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AVAILABILITY OF GROUND WATER TO SUPPLEMENT SURFACE-WATER IRRIGATION SUPPLIES IN THE YAKIMA RIVER BASIN

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This report is written to outline general ground-water conditions in the Yakima River basin with particular reference to the possibility of developing ground water to supplement surface-water supplies for irrigation in the Kittitas and Roza Divisions of the Yakima Project. The information contained in the report was transmitted bo the Bureau of Reclamation, Spokane Planning Area office, by letter dated May 26, 1953.

Introduction

Analysis of the ground-water potentialities in the Yakima River basin involves consideration of both geology and hydrology. The Yakima River basin consists of a number of structural basins and subbasins in which topography is largely controlled by the structure. The chief basins pertinent to this discussion include three along the main stem, the Kittitas, Upper Yakima and Lower Yakima Basins. Each of these basins is separated from the others by structure and topography so that they are separate ground-water areas. Withdrawal or recharge of ground water in one basin will not affect ground-water conditions in other basins, except possibly to the extent that they would affect downstream flow of the Yakima River. Each of the three basins is underlain by three important aquifers or groups of aquifers. These are, in order from the surface downward, 1) unconsolidated or semi-consolidated alluvial sand and gravel, 2) sandstone and conglomerate strata in the Ellensburg formation, and 3) porous zones in the Yakima basalt. The first two units are thickest and most important as aquifers toward the centers of the basins. Both irrigation divisions concerned are on higher lands toward the margins of the basins, so that the alluvial deposits and the Ellensburg formation are of somewhat limited value as a source of ground water in these two irrigation divisions. On the other hand, the basalt which is generally not utilized toward the centers of the basins, because of considerable depth required to reach it, is much nearer the surface toward the margins of the basins. In most parts of the Yakima River basin water from the basalt is utilized only to a small extent. Potentially, it is a very important aquifer.

In evaluating the ground-water resources of a basin, the effect of ground-water withdrawals on surface water discharge should be considered. To a certain extent, it is true that utilization of ground water reduces the amount of surface water available. However, use of ground water nearly always increases the total utilizable supply because generally a large part of the ground-water withdrawal is from storage which is replenished during periods (winter and spring) when the surface water is, to a large extent, wasted.

Kittitas Basin

The Kittitas Basin is an oval-shaped syncline formed by warping of the basalt. The basin is completely enclosed by high anticlinal basalt ridges, except for two narrow gorges; one where the Yakima River enters the basin, the other where it leaves. The significance of this fact is that very little ground water can leave the basin as underground flow.

In the central part of the basin, covering an area approximately 12 miles wide by 25 miles long, the basalt is overlain by the Ellensburg formation and alluvial silt, sand, and gravel. The maximum thickness of the deposits overlying the basalt is not known, but it does exceed 1,210 feet, as a 1,210-foot well drilled at Ellensburg did not encounter basalt. The alluvial sand and gravel deposits and the Ellensburg formation yield moderately large supplies in the central part of the basin. Towards the margins of the basin these deposits thin and will yield smaller supplies. At the elevations followed by North Branch and South Branch Canals which supply water to the Kittitas Division, they probably are too thin to furnish large supplies. For this reason it probably would not be feasible to supply the project with ground water from these deposits in the vicinity of the Main Canals although it might be possible to obtain considerable ground water from them by spreading withdrawals over a larger area in the project, especially at lower altitudes where the deposits presumably are thicker. Wells yielding several hundred gallons a minute each might be constructed along many of the laterals.

Very little information is available on the potentialities of the basalt as an aquifer. Wells in the central part of the basin, in the vicinity of Ellensburg and Kittitas, have not been drilled deep enough to tap aquifers in the basalt. So far as is known there is no record of any irrigation, industrial, or public-supply well obtaining water from the basalt in the Kittitas Basin. However, considering the geology of the basin, and the hydrology of the Yakima basalt in general, the potentiality of the basalt in the basin may be quite high. The edges of the basalt lava flows are exposed in high hills and mountains surrounding the basin where opportunity for recharge is good. Precipitation is comparatively large in these higher areas, probably ranging up to 35 inches annually. The favorable conditions for recharge, the deep synclinal or "basin" structure, and the fact that the basalt has not been tapped by wells are all conditions which suggest the possibility of a large potential ground-water supply. Warm Springs, in sec. 6, T. 17 N., R. 20 E., which issues from the basalt at an elevation of 1,860 feet is about the only actual indication of the quantity of water that might be obtained from the basalt. Discharge from this spring is estimated to range from 3 to 5 cfs. The top of the basalt is estimated to be generally less than 200 feet below the surface along the North Branch Canal. Along the South Branch Canal, basalt is generally exposed at the surface. Wells drilled several hundred feet into the basalt should yield moderate to large supplies of water. Because of the favorable structure, the water might be under considerable artesian pressure, although it might not rise to the surface. Wells drilled into the basalt at lower elevations in the basins might yield water with pressures considerably above land surface.

Upper Yakima Basin

The Upper Yakima Basin is also a structural basin, but the surrounding anticlinal basalt ridges are not nearly as high as in the Kittitas Basin. The downwarped basalt in the central part of the basin is overlain by alluvial sand and gravel and strata of the Ellensburg formation. The combined thickness of these two units near the center of the basin probably is 1,200 to 1,500 feet. These deposits thin rapidly towards the margins, as the top of the basalt slopes upward toward the surface.

The Roza Division lies entirely in the east half of the basin, in the Moxee Valley, mostly between the elevations of 1,100 and 1,200 feet. The first well in the Moxee Valley was drilled in 1891. This well was 314 feet deep and flowed 300 gpm. Discovery of artesian water in the valley resulted in drilling of a large number of wells in the valley during the 1890's and early 1900's. Depths ranged up to 1,000 feet and yields ranged up to an estimated 6,000 gpm. Artesian pressures up to 50 lbs. were recorded. Many of the wells were 6 inches or less in diameter. Yields and pressures declined greatly during subsequent years and at the present time most wells either no longer flow, or flow only small amounts. Most of these wells obtained water from permeable sand and gravel zones in the Ellensburg formation. It is probable that a few of the deeper wells were drilled into the basalt, although the well logs do not definitely state this.

It is evident that, in large part, the water withdrawn was obtained from storage, although present withdrawals may be approximately balanced by recharge. There is no doubt that large yields could be obtained from wells 500 to 700 feet deep, and 10 to 12 inches in diameter, drilled into the Ellensburg formation in the vicinity of the Roza Canal in the Moxee Valley. If a number of such wells were used every year there is also no doubt that the ground water would be rapidly depleted. It is possible however, that they could be used 1 year in 5 or 10 without permanently depleting the supply.

The upper basalt aquifers have been utilized to a lesser extent in the Moxee Valley and the deeper basalt aquifers not at all. It is probable that some of the largest flows from the artesian wells, one to several cfs, were obtained from the upper basalt aquifers. It seems probable that wells 700 to 1,200 feet deep in the vicinity of the Roza Canal would yield large quantities of water. Some of the deeper aquifers might still be under considerable artesian pressure, although the pressure in shallower basalt aquifers probably has declined considerably, as it has in the Ellensburg aquifers.

In contrast to the Kittitas Basin, the hills surrounding the Moxee Basin generally do not rise above an altitude of about 3,000 feet. Precipitation probably does not average more than 8 or 9 inches annually and therefore recharge probably is quite limited. Recharge of 25 percent of the precipitation on the eastern part of this sub-basin would be roughly 15,000 feet per year; recharge of 10 percent of the precipitation would be 6,000 acre-feet per year. It is possible that withdrawal of supplemental irrigation water in occasional dry years would not permanently deplete the supply.

Lower Yakima Basin

Although the lower Yakima Basin is a structural basin, the situation is considerably different from the two structural basins previously described. In the two upper basins the Yakima River crosses the synclines essentially at right angles, which means that the basins are completely closed except where the river has cut a gorge through the Ellensburg formation and the basalts to enter and leave these basins. In the lower Yakima Basin the Yakima River flows parallel to the structure cutting into the Ellensburg formation and the basalt at various places along the length of the river. This means that many aquifers drain into the river and that the water table slopes, more or less uniformly, from the areas of recharge on the flanking hills to the zone of discharge along the river.

Although the structure is basically a simple broad syncline with the Rattlesnake Hills forming the northern limb and the Horse Heaven Hills the southern limb, a subsidiary anticline, expressed topographically in Toppenish Ridge and Snipes Mountain, crosses the basin at an angle. Thus, the syncline is essentially separated into two parts, a broad deep structural basin up valley from Snipes Mountain (Granger to Sunnyside) and a much shallower segment down valley from Sunnyside.

A number of deep wells (800 to 1,500 feet) have been drilled in the lower Yakima Basin; most of these in the valley bottom at elevations not greatly above river level. Water levels in these wells are highest up valley, and decline down valley at about the same slope as the valley floor. From up- to down-valley the water levels are approximately as follows (altitude about sea level): Wapato, 840 ft.; Zillah, 765 ft.; Toppenish, 745 ft.; Sunnyside, 737 ft.; Mabton, 668 ft.; Grandview, 675 ft.; Prosser, 660 ft.

Most wells on the slope of the Rattlesnake Hills north of the valley have not been drilled as deep as those in the valley. Depths range generally between 300 and 600 feet. Static water levels are somewhat higher than in wells in the valley, indicating that the water table slopes toward the river. Generally the water table slopes towards the river at about 10 to 20 feet per mile. This is a much flatter slope than the slope of the land surface, so that at higher elevations, water levels are far below land surface. Along the Roza Canal the water table is generally at an altitude of 750 to 800 feet (300 to 400 feet below the surface).

Yields of the deeper wells in the valley generally range between 500 and 1,000 gpm. Wells on the flank of the Rattlesnake Hills have mostly been drilled for domestic purposes, many of them being drilled only 30 to 50 feet below the water table, so that comparatively small yields have been obtained.

None of the deep wells in that part of the valley, up valley from the Snipes Mountain cross-fold, have reached the basalt; all are producing from permeable zones in the Ellensburg formation. Some wells drilled on the north side of the valley have entered basalt, but few have been drilled deeper than the first basalt layer. It is possible that wells penetrating deeper basalt layers might have higher static levels, but it is doubtful that the levels would be much higher.

The alluvial sand and gravel is too thin along the Roza Canal to furnish large supplies of water. The basalt is the only possible source for large supply, and it is unproven in this area. However, assuming that the basalt is equally good as an aquifer in this area as in adjacent areas, wells penetrating 400 to 500 feet of basalt below the water table should yield 500 to 1,000 gpm, on the average. The water level cannot be assumed to be at a higher altitude than about 750 to 800 feet unless later information indicates otherwise.

Other Possible Sources

In considering the potential water supply of the entire Yakima River basin, several other possible sources of ground water should be mentioned.

The Cle Elum sub-basin, extending up the Yakima and Cle Elum Rivers from the junction of the Teanaway River with the Yakima River, is underlain by unconsolidated and semiconsolidated materials to a considerable depth. The upper strata, approximately 200 feet thick consist chiefly of sand and gravel, which are believed to be at least moderately permeable. Although a large number of logs are available from core drill holes made while testing for coal, practically no information is available as to the hydrologic characteristics of these deposits. Few water wells have been drilled in the basin other than domestic wells, and no quantitative tests have been made. However, it is apparent that a large volume of water is store in the sand and gravel in this basin; possibly as much as 250,000 acre-feet. It is probable that moderately large quantities of water (500 to 1,000 gpm per well) could be obtained from properly constructed wells 150 to 250 feet deep. It is also quite possible that very much larger yields might be obtained, possibly up to several thousand gallons a minute from a large diameter well. However, until quantitative tests are made, this is entirely speculative.

Withdrawal of large quantities of ground water from the Cle Elum sub-basin during periods of low streamflow might decrease streamflow slightly, but most of the water would be taken from storage in the aquifers. Replenishment of the aquifers would occur largely during the following autumn and winter from precipitation and runoff which would otherwise have been wasted.

Downstream from the Kittitas Basin the Yakima River flows southward for about 15 miles in a deep narrow canyon cut into basalt, before entering the broad upper Yakima Basin. In this reach the river bisects several narrow, east-west trending synclinal sub-basins. The total area covered by these sub-basins is moderately large, and the marginal hills rise to more than 4,000 feet at places. Basalt crops out at the surface over most of the area. For these reasons the amount of precipitation available is large and opportunity for recharge is good. Wells drilled into the basalt along this reach might have moderately large yields. However, the river has cut deeply into the basalt so that the water table probably will not be much above river level. Furthermore wells drilled along this reach would necessarily be drilled into somewhat older basalts, which in most other areas are deeply buried, and are therefore untested as to hydrologic characteristics.

Ground Water Supply For the City of Yakima

Because the city of Yakima is located near the central part of the upper Yakima Basin, the basalt is far below the surface. The log of a well drilled on Nob Hill in the western edge of the city shows that basalt was reached at a depth of 1,485 feet. So far as is known, no wells in Yakima obtain water from the basalt. The aquifers utilized in the city are permeable sand and gravel strata occurring in both the Ellensburg formation and the overlying alluvial sand and gravel unit. The best aquifers appear to be in the latter unit in the depth range from about 30 to 300 feet.

It is probable that, if a systematic program of test drilling were followed, a ground-water supply could be developed for the city of Yakima. Wells probably should not average more than 250 feet deep, and with proper type of construction and adequate development, should yield between 500 and 1,000 gpm. Thus, 10 or more wells would be required to produce 10,000 acre-feet per year.

Summary

1. Kittitas Basin.--Based on very little actual data, but on general geology and hydrology, chances of obtaining ground water for supplemental irrigation in the Kittitas Basin appear to be good. If ground water in quantity is found, there appears to be little danger of depleting the supply.

2. Upper Yakima Basin.--Moxee Division (Moxee Valley area). Based on a large number of well records, large supplies of ground water can be obtained. Continuous use of large quantities of ground water would certainly dangerously deplete the supply. Use for one or two seasons in 10 or 15 might not do so.

3. Lower Yakima Basin, Roza Division.--Based on rather scanty hydrologic data and general geologic and hyrologic considerations the prospects of obtaining large quantities of ground water along the canal for supplemental irrigation do not appear to be very good. The possibility of obtaining water from the deeper basalt aquifers might be considered.

4. Cle Elum Basin.--Based on a large number of drill hole records, and on geologicand hydrologic considerations, with no quantitative hydrologic data; the potential ground-water supply is believed to be very large.