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Ruan pool, Cornwall, Control of Water Level

Preliminary Report

Introduction

This report is a preliminary investigation of the hydrology of Ruan Pool, one of the five major pools on the Lizard peninsula (Figure 1). Ruan, located on the southern part of the peninsula, about 12 km south of Helston, is situated in a small depression, with a relatively extensive infilling of alluvial material over serpentinite. The area was declared an SSSI on account of the oligotrophic pool, surrounding marsh and area of Cornish heath. Work by Williams (1992) identified Ruan Pool as being the most susceptible to damage due to increased human activity or fluctuations in climate: agricultural improvement or building activity would necessitate the installation of artificial drainage which would drastically reduce the recharge to the site. Furthermore, annual water budget calculations found the surplus amount of precipitation was very limited (less than 190 mm four years out of 25). The report concluded that Ruan was the most vulnerable of the Pools because of the limited recharge area compared to the area of the pool.

Concern was expressed by the manager, Mr. R. Lawman, about the considerable contraction of the water body from 1000 m2 in winter to 50 m2 in summer. This research was undertaken in order to elucidate the major pathways supplying Ruan Pool in order to determine the optimum site management strategy.

Aims

1. Install hydrological monitoring equipment as agreed with English Nature hydrologist to enable effective long term site monitoring.
2. Undertake seismic survey to determine substrate/soil depth, depth to bed-rock in order to determine hydrological/hydrogeological factors controlling water table fluctuation.

Methodology

Five sites around the Pool were instrumented with piezometers (Figure 2), installed at 1 m and 1.5 - 2 m depth. Sites were selected according to the usual criteria, namely to be situated on the highest and lowest ground, ideally along a transect. Initially, nine piezometers were installed in September. The augering of the holes was hampered, and their depth restricted, by an indurated layer of fine pebbles encountered at about 1 m depth. Subsequently a Minuteman portable drill was brought in to penetrate this layer but was only successful at site 1. A further problem encountered was the flashy nature of the hydrological response to rainfall such that sites 3 - 6, adjacent to the Pool, were inundated one week after installation. An additional piezometer was installed at site 6, therefore, and this has functioned satisfactorily since October. A 1m stage board, located in the deepest part of the Pool, was installed in order to monitor fluctuations in water level height. The piezometers and stage board were levelled in using a Kern automatic level, in order to determine their elevations with reference to an absolute datum. Readings of depth to the watertable and of the pool elevation have been recorded at weekly intervals since 5 th October, 1992 and the figures converted to absolute elevation.

A hammer seismograph was used to determine the depth to bedrock. The principle of the method is that a large shock wave is provided by striking a plate on the ground and a series of waves is transmitted through the soil and regolith to the bedrock and then reflected back to the surface. The time interval between the seismic impact and detection is monitored by a series of geophones set out along a transect. The seismograph has six geophones/channels and these were set out with a spacing of 5 m. A forward and a back traverse, 90 m in length, was conducted. Depth to bedrock was calculated as a function of distance between the source and geophones, and of the times of travel of the reflected waves.

Results

Results for the watertable/Pool elevations were plotted through time (Figure 3). Of particular note are:-

1. Ruan Pool is a perched water body.
2. Large fluctuations through time.
3. Rapid response to autumn rains.
4. Close relationship between watertable and Pool elevation.
5. Limited catchment area.

1. Ruan Pool is a perched water body

Evidence from site 3a and 4 (until it was submerged) which were within Ruan Pool itself, indicated a watertable at about 50 cm below the surface: the Pool was, therefore, perched above unsaturated soil, although the small vertical distance between pool and water table does not rule out their possible hydraulic connection should the intervening soil be disturbed. Its origin must be partly linked to the characteristics of the soil material as well as its location. The loessic soil is weakly aggregated: the structure breaks down when the soil is waterlogged for any length of time, rendering it impermeable.

2. Large fluctuations through time

Several of the sites showed very large response to rainfall, for example piezometers 1,2 and 8 rose more than 50 cm during the week between 20 -26 Oct. Large fluctuations in the watertable are indicative of localised watertable control of Ruan Pool. Such a system is somewhat analogous to the drainage of an asphalt carpark: due to the low permeability of the loessic soil, a large proportion of the incident rainwater runs off and collects in the Pool. Some of the rainwater, nevertheless, infiltrates the soil and then migrates laterally as throughflow along the indurated layer noted above. The Pool acts initially as a sink but as the pool's water level increases, the hydraulic gradient driving the lateral flow diminishes, allowing the soil water storage and water table level of the surrounding recharge area to increase in response to continued rainfall. In addition, when the soil is saturated, for example, in areas adjacent to the Pool, saturated overland flow occurs during storms.

In contrast to the large fluctuations of soil water, examination of data for site 6a, which monitors the height of the watertable below the Pool, steadily increased in height by merely 2 cm per week. The regional watertable response is therefore very damped. Ruan Pool has, therefore two hydrological systems, but the link between the shallow throughflow and overland flow is dominant and fundamental to an understanding of the hydrology.

3. Rapid response of Pool

The inundation of piezometers at sites 3 and 5 at the start of the monitoring period between 30th September and 5th October required that a large volume of water was input rapidly: this can only be accounted for by a surface/shallow interflow system supplying the Pool.

4. Close relationship between watertable and Pool surface elevation.

There is a clear link between the watertable elevations at for example sites 1,2,7 and 8 and the surface of the Pool. Site 1, some 125 m from the open water, rose and fell in height corresponding to changes in the Pool e.g. week beginning 26th October, the watertable at site 1 rose by 47.5 cm and the Pool gained 3.5cm. For a 20cm gain the following week the Pool rose a further 4.5 cm. This close relationship would indicate that the soil water at these sites is part of Ruan's perched system rather than the regional water table.

5. Limited catchment area.

Ruan Pool is being supplied only by a relatively small catchment area. The following conclusions are rather tentative at present since the calculations are based on the piezometer elevation data are dependent on the accuracy of surveying the ground surface height - the piezometers were resurveyed on 26th January, but the results have not yet been computed. Watertable elevations at sites 1, 2 and 9 to the North were similar or slightly below those of the Pool indicating zero or slight water movement to the North. This area, which is mainly dry heath, cannot therefore be supplying Ruan. Conversely, sites 7 and 8 to the south west have a watertable which is higher than the Pool and so water is flowing to Ruan from there. The area of wet heath surrounding sites 7 and 8 is crucial to supplying the Pool.

Seismic survey

The surface and primary surface profiles are shown in Figure 4. Depth to bedrock varied between 2 to 3 m The level ground surface is no indication of the bedrock profile: bedrock profile exhibited rapid change along the transect.

Conclusions

Ruan Pool is extremely vulnerable to human impact: it is a perched water system supplied by surface\shallow throughflow from a limited catchment area. In simple terms the Pool can be thought of as a shallow swimming Pool: if anything damages the 'liner' then the water will drain out. In the case of Ruan Pool, any removal/disturbance of the soil or any improvement in the soil structure will have catastrophic results. Similarly, improved drainage of the wet heathland field will reduce the catchment and again will have a deleterious effect.

Further work

1. Obtain daily rainfall records.
2. Relate rates of watertable rise to rainfall, assuming a porosity of 5-10%.
3. Calculate catchment area based on (2).
4. Continue to monitor piezometers and Pool elevation for at least one year.

5. Verify depth to bedrock by visual inspection - pits to be dug well away from Pool.

6. Four additional seismic transects are required to add to the detail on depth to bedrock.

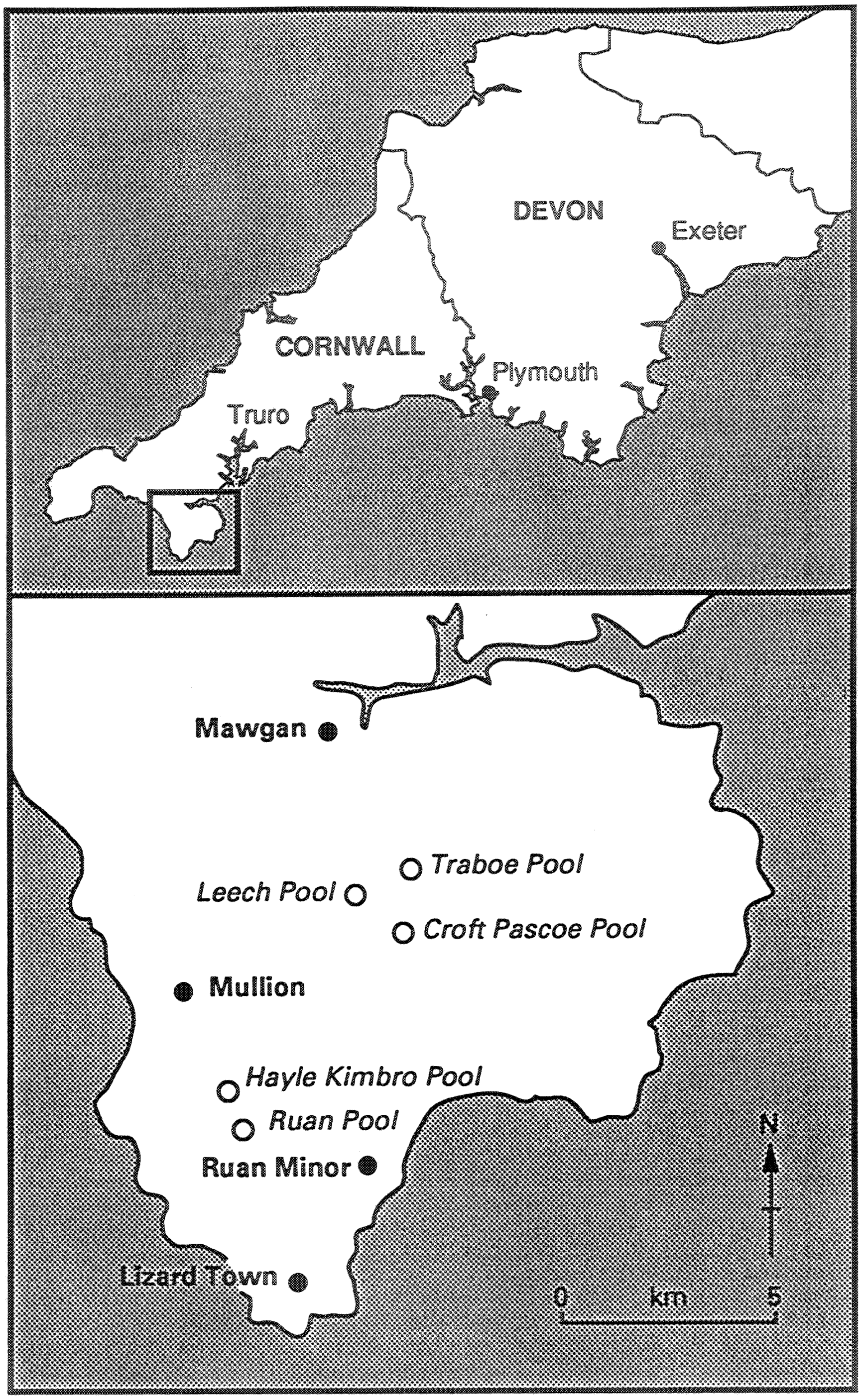

Figure 1 Lizard Peninsula Situation Chart

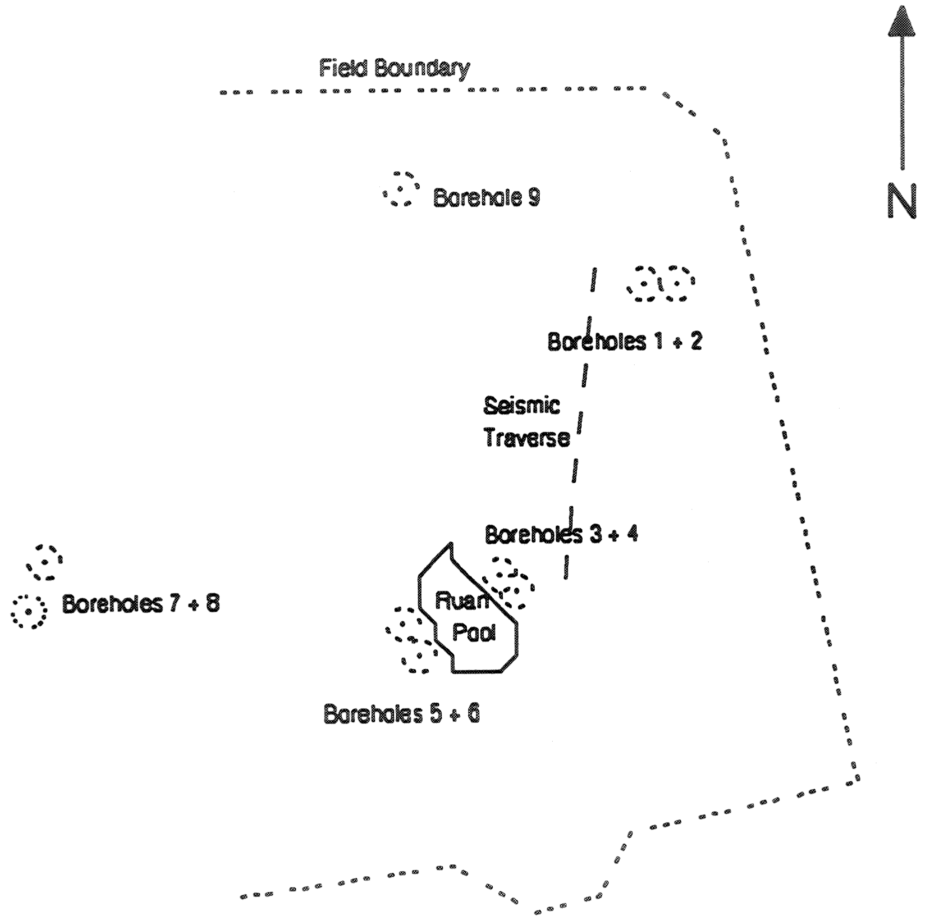

Figure 2 Plan of Borehole Locations at Ruan

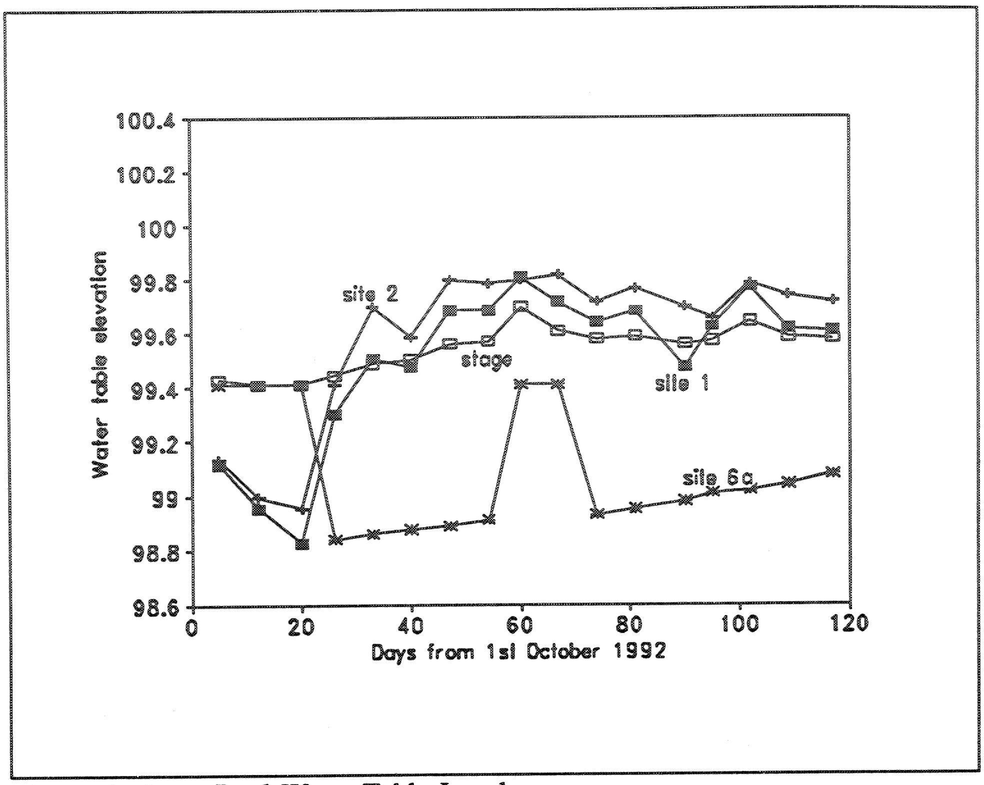

Figure 3a Ruan Pool Water Table Levels

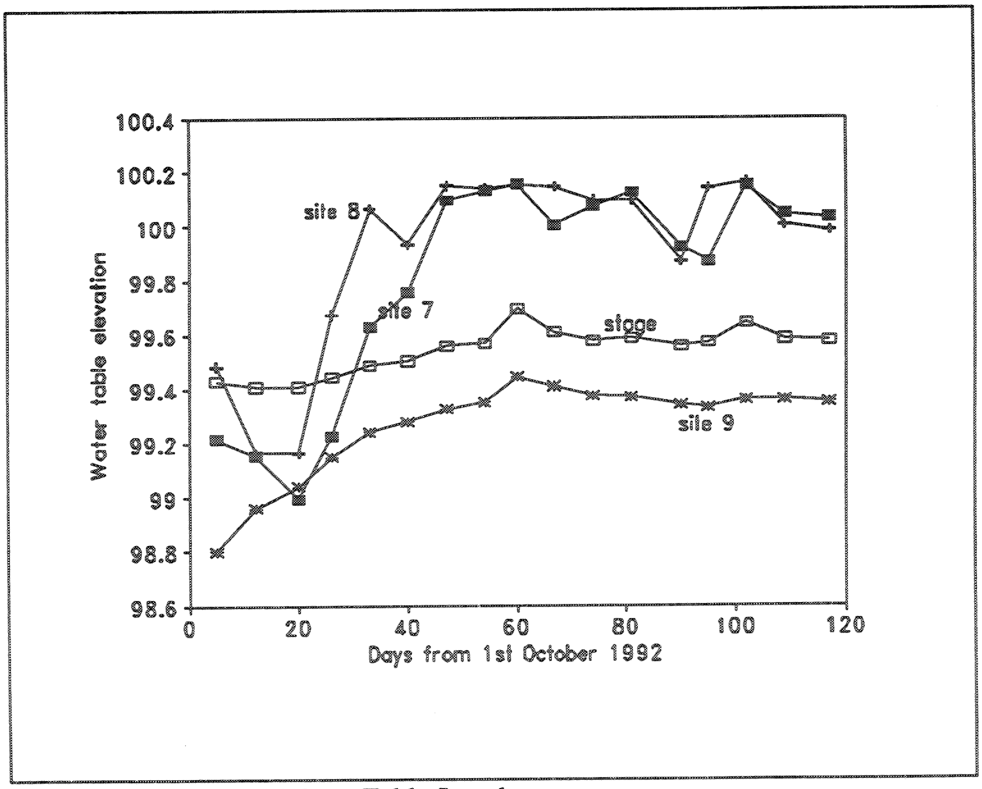

Figure 3b Ruan Pool Water Table Levels

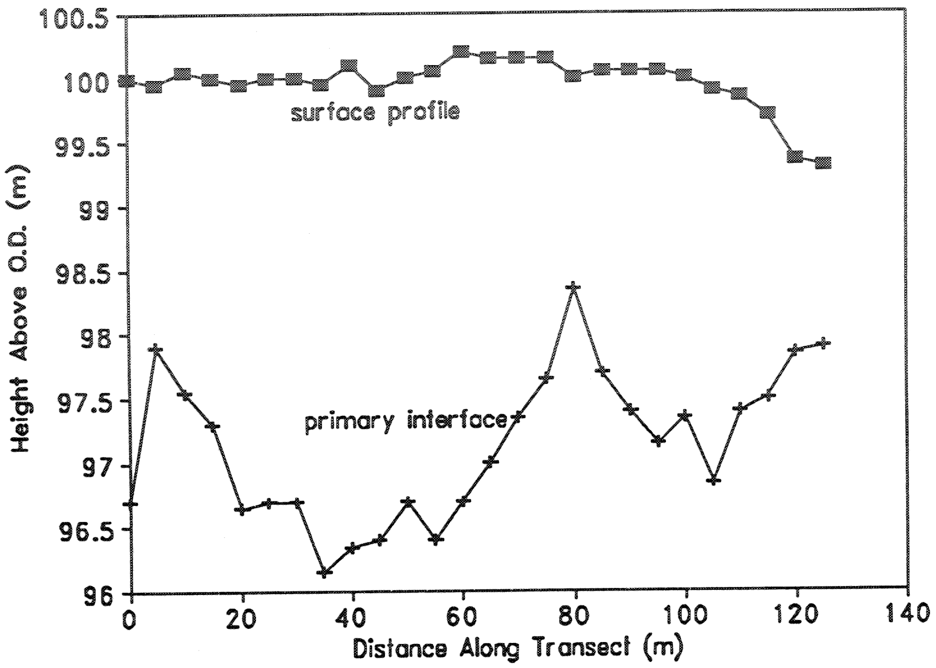

Figure 4 Seismic Transect at Ruan