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INTRODUCTION

Ground water is generally administered with surface water as a flow or renewable resource. In Idaho, the administration is based on the appropriation doctrine of water rights. This doctrine provides for the division of a perennial but limited supply of water between various users. The purpose of this paper is to show that more consideration should be given to the administration of ground water as a nonrenewable stock resource. The development of the water resource of the Raft River basin in Idaho is presented as an example of the inapplicability of the present statutory guidelines for the administration of ground water.

GROUND WATER AS A RENEWABLE OR NONRENEWABLE RESOURCE

Ground water occurs under widely different hydrologic and geologic conditions. The resource is present in humid areas where there is considerable recharge and discharge and in arid areas where little or no replenishment of the resource occurs. Similarly, ground water occurs in a wide range of geologic environments under confined, partially confined and unconfined conditions. Although many generalizations may be made concerning the occurrence of ground water, two are of particular importance in the context of this paper.

First, by the law of continuity, water discharged from an aquifer system must deplete the total resource by that amount. Prior to development by man, the ground-water resource was generally in a state of equilibrium: recharge approximately equaled discharge. The artificial discharge from wells alters this equilibrium. The discharge is initially satisfied by a decrease in ground-water storage. If enough time is allowed and the artificial discharge is not too great, a new equilibrium results with the well discharge being balanced by an increased rate of recharge or a decreased rate of discharge. The time required for this equilibrium to occur varies depending on whether the system is under confined or unconfined conditions. The effect of pumping a well in an unconfined aquifer is much more local than the effect of pumping a well in an artesian aquifer of similar thickness and permeability because of the difference in the storage coefficient. Theis (1940) noted that the cone of depression in an artesian aquifer grows roughly 100 times as fast as a non-artesian aquifer. A new state of equilibrium is thus achieved much faster in an artesian aquifer than in a similar water table system.

The second generalization concerning ground water states that the annual rate of recharge to or discharge from a ground-water system is only a small percentage of the total resource in storage. This statement is obvious in arid areas where large aquifer systems receive only small quantities of recharge. For example, the Ogallala Formation in Texas, Kansas, Oklahoma and Colorado contains an estimated 369 million acre-feet of water but receives only an estimated 0.27 million acre-feet of recharge each year (Bekure, 1971). The statement is also true in more humid areas. Walton (1970) described several shallow aquifer systems in Illinois in which the estimated rate of recharge was less than one percent of the total resource in storage. Thus, only a small percentage of the ground-water resource is renewed in any particular year. For ground-water development to be stabilized on a perennial basis, however, the pumpage must be limited to this renewable portion of the resource.

Ground water may be divided into a flow or renewable component and a stock or nonrenewable component. The flow component is that amount of water recharged to or discharged from the ground-water system on an annual basis. The stock portion is that percentage of the resource in excess of recharge that is in storage. Utilization of the resource on a perennial basis requires that only the flow portion of the resource be developed. Full utilization of this component may be obtained only by maximizing the rate of recharge and eliminating the natural discharge. This requires a general decline in water levels so that the gradient can be maximized. Here again, a major difference is evident between confined and unconfined aquifers. However, in both cases, some of the stock portion of the resource must be mined in order to approach the objective of extracting the full flow portion on a perennial basis. Since the rate of recharge to a basin does not remain constant, some stock must also be mined to allow storage space for fluctuations in the flow component. Several uses are thus apparent for the stock component of the ground-water resource. The stock ground water is most commonly used as an elevator for the flow portion of the resource to minimize well construction and pumping costs. The stock may also be used as a minable resource on a nonrenewable basis. Finally, the stock may be withdrawn to provide storage area for flow management (Bagley, 1961).

Several problems are inherent in the division of the ground-water resource into flow and stock portions. The most serious is the lack of physical meaning since all of the water is in movement. The delineation of flow and stock ground water is thus difficult; there is no direct analogy to a dry streambed for a ground-water system.

The importance of the stock or nonrenewable aspect of ground water is shown by the primary problem facing resource administrators. This problem is not the availability of water but the protection of the means of diversion. Because of the stock characteristics of most ground-water basins, wells are not dry when the flow or renewable component of the resource is exceeded. Additional well development just results in a lower water level. The stock aspect of the resource is good in that it allows a greater level of development by providing subsurface storage for flow fluctuations, but is also bad because it provides the basis for over development of the resource.

ADMINISTRATION OF GROUND WATER IN IDAHO

Idaho follows the appropriation doctrine of water law for both surface and ground waters. In this doctrine, priority is the basis of the right and beneficial use provides the measure of the right. The appropriation doctrine was designed for allocation of a perpetual but fluctuating flow of water among competing users. The system is reasonably applicable to surface water and serves as the basis for water rights in a number of western states. In some of these states, including Idaho, the doctrine has been applied to ground water.

The important aspects of the Idaho Code with respect to ground water are as follows:

> 42-226..., while the doctrine of 'first in time is first in right' is recognized, a reasonable exercise of this right shall not block full economic development of underground water resources, but early appropriators of underground water shall be protected in the maintenance of reasonable ground water pumping levels....
>
> 42-233a...'Critical ground water area' is defined as any ground water basin, or designated part thereof, not having sufficient ground water to provide a reasonably safe supply for irrigation of cultivated lands, or other uses.......
>
> 42-237a-g...Water in a well shall not be deemed available to fill a water right therein if withdrawal therefrom of the amount called for by such right would affect, contrary to the declared policy of this act, the present or future use of any prior surface or ground water right or result in the withdrawing the ground water supply at a rate beyond the reasonably anticipated average rate of future natural recharge...........

The statutes call for the "full economic development" of the resource with the restriction that "reasonable ground water pumping levels" be maintained. The total development is limited to the "reasonably anticipated average rate of future natural recharge". Ground-water pumpage is thus restricted to the flow portion of the resource. Recognition is given that excessive declines in water levels may occur and some protection is noted for the means of diversion. It is difficult to determine if the statement concerning full economic development refers to use of the resource beyond the flow component. No guidelines are given for the use of stock ground water except as an elevator to help maintain reasonable pumping levels.

Ground-water administration in Idaho has been limited to the designation of five critical ground-water areas. This designation closes the area to future applications to appropriate ground water but does not affect any of the existing pumpers or those holding valid outstanding permits.

RAFT RIVER BASIN - AN EXAMPLE OF GROUND-WATER ADMINISTRATION

The Raft River basin is the largest of the designated critical ground-water areas in Idaho. It includes a drainage basin of approximately 1,510 square miles located in southern Idaho and northern Utah (Walker and others, 1970), (Figure 1). The area is composed of rugged mountains rising above aggraded

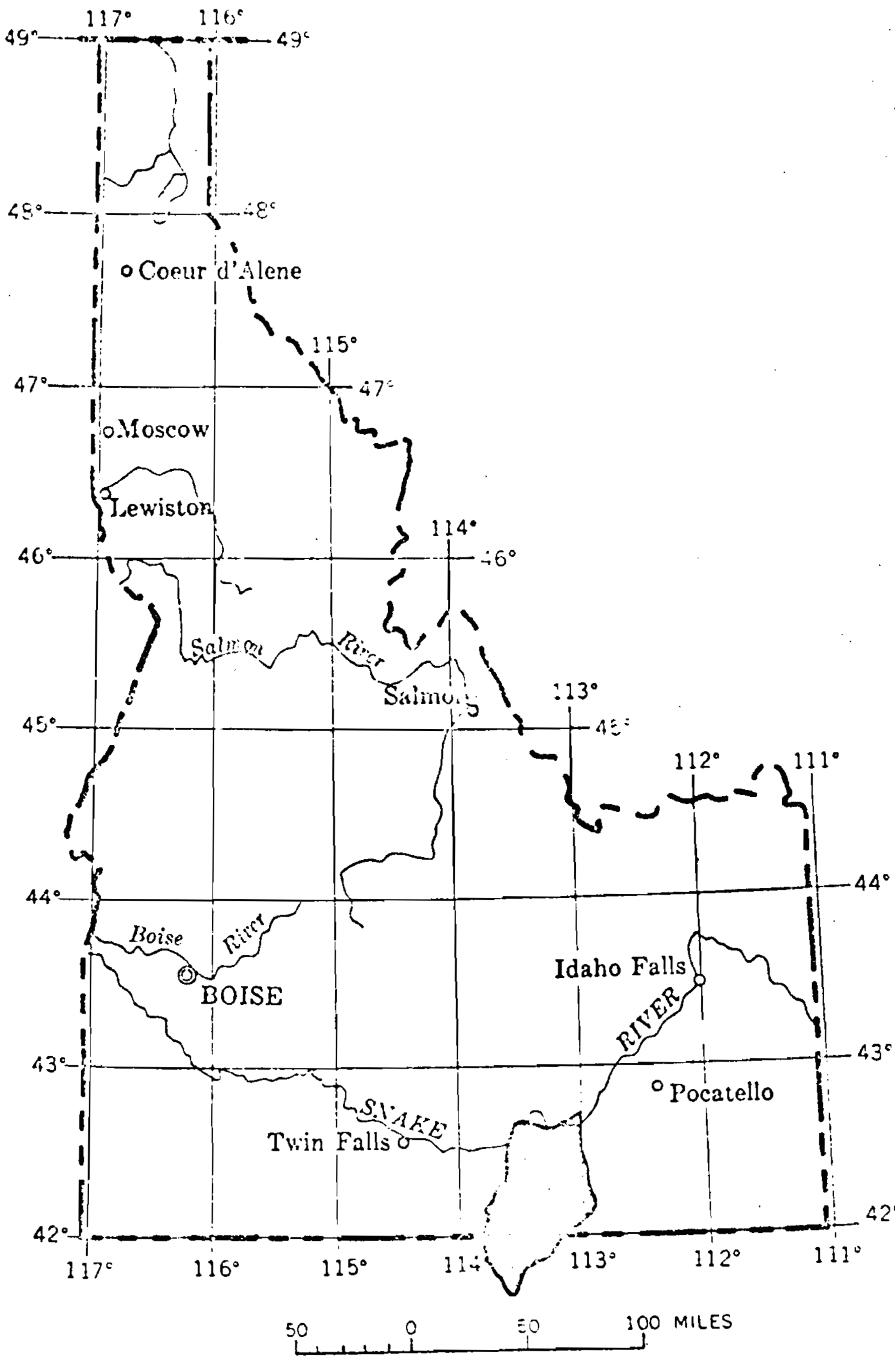


Figure 1. Index map of Raft River Basin.

alluvial valleys (Figure 2). The aquifers consist primarily of gravel and sand of the Salt Lake Formation, the Raft Formation and recent alluvium. Basalt of the Snake River Group is also important as an aquifer in the northern part of the basin. The main body of ground water in the basin occurs under unconfined or water table conditions (Walker and others, 1970, p. 58). Perched water occurs beneath parts of the lowlands; Artesian aquifers have been penetrated in several local areas. The depth to water varies from near land surface in the center of the main valley to greater than 400 feet.

An estimated 290 irrigation wells were in operation in the basin in 1963 with an increase to 320 in 1966 (Figure 2). The mean discharge of these wells is about 1,300 gallons per minute. The total pumpage in the area increased from approximately 14,000 acre-feet in 1950 to an estimated 235,000 acre-feet in 1966. Walker and others (1970) calculated the total water yield of the basin to be approximately 140,000 acre-feet per year. An estimated 9 million acre-feet of water is in storage in the top 200 feet of saturated aquifer in the main valley.

The entire basin was declared critical and closed to future applications to appropriate ground water in July 1963 because of declining water levels. Aside from changes in the critical designation for several small areas not directly related to the primary problem, the basin has remained closed.

The effects of the well development on the ground-water resource are depicted in Figure 3 which is a map of water-level change for 1952-66. Several local areas of water-level decline are present in Township 11 South, Range 26 and 27 East and in Township 12 South, Range 26 East. Scattered areas with 20 feet of decline are noted in Townships 13, 14 and 15 South, Range 27 East. These areas of decline coincide with the concentrations of wells shown on Figure 2. Of particular interest is the absence of water-level decline over most of Township 12 South, Range 27 East, an area withheld from ground-water development by the U.S. Bureau of Land Management. The effect of pumping in the basin has been to create local areas of water-level decline with little basin-wide effect. In particular, very little change in water level has been recorded in the ground-water outflow section at the northern end of the basin.

The pattern of water-level declines shown in Figure 3 is a result of the distribution of wells in the basin and the unconfined condition of the ground-water resource. The discharge from wells in one part of the basin has little effect on the water levels in the remainder of the valley. The water-level declines suffered by users in a particular area is thus the result of ground-water pumpage by those same users.

An equilibrium between recharge, discharge and ground-water pumpage has not yet been achieved in the Raft River Basin. As shown on Figure 3, the pumpage has not appreciably decreased the rate of ground-water outflow. The well discharge is thus being supplied from an increased rate of recharge and from ground water in storage. Walker and others (1970, p. 81) estimated that about 54 percent of the water pumped from the ground-water system had been derived from storage. Mining of ground water has thus occurred in the basin. Equilibrium can occur only with a decrease in the rate of outflow, a decrease

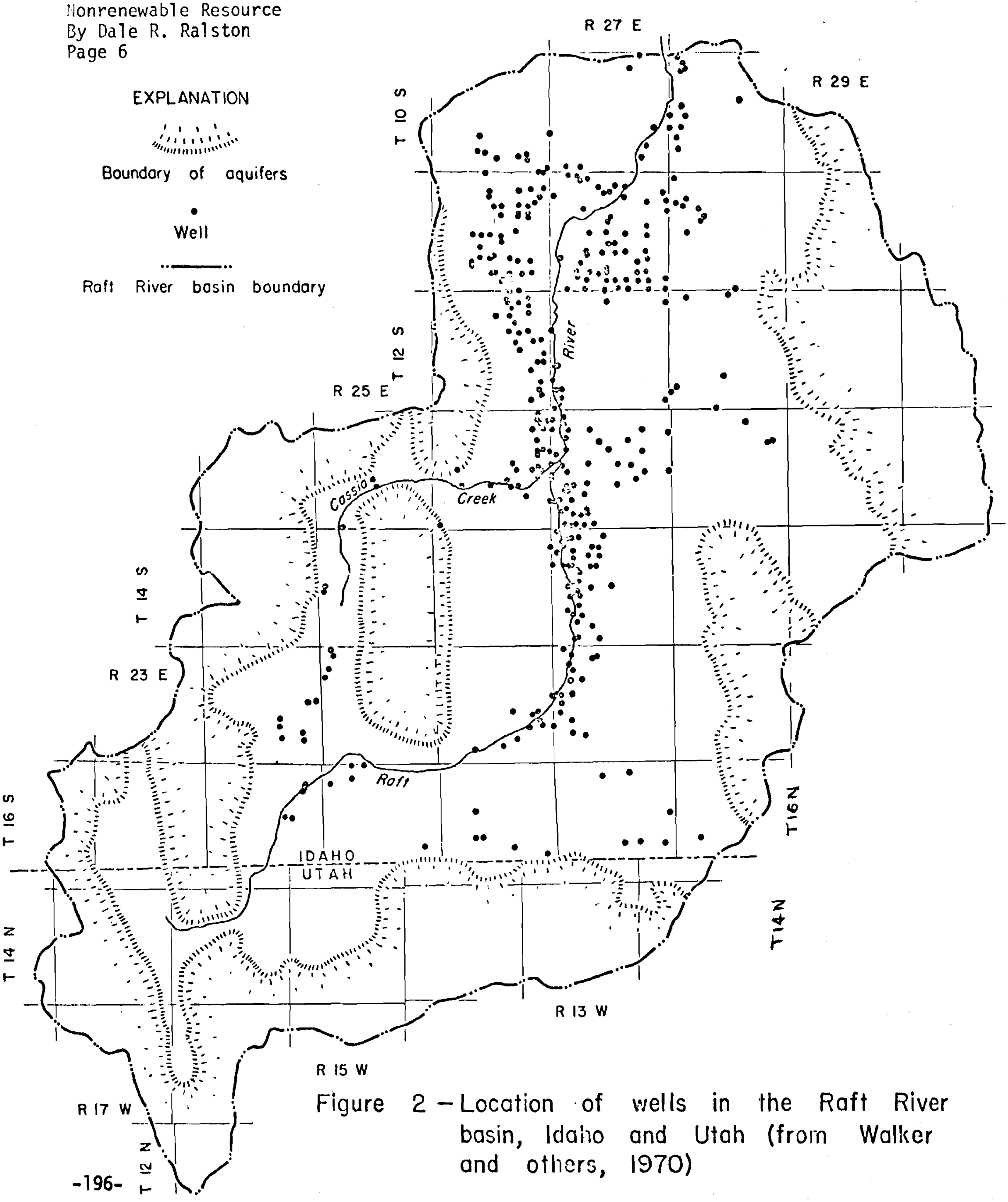
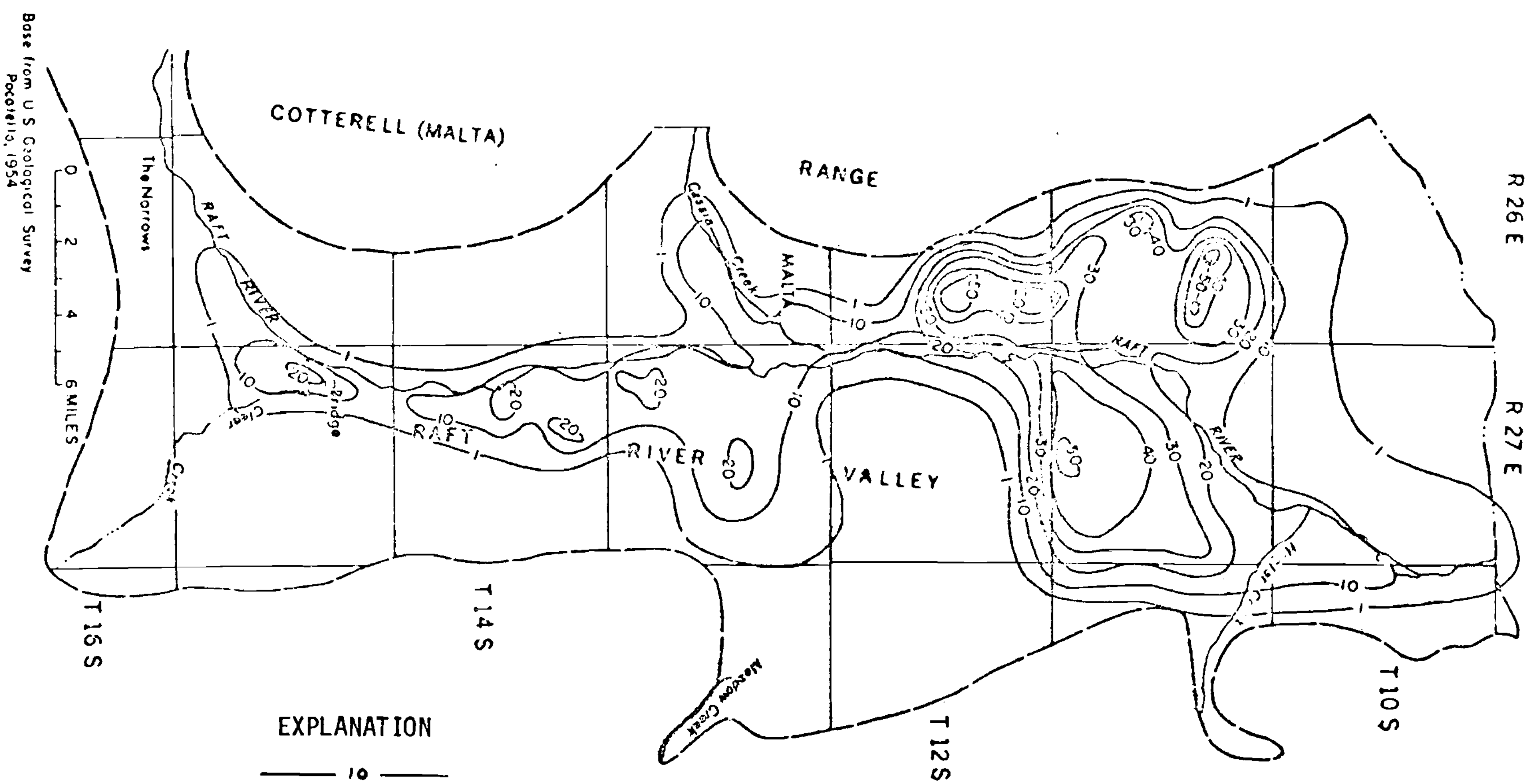


Figure 2 — Location of wells in the Raft River basin, Idaho and Utah (from Walker and others, 1970)



EXPLANATION

——— 10 ———

Line of equal water-level decline
Contour intervals 9 and 10 feet

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Raft River basin boundary

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Boundary of Raft River valley subbasin ground-water storage unit

Figure 3. Net water-level change in Raft River valley sub-basin, spring of 1952 to spring of 1966, by Walker and others, 1970.

in ground-water pumpage or in increase in recharge. Walker and others (1970) estimated that one-hundred years would be required to reduce the ground-water outflow from the basin by one-half under the 1965-1966 pumping conditions. They noted that more than 15 times as much water would have to be removed from storage to achieve this reduction than had been mined by 1966. The equilibrium must thus occur through decreased ground-water pumpage or increased recharge. Preliminary water-level data from 1972 indicate that considerable recharge has been achieved during the past several years of greater than average precipitation and runoff.

Administration of the Raft River basin as a single critical ground-water area is based on the assumption that the area acts as a single hydrologic unit; an additional well at any point in the basin is assumed to reduce the total supply to all other users. However, because of the stock aspects of the resource, a considerable lag in the cause-effect relationship is present. This lag is shown in the Raft River basin by the local areas of water-level decline. The basin-wide critical designation thus assumes a very long administrative base period. Designation of several smaller critical areas in the locations of excessive decline would be based on a much shorter administrative base period. The stock aspect of the resource should thus be an important factor in the selection of boundaries for critical areas.

Administration of ground water in the Raft River basin is not achieving either of the two primary objectives as noted in the Idaho Code. Full economic development of the ground-water resource is not being achieved. Undeveloped land is present in the basin in areas where little or no water-level decline has occurred. The second objective of limiting the ground-water development to the flow portion of the resource is also not being achieved. Water has been taken from storage in local areas while the total ground-water discharge from the basin has not been affected. There is little doubt that the administration of a ground-water resource such as that present in the Raft River basin must be different than the administration of a surface stream.

CONCLUSIONS

Ground water has been shown to possess the characteristics of a non-renewable as well as a renewable resource. Most ground water may be considered as stock or nonrenewable with only a small percentage of the resource renewed in any particular year. Administration of the resource, however, is based on a doctrine devised to allocate a flow resource. As a result, present administrative techniques do not provide effective management of the resource. Administrative regulations should include guidelines for the use of the nonrenewable component of the resource over time.

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