UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

FEASIBILITY OF GROUND-WATER FEATURES OF THE ALTERNATE PLAN FOR THE MOUNTAIN HOME PROJECT, IDAHO

ABSTRACT AND SUMMARY

By

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FORWORD

Committee print no. 4, Committee on Interior and Insular Affairs, House of Representatives, 83d Congr. 1st Sess., May 1953 recommended study of the Alternate Plan, for irrigation of the Mountain Home Project and drainage of waterlogged or threatened land in the Boise Valley. The United States Geological Survey and the U. S. Bureau of Reclamation began an evaluation study in mid-1953 of engineering, hydrologic, geologic, and other factors that would affect or determine the feasibility of the plan. A feasibility report was released to the public in duplicated form by the Bureau of Reclamation in April 1955. A report by the Geological Survey on the feasibility of those parts of the plan that relate to geology and ground water, was released to the open file for public inspection in April 1955. The report is being printed and only a few typewritten copies are available now. These are deposited in State and Federal offices. None are available for distribution.

Owing to intense public interest in the Alternate Plan, an abstract and summary of the Geological Survey report has been prepared and duplicated for distribution. The abstract and summary form the body of the enclosed release. Additional copies are available for distribution from the Ground Water Branch of the Geological Survey, 209 Fidelity Bldg., Boise, Idaho.

ABSTRACT AND SUMMARY

On the arid Mountain Home Plateau of Idaho more than 400,000 acres of arable land is largely unused except for grazing. The Boise Valley, adjoining on the north, was reclaimed from similar land and irrigated with Boise River water. The productivity of about 100,000 acres of the valley land is lowered or threatened, however, by an ever-rising water table, caused to rise by infiltration of excess irrigation water. Surface drains alleviate the drainage problem but areas of water-logging, alkaline land, and inferior vegetation continue to spread.

The Alternate Plan

Irrigation on the Mountain Home Plateau and drainage in the Boise Valley would be integrated under a plan to divert 600,000 acre-feet of Boise River water to the Mountain Home Plateau. Part of this would be surplus river water. The remainder, now used in the Boise Valley would be replaced by pumping additional ground water in that valley and by pumping surface water from the Snake River into the valley. The plan was proposed (Sloan, 1953) as an alternate to an earlier Bureau of Reclamation proposal to irrigate the Mountain Home Plateau with Boise River water replaced by imported Payette River water. The Alternate Plan would reduce applications of surface water for irrigation in the Boise Valley and would involve pumping ground water to drain land and to furnish replacement irrigation water. The present report evaluates the geologic and hydrologic aspects of the proposal as they affect its feasibility.

Environment in Which the Plan Would Operate

The economy of the Boise Valley is basically agricultural and its industries are mostly related to agriculture. The Mountain Home Plateau is largely undeveloped and mostly unpopulated. The chief use of water in the Boise Valley is for irrigation. The electric-power potential of the Snake, Boise, and Payette Rivers in the vicinity of the Boise and Mountain Home Projects is only partly developed, with six generating plants having a combined installed capacity of 138,875 kilowatts, and a median water-year production of 1,068,000,000 kilowatt-hours.

The Mountain Home Plateau and the Boise and Snake River Valleys -- three principal physical subdivisions of the area in which the Alternate Plan would operate -- each has a distinctive water-supply pattern and other characteristics that would affect directly the operation of the plan. The plateau and valleys are underlain at depth by an impermeable, basinlike floor of granitic rocks upon which is a thick accumulation of Tertiary and Quaternary volcanic rocks and lake beds. Quaternary alluvium and basalt, locally interstratified, overlie the younger lake beds. The plateau, a rolling upland plain formed by volcanic rocks, lake beds, and alluvial and windblown sediments, slopes generally northwestward and southwestward toward the Boise and Snake River Valleys. Several small mountain-fed streams extend for short distances onto the plateau, but perennial streams do not cross it. Precipitation is largely absorbed as soil moisture and most of the unabsorbed residue percolates downward to become ground water; there is only a little surface runoff from the plateau. The subsurface rock in much of the plateau is permeable basalt, through which ground water drains southward and westward to the Snake River Valley. Beneath much of the plateau the water table is several hundred feet below the land surface. Artesian ground water occurs at some places. The ground-water supply of the plateau is adequate for farm and domestic use but not for large-scale irrigation development.

The Snake River Valley, carved in volcanic rocks and lake beds along the south and west sides of the Mountain Home Plateau, ranges in character from a narrow canyon 700 feet deep at Swan Falls to a broad, shallow valley at the confluence of the Snake and Boise Rivers. The average calendar-year discharge of the Snake River at Swan Falls is about 7,164,000 acre-feet. Little is known about ground-water conditions in the Snake River Valley.

The Boise Valley includes lowland along the Boise River, terraces, and adjacent foothills on the north, west of Boise Diversion Dam. A series of terraces rises steplike from the river bottom land, forming so-called benches composed of lake beds and older alluvium, overlain by flood-plain gravel, sand, silt, and clay. Some of the area is mantled by wind-blown sand and silt. The average calendar-year discharge of the Boise River at the diversion dam during the base period, 1931-50, was 1,760,000 acre-feet. Small tributary streams in the valley discharge effluent ground water and surface waste from irrigation but contribute relatively little to the gross surface-water supply.

The combined active storage capacity of Arrowrock and Anderson Ranch Reservoirs on the Boise River is 709,000 acre-feet, and the gross storage capacity of Lucky Peak Dam (nearing completion) is 280,000 acre-feet. When Lucky Peak Dam is completed the three dams probably will be used jointly for irrigation, flood control, and power generation, thus increasing the effective usable supply of water in the Boise River basin. The Boise Valley contains a large volume of ground water in storage. Aquifers at shallow depth, especially alluvial gravel, commonly yield water copiously to wells. Artesian aquifers also are good producers.

Precipitation rates are markedly influenced by topography and altitude. The average annual precipitation ranges from 8.8 inches at Mountain Home, on the relatively flat plateau, to 26.1 inches at Atlanta, in the mountainous headwater area of the Boise River. Runoff in the Boise River is chiefly from precipitation on mountain slopes at altitudes above 3,000 feet, east of the Boise Diversion Dam.

The mean annual temperature at Boise is 50.8°F and there is an average of 172 days between killing frosts. Evaporation data are meager, but fragmentary records for Arrowrock Dam and Lake Lowell indicate that the annual evaporation from open-water surfaces is about 33 inches.

The water table in the Boise Valley rose steadily after the beginning of irrigation, shortly after the turn of the century. Pressure in some artesian aquifers increased and local perched zones of saturation developed. Water levels in the irrigated part of the valley are highest shortly after the height of the irrigation season, in late August or early September. The depth to water beneath about 100,000 acres of land south of the Boise River is less than 10 feet, a depth that is critical because a small rise would cause waterlogging. Seventeen percent of the land irrigated from the Boise River is north of the river and much of that land also needs drainage. About 325 miles of surface drains alleviate the valley-wide drainage problem but waterlogging continues or is threatened in extensive areas, owing to a continued general rise of the water table averaging about a foot a year. About 30 wells in the Pioneer Irrigation District, and a few in the Nampa-Meridian Irrigation District, are pumped for drainage during the irrigation season.

The average yearly volume of diversions from the Boise River during the base period was 1,280,000 acre-feet of live water and 201,000 acre-feet of recycled water. Residual discharge past Notus was 701,000 acre-feet. The yearly live-water diversion is equivalent to about 3.8 acre-feet per acre for irrigated lands and reportedly is inadequate. A live-water supply of 1,400,000 acre-feet (4.1 acre-feet per irrigated acre), plus recycled water, would be ample. Gross diversions of record in recent years of ample water supply exceeded 1,800,000 acre-feet. Under existing irrigation practices the average gross diversion of live and recycled water is at least 5.8 acre-feet per acre and may be about 6.0. In contrast, ground water is used in the Boise Valley on a relatively small scale, yearly pumpage being only about 150,000 acre-feet, largely for drainage and irrigation. Many of the drainage and irrigation wells are in the area of potential heavy draft on ground water under the Alternate Plan. The heaviest concentration of wells is in a broad belt extending north-south across the central part of the valley.

Most Boise River water that is usable for irrigation has been appropriated. The feasibility of exporting 600,000 acre-feet of water, as proposed in the Alternate Plan, would depend on the availability of replacement water in the Boise Valley and on the availability of the required surface water in the South Fork of the Boise River at the proposed point of diversion to the Mountain Home Plateau. In 6 of the 20 years from 1931-50, historical diversions of live and return water from the Boise River exceeded the live flow at the Boise Diversion Dam by 3,865 to 107,640 acre-feet. Moreover, although the average residual discharge in the river past Notus was 701,000 acre-feet during the base period, in most years some river reaches above Notus were dry at times, owing to diversion of all water from the river. Much of the flow past Notus is surface waste and effluent ground water, which averages about 422,000 acre-feet a year.

Crops in the Boise Valley consume about 2.2 feet of water yearly, of which about 0.4 foot is soil moisture derived directly from precipitation, and 1.8 feet is supplied by irrigation. The area of surface-water irrigation reportedly is 340,000 acres, but supplemental ground water now pumped is adequate to supply 23,000 acres with 4.0 feet of water. The net area irrigated with surface water thus is about 317,000 acres, on which consumptive use of irrigation water is estimated to be 570,600 acre-feet a year. About 20,000 acre-feet of Boise River water evaporates from Lake Lowell. The computed net consumptive depletion of surface water thus approaches 600,000 acre-feet a year. Observed depletion, based on adjusted runoff at Notus, is 1,070,000 acre-feet. The difference of 470,000 acre-feet represents ground-water recharge and ungaged surface outflow from the area east of Notus.

Most water from the eastern upland of the Boise River basin is at the surface in the narrow, rock-walled canyon of the river at the Boise Diversion Dam. Ground-water underflow is small, probably on the order of 35,000 acre-feet a year. The highland north of the Boise Valley contributes about 86,000 acre-feet of ground water a year by underflow to the valley lowland. Direct ground-water recharge from precipitation on the part of the valley lowland where recovery of replacement ground water would be practicable is about 113,000 acre-feet a year. Thus, the total potential ground-water recharge from precipitation and underflow in the exchange area and areas tributary thereto is about 234,000 acre-feet a year.

Estimated potential recharge of ground water from irrigation in the exchange-pumping area has been about 350,000 acre-feet a year and actual recharge may have been on the order of 320,000 acre-feet. Identified and estimated consumptive depletion of ground water in the entire valley is about 230,000 acre-feet a year, but not all the depletion is within the exchange area or area tributary.

The feasibility of the Alternate Plan is limited by the environment in which it would operate, especially by ground-water features. Success of the plan would depend upon developing an adequate replacement-water supply and concurrently accomplishing satisfactory drainage of waterlogged land in specified areas. The economy of water management would depend on the degree to which economical pumping of irrigation water could be coupled with effective drainage. Principal ground-water features that would limit the effectiveness of the plan therefore are analyzed.

Limitations Imposed by the Environment

Five ground-water districts are defined, chiefly on the basis of well capacities. Wells in the Nampa ground-water district have the largest yields in the valley, obtaining unconfined water from late terrace gravel, alluvium of Indian Creek, basalt, and cinder beds. Artesian water is tapped in shallow basalt aquifers in the southeast part of the district and elsewhere at greater depth in sand aquifers of the Idaho formation. The average depth to the water table is 10 to 15 feet and the maximum depth is 50 feet. The average well yield is 1 cfs for each 8 feet of drawdown, and the average well depth required to develop 2 to 3 cfs of water is about 120 feet. Much waterlogging of land in the district is caused by upward leakage of artesian water through imperfectly confining layers of soil and caliche. This condition could be alleviated by pumping to lower aretesian pressures.

In the Meridian ground-water district unconfined water is obtained from late terrace gravel and Recent alluvium. The average depth to the water table is between 10 and 15 feet and the maximum depth is about 50 feet. Artesian aquifers in the Idaho formation underlie the district at various depths. Water-table wells yield about 1 cfs of water for each 22 feet of drawdown; artesian wells yield up to 1.5 cfs by natural flow and 3 cfs by pumping. Drainage conditions are similar to those in the Nampa district.

The average depth to water and average yield of wells in the Wilder and Kuna ground-water districts are not accurately known. The permeability of aquifers in much of the Wilder district is relatively low. Drainage is needed in the district but the sediments do not drain by ground-water pumping as readily as those in the Nampa and Meridian districts. In much of the Kuna district the depth to water is too great for economical pumping. In the North Side district ground-water occurrence is too poorly known to be described adequately.

The apparent coefficient of transmissibility of aquifers tested at key locations in the Boise Valley ranges from 36,800 to 1,700,000, but individual aquifers are limited in extent and are highly variable in their properties. Observed coefficients of storage of artesian aquifers range from 0.00007 to 0.001; those of nonartesian aquifers range from 0.001 to 0.43. Specific capacities of wells range from 8 to 450 gpm per foot of drawdown. The average performance of existing wells could be surpassed by new wells of improved design, construction, and development.

A well-defined ground-water divide approximately follows the New York (Main) canal from the southeastern part of the Boise Valley to a point north of Melba, from where the divide extends northwestward near the south side of Lake Lowell, and thence to the confluence of the Boise and Snake Rivers. Some ground water moves southward from the divide into the Mountain Home Plateau and Snake River Valley. Pumping ground water north of the New York canal would tend to shift the divide southward, thus enlarging the area in which ground water is tributary to the Boise Valley. North of the divide the general direction of ground-water movement is northwestward and a large part of the total volume of ground water in the valley moves through the Alternate Plan exchange area.

Typical areas in the Boise Valley illustrate the range of conditions that would affect ground-water pumping under the Alternate Plan. In the Pioneer Irrigation District drainage by pumped wells is effective, effects being observable half a mile away, and a large volume of usable water could be obtained. The average depth of the Pioneer wells is 132 feet, and the average depth to water was about 10 feet in the summer of 1953. On the Harry Ellis farm, in sec. 7, T. 2 N., R. 1 W., waterlogging is caused by upward leakage of artesian water from basalt and gravel through imperfectly confining beds of soil and caliche. Observation of existing open drains and flowing wells, and test pumping of an experimental well, show that the artesian pressure can be relieved and that nearby waterlogged land can be dewatered. Conditions like those at the Ellis farm prevail in several areas in the Boise Valley and favor drainage by pumping wells that would produce usable irrigation water.

Conditions are less favorable between Meridian and Ustick in a waterlogged area on the Whitney terrace, where about 35 feet of flood-plain clay, sand, and gravel overlies partly cemented silt and somewhat permeable sand of the Idaho formation. The average depth to the main water table in the flood-plain deposits is less than 10 feet. Locally, at shallower depth, temporarily perched ground water causes saturation to the land surface during each irrigation season. Water in the Idaho formation, below the main water table from a depth of 81 to 120 feet, is under a local separating lens of clayey sediment which simulates an artesian confining layer, and the lower zone reacted as an artesian aquifer during a pumping test. Pumping did not dewater enough of the aquifer to cause a noticeable effect at a domestic well 1,300 feet distant. Pumping wells in the Ustick-Meridian area, where geologic conditions resemble those at the test site, would provide some drainage but would not benefit local areas where ground water is perched temporarily each summer.

About 50 flowing artesian wells on Eagle Island, in T. 4 N., R. 1 W., provide water for stock and domestic use, irrigation, and a trout hatchery. The discharge rate of existing domestic and irrigation wells ranges from 2 to nearly 300 gpm and the average yield by free flow is less than 100 gpm per well. The developed artesian aquifers are chiefly sand and gravel between confining beds of clay and silt. The shut-in artesian pressure ranges from 3 to 27 feet above the land surface. Two adequately constructed and developed new wells at the fish hatchery, 375 and 412 feet deep, have a combined natural flow of 1,140 gpm. Experiments and observations suggest that discharge of ground water from shallow artesian aquifers would assist drainage by diminishing artesian pressure and upward leakage of water. Discharge from deeper aquifers is more copious but local or immediate drainage benefits are not apparent. Regional benefits might be achieved.

Under the water-exchange proposals of the Alternate Plan, pumped ground water at most places would be diluted with the surface water. Nevertheless some land probably would receive a preponderance of ground water. Inasmuch as the ground water is more mineralized than the live surface-water supply, the chemical suitability of the ground water for irrigation is an important environmental feature. Dissolved solids in the surface water range in total amount from 51 to 788 ppm in samples analyzed. The range in ground water is from 69 to 1,040 ppm. In general the concentration of dissolved solids and the percentage of exchangeable sodium in both ground and surface water increase westward (downstream). The temperature of water from representative existing wells in the water-exchange area ranges from 52 to 83°F. Locally in the Boise Valley deep artesian wells tap water as warm as 122°F or even warmer. Water that would be tapped in the exchange area probably would not have a temperature detrimental to agriculture.

The sodium hazard ("alkali" hazard) to soils from Boise Valley waters was evaluated by three standard criteria -- "percent sodium," sodium-adsorption ratio, and residual sodium carbonate. By the "percent sodium" criterion most of the 89 analyzed samples of ground water are excellent to good, a few are permissible to doubtful, and none are unsuitable. The surface waters generally are slightly superior to the ground waters. The "percent sodium" method is not wholly satisfactory because it does not afford a direct measure of potential sodium adsorption by base exchange in the soil. By the "sodium-adsorption" criterion most of 88 ground-water samples have a low sodium hazard and in only 3 is there a medium hazard; the hazard is high in none. On the other hand, the salinity hazard is low in 19 samples, medium in 41, and high in 28. Waters medium to high in both salinity and sodium hazard (doubtful suitability) occur widely in the Boise Valley west of Kuna and Meridian — that is, in a large part of the exchange area and in wells ranging from 50 to 400 feet deep. According to the residual-sodium-carbonate criterion, 4 out of 89 samples of ground water are unsuitable, 18 are of marginal quality, and 67 are "probably safe." All surface water samples are of "probably safe" quality.

The suitability classes of water grade one into another. Moreover, the classifications assume average soil conditions, irrigation practices, climate, and salinity tolerance of plants. Deviations from the "average" may cause some apparently suitable water to be unsuitable. Conversely, some "unsuitable" water would be suitable under some conditions.

The chemical quality of water inevitably depreciates as the water moves through an irrigated area, and such depreciation of both surface and ground water is evident in the Boise Valley. The net effect of the mechanism of depreciation is an increase, with use of the water, in the amount of dissolved solids and in the relative amounts of sodium, sulfate, and chloride. This effect is cumulative as water moves westward through the valley and each cycle of use and reuse contributes to the depreciation. Boise River water in general is somewhat superior to the ground water, but by the time the surface water reaches Notus its quality is depreciated. Water from the Snake River is inferior to that in the Boise River at the Diversion Dam, but it is superior to Boise River return water at Notus.

Available data are not sufficient to disclose the geographic or geologic pattern in which waters of doubtful suitability occur, but full knowledge of these patterns will be essential in the ultimate irrigation development of the valley. Available data suggest that the Boise Valley as a whole may be on the verge of an unfavorable "salt balance," at least during a succession of years of low water supply, as in the 1930's. Intensive investigation is needed to establish the facts. Operation of the Alternate Plan would tend to affect the salt balance in the valley unfavorably because, among other things, pumped ground water and imported Snake River water would be inferior to Boise River water. Whether or not the salt balance in the valley would remain favorable despite this effect remains to be determined.

Feasibility of the Plan

In order to determine whether the Alternate Plan is physically feasible, could be operated successfully for an indefinitely long time, and would be advantageous to execute, the principal features of water management embodied in the plan are reviewed, one by one.

1. The estimate of a diversion requirement of 4.85 acre-feet of water per acre of irrigated land in the Mountain Home Project is optimistically low and appears to be based partly on misconstrual of the records of historical diversions to the Boise Valley lands. Geologic factors suggest that the diversion requirement per unit of land would be appreciably higher. If so, the area that could be irrigated with the specified amount of water would be less than stated in the Alternate Plan.

2. The availability of 600,000 acre-feet of Boise River water, for diversion to the Mountain Home Project at the times and places the water would be needed, has not been demonstrated. Records show that the run-of-the river supply in the South Fork of the Boise River was deficient in 6 of the 20 base-period years. Holdover storage at Anderson Ranch dam and modified reservoir operation would be necessary for operation of the plan, which would reduce the amount of water available for firm-power generation.

3. Snake River water is available and the exchange for Boise River water is physically feasible up to a limit of 300,000 acre-feet a year. More than that amount of water would not be usable on land that could be served from Lake Lowell. Complications in the process of manipulating Lake Lowell for power generation with pumped Snake River water would limit the amount of water that could be used for power generation. Economic feasibility of the Snake River water exchange is beyond the scope of this report.

4. For the Alternate Plan to be acceptable to Boise Valley water users, an undiminished supply of irrigation water presumably must be assured. Such assurance is not possible at the proposed exchange rate of 225,000 to 300,000 acre-feet of ground water for an equal amount of river water. Additional "offset water" would need be pumped to compensate the effects of diminished surface water and diminished ground water in storage. To offset the export of 225,000 acre-feet of surface water the "normal-year" ground-water pumping requirement would be substantially more than 300,000 acre-feet and might approach 400,000 acre-feet. In years of short water supply the total pumpage required might approach 500,000 acre-feet.

5. Uncommitted potential ground-water recharge in the exchange area possibly approaches 400,000 acre-feet a year, but the amount of actual recharge is not known. Potential recharge would be reduced by exporting surface water, but it still might be about equal to the "normal" replacement pumping demand.

6. The full perennial ground-water yield of the exchange area could not be intercepted by pumping during the irrigation season. However, about two-thirds of the pumped water would not be consumed and in part would be potential return recharge. Net ground-water depletion under the Alternate Plan would be on the order of 100,000 to 150,000 acre-feet a year. Return recharge would lag somewhat after pumping, and temporary depletion at the end of the irrigation season would be less than gross pumpage but more than ultimate depletion. Thus, water to operate the Alternate Plan is available in the Boise Valley, but it is not certain that the yearly demand could be withdrawn during the pumping season without local or temporary mining of water. Nor is it certain that mined water would be replenished before the onset of another irrigation season.

7. The average capacity of wells in the Alternate Plan would (or could) be somewhat greater than the plan estimate. The average yield with 30 feet of drawdown would be about 2.6 cfs. The proposed 450 wells could deliver the required amount of offset water in a pumping season of about 180 days. Spacing of wells at quarter-mile intervals along all main canals would not be feasible because pumping would increase percolation loss of water from some canals, drainage of much waterlogged area would not be accomplished, and interference between wells would be unnecessarily great. Wells would have to be dispersed in the exchange area, and possibly in parts of the adjoining area. The "average" depth of 450 wells would be more than 125 feet and the average pumping lift would be about 70 feet.

8. The Alternate Plan estimate that ground-water pumping would lower the water table 4.5 to 5 feet beneath 225,000 acres of land is not supported. The water table would decline progressively for some years to a new equilibrium level which cannot now be predicted. Maximum efficiency of wells for both drainage and production of irrigation water could not be achieved but a reasonable compromise would be feasible. The cost of constructing and pumping wells would exceed the Alternate Plan estimate.

9. Some ground waters in the Boise Valley are chemically suitable for irrigation, but others entail a salinity hazard for certain types of soils and crops. The distribution pattern of unsuitable waters is not apparent from available data. The valley may be on the verge of an unfavorable salt balance, locally or in years of short water supply. Operation of the Alternate Plan would affect the salt balance unfavorably; whether, in time, agricultural prosperity might be impaired is not yet known.

General Evaluation of the Alternate Plan

The Alternate Plan recognizes the basic general principle that in the ultimate analysis ground water and surface water are but two components of a single resource. Failure to develop and manage the two parts effectively is the root of the drainage problem in the Boise Valley, where ground water has been considered largely as a nuisance. The Alternate Plan, in principle, proposes total water management that would turn nuisance ground water into an asset for beneficial use. At the same time, by ignoring the part of the valley north of the river, the plan fails to recognize that the entire valley is a hydrologic unit. The plan also would seek to furnish usable water and drain wet land by pumping wells at sites selected arbitrarily, overlooking natural geologic and topographic factors that would control the effects of pumping.

The chief necessary modifications in hydrologic features of the Alternate Plan would be in the pattern of well installations, the construction characteristics of wells, and the amount of ground-water pumpage. These modifications would change the basis for computing the cost of well construction and pumping, water delivery, and drainage benefits, and other elements of the plan.

The Alternate Plan treats the drainage problem in the Boise Valley as an emergency. Though the drainage situation is bad and is gradually worsening, this "emergency" has existed for more than 30 years. No need is apparent for a "crash" program, initiated without adequate data and without reasonable assurance that the overall plan, even though extensively modified, is feasible. The effects of ground-water pumping on long-term water-level trends or on the flow of drains cannot be forecast with reasonable accuracy at this time. Inasmuch as water from drains satisfies water rights within and beyond the exchange area, there is likewise no basis for estimating the degree of adjustment and exchange of water rights that may become necessary within the Boise Valley. Difficult negotiations would be necessary prior to construction, to arrange for shifting points of diversion and to gain acceptance of substitute water supplies. Obviously it would be necessary to assure present water users of a supply that is adequate in quantity, suitable in quality, economically accessible, and capable of efficient delivery where it is needed. The Alternate Plan does not provide such assurance.

Unresolved major problems that concern the hydrologic heart of the Alternate Plan are in three principal categories; namely (1) the amount of ground water that actually must be pumped to replace live surface water and return water; (2) the amount of ground water that is perennially available and accessible; (3) the chemical suitability of the ground water and the water-management practices necessary to forestall an unfavorable salt balance. In the present report the necessary amount of replacement water has been estimated only crudely, and within possible maximum limits. Availability of the water seems probable, but there is reasonable doubt of its accessibility within the exchange area. Only the general dimensions of the chemical-quality problem are established. Until the problems in these categories are resolved, effective operation of the Alternate Plan for an indefinitely long time cannot be assured.

An intensive hydrologic study alone would not completely resolve all major problems because not all the unknown and indeterminate variables in the water equation could be eliminated. Nevertheless, attack upon the problem is not necessarily at an impasse. Intensive study and observation, along with partial execution of the Alternate Plan, probably would lead to a solution. A trial-and-study suggestion is outlined in the report.