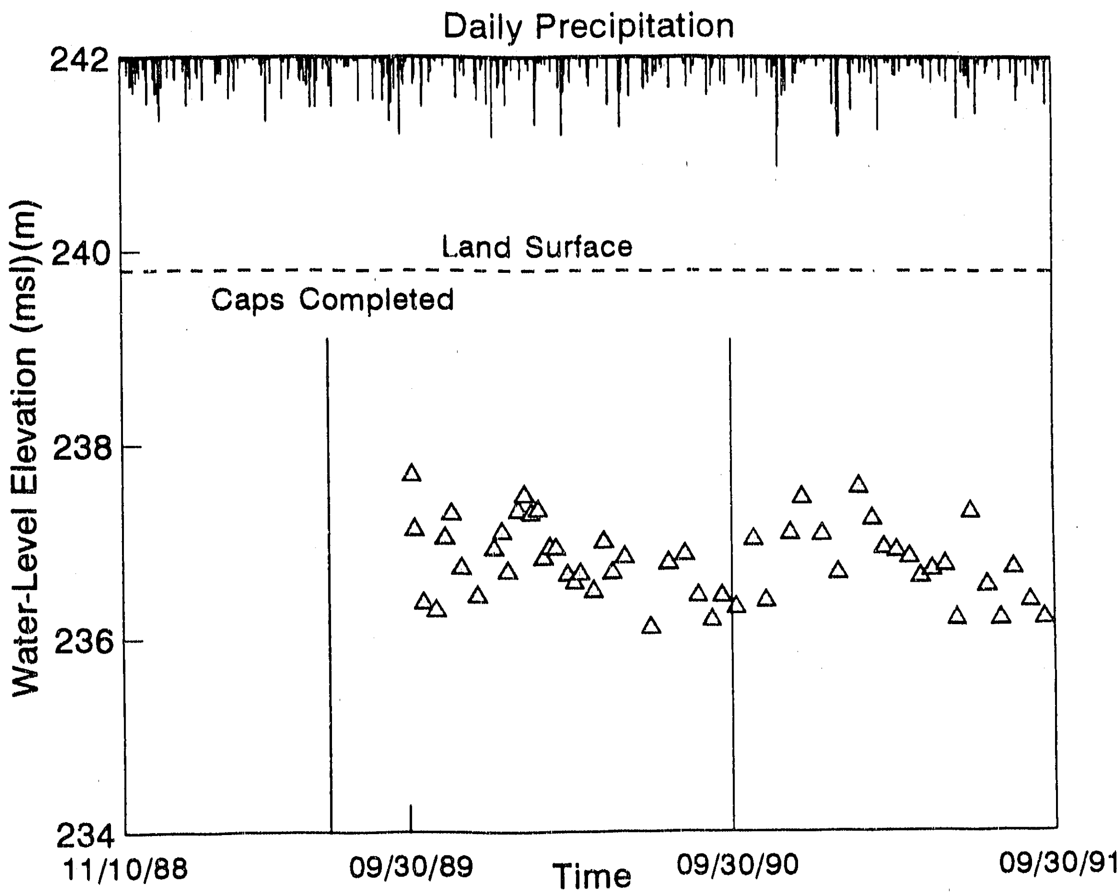

Fig. 28. Hydrograph and associated hyetograph for cap area 5 well C5X1.

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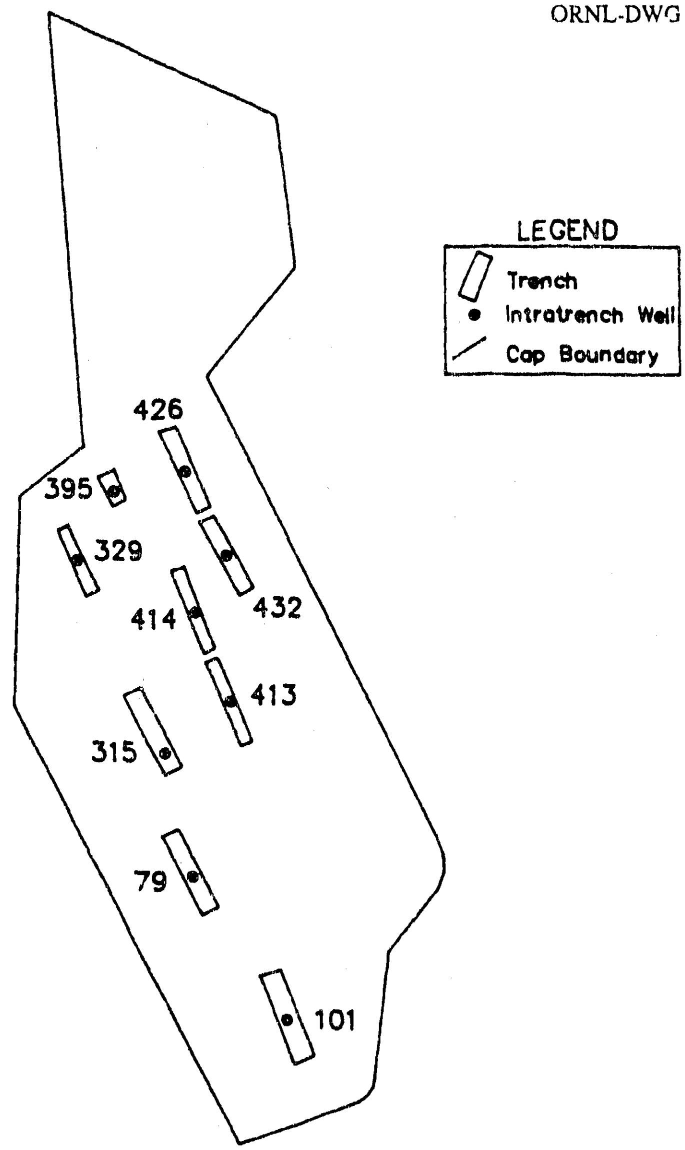

Fig. 29. Burial trench and well locations within cap area 6.

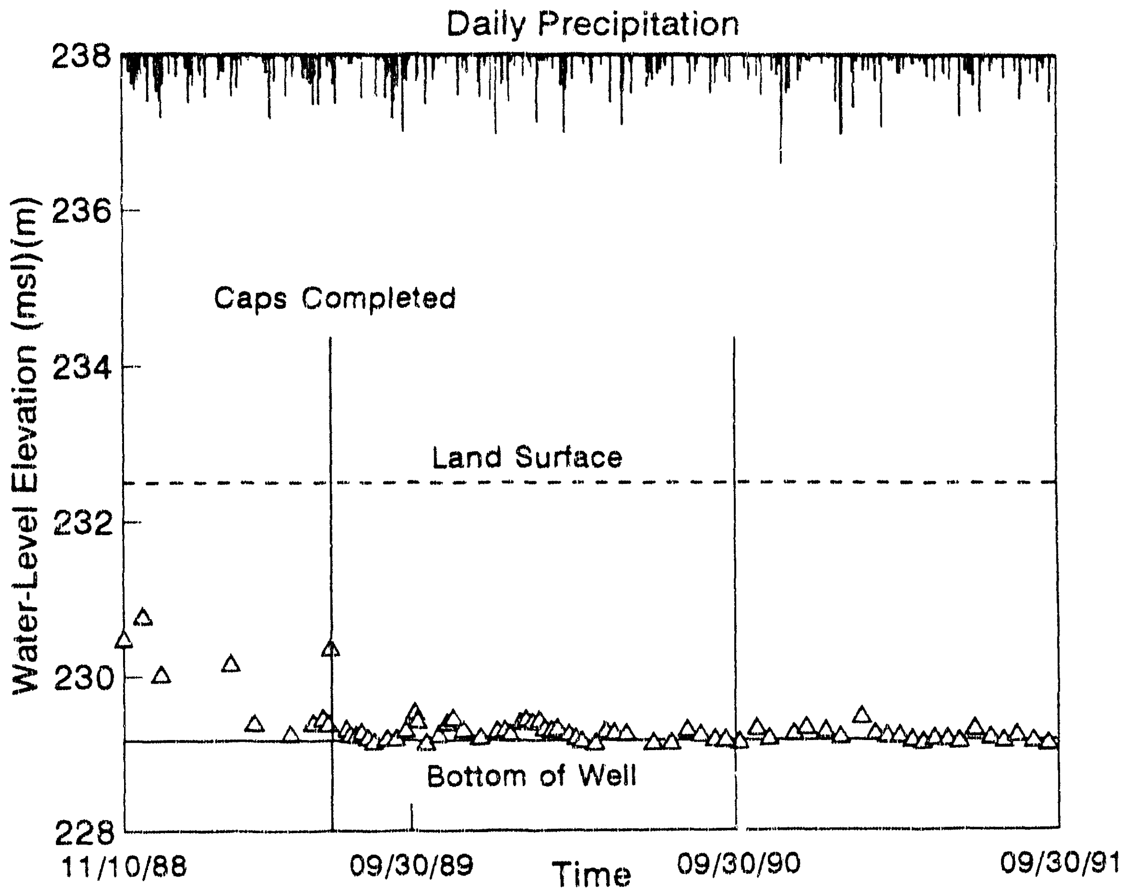

Fig. 30. Hydrograph and associated hyetograph for cap area 6 well T101.

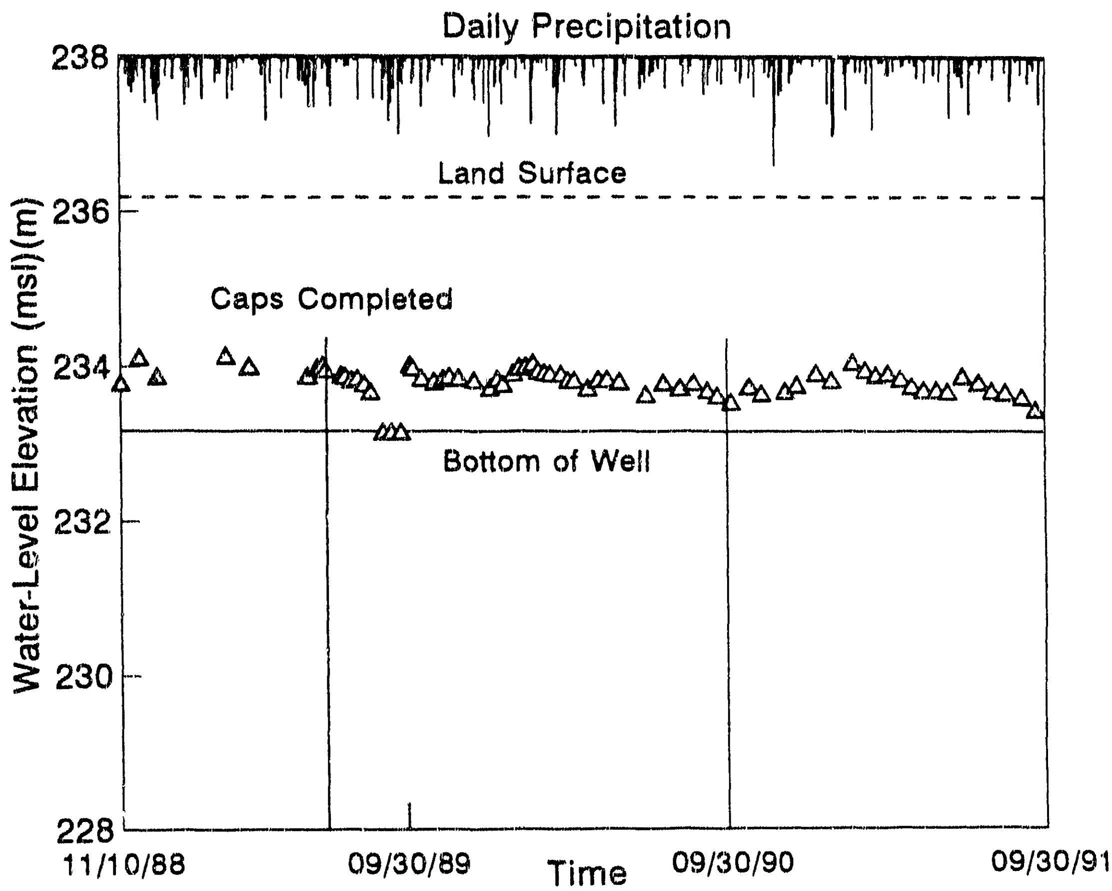

Fig. 31. Hydrograph and associated hyetograph for cap area 6 well 329.

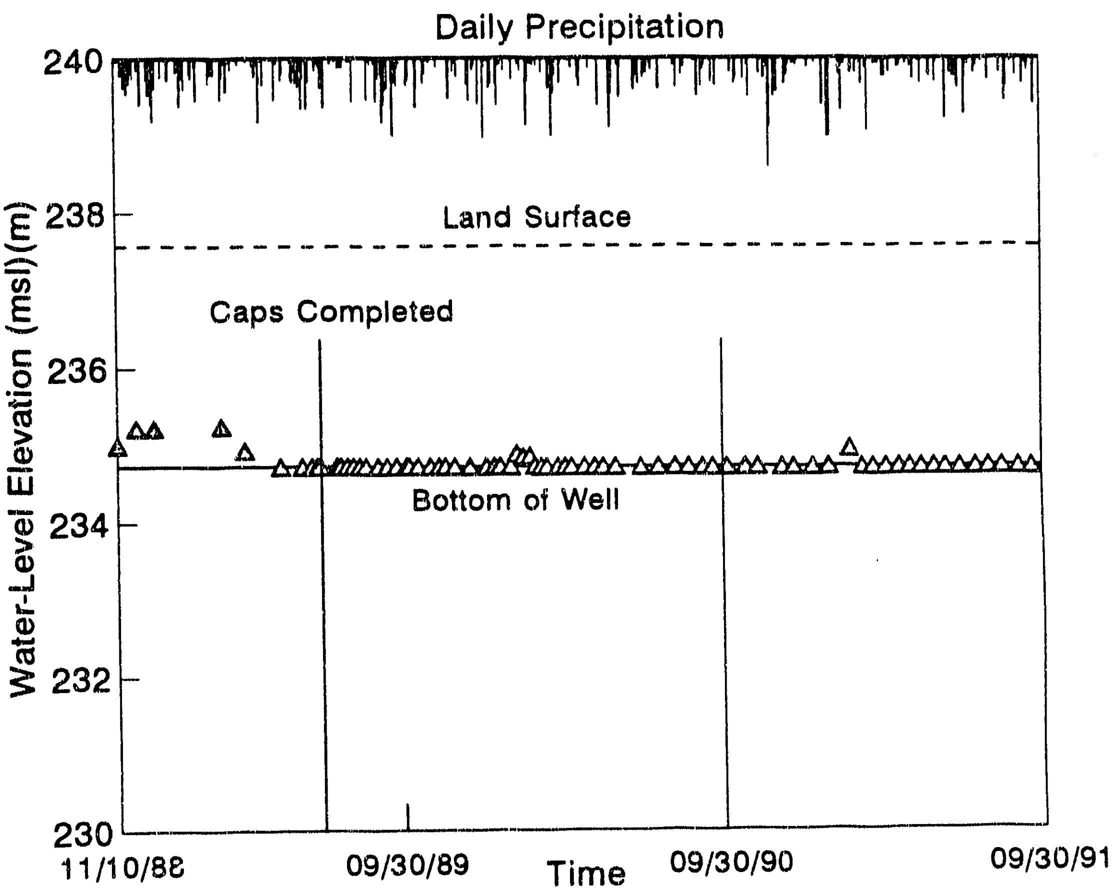

Fig. 32. Hydrograph and associated hyetograph for cap area 6 well T395.

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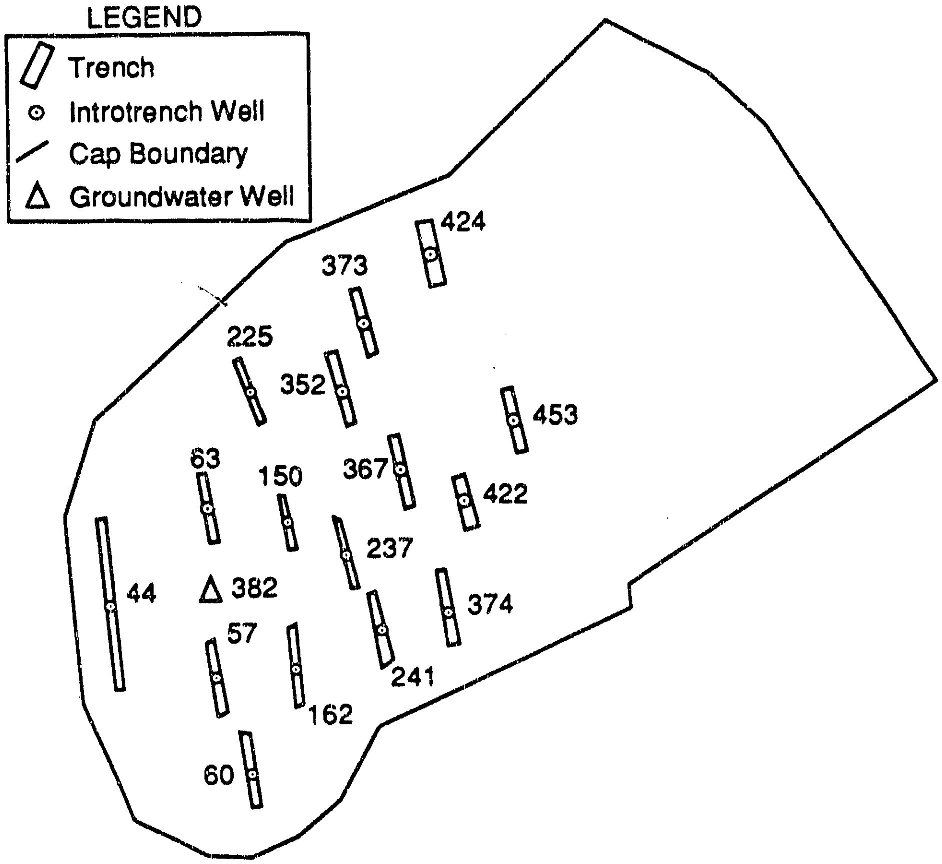

Fig. 33. Burial trench and well locations within cap area 8.

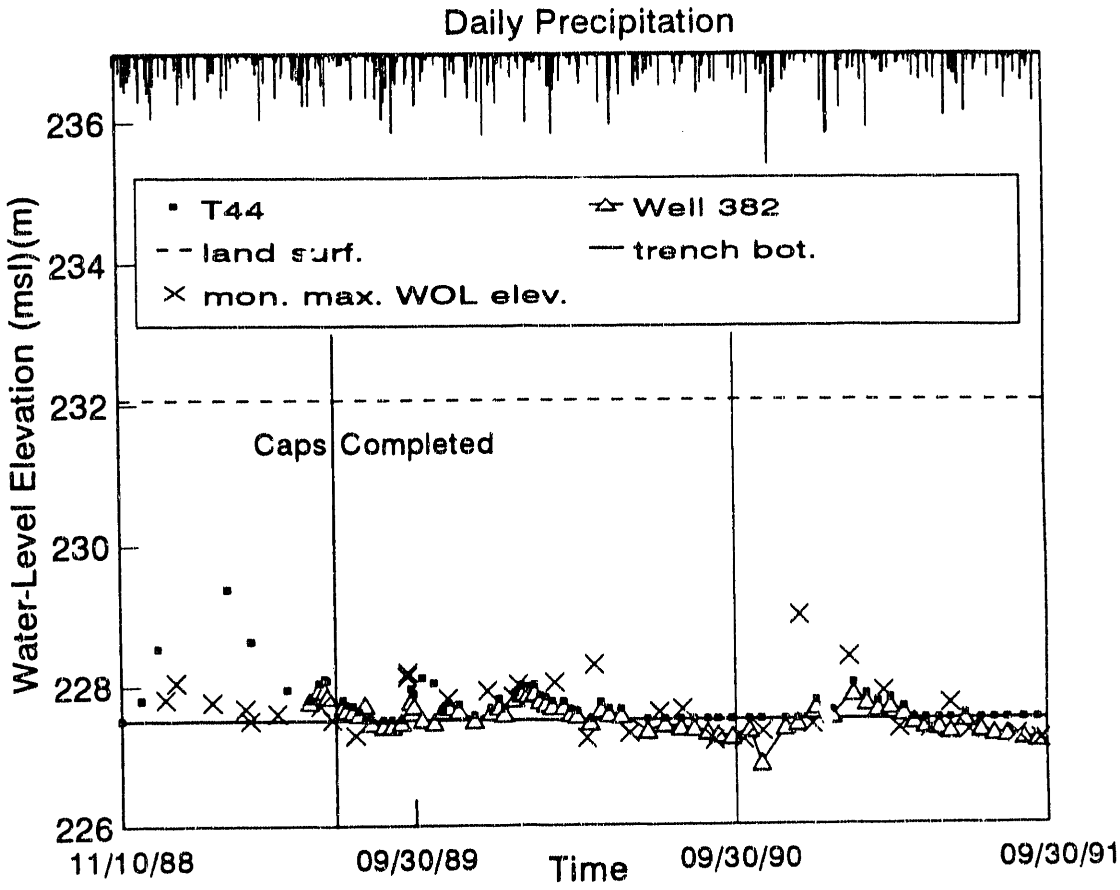

Fig. 34. Hyetograph and hydrographs for T44, well 382, and maximum monthly water elevation of White Oak Lake.

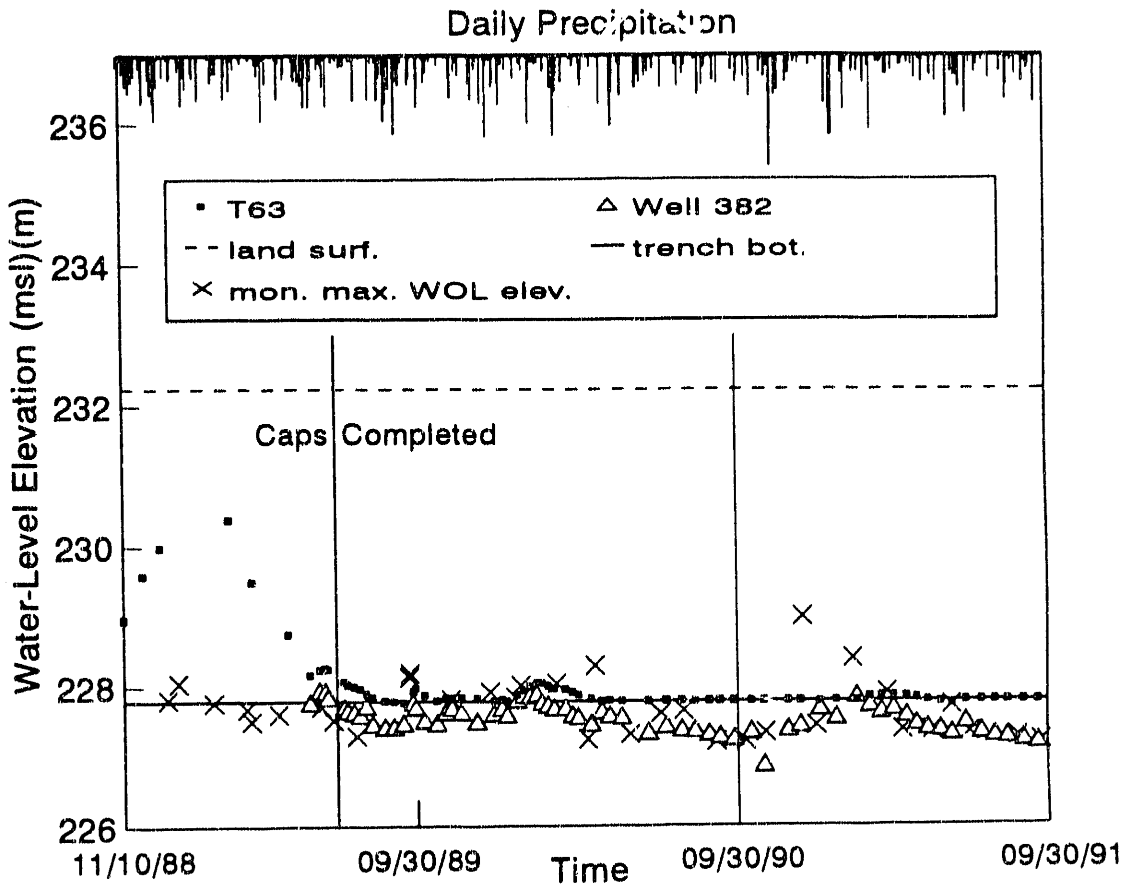

Fig. 35. Hyetograph and hydrograph for cap area 8 well T63, well 382, and maximum monthly water elevation of White Oak Lake.

APPENDIX

Water Level Data from Wells in and Around ICM Caps, Rainfall Data from SWSA 6, and Peak Monthly Elevations of White Oak Lake

Table A.1. Depth to water and water-level elevations for ICM monitoring wells outside of burial trenches in SWSA 6

Well No.	Date measured	Depth to water (m)	Water-level elevation (m)
0276	01/15/90	0.45	230.99
0276	02/15/90	0.42	231.02
0276	04/23/90	0.61	230.83
0276	05/21/90	0.61	230.83
0276	06/26/90	0.90	230.54
0276	07/25/90	0.61	230.83
0276	08/23/90	0.74	230.71
0276	09/25/90	0.96	230.48
0276	10/29/90	0.67	230.77
0276	11/29/90	0.67	230.77
0276	12/20/90	0.26	231.18
0276	01/29/91	0.50	230.94
0276	02/25/91	0.41	231.03
0276	03/28/91	0.42	231.03
0276	04/24/91	0.59	230.86
0276	05/28/91	0.74	230.70
0276	06/26/91	0.18	231.26
0276	07/25/91	0.87	230.57
0276	08/27/91	0.91	230.53
0276	09/23/91	1.06	230.38
0276	10/22/91	0.87	230.58
0318	01/15/90	3.10	240.76
0318	12/20/90	3.34	240.52
0318	06/26/91	3.05	240.80
0345	01/15/90	0.89	229.92
0345	02/15/90	1.09	229.72
0345	04/23/90	1.25	229.56
0345	05/21/90	1.09	229.72
0345	06/26/90	1.17	229.64
0345	07/25/90	1.16	229.65
0345	08/23/90	1.11	229.70
0345	09/25/90	1.25	229.56
0345	10/29/90	1.18	229.63
0345	11/29/90	1.10	229.71
0345	12/20/90	1.01	229.81
0345	01/29/91	1.10	229.71
0345	02/25/91	1.04	229.78
0347	01/15/90	2.19	235.05
0347	02/15/90	1.80	235.44
0347	04/23/90	2.33	234.91
0347	05/21/90	2.03	235.21
0347	06/26/90	2.67	234.56
0347	07/25/90	1.81	235.42

Table A.1 (continued)

Well No.	Date measured	Depth to water (m)	Water-level elevation (m)
0347	08/23/90	2.08	235.16
0347	09/25/90	2.71	234.52
0347	10/29/90	2.41	234.83
0347	11/29/90	2.76	234.48
0347	12/20/90	1.94	235.30
0347	01/29/91	2.10	235.14
0347	02/25/91	1.63	235.61
0347	03/28/91	1.91	235.33
0347	04/24/91	2.17	235.07
0347	05/28/91	2.39	234.84
0347	06/26/91	1.80	235.44
0347	07/25/91	2.28	234.96
0347	08/27/91	2.53	234.70
0347	09/23/91	3.35	233.88
0347	10/22/91	3.08	234.16
0356	01/15/90	3.41	232.12
0356	02/15/90	3.33	232.20
0356	04/23/90	3.79	231.74
0356	05/21/90	3.62	231.91
0356	06/26/90	3.99	231.54
0356	07/25/90	3.29	232.25
0356	08/23/90	3.58	231.96
0356	09/25/90	3.96	231.57
0356	10/29/90	3.78	231.75
0356	11/29/90	3.90	231.64
0356	12/20/90	3.26	232.27
0356	01/29/91	3.71	231.82
0356	02/25/91	3.20	232.33
0356	03/28/91	3.44	232.10
0356	04/24/91	3.70	231.83
0356	05/28/91	3.08	232.46
0356	06/26/91	2.83	232.70
0356	07/25/91	3.66	231.88
0356	08/27/91	3.69	231.85
0356	09/23/91	3.99	231.54
0368	01/15/90	8.25	242.13
0368	02/15/90	8.17	242.21
0368	04/23/90	8.30	242.08
0368	05/21/90	8.27	242.11
0368	06/26/90	8.34	242.04
0368	07/25/90	8.30	242.08
0368	08/23/90	8.33	242.05
0368	09/25/90	8.40	241.95
0368	10/29/90	8.39	241.99
0368	11/29/90	8.42	241.96
0368	12/20/90	8.35	242.03

Table A.1 (continued)

Well No.	Date measured	Depth to water (m)	Water-level elevation (m)
0368	01/29/91	8.28	242.10
0368	02/25/91	8.19	242.19
0368	03/28/91	8.23	242.15
0368	04/24/91	8.28	242.10
0368	05/28/91	8.35	242.03
0368	06/26/91	8.32	242.06
0368	07/25/91	8.40	241.98
0368	08/27/91	8.46	241.92
0368	09/23/91	8.51	241.87
0368	10/22/91	8.55	241.83
0636	01/15/90	9.36	245.06
0636	02/15/90	8.78	245.64
0636	04/23/90	9.60	244.82
0636	05/21/90	9.44	244.98
0636	06/26/9	10.00	244.42
0636	07/25/90	9.59	244.83
0636	08/23/90	9.83	244.59
0636	09/25/9	10.24	244.18
0636	10/29/90	9.89	244.53
0636	11/29/9	10.01	244.41
0636	12/20/90	9.27	245.15
0636	01/29/91	9.52	244.90
0636	02/25/91	8.68	245.74
0636	03/28/91	9.00	245.42
0636	04/24/91	9.36	245.06
0636	05/28/91	9.73	244.69
0636	06/26/91	8.98	245.44
0636	07/25/91	10.01	244.41
0636	08/27/91	10.16	244.26
0636	09/23/91	10.29	244.13
0636	10/22/91	10.24	244.18
0640	01/15/91	10.17	244.98
0640	02/15/90	9.70	245.45
0640	04/23/90	10.34	244.81
0642	01/15/90	1.54	235.28
0642	02/15/90	1.13	235.69
0642	04/23/90	1.95	234.87
0642	05/21/90	1.83	234.99
0642	06/26/90	2.10	234.72
0642	07/25/90	1.94	234.88
0642	08/23/90	2.08	234.73
0642	09/25/90	2.42	234.39
0642	10/29/90	2.30	234.52
0642	11/29/90	2.34	234.48
0642	12/20/90	1.80	235.02

Table A.1 (continued)

Well No.	Date measured	Depth to water (m)	Water-level elevation (m)
0642	01/29/91	1.37	235.45
0642	02/25/91	1.06	235.76
0642	03/28/91	1.37	235.44
0642	04/24/91	1.66	235.16
0642	05/28/91	2.03	234.79
0642	06/26/91	1.68	235.14
0642	07/25/91	1.91	234.91
0642	08/27/91	2.24	234.58
0642	09/23/91	2.64	234.18
0642	10/22/91	2.69	234.13
0645	01/15/90	1.99	231.58
0645	02/15/90	0.00	0.00
0645	04/23/90	2.17	231.40
0645	05/21/90	2.15	231.42
0645	06/26/90	2.39	231.18
0645	07/25/90	2.25	231.32
0645	08/23/90	2.19	231.38
0645	09/25/90	2.38	231.19
0645	10/29/90	2.38	231.19
0645	11/29/90	2.27	231.30
0645	12/20/90	2.11	231.46
0645	01/29/91	2.17	231.40
0645	02/25/91	2.04	231.53
0645	03/28/91	1.99	231.58
0645	04/24/91	2.17	231.40
0645	05/28/91	2.03	231.54
0645	06/26/91	1.93	231.64
0645	07/25/91	2.25	231.32
0645	08/27/91	2.24	231.33
0645	09/23/91	2.41	231.16
0645	10/22/91	2.45	231.12
0646	01/15/90	4.50	235.35
0646	02/15/90	0.00	0.00
0646	04/23/90	4.61	235.24
0646	05/21/90	4.49	235.36
0646	06/26/90	4.72	235.13
0646	07/25/90	4.56	235.29
0646	08/23/90	4.59	235.26
0646	09/25/90	4.86	234.99
0646	10/29/90	4.69	235.16
0646	11/29/90	4.64	235.21
0646	12/20/90	4.33	235.52
0646	01/29/91	4.34	235.51
0646	02/25/91	4.05	235.80
0646	03/28/91	4.17	235.68
0646	04/24/91	4.52	235.33

Table A.1 (continued)

Well No.	Date measured	Depth to water (m)	Water-level elevation (m)
0646	05/28/91	4.75	235.09
0646	06/26/91	4.55	235.30
0646	07/25/91	4.93	234.92
0646	08/27/91	4.99	234.86
0646	09/23/91	5.24	234.61
0646	10/22/91	5.29	234.56
0647	01/15/90	9.93	240.10
0647	02/15/90	9.71	240.32
0647	04/23/90	9.94	240.09
0647	05/21/90	9.92	240.11
0647	06/26/90	10.01	240.01
0647	07/25/90	10.00	240.03
0647	08/23/90	10.03	240.00
0647	09/25/90	10.12	239.91
0647	10/29/90	10.12	239.91
0647	11/29/90	10.13	239.89
0647	12/20/90	9.97	240.06
0647	01/29/91	9.89	240.14
0647	02/25/91	9.70	240.33
0647	03/28/91	9.80	240.23
0647	04/24/91	9.87	240.16
0647	05/28/91	9.99	240.04
0647	06/26/91	9.85	240.18
0647	07/25/91	10.03	240.00
0647	08/27/91	10.10	239.92
0647	09/23/91	10.19	239.83
0647	10/22/91	10.22	239.81
0648	01/15/90	7.71	243.67
0648	02/15/90	7.23	244.15
0648	04/23/90	7.74	243.64
0648	05/21/90	7.68	243.70
0648	06/26/90	7.92	243.46
0648	07/25/90	7.77	243.60
0648	08/23/90	7.91	243.47
0648	09/25/90	8.15	243.22
0648	10/29/90	8.23	243.15
0648	11/29/90	8.37	243.01
0648	12/20/90	8.05	243.33
0648	01/29/91	7.77	243.60
0648	02/25/91	7.42	243.96
0648	03/28/91	7.59	243.79
0648	04/24/91	7.75	243.63
0648	05/28/91	7.94	243.44
0648	06/26/91	7.71	243.67
0648	07/25/91	8.15	243.23

Table A.1 (continued)

Well No.	Date measured	Depth to water (m)	Water-level elevation (m)
0648	08/27/91	8.32	243.06
0648	09/23/91	8.48	242.90
0648	10/22/91	8.63	242.74
0655	01/15/90	12.05	243.87
0655	02/15/90	11.58	244.34
0655	04/23/90	12.31	243.61
0655	05/21/90	12.06	243.86
0655	06/26/90	12.50	243.42
0655	07/25/90	12.42	243.50
0655	08/23/90	12.53	243.39
0655	09/25/90	12.86	243.06
0655	10/29/90	12.89	243.03
0655	11/29/90	12.95	242.97
0655	12/20/90	12.72	243.21
0655	01/29/91	12.02	243.90
0655	02/25/91	11.57	244.35
0655	03/28/91	11.84	244.08
0655	04/24/91	12.08	243.85
0655	05/28/91	12.59	243.33
0655	06/26/91	12.63	243.29
0655	07/25/91	12.60	243.32
0655	08/27/91	12.90	243.02
0655	09/23/91	13.16	242.76
0655	10/22/91	13.22	242.70
0656	01/15/90	11.15	247.26
0656	02/15/90	10.33	248.08
0656	04/23/90	11.09	247.31
0656	05/21/90	10.82	247.59
0656	06/26/90	11.54	246.87
0656	07/25/90	11.73	246.67
0656	08/23/90	11.83	246.58
0656	09/25/90	12.23	246.18
0656	10/29/90	12.28	246.12
0656	11/29/90	12.22	246.18
0656	12/20/90	11.98	246.43
0656	01/29/91	10.93	247.48
0656	02/25/91	10.70	247.71
0656	03/28/91	10.60	247.80
0656	04/24/91	10.67	247.74
0656	05/28/91	11.43	246.98
0656	06/26/91	11.76	246.65
0656	07/25/91	11.64	246.76
0656	08/27/91	12.13	246.27
0656	09/23/91	12.47	245.94
0656	10/22/91	12.66	245.75

Table A.2. Locations, elevations, and depth to water measurements for intratrench wells in SWSA 6 ICM capped areas

Well	ORNL Northing	ORNL Easting	Top of casing (m)	Ground Surface (m)	Bottom of well	10-04-90	10-24-90	11-07-90	12-05-90
					Cap Area 1				
S11	17628	24621	252.72	252.26	238.44	244.14	244.35	244.27	244.40
					Cap Area 2				
T69	16870	24565	245.30	242.77	239.61	dry	dry	240.13	240.16
T363	16989	24567	244.86	244.42	240.64	dry	240.95	241.08	240.68
C2-X3	17146	24749	250.07	249.28	238.17	239.94	239.60	239.92	239.62
C2-X4	17024	24609	246.49	245.92	232.10	239.29	238.79	239.24	238.74
					Cap Area 5				
T85	16638	24614	239.00	238.53	235.33	235.63	236.38	235.76	236.41
T92-1	16733	24613	241.44	239.99	236.46	236.79	241.44	241.44	237.27
T92-2	16728	24615	240.82	239.80	236.40	236.72	237.21	236.70	237.29
T105	16574	24642	238.03	237.54	234.46	235.15	235.13	235.11	234.91
T112	16628	24651	238.77	238.36	235.18	235.74	235.88	235.72	235.70
T308	16757	24673	239.86	239.16	236.19	dry	dry	dry	dry
T318	16638	24719	237.56	237.24	234.25	234.48	234.93	234.62	234.70
C5-X1	16718	24608	240.35	239.83	231.27	236.35	237.06.	236.42	237.12
C5-X2	16716	24617	240.31	239.80	23[illegible].39	236.44	237.21	236.41	237.29
C5-X3	16524	24602	237.34	236.85	233.02	234.25	235.19	234.61	235.03
					Cap Area 6				
T101	16423	25037	232.83	232.49	229.16	229.15	229.33	229.20	229.26
T329	16678	24922	236.98	236.17	233.15	233.54	233.74	233.65	233.68
T395	16718	24942	237.96	237.56	234.72	237.96	237.96	237.96	237.96
					Cap Area 8				
T44	15809	23965	232.62	232.07	227.51	232.62	232.62	232.62	232.62
T63	15873	24026	232.82	232.23	227.78	232.82	232.82	232.82	232.82
382	15814	24025	233.29	232.78	226.25	227.25	227.35	226.87	227.38

Table A.2 (continued)

Well	Depth Meters 12-19-90	Depth Meters 01-10-91	Depth Meters 01-28-91	Depth Meters 02-21-91	Depth Meters 03-08-91	Depth Meters 03-21-91	Depth Meters 04-04-91	Depth Meters 04-19-91	Depth Meters 05-01-91
Cap Area 1									
S11	244.59	244.84	244.92	245.13	244.68	245.02	245.00	244.87	244.65
Cap Area 2									
T69	240.14	240.12	240.17	240.08	240.03	239.90	239.81	dry	dry
T363	240.97	240.81	240.72	244.86	244.86	244.86	244.86	244.86	244.86
C2-X3	240.13	239.87	240.18	240.52	239.93	240.29	240.33	240.23	240.15
C2-X4	239.29	239.55	239.13	239.60	239.71	239.70	239.72	239.68	239.62
Cap Area 5									
T85	236.78	236.66	236.26	237.47	236.89	236.58	236.64	236.45	236.14
T92-1	237.61	237.23	236.81	238.16	237.43	237.07	237.09	237.12	236.83
T92-2	237.27	237.36	236.86	237.69	237.44	237.15	237.10	237.12	236.94
T105	234.80	235.58	235.55	235.45	235.56	235.55	235.53	235.45	235.42
T112	235.87	236.25	235.94	236.25	236.24	236.02	236.11	235.90	235.85
T308	dry	236.42	dry	236.76	236.50	236.31	236.36	dry	dry
T318	234.89	235.15	234.94	235.13	235.17	235.04	235.08	234.95	234.73
C5-X1	237.49	237.11	236.71	237.60	237.27	236.97	236.94	236.87	236.67
C5-X2	237.64	237.21	236.74	238.17	237.42	237.06	237.10	237.05	236.80
C5-X3	235.33	235.59	235.29	235.82	235.66	235.54	235.62	235.34	235.03
Cap Area 6									
T101	229.34	229.30	229.22	229.48	229.26	229.23	229.23	229.18	229.15
T329	233.76	233.91	233.82	234.05	233.95	233.89	233.91	233.84	233.74
T395	dry	dry	dry	235.35	dry	dry	dry	dry	dry
Cap Area 8									
T44	dry	227.77	227.62	228.01	227.86	227.75	227.80	227.67	dry
T63	dry	227.77	227.79	227.79	227.84	227.85	227.85	227.84	227.82
382	227.44	227.68	227.55	227.86	227.73	227.64	227.68	227.58	227.46

Table A.2 (continued)

Well	Depth Meters 05-14-91	Depth Meters 05-29-91	Depth Meters 06-11-91	Depth Meters 06-28-91	Depth Meters 07-16-91	Depth Meters 07-31-91	Depth Meters 08-15-91	Depth Meters 09-03-91	Meters 09-19-91
Cap Area 1									
S11	244.54	244.47	244.36	244.57	244.46	244.32	244.29	244.15	244.04
Cap Area 2									
T69	dry	dry	dry	dry	dry	dry	dry	dry	dry
T363	dry	dry	dry	dry	dry	dry	dry	dry	dry
C2-X3	240.11	240.09	240.02	240.17	240.07	240.00	239.99	239.93	239.88
C2-X4	239.57	239.50	239.45	239.42	239.43	239.38	239.35	239.29	239.26
Cap Area 5									
T85	236.11	235.98	235.75	236.75	236.07	235.74	235.99	235.87	235.57
T92-1	236.92	236.99	dry	237.45	236.78	dry	237.06	dry	236.84
T92-2	237.03	236.95	236.76	237.43	23.824	236.70	237.03	236.79	236.62
T105	235.31	235.24	235.21	235.21	235.38	235.25	235.18	235.14	2235.11
T112	235.80	235.77	235.76	235.95	235.87	235.82	235.80	235.79	235.77
T308	dry	dry	dry	236.36	dry	dry	dry	dry	dry
T318	234.69	234.67	234.52	235.02	234.92	234.59	234.68	234.68	237.56
C5-X1	236.74	236.79	236.23	237.34	236.58	236.23	236.76	236.42	236.24
C5-X2	236.90	236.95	236.08	237.49	236.61	236.11	236.91	236.43	236.50
C5-X3	234.96	235.01	234.81	235.90	235.27	234.84	234.94	234.70	233.98
Cap Area 6									
T101	229.20	229.19	229.16	229.32	229.1	229.17	229.24	229.17	229.13
T329	233.69	233.69	233.67	233.87	233.79	233.68	233.61	233.60	233.44
T395	dry	dry	dry	dry	dry	dry	dry	dry	dry
Cap Area 8									
T44	dry	dry	dry	227.57	dry	dry	dry	dry	dry
T63	227.79	227.76	227.74	dry	dry	dry	dry	dry	dry
382	227.40	227.38	227.32	227.49	227.34	227.29	227.27	227.23	227.20

Table A.3. Daily rainfall in SWSA 6 from October 1990 through September 1991

10/01/90	2.29	11/17/90	0.00	01/03/91	0.00	02/19/91	56.13	04/07/91	0.00	05/24/91	0.00
10/02/90	0.00	11/18/90	0.00	01/04/91	0.00	02/20/91	6.35	04/08/91	4.32	05/25/91	0.51
10/03/90	0.00	11/19/90	0.00	01/05/91	0.00	02/21/91	0.00	04/09/91	3.81	05/26/91	0.00
10/04/90	27.18	11/20/90	0.00	01/06/91	0.00	02/22/91	0.00	04/10/91	0.00	05/27/91	11.94
10/05/90	0.00	11/21/90	0.00	01/07/91	18.54	02/23/91	0.00	04/11/91	0.00	05/28/91	13.46
10/06/90	0.00	11/22/90	0.76	01/08/91	0.00	02/24/91	0.00	04/12/91	1.52	05/29/91	0.00
10/07/90	0.00	11/23/90	0.76	01/09/91	0.00	02/25/91	0.00	04/13/91	12.70	05/30/91	0.00
10/08/90	20.57	11/24/90	0.00	01/10/91	12.19	02/26/91	0.00	04/14/91	0.00	05/31/91	0.00
10/09/90	0.00	11/25/90	0.00	01/11/91	5.33	02/27/91	0.00	04/15/91	13.21	06/01/91	0.00
10/10/90	8.13	11/26/90	0.00	01/12/91	0.00	02/28/91	0.00	04/16/91	0.00	06/02/91	17.53
10/11/90	5.59	11/27/90	0.00	01/13/91	0.00	03/01/91	11.94	04/17/91	0.00	06/03/91	4.06
10/12/90	1.52	11/28/90	14.99	01/14/91	0.00	03/02/91	0.25	04/18/91	0.00	06/04/91	0.00
10/13/90	0.00	11/29/90	0.00	01/15/91	4.32	03/03/91	37.85	04/19/91	10.16	06/05/91	0.00
10/14/90	0.00	11/30/90	0.00	01/16/91	3.56	03/04/91	0.51	04/20/91	0.00	06/06/91	0.00
10/15/90	0.00	12/01/90	0.00	01/17/91	0.00	03/05/91	0.00	04/21/91	0.00	06/07/91	0.00
10/16/90	0.00	12/02/90	5.59	01/18/91	0.00	03/06/91	5.08	04/22/91	0.00	06/08/91	0.00
10/17/90	2.03	12/03/90	28.45	01/19/91	5.33	03/07/91	0.00	04/23/91	0.00	06/09/91	0.00
10/18/90	17.27	12/04/90	0.00	01/20/91	2.03	03/08/91	0.00	04/24/91	0.00	06/10/91	0.00
10/19/90	0.00	12/05/90	0.00	01/21/91	0.00	03/09/91	0.00	04/25/91	0.00	06/11/91	0.51
10/20/90	0.00	12/06/90	0.00	01/22/91	0.00	03/10/91	0.00	04/26/91	0.00	06/12/91	43.69
10/21/90	0.00	12/07/90	0.00	01/23/91	0.00	03/11/91	0.00	04/27/91	6.35	06/13/91	0.00
10/22/90	19.56	12/08/90	0.00	01/24/91	0.00	03/12/91	10.92	04/28/91	1.02	06/14/91	0.00
10/23/90	0.00	12/09/90	0.00	01/25/91	0.00	03/13/91	8.38	04/29/91	5.84	06/15/91	0.00
10/24/90	0.00	12/10/90	0.00	01/26/91	0.00	03/14/91	0.00	04/30/91	1.78	06/16/91	0.25
10/25/90	0.00	12/11/90	0.00	01/27/91	0.00	03/15/91	0.00	05/01/91	0.00	06/17/91	11.18
10/26/90	0.00	12/12/90	0.00	01/28/91	0.00	03/16/91	0.00	05/02/91	0.00	06/18/91	0.51
10/27/90	0.00	12/13/90	11.43	01/29/91	0.00	03/17/91	10.41	05/03/91	0.51	06/19/91	0.00
10/28/90	0.00	12/14/90	2.54	01/30/91	6.35	03/18/91	2.29	05/04/91	0.00	06/20/91	13.46
10/29/90	0.00	12/15/90	2.03	01/31/91	0.00	03/19/91	0.00	05/05/91	4.32	06/21/91	0.00
10/30/90	0.00	12/16/90	0.00	02/01/91	0.00	03/20/91	0.00	05/06/91	0.00	06/22/91	13.46
10/31/90	0.00	12/17/90	14.48	02/02/91	0.00	03/21/91	0.00	05/07/91	0.00	06/23/91	3.81
11/01/90	0.00	12/18/90	14.48	02/03/91	0.00	03/22/91	4.83	05/08/91	0.00	06/24/91	19.81
11/02/90	0.00	12/19/90	0.00	02/04/91	0.00	03/23/91	18.80	05/09/91	6.10	06/25/91	21.59
11/03/90	0.00	12/20/90	7.11	02/05/91	0.51	03/24/91	0.00	05/10/91	0.00	06/26/91	0.00
11/04/90	0.00	12/21/90	0.51	02/06/91	3.30	03/25/91	0.00	05/11/91	0.00	06/27/91	0.00
11/05/90	9.91	12/22/90	78.23	02/07/91	0.00	03/26/91	0.00	05/12/91	15.24	06/28/91	0.00
11/06/90	0.00	12/23/90	49.78	02/08/91	0.00	03/27/91	6.86	05/13/91	0.00	06/29/91	0.00
11/07/90	0.00	12/24/90	1.27	02/09/91	0.00	03/28/91	4.06	05/14/91	0.00	06/30/91	0.00
11/08/90	0.00	12/25/90	0.00	02/10/91	0.00	03/29/91	52.32	05/15/91	0.00	07/01/91	40.64
11/09/90	8.54	12/26/90	1.52	02/11/91	0.00	03/30/91	0.00	05/16/91	2.03	07/02/91	14.73
11/10/90	15.24	12/27/90	27.69	02/12/91	0.00	03/31/91	0.00	05/17/91	0.00	07/03/91	0.00
11/11/90	0.00	12/28/90	15.75	02/13/91	33.53	04/01/91	0.00	05/18/91	2.54	07/04/91	0.00
11/12/90	0.00	12/29/90	6.10	02/14/91	1.27	04/02/91	0.00	05/19/91	18.29	07/05/91	5.08
11/13/90	0.00	12/30/90	24.64	02/15/91	0.00	04/03/91	0.00	05/20/91	2.79	07/06/91	0.00
11/14/90	0.00	12/31/90	0.00	02/16/91	0.00	04/04/91	0.00	05/21/91	0.00	07/07/91	0.00
11/15/90	0.00	01/01/91	0.00	02/17/91	38.86	04/05/91	4.06	05/22/91	0.00	07/08/91	0.51
11/16/90	0.00	01/02/91	0.00	02/18/91	56.64	04/06/91	0.00	05/23/91	0.00	07/09/91	0.25

Table A.3 (continued)

07/10/91	0.00	08/26/91	18.54
07/11/91	11.18	08/27/91	0.25
07/12/91	3.81	08/28/91	0.00
07/13/91	6.35	08/29/91	4.57
07/14/91	0.00	08/30/91	1.02
07/15/91	0.00	08/31/91	0.00
07/16/91	0.00	09/01/91	0.00
07/17/91	0.00	09/02/91	0.00
07/18/91	3.30	09/03/91	0.00
07/19/91	0.00	09/04/91	0.00
07/20/91	0.00	09/05/91	0.00
07/21/91	0.00	09/06/91	0.00
07/22/91	0.00	09/07/91	0.00
07/23/91	0.00	09/08/91	0.00
07/24/91	16.00	09/09/91	0.00
07/25/91	0.00	09/10/91	0.00
07/26/91	0.25	09/11/91	0.00
07/27/91	0.00	09/12/91	0.00
07/28/91	0.00	09/13/91	0.00
07/29/91	0.00	09/14/91	0.00
07/30/91	0.00	09/15/91	0.00
07/31/91	0.00	09/16/91	0.00
08/01/91	0.00	09/17/91	0.00
08/02/91	0.00	09/18/91	9.14
08/03/91	0.00	09/19/91	6.35
08/04/91	10.92	09/20/91	0.00
08/05/91	0.00	09/21/91	0.00
08/06/91	0.00	09/22/91	0.00
08/07/91	0.00	09/23/91	0.00
08/08/91	1.27	09/24/91	33.02
08/09/91	31.50	09/25/91	5.08
08/10/91	20.83	09/26/91	0.00
08/11/91	0.00	09/27/91	0.00
08/12/91	0.00	09/28/91	0.00
08/13/91	1.52	09/29/91	0.00
08/14/91	3.56	09/30/91	0.00
08/15/91	2.54		
08/16/91	0.00		
08/17/91	0.00		
08/18/91	1.52		
08/19/91	12.95		
08/20/91	0.00		
08/21/91	0.00		
08/22/91	0.00		
08/23/91	0.00		
08/24/91	0.00		
08/25/91	0.00		

Table A.4. Peak monthly elevations of White Oak Lake from October 1988 through September 1991

Month	WOL Elev. (ft)	WOL Elev. (m)
10/02/88	745.08	227.16
12/31/88	747.44	227.88
01/12/89	748.19	228.11
02/21/89	747.28	227.83
03/30/89	746.98	227.74
04/04/89	746.41	227.56
05/05/89	746.75	227.67
06/22/89	747.11	227.78
07/06/89	746.45	227.58
08/01/89	745.72	227.35
09/30/89	748.47	228.19
10/01/89	748.65	228.25
11/16/89	747.43	227.88
12/31/89	747.78	227.98
01/29/90	747.52	227.90
02/04/90	748.08	228.07
03/17/90	748.16	228.10
04/22/90	745.56	227.30
05/01/90	749.00	228.35
06/09/90	745.78	227.37
07/14/90	746.76	227.67
08/09/90	746.90	227.71
09/15/90	745.44	227.27
10/18/90	745.47	227.28
11/10/90	745.86	227.40
12/23/90	751.28	229.05
01/07/91	746.17	227.49
02/18/91	749.34	228.46
03/29/91	747.72	227.96
04/15/91	745.97	227.43
05/20/91	745.93	227.42
06/12/91	747.14	227.79
07/03/91	745.85	227.39
08/28/91	745.66	227.34
09/24/91	745.44	227.27

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