PLATE 2. OCCURRENCE OF WATER IN UNCONSOLIDATED DEPOSITS IN THE BARRE-MONTPELIER AREA, VERMONT
THICKNESS OF UNCONSOLIDATED DEPOSITS
GROUND-WATER AVAILABILITY IN UNCONSOLIDATED DEPOSITS
GROUND-WATER LEVELS

GROUND WATER RESOURCES OF THE BARRE-MONTPELIER AREA, VERMONT

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EXPLANATION

LINE OF EQUAL THICKNESS OF UNCONSOLIDATED DEPOSITS
50 FOOT CONTOUR INTERVAL (15 METRES)

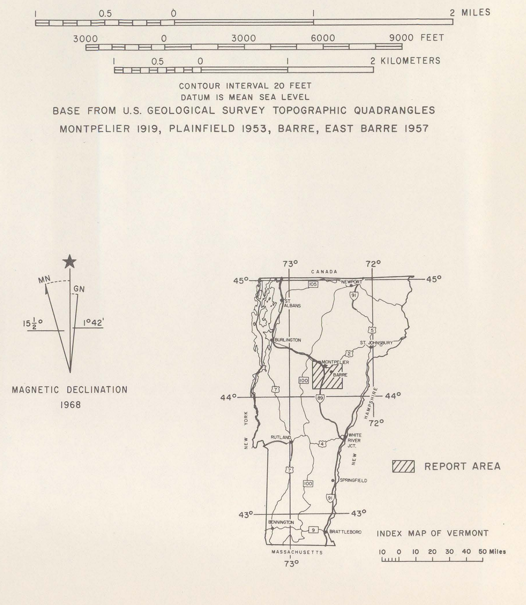
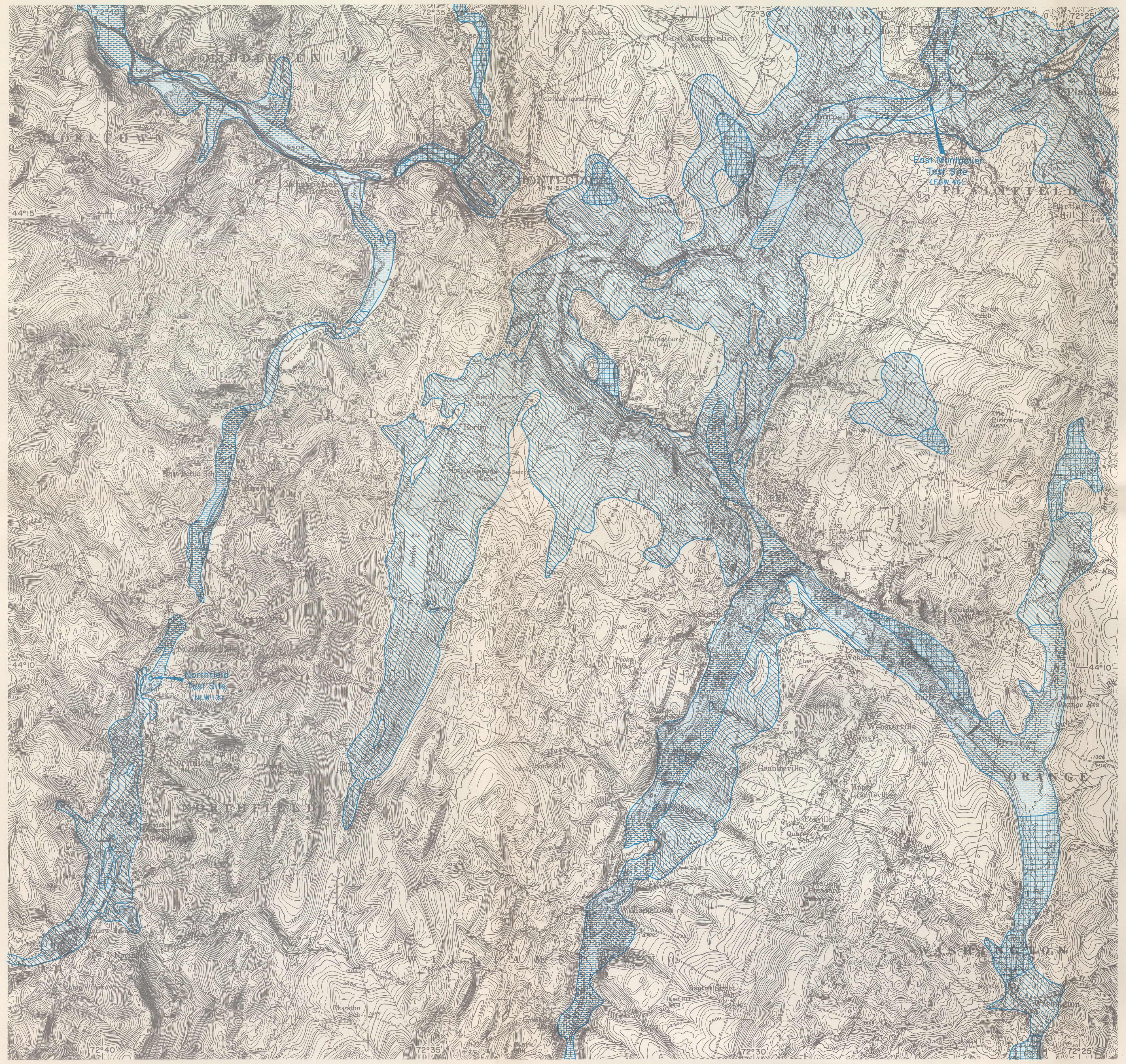
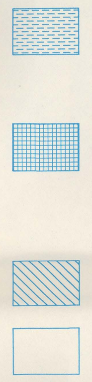


FIGURE 1. - - THICKNESS OF UNCONSOLIDATED DEPOSITS



EXPLANATION



AREAS UNDERLAIN BY SAND AND GRAVEL OF SUFFICIENT EXTENT AND THICKNESS TO SUPPLY QUANTITIES OF WATER ADEQUATE TO MEET INDUSTRIAL AND MUNICIPAL REQUIREMENTS.

AREAS UNDERLAIN BY SATURATED SAND AND GRAVEL OF SMALL EXTENT AND THICKNESS. THESE DEPOSITS MAY YIELD TO WELLS AND INFILTRATION GALLERIES SUFFICIENT WATER FOR DOMESTIC, COMMERCIAL, AND LIGHT INDUSTRIAL USE.

AREAS UNDERLAIN BY SATURATED FINE-GRAINED DEPOSITS THAT MAY YIELD SUFFICIENT WATER FOR DOMESTIC USE.

AREAS UNDERLAIN BY BEDROCK AND BY UNCONSOLIDATED DEPOSITS OF VERY LIMITED SATURATED THICKNESS AND BY TILL. THESE DEPOSITS MAY HAVE SUFFICIENT YIELD FOR DOMESTIC USE.

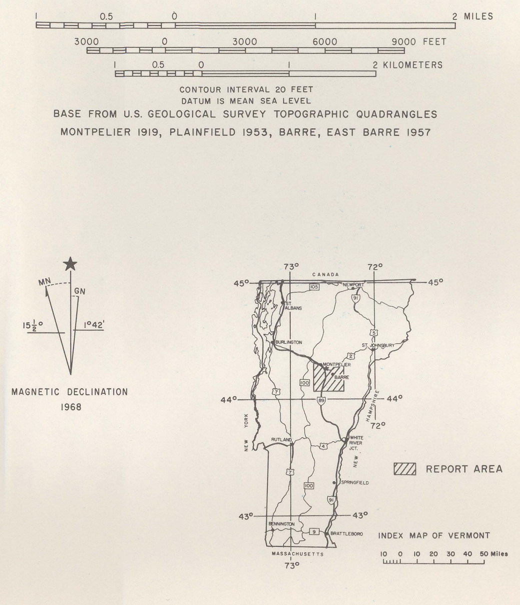


FIGURE 2. - - GROUND-WATER AVAILABILITY IN UNCONSOLIDATED DEPOSITS

THICKNESS OF THE UNCONSOLIDATED DEPOSITS

The thickness of the unconsolidated deposits overlying bedrock in the Barre-Montpelier area is illustrated in figure 1. Thickness ranges from zero on the many rock outcrops in the area to 303 ft (92 m) in Berlin (well BLW 17). Thickness and texture of these deposits is important because it affects their water-yielding properties and it may affect the yield and the cost of constructing bedrock wells. Thick deposits of clay or till may restrict the movement of recharge into bedrock fractures that are not part of a widespread fracture system, resulting in bedrock wells of low sustained yield. Conversely, thick deposits of sand and gravel may act as large storage reservoirs and, if connected with underlying bedrock fractures, could result in high sustained yields for bedrock wells. The cost of construction of a bedrock well is, in part, determined by the length of steel casing used to seal off overlying unconsolidated deposits. Knowledge of the length of casing required for a proposed well is useful in estimating the cost of the well.

SAND AND GRAVEL AQUIFERS

Deposits of sand and gravel have a higher permeability than any other subsurface materials in the Barre-Montpelier Area. At places where these deposits contain water, are sufficiently thick, and are connected to a source of recharge, they are capable of yielding large quantities of water to properly constructed wells (Hodges, 1969). Extensive beds of coarse gravel were deposited in the valley now drained by the Kingsbury Branch, the Winooski River, Gunners Brook, Stevens Branch, and the Second Branch of the White River. Locations of sand and gravel aquifers having sufficient water-saturated thickness to yield large quantities of water are shown on figure 2. In addition, deposits of sand and gravel with sufficient saturated thickness to yield the quantities of water necessary for domestic, commercial, or light industrial use are shown on the same figure.

Pumping tests of the aquifer in East Montpelier show that the transmissivity is about 43,000 ft^2/day (4,000 m^2/day). It is estimated that the potential sustained yield is about 1 Mgal/day (4,000 m^3/day). Additional information on aquifer testing is given in an earlier report, "Ground water availability in the Barre-Montpelier area, Vermont" (Hodges and Butterfield, 1972).

WATER IN FINE-GRAINED SEDIMENTS

Deposits of fine sand, silt, and clay cover much of the Barre-Montpelier area below an altitude of 1,300 ft (400 m). The most prominent areas include the valley of Berlin Pond, part of Stevens Branch, and much of the Winooski River valley between Montpelier and Plainfield. These deposits (fig. 2) have low potential for ground water development. Even where saturated, they yield water at a very low rate because of their low permeability. Occasional intercalated lenses of coarser-grained materials may increase the yield of wells in these deposits.

GROUND WATER IN TILL

Two types of till have been described in the Barre-Montpelier area by Stewart and MacClintock (1969). Basal till is a compact, grey mixture of material ranging in size from clay to boulders. It is often fissile, suggesting a subglacial origin. Ablation till is a loose mixture of brown sand, cobbles, and boulders containing minor amounts of silt and clay. Stewart and MacClintock ascribe the formation of this material to slow settling of supraglacial debris during ice-wasting. Water velocities were assumed to be only fast enough to remove clay and silt, while leaving the larger particles undisturbed. Thickness of the till ranges from less than 10 ft (3 m) in the uplands to many tens of feet (several tens of metres) in the valleys underlying the water-sorted sediments.

Most of the water taken from the till aquifer in the project area comes from large-diameter dug wells. Those wells penetrating basal till yield small quantities of water. Permeability of basal till is usually low because of the high percentage of the clay-silt component. If the well reaches the top of the underlying bedrock, however, a thin layer of permeable, water-bearing till is often found at the till-bedrock interface.

Dug wells finished in ablation till may yield adequate quantities of water for domestic use. Because ablation till has a low percentage of clay and silt, a loose matrix structure, and intercalated lenses of sand, its permeability is higher than that of basal till.

Almost all dug wells supplying water from till are located on hillsides or hilltops above the major stream valleys. Unless permeable zones in the till are directly connected to perennial streams, recharge is dependent upon local precipitation, and during drought, yield may become inadequate to meet domestic demand.

RECHARGE AND DISCHARGE

Water movement into and out of the project area can be expressed by the following equation:

$$P = R + ET + \triangle S$$

where P = precipitation

R = runoff

ET = evapotranspiration

$\triangle S$ = change in storage

Inflow as precipitation is equal to runoff and evapotranspiration adjusted for changes of water in storage, largely as ground water.

Precipitation measured at the Barre-Montpelier Airport averages 34 in (860 mm) per year, and is somewhat greater during summer than during winter. Average yearly snowfall is 94.4 in (2400 mm) per year, but accumulations are greater at higher altitudes.

Evapotranspiration returns 14 in (360 mm) to the atmosphere each year through direct evaporation of surface water and snow, and through transpiration of living organisms. Evapotranspiration is greatest during the spring and summer growing season. Ground water storage and levels decline during this period (fig. 3), as trees and plants remove water from the soil and release it to the atmosphere as water vapor. Killing frosts in September or October end the yearly growth cycle, and, as transpiration declines, ground water storage increases and water levels begin to rise.

Approximately 20 in (510 mm) leaves the area each year as runoff; runoff includes water that runs directly over the land surface and water that seeps into the ground, recharges ground water bodies, and moves to points of discharge in the streams. Ground water discharge to streams forms a significant proportion of total streamflow and sustains streamflow during drought and periods of below freezing temperature.

When water in a stream is at a higher level than the water table in adjacent permeable materials, stream water may move into the materials, raising the water table. Wells adjacent to a river commonly have high sustained yields because pumping lowers the water table and induces water to flow from the river into the ground.

Monthly measurements of water levels in seven wells in the Barre-Montpelier area (fig. 3) reflect the continuous change of storage in the ground water body. All the wells measured are in unconfined aquifers and, therefore, respond rapidly to local recharge. Normally, water levels are highest in March or April, coinciding with melting of the snow pack and breakup of ice in the rivers, and lowest in September and October, at the end of the growing season. This sequence, however, can be modified substantially by excessive rainfall or prolonged drought.

REFERENCES

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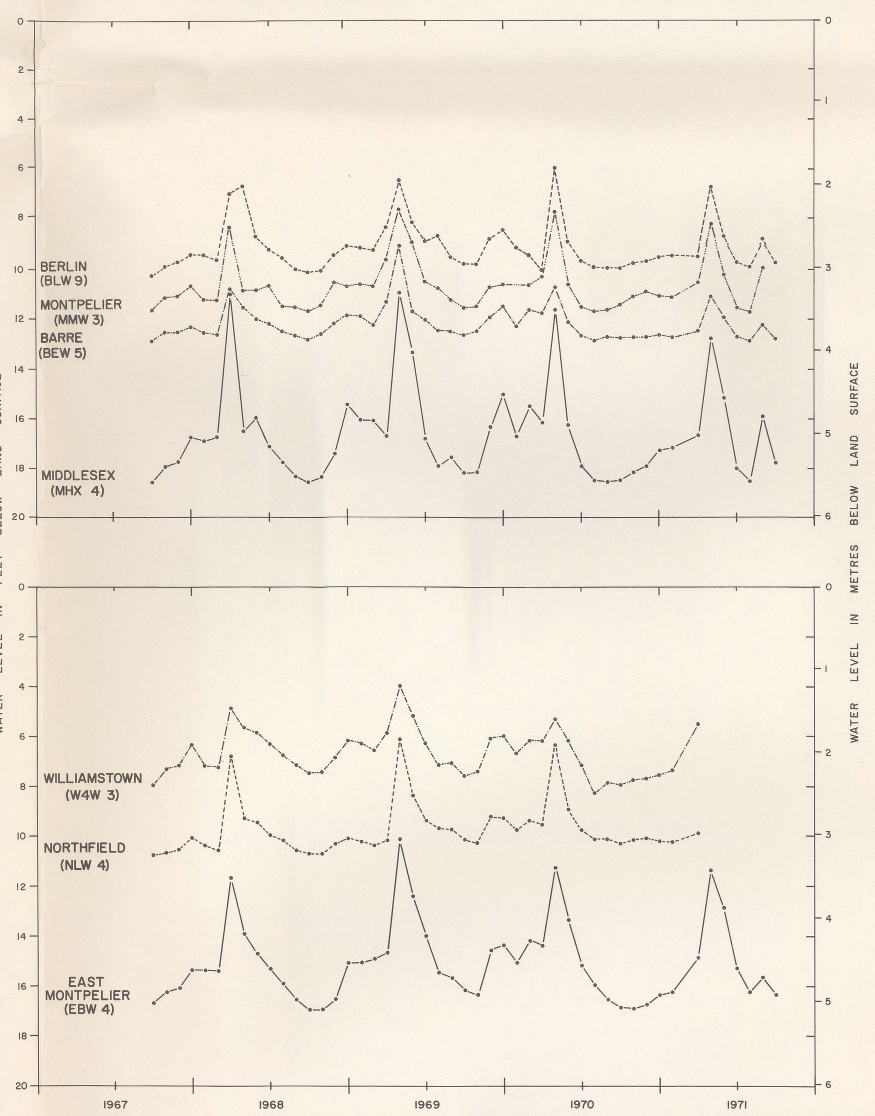

FIGURE 3. - - GROUND-WATER LEVELS IN THE BARRE-MONTPELIER AREA