May 9, 1843.

The PRESIDENT in the Chair.

No. 619. "Observations on the periodical drainage and replenishment of the subterraneous Reservoir in the chalk basin of London."

Continuation of the paper read at the Institution, May 31st, 1842.*

By the Rev. J. C. Clutterbuck, M.A.

Water in
the Chalk
Basin.

The author commences by answering an objection founded upon a passage of Conybeare and Phillips' *Geology* (Book 1, Chap. IV. sec. 11), which was urged against his former statements.

The water, it was said, appeared to rise in different places to different heights—at Mile End it stood at the level of high-water mark in the Thames; at Tottenham 60 feet; at Epping 314 feet; and at Hunter's Hall, two miles beyond Epping, at 190 feet above that level. Especial stress was laid on the height to which the water was supposed to have risen in the well at Epping, namely, to within 26 feet of the surface, and to 314 feet above high-water mark. It appeared from a note appended to the statement referred to, that the first 27 feet from the surface of this well consisted of gravel, loam, and yellow clay, and that after sinking 200 feet, and boring 220 feet, as no water was found, it was considered a hopeless labour, the boring was discontinued, and the well covered over; that at the end of five months, it was found that the water had risen to within 26 feet of the surface; from which it might be inferred, as was afterwards proved, by information obtained from the owner of the well, that this supply of water was to be attributed to a landspring, and was not derived from the sand of the plastic clay formation, to which the boring had not penetrated.

Having thus answered this objection, it is shown that a line drawn from the water level at Hunter's Hall to mean tide level in the Thames, 10 feet below high-water mark, would cut the level in the other wells, and give a water level dipping at an average inclination, very nearly coinciding with that insisted on in the statement to which the objection was raised (Fig. 1). It appeared that the difficulty of determining the exact dip of the water level between the river Colne and London, had in some measure been removed, by the sinking of three wells in the direct line of the author's observations, namely, from the river Colne one mile N.E. of Watford, in a straight line to Edgware, and thence by the high road to London; the information thus obtained, proved the general correctness of the author's former calculation as to the line that would represent the natural water level.

It is then shown that a line drawn from a point 3 miles south of

* Minutes of Proceedings, 1842, p. 155.

the Colne, at the level of that river, or 170 feet above Trinity high-water mark, to mean tide level in the Thames below London Bridge (a dip of about 180 feet in 14 miles, or an average inclination of 13 feet in the mile) cuts the water level at the point whence it is drawn, at Hendon Union Workhouse, and at Cricklewood, between that place and Kilburn, whence it may be inferred that up to this point there is no apparent trace of a depression of level caused by the exhaustion of water under London (Fig. 3).^{*} At Kilburn, the water level (which is known to have stood some years since about 20 feet higher than at present,) is considerably depressed below the line drawn, which depression may be attributed to the influence of the London pumping—it is suggested, that it is desirable that the wells on the confines of London, and throughout the district, should be periodically measured, to ascertain to what distance, and in which direction this yearly increasing depression may be found to extend.

The author proceeds to describe a phenomenon connected with the periodical replenishment of that portion of the London basin which underlies the London and plastic clays, and which cannot, as in the upper or chalk district, be fed by infiltration. This phenomenon is by him called the “oscillations of the water level,” caused by the irruption of rain water, which runs from the surface of the London and plastic clays, and which sinks into the subjacent chalk through “swallow-holes,” on its arrival at the outcrop of the sand of the plastic clay formation. This point of irruption lies to the southward of the river Colne, and forms the line of demarcation between the clay and chalk portions of the surface of the London basin, leaving a belt of the latter varying from two to three miles, or more, in width, between the river and the outcrop of the clays.

The water level rises to a point within the outcrop (called the fixed summit level,) at an angle of not less than 10 feet in the mile, when most depressed by the springs; below an angle fixed on as the lowest line of inclination to which the water in the chalk will fall. From the fixed summit the level declines towards London; in the line taken, it is found at the level of the Colne, 3 miles from the river. After heavy rains, when the clays throw the water from their surface, the irruption of water may be seen at the outcrop of the sand of the plastic clay formation; the level will then be raised in proportion to the quantity of water which passes through the sand into the chalk beneath it, the elevation of level extending towards

^{*} The surface levels on this line having been obtained, and a section having been made, the line drawn from the two points, namely, three miles south of the Colne, to mean tide level in the Thames, enabled the author to determine the height to which the water was found to rise at Hendon Union Workhouse and at Cricklewood (the only points at which the height of water could be ascertained), in both cases to within three feet (Fig. 3).

the river in a ratio increasing with the distance from the river ; the fixed summit will remain unaltered, until the level at the point of irruption has attained an elevation at which the water can flow towards the south. After a period of protracted drought the level will decline in the same ratio as it had risen, until it assumes a line in which little or no variation can be traced.

In a given line from the Colne at Watford, to the village of Bushey, one mile and a half distant (Fig. 2), in the autumn of 1841, the level was found to rise from the river, at a regular inclination, to a point within the outcrop of the clays. After heavy rains, the level, near the swallow-hole which receives a large body of water, began to rise rapidly, the fixed summit level (A) not being affected till the level, at the point of irruption (B) rose above it ; the total rise at the point of irruption was 20 feet, and at the fixed summit 2 feet. The position of the summit level had then varied from the fixed summit to the point of irruption ; coincidentally with this elevation the level under London rose also, and began to decline at the same time that the level, at the point of irruption, sank below the fixed summit. The subsidence of the level at the point of irruption, was,—in April, 4 feet ; May, 3 feet ; June, 2 feet ; July, 1 foot ; August, 9 inches ; September, 6 inches ; in October, and to November 8th, $1\frac{1}{2}$ inch ; the average inclination, from the fixed summit to the river, then being about 15 feet in the mile. The subsidence of the level to this inclination, was coincident with a visible defalcation in the product of the springs discharging themselves into the river Colne. In the autumn of 1842, and in the preceding spring, similar effects were observed, both as to the rising of the level at the point of irruption, and the coincident elevation of the level under London. This oscillation of level has been traced at various points, both to the east and west of that here described.

It is probable that near the junction of the Colne and the Ver, the level dips directly from the level of the latter river, at a point where the plastic clay extends itself under the Colne to the margin of the Ver. This suggests the probability of that to which the author alluded in his former communication—namely, the possibility of connecting a periodical defalcation observed in the waters of the Ver or the Colne, at those seasons when the water is short, with the exhaustion of water under London. The evidence in favour of this supposition has been strengthened, during the past year, by a repeated coincidence of variation in the London level with the supply of water in the river. The height of the water in the river (about 210 feet above Trinity high-water mark), gives the same average inclination of level towards London as observed in other places, and strengthens the probability that the supply of water to the river may be affected at this point by

the London pumping, the daily increasing demand of which will, if (as is contended) there be any ground for this supposition, very soon put this question beyond a doubt.

Mr. Dickinson said, that Mr. Clutterbuck's observations had been caused by a project for obtaining a supply of water for the metropolis, from wells to be sunk in the valley of the Colne. It had been stated, in support of the plan, that the rapidity with which the rain water percolated into the bowels of the earth, in a great measure prevented evaporation, and hence it might be assumed, that the quantity which descended upon the surface of the chalk found its way, with very slight diminution, into the fissures below. This reasoning was not in accordance with the deductions Mr. Dickinson had drawn from an extended series of observations, and, fearing that his mill property might be injured by the diminution of the supply of water, he had opposed the project.

He had found it necessary, several years since, to investigate strictly the nature and extent of the supply of water to the springs and rivers of the chalk district, for which purpose he had a common rain gauge, which was corrected by observations upon that kept in the same district by the Grand Junction Canal Company; he also fixed a rain gauge on the principle suggested by Mr. Dalton, which demonstrated the quantity or proportion of the rain falling on the surface, which descended so far into the earth as to be beyond the reach of evaporation, and, therefore, must be calculated to reach the internal reservoir of the country whence the springs were fed. This gauge demonstrated that the greater part of the rain that fell on the surface, was either consumed by vegetation or evaporated. It furnished information of the most valuable kind, both as regarded his mills and business, and as to any engineering operations, having reference to the perennial supply of water in the springs and rivers of the district.

Mr. Dickinson presented the following statement (No. 650) of the comparative result of his two gauges for the last eight years, pointing out, as was generally the case, that none of the rain-water penetrated to the springs between the 1st of April and the 30th of September. He also stated that the indications of the gauge were not only certain, but that they preceded generally by about two months, any thing that could be deduced from the observation of wells, with reference to the effect upon the rivers; and that, as to the latter, the only guidance to be derived from the state of the wells, was from those in the higher range of the chalk, because, along the valleys where the streams flowed, the level of the wells continued nearly the same throughout the year.

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