

MEMO

State of Idaho Department of Water Resources

322 E Front Street, P.O. Box 83720, Boise, Idaho 83720-0098

Phone: (208) 287-4800 Fax: (208) 287-6700

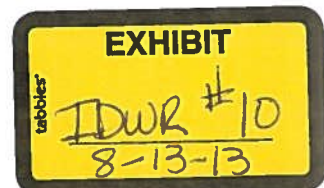
Date: April 30, 2013
To: James Cefalo, Hearing Officer
From: Dennis Owsley, Hydrology Section, State Office
cc: Sean Vincent
Subject: Application for Transfer No. 77610 in the Name of Parkinson Farms

Overview

On February 14, 2013, the Hearing Officer for the subject transfer requested a staff memorandum to augment the record through a technical memorandum. The following questions were posed in the request:

1. What is the hydrogeology of the Big Lost River aquifer and any aquifer subunits from approximately Moore, Idaho, downstream to a location south of Arco, Idaho, where the gradient of the aquifer suddenly steepens, and becomes part of the larger Snake River Plain Aquifer?
2. Is the water in sub-aquifers of the Big Lost River aquifer the source of the "rising waters" in the Arco area, and, if not, what is the source of the rising waters?
3. Is the water in the various sub-aquifer units commingling in the deepened Parkinson well because of the decreasing gradient with depth?
4. What is the impact of pumping from the proposed point of diversion on each of the sub-aquifer units?
5. What is the impact of pumping from the proposed point of diversion on rising water in the Big Lost River?
6. What would be the impact on rising waters of pumping Parkinson's water right from the existing points of diversion?
7. Over the last 20 years, what are the quantities of water diverted by Water District 34 and delivered for ground water recharge?

The following sections address each question sequentially.



1. What is the hydrogeology of the Big Lost River aquifer and any aquifer subunits from approximately Moore, Idaho, downstream to a location south of Arco, Idaho, where the gradient of the aquifer suddenly steepens, and becomes part of the larger Snake River Plain Aquifer?

Hydrogeologic Framework

The hydrogeology of the Big Lost River Aquifer in the area of interest consists of an alluvial aquifer bound by carbonate bedrock formations that form the ridges along the east and west sides of the valley. Basalt flows are observed near the mouth of the valley (Figure 1). The valley fill is comprised of alternating layers of sand, gravel, silt, clay, and boulders. The majority of wells drilled in the area are completed in the valley fill.

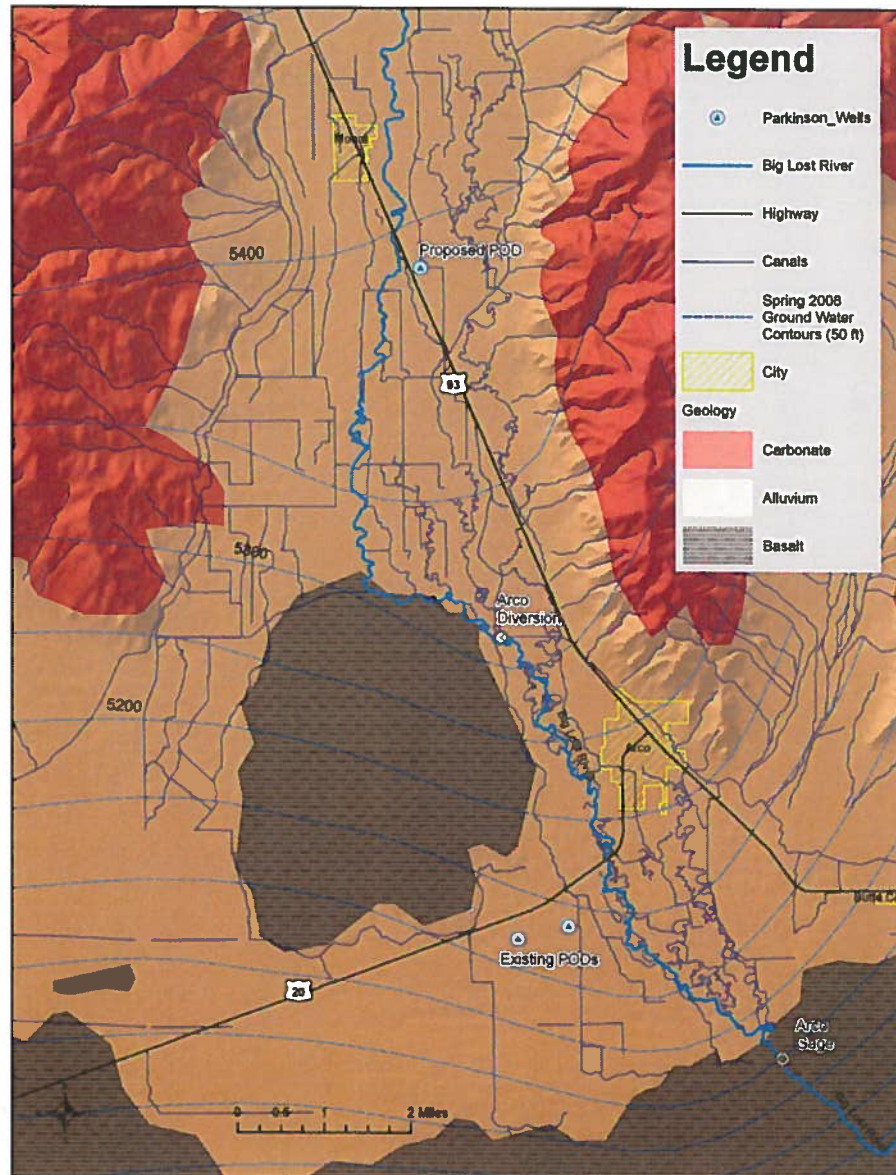


Figure 1. Generalized geologic map of the Big Lost River Valley from approximately Moore, Idaho south to the Eastern Snake River Plain.

The sedimentary aquifer system in the Big Lost River valley north of Arco is over 2,000 feet thick (Crosthwaite et. al, 1970). Clay layers range from 5 to over 50 feet thick and act locally as confining beds separating saturated zones of sand and gravel as well as perching unconfined zones. The clay units were deposited during flood events when streams were dammed by the encroachment of basalt flows from the south (Crosthwaite et. al, 1970). The encroachment occurred during several episodes forming lakes which deposited clays. The clay deposits have since been eroded and reworked by the Big Lost River, resulting in a series of disconnected clay lenses. The areal extent of individual clay lenses is unknown, but in the Arco area, the clay and basalt sequences are laterally extensive and strongly influence lateral movement of ground water (Crosthwaite, et. al, 1970). Additionally, data from well logs suggest that the clay lenses confine or influence the vertical movement of water.

Although the clay horizons cannot be precisely mapped with confidence, a generalized conceptual geologic cross section was developed to illustrate the geologic variability encountered in the subsurface (Figure 2). As shown in Figure 2, nearly all of the wells examined in this area encounter at least one clay layer.

Quaternary basalts from the Eastern Snake River Plain are found at the mouth of the valley near Arco. A basalt outcrop can be observed just west of Arco, and has an impact on the surface water flow regime and possibly the ground water in the uppermost aquifer subunit. This basalt flow appears to have re-routed the channel of the Big Lost River as the river bends nearly 90 degrees as it approaches the northern edge of the outcrop (Figure 1). This indicates that the basalt is resistant to weathering and acts as a barrier to surface flow.

The outcrop is the northern-most surface exposure of basalt in the valley. The basalt flow appears to reduce the width of the alluvial aquifer from approximately four miles near Moore to less than two miles near Arco (Figure 1). The constriction reduces the cross sectional area of the uppermost portion of the aquifer, which in turn reduces the area that is available to store and transmit water.

The Big Lost River Aquifer merges with the larger Eastern Snake River Plain Aquifer (ESPA) a few miles south of Arco. In this transition area, the depth to water increases significantly, resulting in a relatively steeper hydraulic gradient as shown on Figure 1. The increase in hydraulic gradient is due to a reduction in aquifer transmissivity in the transition area from the Big Lost River Aquifer to the ESPA. The reduction in transmissivity is a result of the lacustrine clay deposits interbedded between relatively impermeable basalt which impede ground water flow and effectively reduce the thickness of the aquifer.

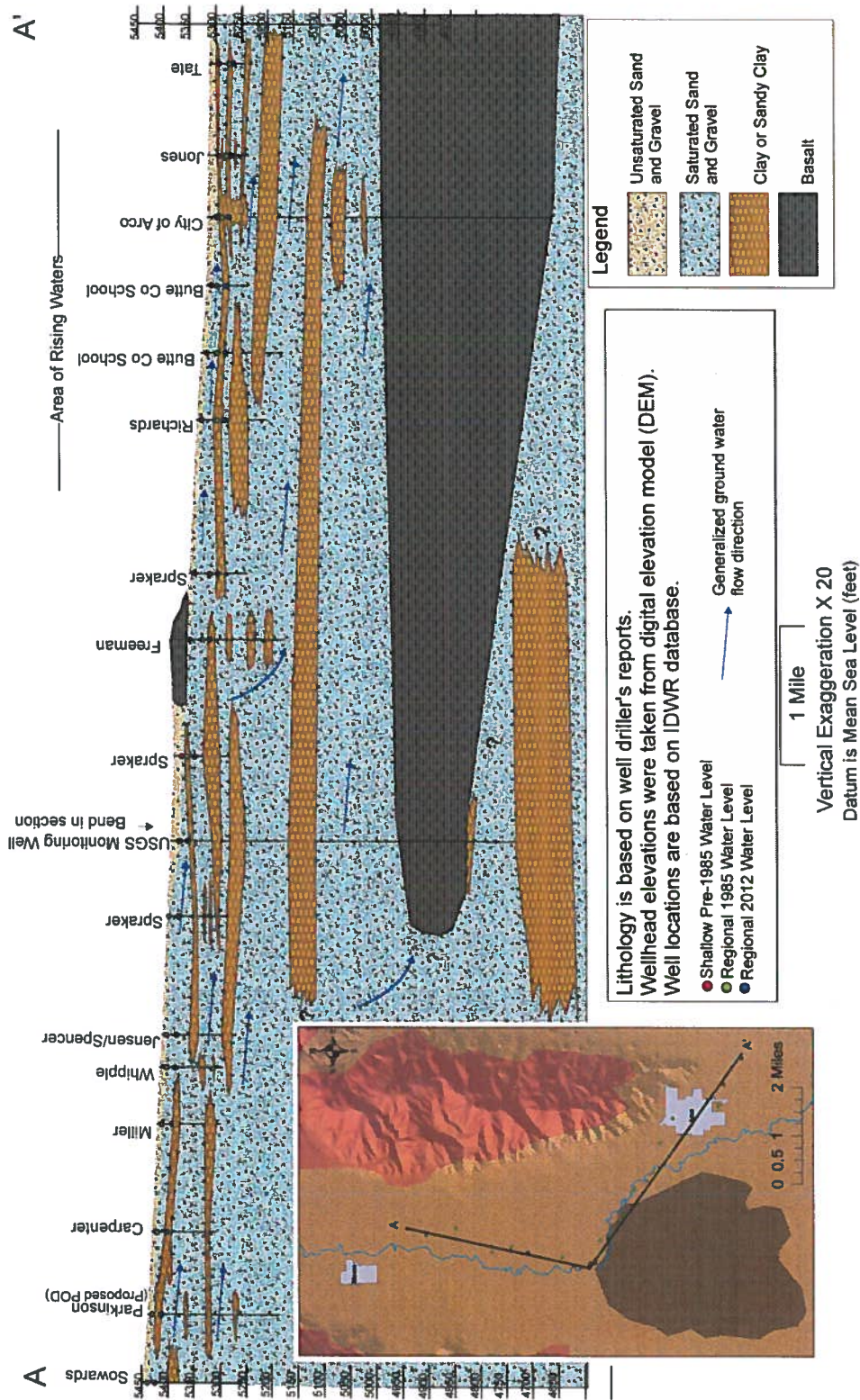


Figure 2. Generalized geologic cross section A-A'.

Aquifer Subunits

Individual aquifer subunits within the Big Lost River Aquifer system are difficult to identify on a basin-wide scale due to the heterogeneity of the alluvial deposits, the variability of the width of the aquifer, and the interconnection within wells completed at various depths. For discussion purposes, the uppermost and multiple deep aquifer subunits are described in this memo.

Available data indicate that the uppermost subunit is perched when water levels in the regional aquifer are low and comprises the top of the regional aquifer system if water levels in the regional aquifer system are high enough. Reviewing the driller's reports for the area that have construction dates included, only a few dozen domestic wells that have been drilled to 60 feet or less exist in the area. Of these wells, all but two of them were drilled prior to 1985. Many of these shallow wells have been deepened or replaced, due to declining aquifer levels. This suggests that the uppermost subunit is not a reliable source of water to domestic wells.

The multiple deep aquifer subunits contain sequences of clay layers interbedded with saturated sands and gravels. It is these subunits that are relied upon for majority of the domestic and irrigation wells in this area and are coincidental with the term "regional aquifer".

Water Levels

The direction of ground water flow is from north to south and generally parallels the course of the Big Lost River channel. Depth to water in most wells is generally less than 50 feet below land surface. The depth to water and hydraulic gradient through the valley are dependent on variations in the permeability of the alluvial material, the cross-sectional width of the valley, the depth below land surface, and the quantity of water moving through the aquifer (Crosthwaite et. al, 1970). It is important to note that aquifer head decreases with depth in this region. A review of well driller's reports of shallow wells (< 60' deep) indicates that the water levels in these wells are higher than the water levels in the deeper wells in the area.

Comparison of water levels to geologic information on well logs reveals that the aquifer system varies from unconfined near land surface to semi-confined at depth. Clay layers are commonly reported as not water yielding in the driller's logs and wells completed below these clay horizons often display semi-confined conditions., indicating the clay is relatively impermeable.

A review of hydrographs from wells routinely monitored in the area indicates that the seasonal and long term trends appear similar for most of the wells, regardless of the depth of completion (Figure 3). It is not known whether the apparent hydraulic connection throughout the aquifer subunits is due to clay layer discontinuities or to vertical communication provided by wells that lack annular well seals.

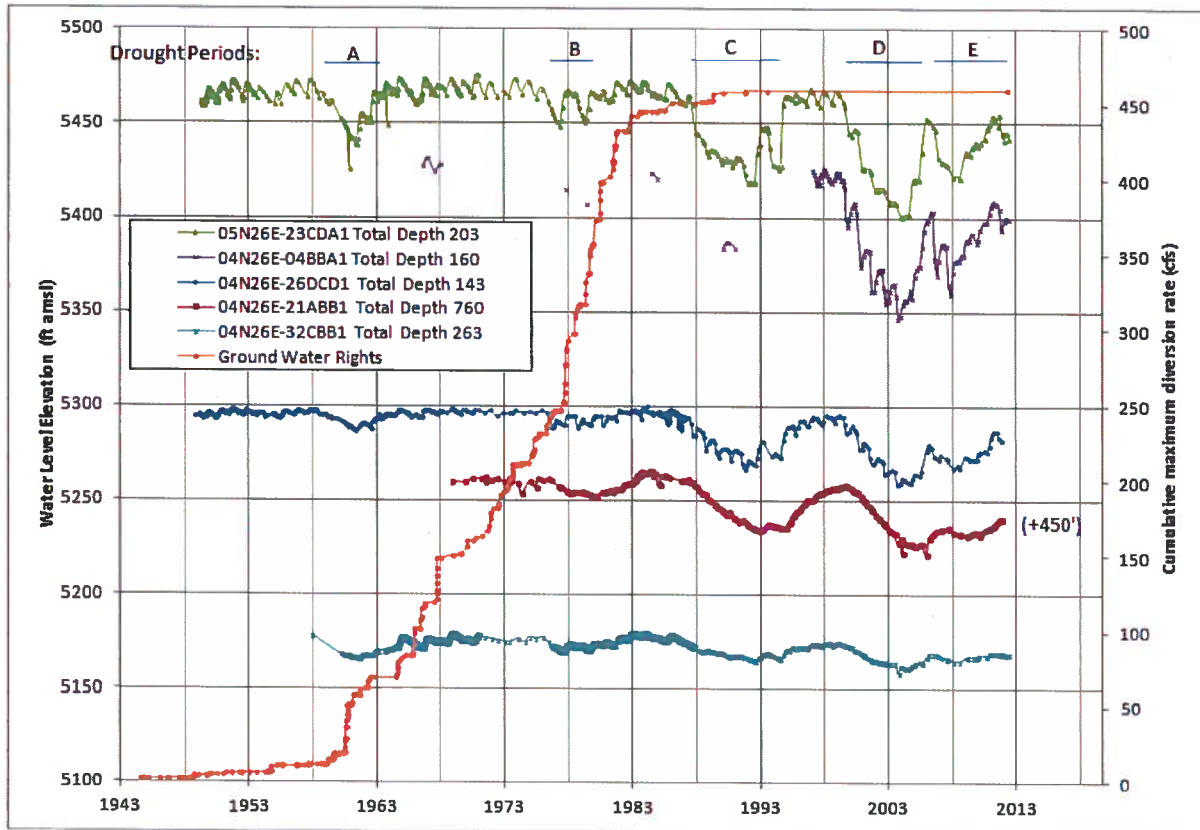


Figure 3. Hydrographs of five routinely monitored wells in the Moore to Arco area with cumulative maximum diversion rates for ground water rights superimposed. Note that 450' has been added to the water level elevation of well 04N26E-21ABB1 in order to plot on the same scale. Well locations can be seen in Appendix A.

On an annual basis, aquifer water levels respond to the water supply conditions in the valley. In water short years, aquifer levels decline in response to additional pumping and a reduction in incidental recharge from irrigation practices and leaking diversion networks. In water rich years, water levels increase in response to less ground water pumping and more incidental recharge from leaking canals, irrigation seepage, and leakage from flow in the Big Lost River (Figures 3 and 4). Although the individual dry years can be seen in the hydrographs (drought periods A through E), water levels were relatively stable until the mid 1980s. At this time, aquifer levels dropped significantly and have yet to return to "pre-1985" conditions. The overall reduction in the water table appears to coincide with the development of groundwater, expansion of irrigated lands in the area, and more efficient irrigation practices that result in less incidental recharge through excess surface water application. The cumulative maximum diversion rate for ground water rights in the Moore to Arco area increased beginning in about 1960 and steadily increased until the early 1980s. Since 1992, there has been a basin-wide moratorium on new ground water rights for consumptive use.

Although drought periods can be identified in the observation well hydrographs, the years of adequate and abundant water supply can also be seen. As seen in Figure 3, water levels respond rapidly to periods of high water supply. In the mid to late 1990s, water levels rose to near historic levels in response to five consecutive years of high water supply. Recent high water years (2007 and 2011) also

are represented in the hydrographs with rising ground water levels, but not to the extent that was observed in the mid to late 1990s.

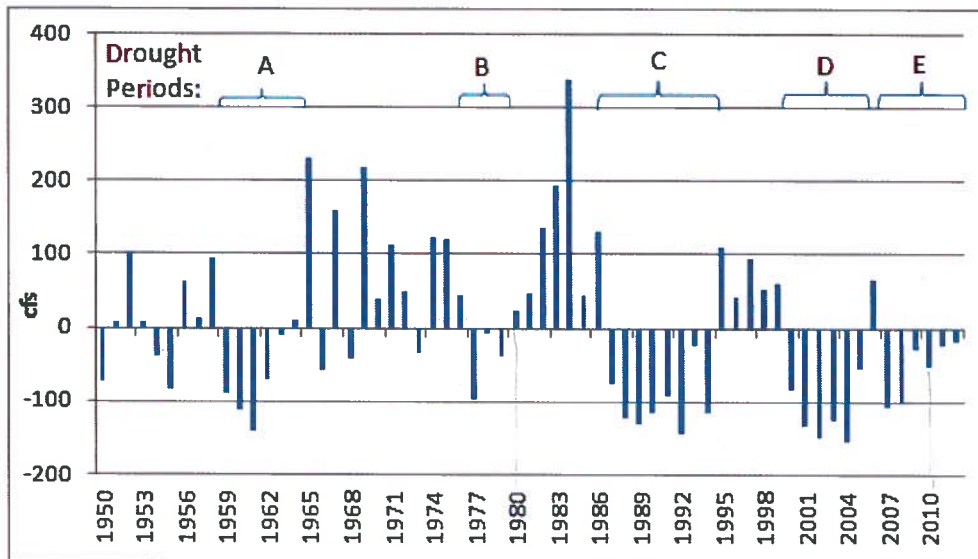


Figure 4. Departure from 1950-2012 average of Big Lost River flows below Mackay Reservoir.

As previously mentioned, there is a downward hydraulic gradient throughout the valley between Moore and Arco. Decreasing water levels with depth were documented during the drilling of the 760-foot deep monitoring well 04N 26E 21ABB1 in 1969. USGS personnel noted that several wells had cascading water during a study conducted in 1985, further supporting the idea of a decreasing potential with depth (Baker, 1989). The existence of a downward gradient makes it important to consider the depth of the well when evaluating water levels in this area. This is especially important when correlating surface water flows to aquifer levels, although, few water level data are available for shallow wells completed in this area.

Hydraulic Connection with the Big Lost River

The Big Lost River and the underlying aquifer system of the valley are managed as one water resource. In areas where aquifer levels are at or near the land surface, ground water discharges into the Big Lost River channel and contributes to the flow of the river. In areas where the aquifer levels are below the elevation of the bottom of the river channel, water seeps from the bottom of the river channel into the underlying aquifer. Historically, the Big Lost River was connected to the aquifer throughout most of the valley, with some historic areas of losing reaches (Figure 5).

Current conditions indicate that the river and aquifer are now disconnected throughout most of the valley below the Darlington Sinks due in part to ground water development that has lowered the water table. Most of the reach between Moore and Arco was hydraulically connected in 1968 and gaining from the aquifer. In 1998, it appears the area near Moore was the furthest hydraulically connected downstream location.

The width of the valley appears to control, in part, which reaches of the river are gaining (ground water contributing to the river) and which reaches of the river are losing (river water contributing to the aquifer). Areas of the valley that are constricted correlate with historically gaining reaches and areas where the valley widens correlates with losing reaches. In addition, the depiction of vegetation on the

1960s 1:24,000 USGS topographic maps correlates well with the historically connected reaches of the river with the aquifer. South of Arco, the regional water table of the Big Lost River Aquifer merges with the deeper regional water table of the ESPA. Available data indicate that the river and aquifer have never been hydraulically connected where the Big Lost River Aquifer flows into the ESPA.

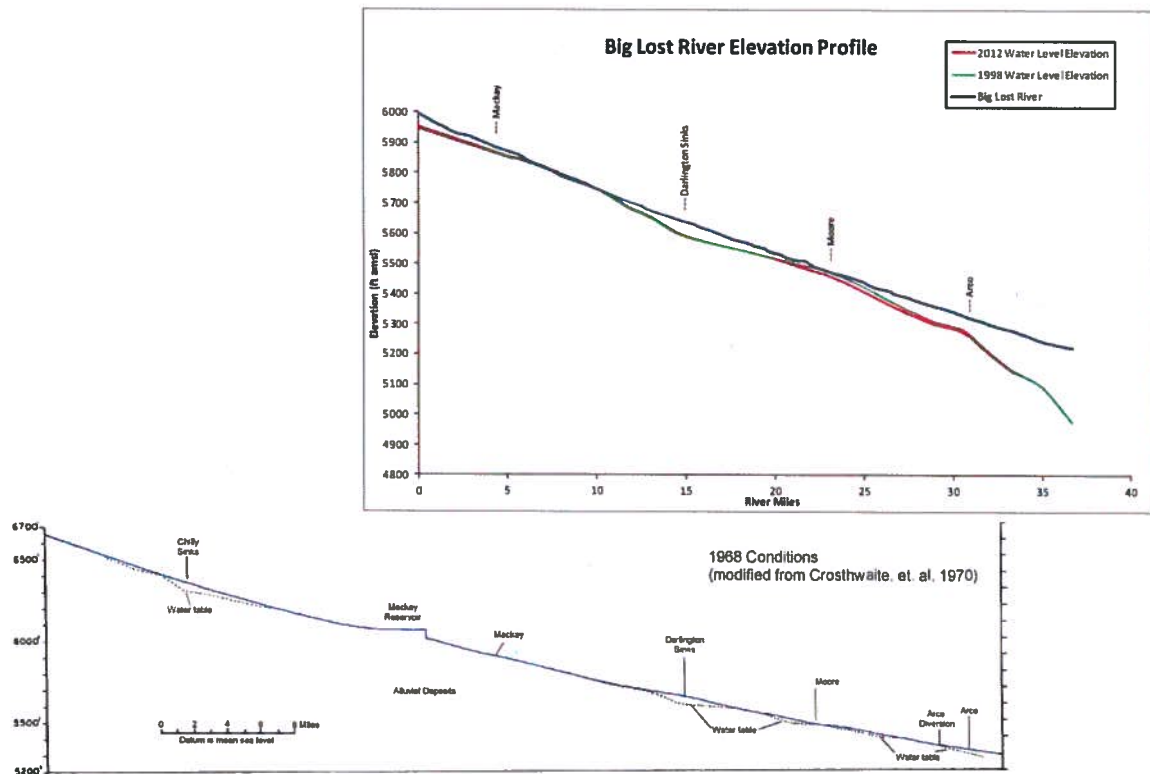


Figure 5. Big Lost River profiles comparing current conditions to 1998 and 1968 conditions.

2. Is the water in sub-aquifers of the Big Lost River aquifer the source of the “rising waters” in the Arco area, and, if not, what is the source of the rising waters?

For the purpose of this staff memo, the term “rising water” is used to refer to ground water that discharges from the aquifer system and emerges in the Big Lost River channel and in seeps and springs in the reach from approximately the Arco diversion to approximately the Arco gage (Figure 6). The water is described as “rising” because it provides a gain to the river and emerges as springs at the land surface. The source of the rising water is leakage from the Big Lost River and incidental recharge from irrigation in the area between Moore and Arco that causes the water table to intersect land surface.

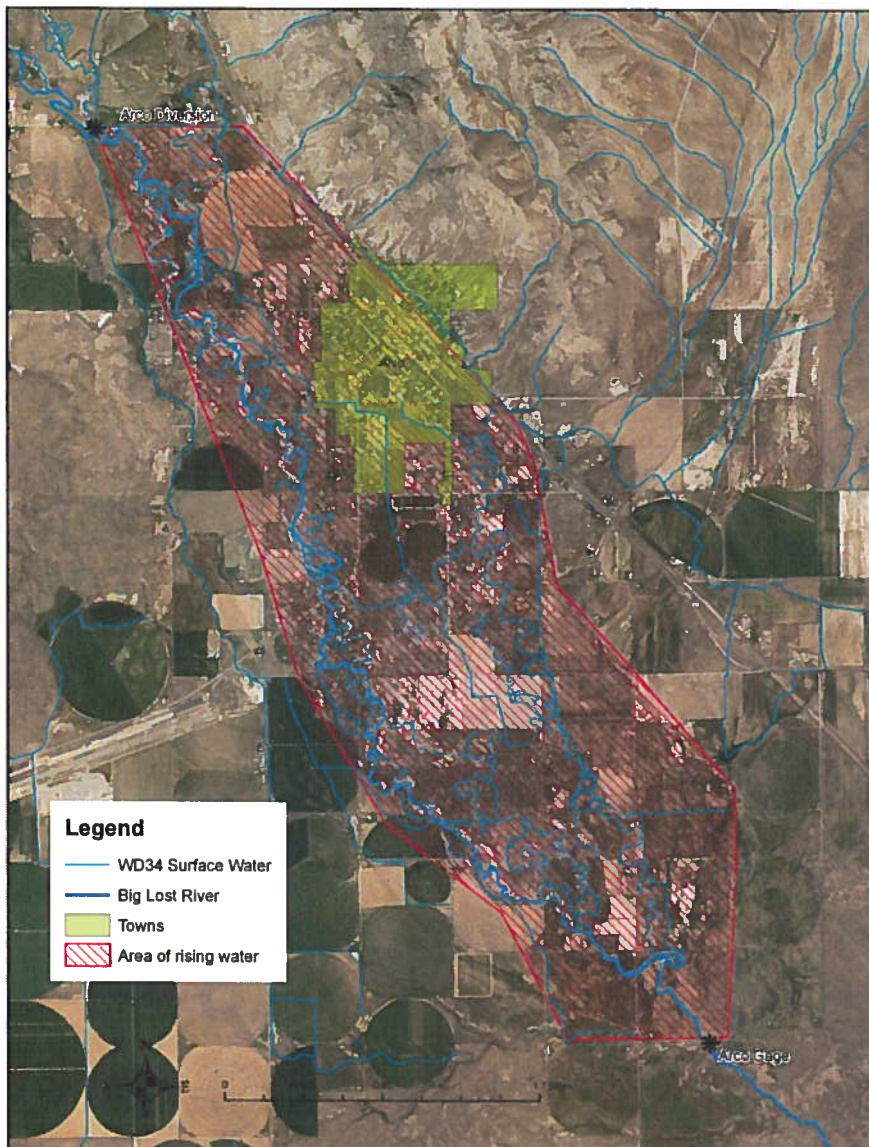


Figure 6. Area of occurrence and distribution of rising water.

Historically, rising water was observed in years of plentiful water supply when the river would flow beyond Moore and large amounts of water were used as irrigation in that area between Moore and Arco (Stearns, et. al, 1938). In such years, as much as 75 cfs would rise in the river channel and spring fed creeks just north of Arco (Stearns, et. al, 1938). In years of low water supply, the rising water is negligible. When aquifer levels are significantly lower than the elevation of the river, over 200 cfs must flow past the Moore Dam for any water to reach Arco (Stearns, et. al, 1938). According to the Water District 34 Annual Watermaster Report for 2011, the rising water has been low to non-existent for approximately the past 30 years:

"The water level is still increasing in the aquifer for example the static water level in June 2011 was 32 feet by December 2011 it had risen to 26 feet and for the first time in about 30 years there was rising water at the Arco Gage and in the ferris slough this fall."

There appear to be two different mechanisms that facilitate the occurrence of rising water: 1) the regional aquifer water levels are elevated to a point that the water table in the uppermost aquifer subunit intersects land surface, and 2) incidental recharge percolates until it encounters a clay layer that impedes downward flow, perching shallow water that eventually intersects the land surface in the area of the rising waters. Both mechanisms require the source water (either flow in the river or incidental recharge from irrigation) to be delivered to the southern portion of the basin. The lowering of the aquifer levels has moved the point of hydraulic connection up valley from Moore. As a consequence, the Big Lost River does not flow as far down valley as it had historically. This has reduced, if not eliminated, the source of the rising water.

The amount of water contributing to the rising water from the regional aquifer versus the uppermost perched aquifer cannot be quantified with currently available data. However, it appears that the perched component of the rising water is minimal in comparison to the contribution of the regional aquifer. For example, following several years of drought when the aquifer levels are low, a minor amount of rising water may appear from incidental leakage between Moore and Arco, but in quantities too low to divert to the local water users or to sustain river flows. In contrast, the pre-1985 aquifer levels were high enough to sustain rising water and flow in the Big Lost River in the Arco area. Contributions from the perched and regional systems are dependent on the amount of water that flows beyond Moore, as aquifer levels will rise if Big Lost River flows are sustained beyond Moore and more water is available to divert in the area between Moore and Arco. Observations support the existence of both uppermost and deep aquifer subunits contributions to the rising water.

The following observations support the deep aquifer subunits contributions:

- The area in which the rising waters have been observed is in a section of the Big Lost River valley that is restricted in width. The restriction of the cross-sectional area of the valley would facilitate higher water levels than in places where the valley is wider and water can spread out and flow through a greater volume of material.
- Although the data is anecdotal, it appears the reduction of the rising water is coincident with the lowering of the aquifer levels over the past few decades. It is apparent that, in the past, the rising waters were a significant source of water for local irrigators, as evidenced by the existence of multiple sloughs and irrigation diversions from the sloughs. Water right records indicate multiple rights exist on the rising waters, with priority dates as old as 1880.
- The hydrograph for well 03N27E-08BCB1 (Figure 7) shows a correlation between the winter water levels and the annual diversion volumes to the Arco canal. This well, located approximately 2.5 miles south of Arco, is 93 feet deep and it assumed to represent the deep aquifer subunits. Historically, depth to water in this well has been as shallow as 3 feet below land surface. The well driller's report is not available, so the depth to water when the well was drilled is unknown. Many wells in the area exhibit semi-confined conditions, and it is not apparent whether this shallow water level represents the uppermost saturated zone or semi-confined conditions.
- The depth to water across the valley from approximately Moore and extending down south of Arco was mapped as less than 10 feet in the fall of 1968 (Crosthwaite, et. al, 1970).
- Semi-confining to confining conditions are reported in many of the driller's reports in the area of rising water. These conditions may allow ground water from the deep aquifer subunits to flow upwards into the uppermost aquifer subunit through the annular spaces or screened interval of the wells drilled in the area.

- The cut and fill nature of alluvial deposits in the valley suggests that at least some of the clay units are discontinuous. Hydraulic communication between aquifer subunits would be facilitated by the absence of clay layers.

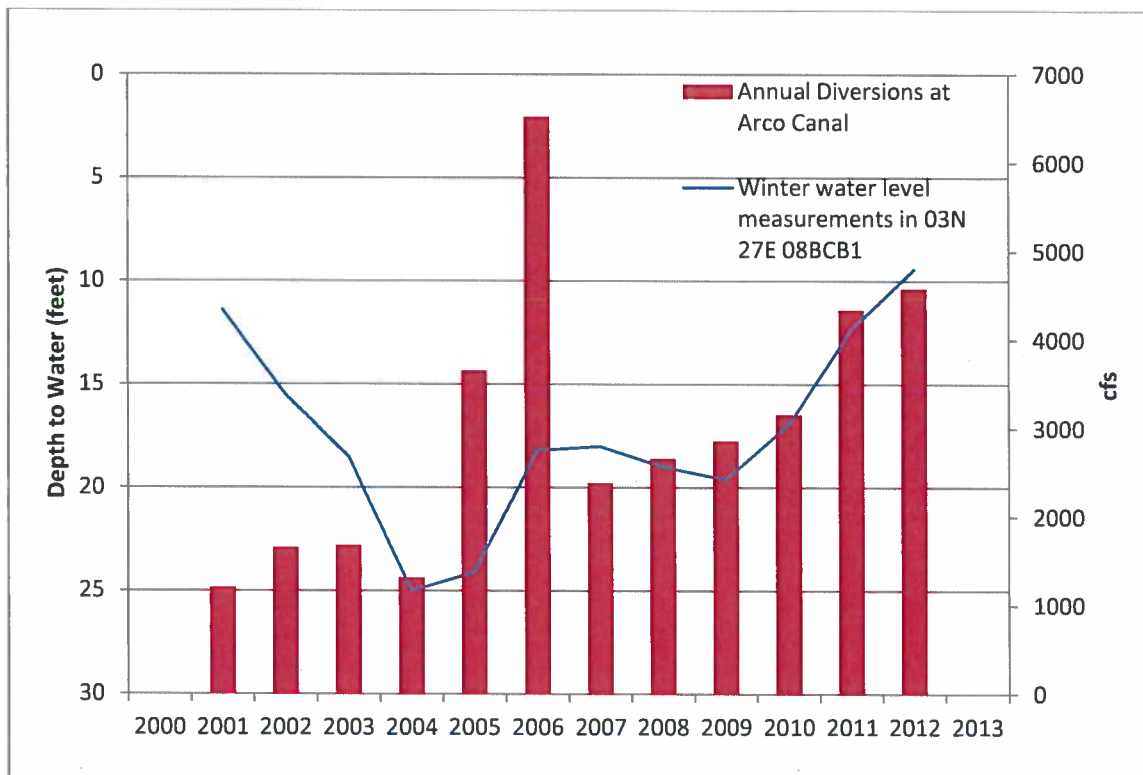


Figure 7. Comparison of winter water level measurements in observation well 03N 27E 08BCB1 and the annual diversions into the Arco canal.

Observations that support the occurrence of uppermost aquifer subunit contribution to the rising water are as follows:

- The timing of the appearance of the rising water coincides with the irrigation season. Based on discussions with the current Basin 34 Watermaster, in the past few years, the limited amount of rising water generally appears in late June to early July, approximately two weeks after the water disappears at its southernmost point in the river channel. (Totten, 2013).
- Although the flows were minimal, the existence of rising water in the past few years indicates that the source cannot be entirely ground water from the deep regional aquifer subunit, as water levels are currently well below the land surface elevation.
- Well driller's reports for the four wells closest to the head of the Ferris Slough (one of the main delivery systems of the rising water) were reviewed. All four wells indicate semi-confined to confined conditions as the static water levels are significantly higher than the first water zone encountered and/or the open interval of the well. The fact that the water levels in these wells are higher than the top of the uppermost water bearing zone indicates that there is a relatively impermeable confining layer. If the layer is impermeable enough to create semi-confined

conditions, it would seem reasonable that it would also impede the downward flow of seepage from localized irrigation and canals, creating a perched system.

- The driller's report for a Butte County School well, drilled in January of 1981, indicates that the first water was encountered at 21 feet, below a sandy clay horizon. The well is located up-gradient of the start of the Ferris Slough and was screened between depths of 30 and 75 feet, with a static water level 9 feet below ground surface. At the time the well was drilled, there was approximately 21 feet of unsaturated soil and clay separating the upper water bearing zone from the land surface. Therefore, it seems unlikely that the upper water bearing zone is the source of the rising water that is observed a few hundred yards south of this well.
- The hydrograph for well 04N26E-26DCD1 indicates that the water levels have historically been well below the elevation of the river (Figure 8). This well is routinely measured by IDWR and has water level data dating back to 1949. The well is 143 feet deep, and is located approximately ½ mile northwest of the town of Arco and is approximately 350 feet north of the Big Lost River channel. Depth to water in this well has ranged from 37 to over 75 feet below land surface and the bottom of the Big Lost River channel. Currently, the regional aquifer level is approximately 50 feet below the Big Lost River channel. The only plausible explanation for the occurrence of rising water at this location is contribution from a perched system.

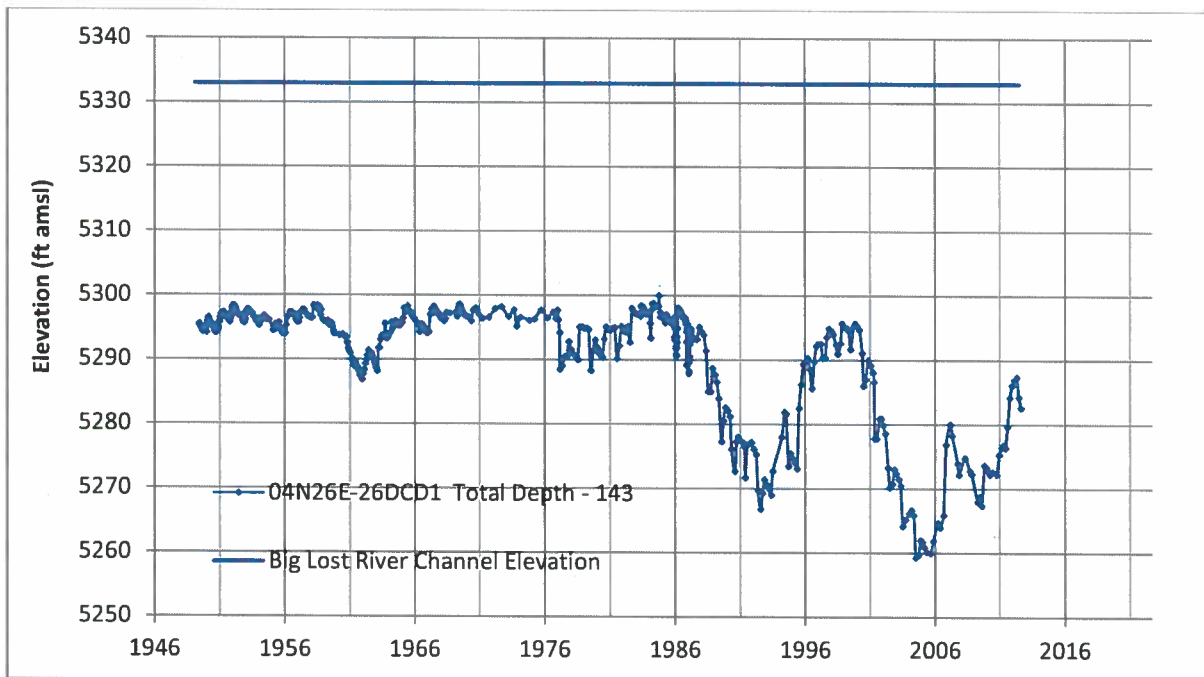


Figure 8. Comparison of water levels in 04N26E-26DCD1 to the elevation of the Big Lost River channel.

During low water years, the volume of rising water is expected to be reduced, if not zero. This is due to the fact that during low water years, the only source of rising water is incidental leakage from irrigation between Moore and Arco. During these low water years, the Big Lost River typically does not flow down to Arco as all of the river water is diverted into canals for irrigation. Therefore, the water that incidentally leaks into the subsurface encounters shallow clay horizons that perch the water and allow it to flow laterally, rather than seep into the deep aquifer subunit. If the volume of water is sufficient, seeps and springs flow where the clay horizons intersect the land surface or the bottom of the river channel.

During historic (pre-1985) years of high water supply, rising waters appeared due to a combination of two factors. First, if the regional aquifer levels were elevated to a point that the uppermost aquifer subunit became saturated, the water migrated laterally in the area of Arco and discharged as rising water. Second, and more importantly, if elevated regional aquifer levels increased to the point that the aquifer and river become reconnected near Moore, this reconnection provided additional flow in the Big Lost River, which in turn, increased the source of the rising water.

3. Is the water in the various sub-aquifer units commingling in the deepened Parkinson well because of the decreasing gradient with depth?

The water in the various aquifer subunits is commingling in the Parkinson well due to the design and construction of the well (Figure 9). There is a downward hydraulic gradient in the area (evidenced by decreasing static water levels with depth while drilling monitoring well 04N26E-21ABB1 approximately 3.5 miles south of the proposed POD), and the long screened interval within the well allows the aquifer subunits to commingle. The screened interval of the well extends from 30' to 244' below ground surface and penetrates four water bearing zones separated by clay formations. Therefore, water is allowed to migrate from the uppermost aquifer subunit to the deeper subunit through the large section of screen within the well. When this well is not pumping, water flows naturally from the uppermost aquifer subunit down into deep aquifer subunits via the screened portion of this well.

The water level in this well has declined since the well was drilled in May of 1977. The difference in water levels in the Parkinson well at the time of drilling and at the time of deepening (December 2009) was 26 feet (Figure 9). For comparison, the water level in observation well 04N26E-26DCD1 (approximately 5.5 miles southeast of the Parkinson well) was 41.3 feet below land surface in May 1977 and 62.3 feet below land surface in December 2009, a difference of 21 feet.

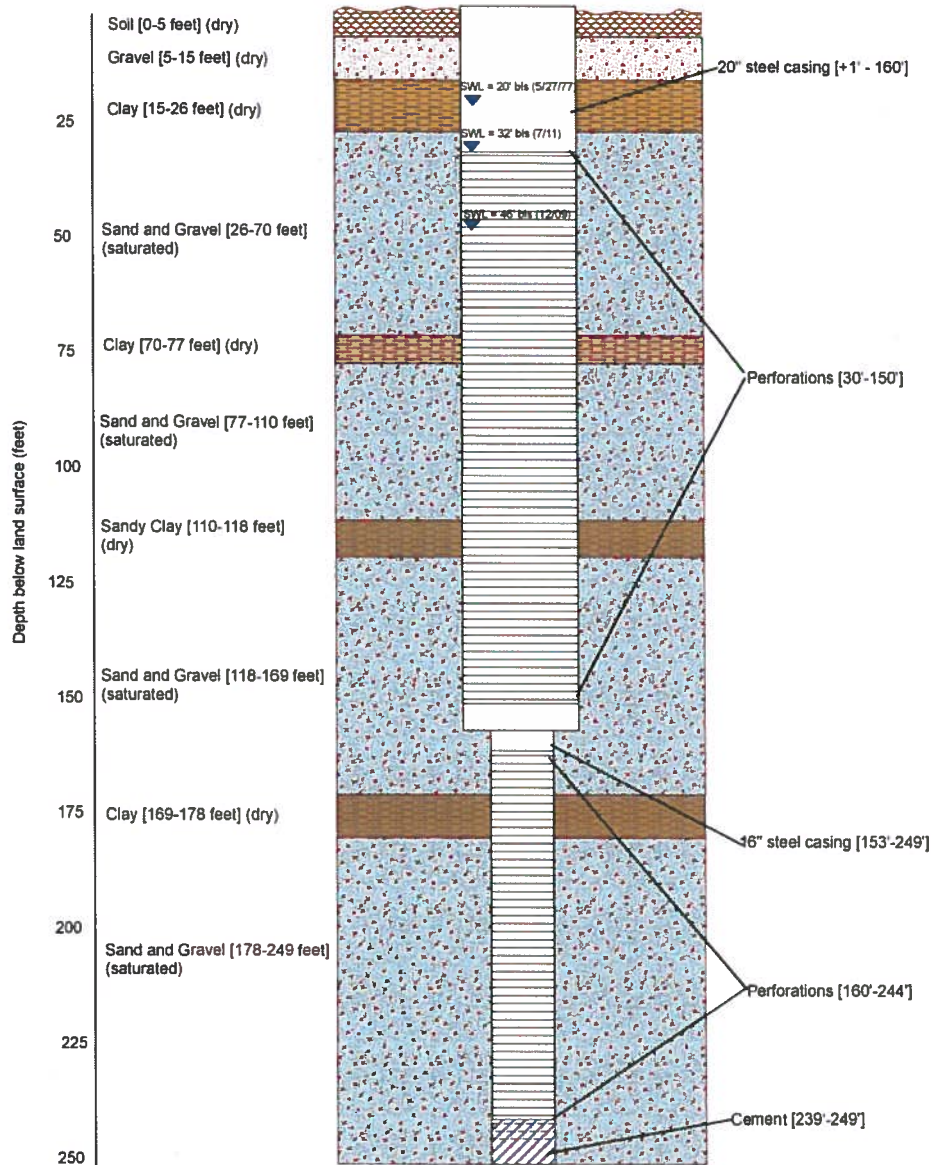


Figure 9. Schematic diagram of the proposed point of diversion.

4. What is the impact of pumping from the proposed point of diversion on each of the sub-aquifer units?

It can reasonably be assumed that there is hydraulic communication between the aquifer subunits that are accessed by the proposed point of diversion since the clay units are discontinuous and the screened section of the well spans across three confining units. However, information for quantifying the impacts to each individual aquifer subunit is lacking.

Although hydraulic property estimates for each of the aquifer subunits is lacking, an aquifer test was conducted by Clearwater Geosciences using the proposed point of diversion as the pumping well on July 28, 2011 (Clearwater Geosciences, 2011). The well was pumped at a rate of 5,117 gpm for four days. The test results were used to estimate aquifer properties in the area and to predict drawdown from pumping the proposed point of diversion at the rate applied for in the transfer application (4 cfs). The simulation of the pumping of this well at 1,800 gallons per minute for 6 months resulted in an estimated drawdown of 14 feet at the pumping well and 4 feet at a distance of ¼ mile from the pumping well (Clearwater Geosciences, 2011).

5. What is the impact of pumping from the proposed point of diversion on rising water in the Big Lost River?

The impact of pumping from the proposed point of diversion on the rising water in the Big Lost River is indirect, but important. The pumping at the proposed point of diversion will lower the aquifer level in the area of the well. Historically, lowering of aquifer water levels has caused the hydraulic connection between the river and the aquifer to migrate up-valley and reduce the volume of water flowing in the Big Lost River. Available data indicate that seepage from the Big Lost River and diversion infrastructure is the source of the rising water. Therefore, moving the separation line between the aquifer and the river up-valley will tend to reduce the volume of rising water near Arco.

As described above, the predicted impacts at the pumping well from the approval of this transfer would be approximately 14 feet at the pumping well and approximately 4 feet at a distance of ¼ mile from the well. Moving the point of diversion up-valley will cause greater impacts to the currently connected reach of the river which will move the connection point between the river and the aquifer further up the valley.

6. What would be the impact on rising waters of pumping Parkinson's water right from the existing points of diversion?

The impact on rising water from pumping at the existing points of diversion are likely not significant since the existing points of diversion are located southwest of the area of rising water. In addition, in one of the existing points of diversion, the first water encountered was approximately 50 feet below land surface, below a significant sequence of clay (Figure 10). It appears the water being pumped at the existing point of diversion has already infiltrated below the depth of the perching clay layers near Arco.

Any impacts to rising water from pumping at this location will be due to lowering of the aquifer levels in the area west of Arco and allowing the uppermost aquifer subunit water (rising water) to drain into lower deep subunit through non-continuous clay units or through the un-sealed annular space in the numerous wells completed in the area. It can reasonably be assumed that pumping from wells completed in the uppermost aquifer subunit would have a more significant and direct impact on the rising water than the pumping of a deeper well (such as the existing PODs) due to the existence of numerous clay layers that separate the aquifer subunits in this area.

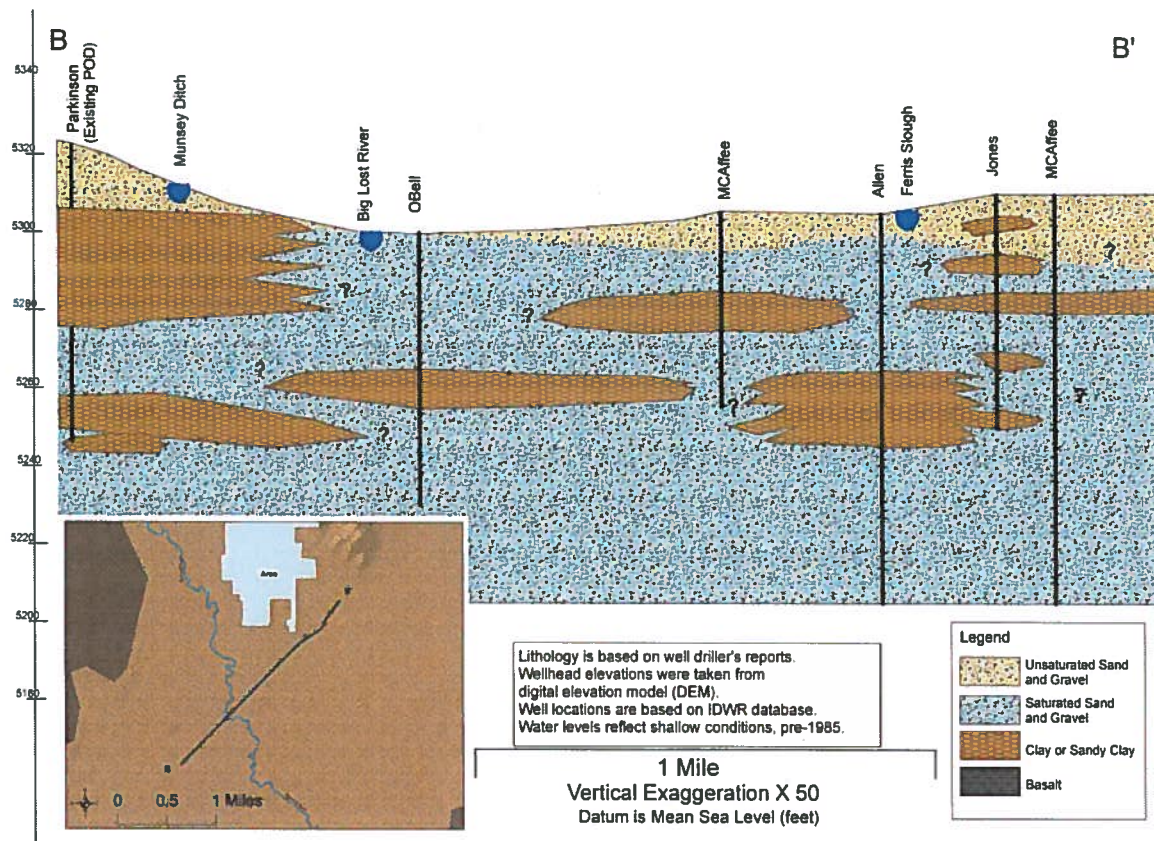


Figure 10. Generalized geologic cross section B-B'.

7. Over the last 20 years, what are the quantities of water diverted by Water District 34 and delivered for ground water recharge?

The aquifer has been recharged by river seepage for as long as water has flowed in the valley, hence the name Big Lost River. Aquifer recharge increased with the development of canals and water delivery systems that have been shown to have high seepage rates. In the 1990s, a managed recharge program was developed with the creation of a recharge committee and the approval of recharge water right permits 34-07571 and 34-07537. Initially, approximately 12 sites, both below and above Mackay Reservoir, were selected as suitable recharge locations. Currently, Water District 34 is diverting water for managed recharge at more than 20 sites in the basin.

Recharge records for Water District 34 are incomplete for the last 20 years. Some annual reports do not contain recharge volumes because of multiple years of low water supply, eliminating any recharge activities. It is unclear as to whether the reported recharge amounts reported for some years include water that incidentally recharged or if all of the reported values were managed recharge volumes.

Figure 11 shows the quantities of water diverted for ground water recharge in Water District 34 according to the watermaster's annual reports. It appears there may have been differences in what is considered recharge by the watermasters. For example, much of the water reported as recharge in the late 1990s was likely incidental recharge that occurred through the normal operations of the irrigation system. Allowing for natural variations in the available supply, the values reported by the current

watermaster do not match historic values (Totten, 2013). The values reported in the past four years appear to represent actual managed recharge volumes exclusive of incidental recharge.

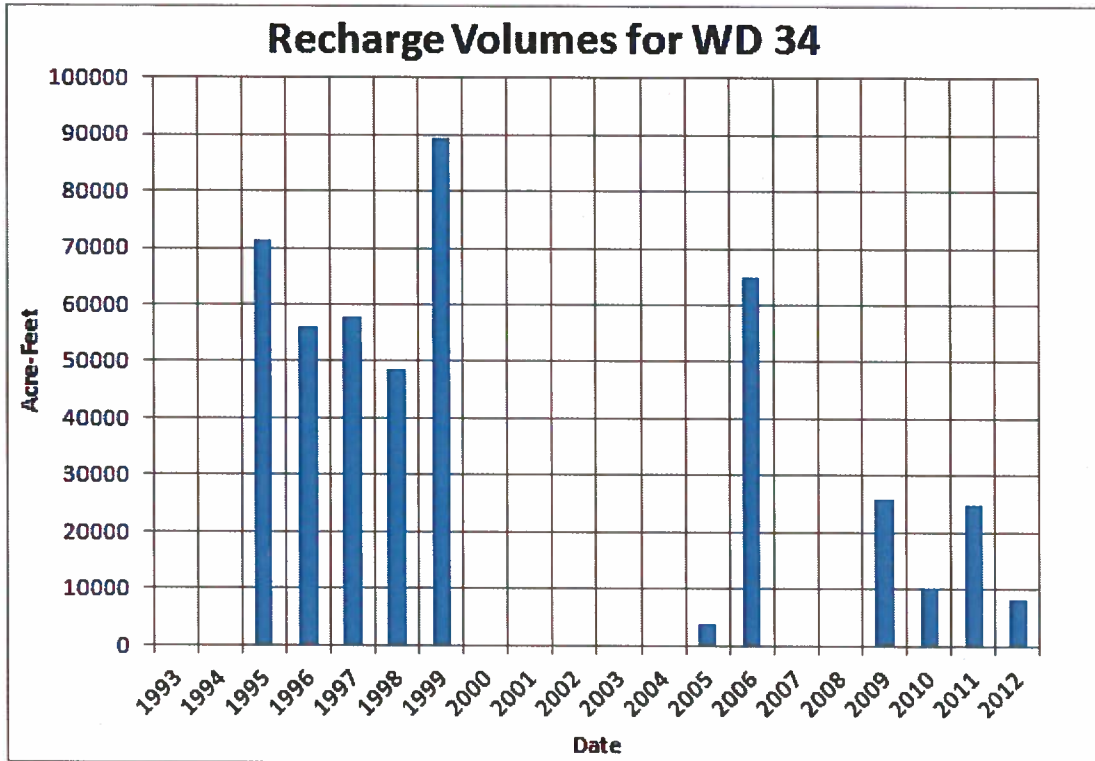


Figure 11. Historic recharge volumes for Water District 34.

Conclusions

Historically, ground water levels were high enough to sustain a hydraulic connection between the Big Lost River and the underlying aquifer system. This connection resulted in the Big Lost River flowing for a longer duration and further down the valley than what is observed today. Aquifer water level declines over the past few decades have reduced the length of river that is hydraulically connected and reduced the volume of the rising water.

Specific conclusions are as follows:

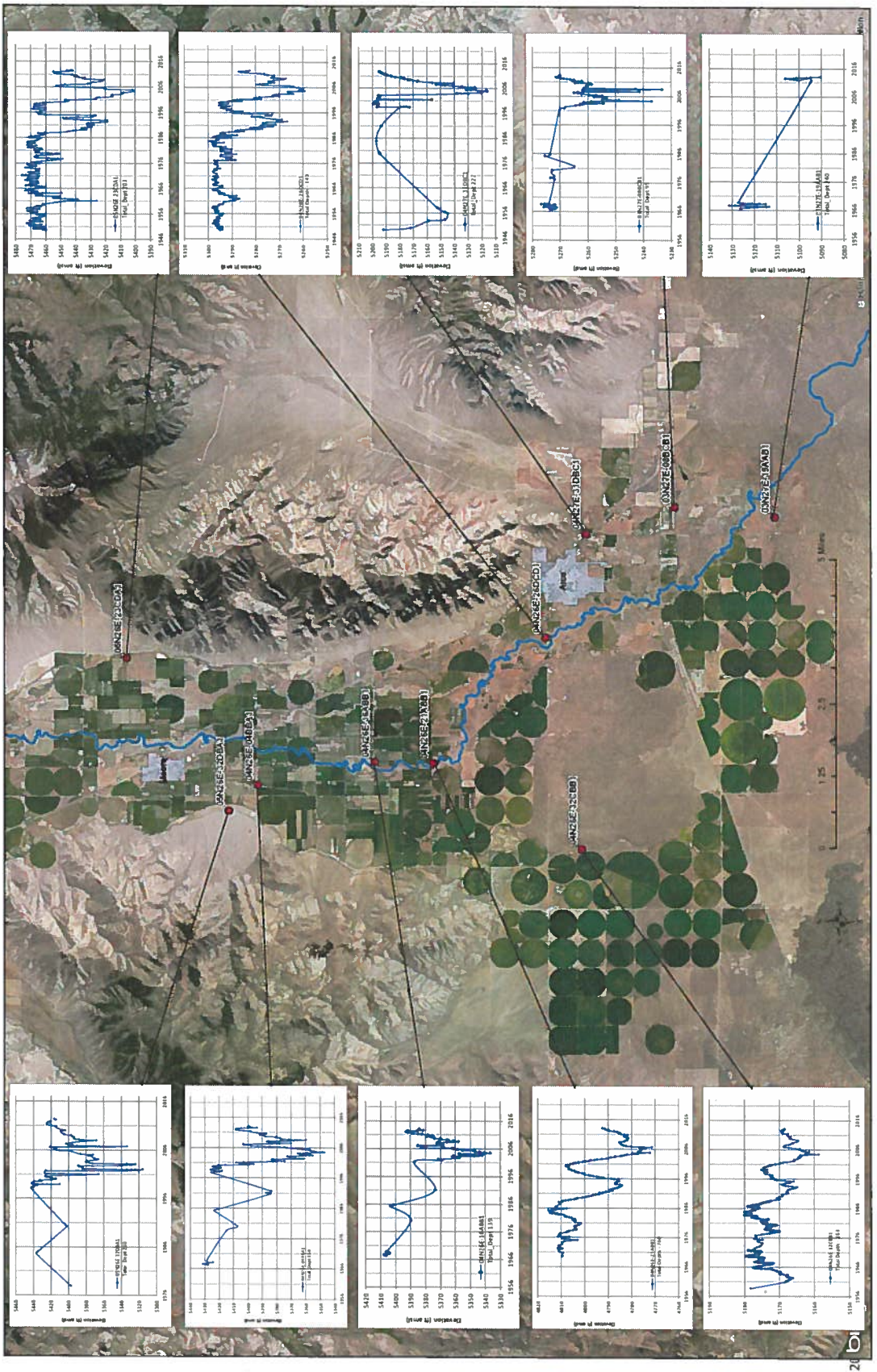
- Flow in the Big Lost River below Moore increases the likelihood that rising water will appear.
- Approval of the proposed transfer will result in a further separation of the Big Lost River and the aquifer near Moore. Since water in the river below this point is considered the source of the rising water near Arco, approval of this transfer will further reduce the likelihood that rising water will appear.
- The incidental leakage through the delivery of the 4 cfs proposed in this transfer will not overcome the impacts from lowering the water table at the current hydraulic connection point. At the point where the river and the aquifer are connected, there is a constant and significant supply of ground water from the deep aquifer subunits entering the river and the uppermost aquifer subunit. The leakage back to the aquifer from the diversion of the proposed transfer will be a volume less than the total 4 cfs pumped from the aquifer.

- If aquifer levels were to return to “pre-1985” conditions, the rising water would be more likely to appear, even during low water years.
- Based on the hydrographs of the observation wells in the area, aquifer water levels may return to “pre-1985” conditions following several good water supply years that would help facilitate rising water.
- Due to the rising waters being virtually absent for the past few decades, many of the diversion structures have been buried or filled in. If the rising waters were to return at a substantial amount of flow, maintenance work will be required to facilitate diversion and delivery of the water.

References

- Baker, Steve, 1989. Possibility of a Transition Zone near the Mouth of Big Lost River Valley, IDWR Internal Memo to Norm Young, 5 p.
- Clearwater Geosciences, 2011. Final Aquifer Analysis – Parkinson Water Right Transfer, Consultant Report, 25p.
- Crosthwaite, E.G., Thomas, C.A., and Dryer, K.L., 1970, Water Resources in the Big Lost River Basin, South-Central Idaho, Open-File Report, U.S. Geological Survey, 109 p.
- Idaho Department of Water Resources (IDWR), 2013, Well Driller’s Report Database, <http://www.idwr.idaho.gov/apps/appswell/searchWC.asp>.
- Stearns, H.T., Crandall, Lynn, and Steward, W.G., 1938, Geology and ground-water resources of the Snake River Plain in southeastern Idaho: U.S. Geol. Survey Water-Supply Paper 774, 268 p., 16 figs.
- Totten, Roger, 2013. Personal Communication with Water District 34 Water Master.

Appendix A -- Regional Well Hydrographs



Big Lost River Irrigation District

P. O. Box 205
MACKAY, ID 83251

January 22, 1992

RECEIVED
JAN 27 1992

Department of Water Resources

Mr. R. Keith Higginson
Director
Idaho Dept. Water Resources
Statehouse mail
Boise, Id. 83720

Dear Mr. Higginson:

Enclosed for you is a copy of the "Short history of Lost River Valley". We hope that you will find it interesting and enlightening.

Yours truly,

Rita M. Lundy
Assistant Secretary-treasurer

IDWR11

A SHORT HISTORY ON THE LOST RIVER VALLEY
THE MACKAY RESERVOIR-DROUGHTS AND FLOODS

IN THE EARLY 1900'S THERE WAS SO MUCH SNOW AND RUN-OFF(291,000 ACRE FEET) THAT A MAN NAMED W.R.THOMAS WAS CONVINCED THERE WAS SUFFICIENT QUANTITY TO IRRIGATE ALL THOSE LANDS EAST AND WEST OF ARCO .HE MADE APPLICATION WITH THE STATE OF IDAHO UNDER THE CAREY ACT TO CONSTRUCT THE MACKAY RESERVOIR ASSURING ALL CONCERNED THAT THE STORING OF THE WINTER RUN-OFF IN THE RESERVOIR AND THE SURPLUS RUN-OFF WOULD BE AN ADEQUATE WATER SUPPLY AND WOULD NOT DEPRIVE THE VALLEY SETTLERS OF THEIR WATER RIGHTS.

HISTORY TELLS US THAT HIS FILINGS ON THIS LAND AND HIS GRANDIOSE PLAN FAILED TOTALLY.THERE WERE SO MANY LAW SUITS BY CONCERNED RESIDENTS OF LOST RIVER VALLEY WHO FEARED FOR THEIR SAFETY,IN THE EVENT OF A DAM FAILURE, THAT THE OWNERS OF THE RESERVOIR PROJECT WERE NOT ABLE TO COMPLETE THE STRUCTURE.IT FINALLY WAS SOLD AT A SHERIFF'S SALE IN 1914 TO THE UTAH CONSTRUCTION CO.WHO OBTAINED AUTHORITY FROM THE STATE TO COMPLETE THE PROJECT PROVIDING THE EAST CAREY ACT LANDS WERE NOT DEVELOPED.THIS PROJECT WAS SUBSEQUENTLY COMPLETED IN 1917 AND READY TO DELIVER WATER TO THE CAREY ACT SETTLERS. THE UTAH CONSTRUCTION COMPANY WAS TO DELIVER THE DECREED RIGHTS TO THE SETTLERS ALONG THE RIVER AND THE MACKAY RESERVOIR WATER AND SURPLUS WATER TO THE ERA FLATS LANDS.BY THE EARLY TWENTIES ,WITH THE DROUGHT STILL PLAGUING THE VALLEY THE SETTLERS ALONG THE RIVER WERE BUILDING UP RESENTMENTS THAT THOSE LANDS OUT OF THE DISTRICT WERE RECEIVING STORAGE AND SURPLUS WATER WHILE THE LANDS OF THE PEOPLE IN THE DISTRICT WERE DRYING UP.

MANY STUDIES AND REPORTS WERE SUBMITTED AT THIS TIME TRYING TO SAVE A PART OF THE LARGE LOSSES TO THE UNDERGROUND FLOW.

THERE WAS A COMPREHENSIVE REPORT BY THE WATER COMMISSIONER OF THE BIG LOST RIVER LYNN CRANDALL AND GEOLOGIST HAROLD T. STEARNS ENTITLED "GEOLOGY AND GROUND WATER RESOURCES OF THE SNAKE RIVER BASIN" AND A REPORT ENTITLED "BIG LOST RIVER INVESTIGATIONS, IDAHO." BY ONE OF THE FOREMOST ENGINEERS WITH THE BUREAU OF RECLAMATION IN THE UNITED STATES, MR. E. B. DEBLER.

SIMULTANEOUSLY THE SERVICES OF W. G. SLOAN, CIVIL ENGINEER, WERE OBTAINED AND HE SUBMITTED "REPORT ON THE REHABILITATION OF THE BIG LOST RIVER". THIS REPORT COVERED HIS INVESTIGATIONS AND THE COSTS OF PROPOSED CONSTRUCTION WHICH WOULD INCREASE THE WATER SUPPLY BY REDUCING THE LOSSES TO THE UNDERGROUND.

THE "SUB" OF THE VALLEY HAD DRIED UP AND PEOPLE FELT IT WAS DUE TO THE RESERVOIR DELIVERIES TO THE SETTLERS IN ERA-FLATS. THIS LED TO A COURT ACTION BY THE UTAH CONSTRUCTION CO. VS. ABBOTT ET AL (THE PEOPLE OF THE VALLEY). THIS SUBSEQUENTLY WAS THE COURT ORDER ADJUDICATION OF THE DECREES OF THE WHOLE VALLEY IN 1923.

IN 1925 THE MACKAY RESERVOIR HAD TO BE DRAINED DUE TO A MALFUNCTION OF ONE OF THE GATES. LYNN CRANDALL, THE COMMISSIONER OF BIG LOST RIVER, OPTED TO LET ALL THE WATER GO DOWN THE ARCO CANAL INSTEAD OF DIVIDING IT FOR THE ERA FLATS (CAREY ACT) SETTLERS AT THE BLAINE DIVERSION. HIS REPORT FROM THAT TIME STATES AS FOLLOWS:

"WATER FOR THE CANALS IN THE VICINITY OF ARCO WAS CARRIED DOWN THE RIVER CHANNEL BETWEEN THE MOORE AND ARCO DIVERSIONS, INSTEAD OF CARRYING THE STORAGE WATER DOWN THE BLAINE CANAL. AT FIRST THERE WERE HEAVY LOSSES, ON ACCOUNT OF THE DEPLETED WATER TABLE IN THAT SECTION RESULTING FROM THE PREVIOUS DRY YEARS, BUT EXPERIENCE ON THE STREAM AMPLY DEMONSTRATED THE FACT THAT MATERIAL AND CONSIDERABLE BENEFIT RESULTS FROM THE MAINTENANCE OF A HIGH WATER TABLE IN THIS SECTION OF THE RIVER, NOT ONLY TO LANDS THAT ARE THUS "SUB-IRRIGATED", BUT ALSO TO THE HOLDERS OF NATURAL FLOW RIGHTS AROUND ARCO WHO RECEIVE A LARGE AMOUNT OF WATER FROM THE DRAIN OFF OF THIS WATER TABLE LATE IN THE SUMMER THAT THEY WOULD NOT OTHERWISE OBTAIN, IT THUS FOLLOWS THAT IT IS A FAIR AND PROPER PROCEDURE TO CARRY THE WATER THROUGH THIS SECTION OF RIVER CHANNEL, SO THAT THE LOSSES THAT THUS OCCUR

MAY BUILD UP THE WATER TABLE IN YEARS OF AVERAGE OR BETTER THAN AVERAGE RUN-OFF.

IN YEARS OF EXTREME SHORTAGE HOWEVER,WHEN THE AVAILABLE RUN-OFF WOULD BE ENTIRELY INSUFFICIENT TO BUILD UP THE WATER TABLE,IT IS MORE PRACTICAL TO CARRY THE WATER THROUGH THE BLAINE CANAL WITH AS LITTLE LOSS AS POSSIBLE."

1931 WAS ANOTHER DROUGHT YEAR WITH THE RUN OFF BEING THE LOWEST EVER RECORDED WITH A TOTAL RUN OFF OF ONLY 120,496 AF.

IN JULY 1931 ,UNDER THE AUTHORIZATION OF THE BIG LOST RIVER RECLAMATION ASSOCIATION,FUNDS WERE COLLECTED BY SUBSCRIPTION FROM DECREED WATER USERS AND THE UTAH CONSTRUCTION CO.,TO CONSTRUCT A BY-PASS CANAL AROUND A PORTION OF THE RIVER CHANNEL KNOWN AS "THE DARLINGTON SINKS".THIS WORK WAS COMPLETED THE LATTER PART OF JULY AND WATER TURNED THRU THE NEW BY-PASS.

ON THE FIRST OF AUGUST,SAVINGS WERE MADE CUTTING THE PREVIOUS LOSSES SIXTY TO SEVENTY PERCENT

THIS CANAL PROJECT HAD BEEN RECOMMENDED BY THE BOARD OF ENGINEERS. THE DEPLETION OF GROUND WATER OVER A PERIOD OF THE PREVIOUS 5 YEARS CAUSED A GREATER THAN AVERAGE CARRIAGE LOSS IN THE DELIVERY OF WATER IN THE CANALS WITH THE YEAR 1932 HAVING A LOSS OF 71,846 AF AS COMPARED TO 29,460 AF IN THE YEAR FOLLOWING A GOOD YEAR.AN EXCERPT FROM LYNN CRANDALL,THE WATER COMMISSIONER OF THE BIG LOST RIVER FOLLOWS:

"NO WATER WAS DELIVERED FROM RIVER CHANNEL BELOW MOORE DAM,THE RIVER BEING DRY BELOW THIS POINT DURING THE IRRIGATION SEASON. THE DECREED USERS IN THE VICINITY OF ARCO RECEIVED NO IRRIGATION WATER DURING THE YEAR,EXCEPT THROUGH THE COURTESY OF THE UTAH CONSTRUCTION CO..WHO FURNISHED ENOUGH OF THEIR WATER,SUPPLEMENTED BY A SMALL AMOUNT OF DECREED WATER RUN THROUGH THE BLAINE CANAL (UC) TO KEEP TREES AND LAWNS FROM DYING."

THE GOVERNOR CAME FOR THE LARGEST MEETING EVER HELD TO DISCUSS THE WATER SHORTAGE THAT WAS BEING MADE WORSE BY THE STORAGE WATER GOING OUT TO CAREY ACT LANDS THAT WAS NOW CALLED "ERA FLATS" .

OVER 500 PEOPLE ASSEMBLED IN MOORE TO ADVISE THE GOVERNOR OF THE SHORTAGE AND THE WATER GOING OUT AND LEAVING THE

VALLEY. AT THAT TIME GOVERNOR ROSS SAID HE WAS THERE TO LISTEN AND PROMISED ACTION.

THE SETTLERS CHARGED THAT STORAGE RIGHTS HAD BEEN GIVEN TO THE UTAH CONSTRUCTION COMPANY FOR ERA FLATS SETTLERS UNDER MISREPRESENTATION OF FACTS. THEY HAD BEEN ASSURED THAT THIS WATER, WHICH RIGHTFULLY BELONGED TO THE SETTLERS ALONG THE RIVER, WOULD NOT DEPRIVE THEM OF THE SURPLUS WATERS. HOWEVER THE "SUB" WAS DRYING UP AND SURPLUS WATER WAS NO LONGER AVAILABLE TO THEM FOR IRRIGATION. W.M. PHILLIPPI OF BIG LOST RIVER IRRIGATION DISTRICT STATED HE AGREED WITH THE PEOPLE AND WOULD DO EVERYTHING IN HIS POWER TO ASSIST THE GROUP TO SOLVE THE PROBLEMS.

THE GROUP WAS DIVIDED INTO SEVERAL CAMPS-SOME WANTED TO PURCHASE THE RESERVOIR WHEREAS OTHERS WANTED TO FIGHT IT OUT IN COURT. THE PEOPLE WORKING WITH GOVERNOR BEN ROSS, ATTORNEY GEO. AMBROSE AND OTHERS, WERE ATTEMPTING TO PURCHASE THE MACKAY RESERVOIR. THE NEGOTIATIONS WERE FRUSTRATING AS THE UTAH CONSTRUCTION COMPANY FELT IT HAD TO HAVE A PRICE OF \$ 2 MILLION.

AFTER MANY STUDIES OF THE WATER SHORTAGE , COMMITTEES WERE FORMED TO CONSIDER THIS PURCHASE OF THE MACKAY RESERVOIR.

THE IDAHO LEGISLATURE HAD PASSED A BILL IN 1931 ALONG WITH THE FEDERAL CONGRESS TO ALLOW BIG LOST RIVER RECLAMATION ASSOCIATION TO PURCHASE THE CAREY ACT PROJECT (MACKAY RESERVOIR).

THE DROUGHT WAS STILL PLAGUING THE VALLEY WITH VERY LITTLE STORAGE AND HARDLY ENOUGH NATURAL FLOW RIGHTS. THE SETTLERS ALONG THE RIVER WERE HIGHLY FRUSTRATED. THEY WERE WILLING NOW AND ABLE TO BUY THE PROJECT BUT THE PRICE WAS PROHIBITIVE. MATTERS WERE TAKEN TO A CLIMAX IN 1933 WHEN FRUSTRATED PERSONS, STILL UNKNOWN, DYNAMITED THE RESERVOIR TOWER AND THE BLAINE DIVERSION. THAT DECISIVE ACTION CAUSED THE UTAH CONSTRUCTION COMPANY TO REDUCE THE PRICE OF THE RESERVOIR FROM TWO MILLION TO \$258,000. THE SALE TO THE BIG LOST RIVER IRRIGATION DISTRICT (IN 1936) OF THE MACKAY RESERVOIR MEANT BONDING THE PEOPLE FOR THE NEXT 20 YEARS, AT A TIME WHEN THE COUNTRY WAS IN ITS VERY WORST DEPRESSION.

AN INSPECTION BY THE COMMISSIONER OF THE UNITED STATES DEPT. OF THE INTERIOR ALONG WITH THE CHIEF ENGINEERS APPROVED OF THE

ENGINEERING FEASIBILITY OF THE PLAN TO PURCHASE THE CAREY ACT PROJECT AND KEEP THE WATER IN THE VALLEY PROPER. THE PLAN ALSO CALLED FOR BY-PASS CANALS TO CARRY THE RIVER FLOW AROUND THE THE MOST IMPORTANT SINKS AND THE UNIFICATION OF DITCHES, WHICH WOULD AUGMENT THE WATER SUPPLY BY SAVING WATER WHICH WAS THEN LOST TO THE UNDERGROUND.

ON APRIL 1ST, 1935 A "PLAN OF OPERATIONS" MEETING WAS HELD ACCORDING TO THE PROVISIONS OF IDAHO CODE 42-401 THIS GENERAL PLAN OF OPERATIONS WAS REQUIRED PURSUANT TO THE APPLICATION FOR THE LOAN. IN THAT PLAN OF OPERATIONS IT STATED "IT IS PLANNED THAT BY THIS DISTRICT HAVING THE PROPERTY AND CONTROL OF THE STORED SURPLUS WATER, WHICH WILL BE USED TO FURNISH A SUPPLEMENTAL WATER SUPPLY TO THOSE LANDS IN THE BIG LOST RIVER IRRIGATION DISTRICT AND NOW HAVING AN INSUFFICIENT WATER SUPPLY, AND THE EMPLOYMENT OF A ROTATION SYSTEM OF WATER FOR IRRIGATION PURPOSES, AND THE STORAGE OF THE NATURAL FLOW RIGHTS PRIVATELY OWNED, AT DIFFERENT TIMES IN THE SAID MACKAY DAM, THE BIG LOST RIVER IRRIGATION DISTRICT WILL BE ENABLED TO SAVE AND CONSERVE LARGE AMOUNTS OF WATER AND MAKE A SUCCESSFUL PROJECT OUT OF ONE THAT HAS HERETOFORE BEEN SHORT OF WATER".

THE "PROPOSED PLAN OF OPERATIONS AND BENEFITS" AS RECOMMENDED BY J. RAY WEBER, ENGINEER FOR THE BIG LOST RIVER IRRIGATION DISTRICT WAS SUBMITTED TO THE SIXTH JUDICIAL DISTRICT OF THE STATE OF IDAHO, IN AND FOR THE COUNTY OF CUSTER. THE JUDGMENT AND DECREE ISSUED BY JUDGE GUY STEVENS ON JANUARY 25TH, 1936 ACCEPTED THE PLAN AS FOLLOWS:

"1) TO RETIRE FROM PRESENT PRODUCTION THOSE LANDS NOW HELD BY THE UTAH CONSTRUCTION COMPANY AND WHICH ARE FULLY DESCRIBED IN SCHEDULE "A", EXHIBIT "A" OF THE APPLICATION ABOVE REFERRED TO AND SITUATED ON CAREY ACT PROJECT TRACTS BELOW ARCO, BUTTE COUNTY, IDAHO AND COMPRISING OF APPROXIMATELY 6064.74 ACRES, AND TO SO DISPOSE OF THEM AS THE BOARD OF DIRECTORS OF THE BIG LOST RIVER IRRIGATION DISTRICT MAY DETERMINE.

2. TO RETIRE FROM PRESENT PRODUCTION OR DISPOSE OF, AS THE BOARD OF

DIRECTORS OF THE BIG LOST RIVER IRRIGATION DISTRICT MAY DETERMINE, THOSE LANDS PRIVATELY OWNED AND LYING WITHIN THE SAID CAREY ACT PROJECT OF THE UTAH CONSTRUCTION COMPANY, COMPRISING 1564.83 ACRES, AND FULLY DESCRIBED IN SCHEDULE B, EXHIBIT A OF THE SAID LOAN APPLICATION.

3. TO ABANDON ALL CANALS AND DISTRIBUTING SYSTEMS NOW IN USE, OR HERETOFORE IN USE BY THE UTAH CONSTRUCTION COMPANY BELOW THAT POINT ON THE BLAINE CANAL KNOWN AS THE BIFURCATION WORKS, AND WHICH WERE USED TO SERVE THE LANDS DESCRIBED ABOVE IN PARAGRAPHS 1 AND 2, EXCEPTING SUCH PART OF THE LOWER BLAINE CANAL AND THE ARCO CANAL WHICH WILL BE NECESSARY TO USE IN SERVING THE WATER USERS WITHIN THE DISTRICT UNDER THIS PLAN IN THE VICINITY OF ARCO.

4. TO HOLD THE MAIN BLAINE CANAL AND THE LOWER BLAINE CANAL IN RESERVE FOR FUTURE SERVICE AS MAY BE REQUIRED IN TIMES OF HIGH RUN OFF TO SERVE MORE EFFICIENTLY LANDS IN THE WEST SIDE OF BIG LOST RIVER VALLEY IN THE VICINITY OF MOORE AND THOSE BEING SERVED FROM THE ARCO CANAL AND ITS TRIBUTARIES IN THE VICINITY OF ARCO.

ALSO TO ACT AS A SUPPLEMENTARY CARRIER TO THE REGULAR SYSTEM IN USE DURING SUCH TIMES AS OCCASION MAY REQUIRE. ALSO TO USE THE SAID BLAINE CANAL AS A COLLECTOR OF FLOOD WATER ISSUING FROM THE ANTELOPE CREEK VALLEY AND TO DIVERT THE SAME TO THE MOORE WEST SIDE CANAL SYSTEM FOR MORE EFFICIENT APPLICATION TO LANDS ADJACENT TO MOORE.

5. TO MAINTAIN AND TO USE THE BLAINE DIVERSION DAM, AT THE HEAD OF THE BLAINE CANAL, AS NOW CONSTRUCTED, IN SUCH A MANNER AS REQUIREMENTS MAY DEMAND FOR THE PROPER CONTROL OF ALL WATER PASSING THAT POINT.

6. TO MAINTAIN AND TO OPERATE THE MACKAY RESERVOIR, THE DAM AND ALL CONTROL WORKS IN CONNECTION THEREWITH FOR THE STORAGE OF WINTER FLOW WATERS AND EXCESS FLOOD WATERS BEYOND THE REQUIREMENTS OF THE PRESENT DECREED USERS IN THE SAID DISTRICT BELOW THAT POINT, AND TO EXERCISE IN CONNECTION THEREWITH ALL THE RIGHTS AND PRIVILEGES WHICH ARE SET FORTH IN THE DESCRIPTION OF RIGHTS AND HOLDINGS BEING ACQUIRED FROM THE UTAH CONSTRUCTION CO.

7. TO APPLY THE SAID STORED WATER, FLOOD WATER AND NATURAL FLOW RIGHTS ON THE BIG LOST RIVER AND ITS TRIBUTARIES, WHICH MAY BE

ACQUIRED FROM THE UTAH CONSTRUCTION COMPANY, AND THE PRIVATE RIGHTS TO BE PURCHASED, TO SUCH LANDS NOW OWNED BY THE LANDOWNERS WITHIN THE DISTRICT IN A MANNER AND ON SUCH TERMS AS MAY BE DETERMINED BY ACTION OF THE BOARD OF DIRECTORS OF THE BIG LOST RIVER IRRIGATION DISTRICT.

THE BENEFITS

1) WATER STORED IN THE MACKAY RESERVOIR WOULD BE MADE AVAILABLE FOR EQUITABLE DISTRIBUTION AMONG THE LANDOWNERS IN THE DISTRICT.

STORED WATERS DELIVERED TO THE UTAH CONSTRUCTION CO. PROPERTY IN THE CAREY ACT PROJECT IN THE AMOUNT OF 29,163 ACRE FEET ANNUALLY (TEN YEAR AVERAGE PRIOR TO 1935) WOULD BE AVAILABLE TO DISTRICT LANDS. BY ABANDONMENT OF THE LANDS IN THE CAREY ACT PROJECT AND APPLYING THE WATER TO THE LAND WITHIN THE DISTRICT, EXISTING WATER RIGHTS WOULD BE SUBSTANTIALLY AUGMENTED AND LARGE QUANTITIES OF WATER SAVED THAT WOULD OTHERWISE BE LOST IN TRANSMISSION.

2) SUCH APPLICATION OF STORED WATER WITHIN THE DISTRICT ABOVE THE SECTION NORTH AND WEST OF LESLIE WOULD BE EXPECTED TO DO DOUBLE DUTY TO A LARGE EXTENT BECAUSE A MATERIAL AMOUNT OF RETURN FLOW WOULD BE COLLECTED AND AGAIN MADE AVAILABLE FOR USE BELOW LESLIE.

3) THE OPERATION OF THE MACKAY RESERVOIR UNDER CONTROL OF THE DISTRICT WOULD PROVIDE A DEFINITE CONTROL AND REGULATION OF THE ENTIRE FLOW OF THE RIVER AT ALL TIMES, MAKING IT POSSIBLE TO PREVENT EXCESSIVE LOSS THROUGH UNCONTROLLED DISSIPATION OF FLOOD WATER BELOW THAT POINT, AND WOULD PROVIDE FOR MORE EFFICIENT DELIVERY AND UNIFORM CONTROL OF DELIVERY TO THE VARIOUS CANALS SUPPLYING THE LANDS WITHIN THE DISTRICT.

4) THE USE AND CONTROL OF THE RESERVOIR AND OTHER CONSTRUCTION WORKS WOULD MAKE POSSIBLE AN EFFICIENT SYSTEM OF ROTATION AMONG THE WATER USERS AND INCREASE THE DUTY AND CONSERVATION OF WATER.

(IT WAS FURTHER SET FORTH THAT NOTHING IN THE APPLICATION SHOULD BE CONSTRUED TO PREVENT THE STORAGE IN SAID RESERVOIR, WHENEVER THE SAME MAY BE LAWFULLY DONE, OF DECREED WATER BELONGING TO ANY INDIVIDUAL LANDOWNER OF THE DISTRICT AND SUBSEQUENT DISTRIBUTION TO SUCH LANDOWNER FOR HIS USE, WITH SUCH REASONABLE DEDUCTION FOR

LOSSES AS MAY HEREAFTER BE FIXED BY THE RULES AND REGULATIONS OF THE DISTRICT.)

5) THE OPERATION AND CONTROL OF ALL IRRIGATION WORKS AND RIGHTS BEING ACQUIRED FROM THE UTAH CONSTRUCTION COMPANY AND THE PRIVATE WATER RIGHTS TO BE PURCHASED, WHEN USED IN CONJUNCTION WITH THE EXISTING SYSTEM NOW OWNED BY LANDOWNERS WITHIN THE DISTRICT WOULD PROVIDE FOR A CONCENTRATED APPLICATION OF ALL AVAILABLE WATER FROM BIG LOST RIVER AND PRINCIPAL TRIBUTARIES WITHIN THE DISTRICT, WITH AN ANTICIPATED RESULT THAT THE UNDERGROUND WATER TABLE WOULD GRADUALLY BE BUILT UP THROUGH SUCH OPERATION, ACCRUING MATERIAL BENEFITS TO DECREED WATERS WITHIN THE DISTRICT."

IN 1938 THE FOLLOWING WAS REPORTED BY THE WATERMASTER:

"THE ANNUAL SNOW SURVEY OF THE WATERSHED OF THE BIG LOST RIVER WAS NOT MADE AS USUAL ON APRIL 1ST, DUE TO EXTREME WEATHER CONDITIONS. ALL ROADS WERE CLOSED TO TRAVEL EXCEPT BY SKIS BECAUSE OF HEAVY SNOW. THE RUNOFF WAS ESTIMATED AT 300,000 ACRE FEET, HOWEVER THE ACTUAL RUN-OFF WAS 299,683 ACRE FEET WHICH WAS THE 3RD LARGEST RUN-OFF FOR THE PAST 34 YEARS DURING WHICH TIME RECORDS HAVE BEEN KEPT AND NEARLY DOUBLE FOR THE YEARS 1928 TO 1938. THE RECORDED PRECIPITATION WAS TWICE THE AVERAGE AT 16.39".

THE MACKAY RESERVOIR FILLED TO ITS CAPACITY AND IT WAS A TIME OF GREAT REJOICING. WATER WAS TURNED IN TO ALL CANALS AND DITCHES AND OVERFLOWED IN MANY OLD CHANNELS WHICH HAD BEEN DRY FOR YEARS.

WATER OVERFLOWED INTO THE EAST AND WEST CHANNELS OF THE BIG LOST RIVER BELOW THE BLAINE HEADING, AND THE LESLIE BY-PASS WAS ALSO USED AS A CARRIER UNTIL AUGUST 1ST, WHEN ALL WATER THEN WAS TURNED INTO THE EAST CHANNEL. THE EAST SIDE CANAL FROM MOORE DAM TO ARCO WAS ALSO USED, NOT ONLY TO CARRY WATER TO ARCO, BUT TO SPILL WATER INTO THE OLD DRY BEDS BETWEEN THE MOORE DAM AND JAMES LANE TO ASSIST IN FILLING THE DRY UNDERGROUND."

THE YEAR OF 1939 WAS A STARK COMPARISON TO THE ABUNDANT WATER OF 1938. WHEREAS 1938 HAD A HIGH AT THE HOWELL GAGE OF 2970 CFS, THE YEAR OF 1939 BROUGHT ONLY A HIGH OF 840 CFS. THE RUN-OFF WAS ONLY

51% OF THE PREVIOUS YEAR. AN AVERAGE RUN OFF FOR THE 35 YEARS OF RECORD KEEPING WAS 212,051 ACRES FEET BUT FROM 1928 TO 1939 THE RUN OFF WAS AN AVERAGE OF ONLY 162,114 ACRE FEET WITH 9.66" OF PRECIP.

BUT IN 1939 THIS PRECIP WAS RECORDED AS 5.76 " .THIS WAS THE LOWEST RECORDED PRECIP EXCEPT FOR THE YEARS 1924 (3.94"PRECIP) AND 1937 AT (4.87" PRECIP).THE LEVEL OF THE RESERVOIR FOR FULL AT THAT TIME(1937) 38,405AF THE WATER WENT OVER THE SPILLWAY FOR THE FIRST TIME SINCE 1925 .

AT THIS TIME THE BURNETT DITCH WAS TURNED OVER TO THE BLRID,AS WELL AS THE SHARP,HARRIS/VAUGHT/SWAUGER AND SUTTER,A RIGHT OF WAY WAS PURCHASED FOR \$30.00 FOR THE BECK DITCH HEADING.

PROBLEMS WERE ARISING WITH MR. ZOLLINGER ABOUT USING THE LANDS AT THE RESERVOIR BACK WATERS FOR PASTURE AND PROBLEMS WITH MR. CLARK FOR THE SEEPAGE ON HIS HOMESTEADED LAND AT THE BASE OF MACKAY DAM.

FARMERS WERE UPSET AT THE ASSESSMENTS BECAUSE THEY ALSO HAD TO PAY FOR THE BONDED INDEBTEDNESS ON THE PURCHASE OF THE RESERVOIR. A DECISION WAS MADE AT THIS TIME TO SELL THE ERA FLATS LAND TO REDUCE EXPENSES.FORTY ACRES WAS SOLD TO W.H.JONES FOR \$400.00. MR.A.R.BABCOCK AGREED TO LOAN THE BLRID \$3500.TO BE REPAID AT 6% INTEREST AT \$500 PER PAYMENT THROUGH 7/1/1944 BECAUSE THE BLRID COULD ONLY BORROW \$3500 FROM THE BANK.THIS WAS TO PAY OFF THE UTAH CONSTRUCTION COMPANY ON A DEBT OF 11,219.50.(THEY HAD NEGOTIATED TO PAY A REDUCED AMOUNT OF ONLY \$7000).

THE CREW WAS ALSO WORKING ON THE RIVER CHANNEL AT CHILLY IN JUNE OF 1940.THIS WORK WAS COMPLETED 11/13/1940 AND ALL WATERUSERS WERE INVITED TO ATTEND THE INSPECTION .AT THAT TIME THE BLRID WAS SO PLEASED WITH THE WORK ACCOMPLISHED THAT THERE WAS TALK OF COOPERATING WITH THE WATER USERS ABOVE THE MACKAY DAM IN EVERY WAY POSSIBLE,EVEN CONSIDERING SPONSORING THE INSTALLATION OF HEADGATES ABOVE THE DAM ON THE SEVERAL DITCHES AND CANALS.THE INSPECTION ALSO INCLUDED THE CONSTRUCTION WORKS ON THE DARLINGTON WHERE CONSIDERABLE WORK HAD ALSO BEEN DONE ON THE RIVER CHANNEL.

THERE WAS A MEETING OF OVER 200 PEOPLE REPRESENTING THE ENTIRE

VALLEY; A VOTE WAS TAKEN AND IT WAS ALMOST UNANIMOUSLY AGREED THAT THE WATER USERS WOULD DO ALL THE MAINTENANCE ON THE CANALS IN THE BLRID AND THE BLRID WOULD INSTALL ALL THE HEADGATES, WEIRS AND CHECKS..

BY 1942 MR. CLARK RELINQUISHED HIS HOMESTEAD APPLICATION ON THE LANDS AT THE BASE OF THE MACKAY DAM AND THE BIG LOST RIVER IRRIGATION DISTRICT MADE A NEW APPLICATION FOR THE LAND. THEY ALSO PURCHASED 40 ACRES FOR \$400 FROM MR. CLARK FOR OTHER PRIVATELY OWNED LANDS AT THE BASE OF THE MACKAY DAM.

A UNIQUE THING THAT WAS DONE IN THE YEARS 1943/44/45 WAS TO END THE IRRIGATION SEASON EARLIER-AS EARLY AS SEPTEMBER 24TH TO GET THE RUN OFF TO FILL THE RESERVOIR AS MUCH AS POSSIBLE, THEN TO RELEASE THIS EXCESS WATER STARTING IN THE WINTER MONTHS, STILL BEING SURE THE RESERVOIR WOULD FILL BY MAY 1ST.

WATERMASTER J.H. PEARSON IN HIS 1943 REPORT SAID:

"THE RESULTS OF SURVEYS FOR THE LAST 8 YEARS WERE 75% AND 55% FOR 1943. THE PROSPECTS FOR THE SEASON ARE NOT TOO BRIGHT AT THIS TIME, HOWEVER THE MACKAY RESERVOIR FILLED EARLY IN THE WINTER (37,000 AF DECEMBER 9TH) AND WATER WAS RELEASED THROUGH THE CONTROL GATES AND DISSIPATED WHERE EVER POSSIBLE THROUGHOUT THE VALLEY, WHICH WAS A VERY MATERIAL HELP IN FEEDING AND KEEPING THE UNDERGROUND WATER TABLE AT A HIGH LEVEL WHERE THE RETURN FLOW LATER IN THE SEASON WOULD HELP TO OFF-SET THE SHORTAGE OF THE SNOW FALL ON THE WATER SHED"

IN 1946 THE FLOW AT HOWELL'S GAGE REACHED 1580 ON APRIL 25TH AND WHEN THE IRRIGATION SEASON OPENED ON MAY 1ST THE THE RIVER WAS ADMINISTERED AS ONE CONTINUOUS STREAM WITH DECREES ON FOR ABOVE THE RESERVOIR AND BELOW THE RESERVOIR UNTIL JULY 20TH.

BY 1947 THE PRECIPITATION WAS ONLY 5.75", THE LOWEST ON RECORD SINCE 1937 WHEN IT WAS 4.87" THE FLOW AT THE HOWELL GAGING STATION REACHED 750 CFS ON MAY 17TH AND CONNECTED AS A SURFACE FLOW OVER

THE CHILLY SINKS ON THE 19TH. AT THIS TIME THE RIGHTS WERE CUT TO 1884 IN THE CHILLY BARTON SECTIONS, THIS BEING THE PRIORITIES THAT WERE BEING FILLED BY THE NATURAL FLOW OF THE RIVER IN THE SECTION BELOW THE MACKAY RESERVOIR.

ON APRIL 2ND, 1947 THERE WAS A MEETING OF THE ADVISORY BOARD FOR THE PURPOSE OF DISCUSSING WAYS AND MEANS OF HAVING HEADGATES AND WEIRS INSTALLED WHERE THERE WERE NONE, AND THE ONES REPAIRED WHERE NECESSARY SO AS TO BETTER CONTROL THE WATERS OF THE RIVER. A COMMITTEE FROM THE GRANGE AND THE FARM BUREAU ALONG WITH MR. ROY THOMPSON OF THE BUREAU OF RECLAMATION WERE PRESENT. "THE MOST URGENT NEED AT THIS TIME, FOR GATES, BEING IN THAT SECTION OF THE RIVER ABOVE THE MACKAY RESERVOIR."

A MEETING WAS CALLED AND HELD AT THE BARTON SCHOOL HOUSE ON THE 5TH OF APRIL WITH NEARLY ALL THE USERS THERE OR REPRESENTED. AT THIS MEETING A COMMITTEE OF FIVE, CONSISTING OF JOHN MCKELVEY, GEORGE MILLER, FRANK LEAVITT, LOU BITTON AND CHARLES HOWELL WERE APPOINTED TO SEE THAT GATES WERE INSTALLED. GATES WERE INSTALLED ON WARM SPRINGS CREEK BUT NONE ON THE RIVER.

IN 1949 A SPECIAL FUND WAS APPROVED AT THE ANNUAL WATERMASTERS MEETING TO INSTALL HEAD GATES AT THE POINTS OF DIVERSION OF ANY CANALS WHERE USERS HAD FAILED TO INSTALL THEM WITH THE COST TO BE SHARED PRO-RATA TO USERS IN SAID CANALS. THE HEADGATE AND SPILLWAY WAS INSTALLED AT THE HEAD OF THE CHILLY CANAL IN 1950.

THE DROUGHT CONTINUED INTO 1950 WITH DECREES ABOVE THE RESERVOIR CONTINUING UNTIL EARLY JULY WHEN THE RIVER DROPPED BACK TO 300 CFS. BY 1951 THE SNOW PACK WAS HIGH ENOUGH THAT THE RESERVOIR WAS FULL SO NO DECREES WERE CUT IN THE CHILLY BARTON AREA. WITH GOOD RAIN THE SEASON ENDED WITH 29,350 AF IN STORAGE ON OCTOBER 15TH.

HEAVY STORMS IN 1954 BROKE THE DROUGHT AND THE HEAVY MELTING SNOW WASHED OUT THE WILD HORSE AND THE KENT BRIDGE WITH HOWELL GAGE CRESTING AT 3,980 CFS. HOWEVER THE FOLLOWING YEAR OF 1955 WAS ONE OF THE LOWEST WATER YEARS WITH HOWELL GAGE STATION REACHING A PEAK AT 1740 CFS.

BY THE 19TH OF SEPTEMBER THE RESERVOIR WAS DOWN TO 393 ACRE FEET. 1956 HAD SUCH AN EXTREMELY HIGH RUN-OFF THAT THE RUN-OFF WASHED

OUT THE HERB BROWN HEADGATE IN KENT DITCH AND THE HEADGATES IN BOTH CLARK DITCHES, THE JOHNSON-DONAHUE DITCH, THE HEADGATE IN THE KIMBALL WARREN DITCH AND HEADGATE IN THE PENCE PARKER DITCH. ALSO ABOUT WRECKED THE IMPROVED CHANNEL OF THE RIVER FROM THE DIVERSION POINT OF THE BACK CHANNEL TO ABOUT A MILE BELOW. WASHED OUT FOUR DROPS AND LEVELED THE RIVER BANKS IN SEVERAL PLACES, CAUSING DAMAGE TO THE IMPROVED CHANNEL OF MANY DOLLARS. THE BACK CHANNEL, BELOW THE LOWER OUTLET FROM THE RIVER, WAS BADLY DAMAGED BY GRAVEL FILLS AND TREES LODGED IN THE CHANNEL. THE MAIN RIVER WASHED BADLY BUT NOT TOO MUCH DAMAGE WAS DONE.

IN 1957 THE BIG LOST RIVER IRRIGATION DISTRICT DECIDED TO INSTALL A 5 FOOT CREST ON THE EXISTING SPILLWAY TO BE ABLE TO STORE MORE WATER IN THE MACKAY RESERVOIR. THE DEPT. OF WATER RESOURCES OBJECTED TO THIS METHOD AND WISHED TO SEE TAINTER GATES INSTALLED. COURT ACTION FOLLOWED AND THE COURTS UPHELD THE DECISION OF BIG LOST RIVER IRRIGATION DISTRICT TO INSTALL WHAT IS NOW CALLED "THE OGEE PLUG". EXTRA STORAGE WATER WAS NOW AVAILABLE DUE TO THE FIVE FOOT CREST IN THE SPILLWAY. HOWEVER THE PEOPLE BELOW THE MACKAY RESERVOIR WERE CONCERNED FOR THEIR SAFETY AND GOVERNOR SMYLLIE AND TWO ENGINEERS, MR. HOWARD PRESTON AND MR. SPECK WERE SENT TO MAKE AN INSPECTION. AFTER CAREFUL CHECKING THEY STATED THERE WAS NO CAUSE FOR ALARM.

BY MAY OF 1959 THERE WAS DISCUSSION OF SETTling THE LAW SUIT WITH MR. ZOLLINGER OVER THE USE OF SOME OF HIS PROPERTY FOR THE EXTRA STORAGE CAUSED BY THE 5 FOOT CREST. THROUGH THIS COURT ACTION AN EASEMENT TO ELEVATION 6700 FT. WAS OBTAINED.

ABOUT THE SAME TIME THERE WAS A LAWSUIT AGAINST THE BIG LOST RIVER IRRIGATION BY WATER USERS ABOVE THE MACKAY RESERVOIR. THE IRRIGATION DISTRICT CREW HAD WORKED ON THE RIVER CHANNEL TRYING TO REPAIR SOME OF THE DAMAGE THAT HAD BEEN DONE ON THE RIVER BY THE PREVIOUS YEARS FLOODING.

BIG LOST RIVER IRRIGATION DISTRICT WAS ALSO TRYING TO REDUCE THE RIVER LOSSES CAUSED BY THE SINKS. THIS LAWSUIT RENDERED IN FAVOR OF THE WATER USERS SINCE THE IRRIGATION DISTRICT HAD NOT OBTAINED THE AUTHORITY TO PERFORM SUCH SERVICE.

GOOD WATER CONTINUED THROUGH 1957,1958,BUT IT WAS A DROUGHT AGAIN FOR THE YEARS 1959,1960,1961,1962.IT WAS ABOUT THIS TIME THAT THE UNITED STATES GOVERNMENT ASSISTED THE VALLEY FARMERS WITH THE CAPITAL TO INSTALL GROUNDWATER PUMPS TO SUPPLEMENT THE SURFACE RIGHTS.

1963 AND 1964 WERE BETTER WATER YEARS WITH HOWELL GAGING STATION REACHING A PEAK OF 1940 CFS IN 1964.

1965 WAS ONE OF THE BIGGEST WATER YEARS ON RECORDS IN LOST RIVER VALLEY HISTORY WITH A RUN-OFF OF 388,452 ACRE FEET .THERE WAS A GREAT DEAL OF DESTRUCTION AND THE CORPS OF ENGRS. WERE ASKED TO COME IN AND HELP WITH SOME OF THE CLEAN UP OF THE RIVER.

IN 1969 THERE WAS EARLY PRECIPITATION AND ALL RIGHTS WERE ON FOR THE ENTIRE SEASON.

THE YEARS 1970,1971,1972,1973 WERE ONCE AGAIN BELOW AVERAGE YEARS.

1974 SHOWED AN ACTUAL 282,380 ACRE FEET GIVING THE VALLEY FARMERS AN EXCELLENT YEAR.THERE WAS SOME DAMAGE TO THE RIVER AND THE CORPS OF ENGINEERS CAME IN AND HELPED OUT.

BACK TO BELOW AVERAGE AGAIN IN 1976 WITH DROUGHT CONDITIONS VERY SEVERE IN 1977.

BY 1978 THE SNOW PACK HAD INCREASED AND A MODERATE WATER YEAR BROUGHT A HIGH RIVER AT HOWELL'S GAGE OF 2200 CFS.THIS CONTINUED THROUGH THE YEARS 1978,79,80,81.BY 1982 THERE WAS AN AVERAGE AMOUNT OF WATER FOR CROPS.

IN 1985 THERE WAS A FLASH FLOOD IN WILDHORSE THAT WIPED OUT THE WILDHORSE BRIDGE .WHEREAS IT NORMALLY TAKES 24 HOURS FOR BIG LOST RIVER TO ENTER THE RESERVOIR FROM THE HEADWATERS,IT ONLY TOOK 4 HOURS WITH THE GAGE AT HOWELL UNOFFICIALLY AT 4300 CSF.

DUE TO THE EARTHQUAKE OF 10/28/1983 THE RECORDED FLOW IN 1984 WAS 369,800 ACRE FEET,173% OF THE 20 YEAR AVERAGE..

IN MAY OF 1986 THERE WERE 10 UNSEASONAL VERY HOT DAYS AND 61,000

ACRE FEET OF THE WATER IN WATER SHED MELTED ALL AT ONCE CAUSING DAMAGE TO THE LESLIE BRIDGE BUT IT WAS A DROUGHT BY JULY WITH VERY LITTLE NATURAL FLOW, ONLY THE STORAGE WATER IN THE RESERVOIR MADE COMPLETION OF CROPS POSSIBLE.

THE YEARS 1987, 1988, 1989, 1990, 1991 HAVE BEEN DROUGHT YEARS WITH MORE THAN 300 DOMESTIC AND IRRIGATION WELLS DRILLING DEEPER. MANY OF THE TREES IN THE ARCO AREA HAVE DIED, THE SUB (WATER) HAS NOT BEEN SEEN FOR MANY YEARS.

THE SIXTH DISTRICT COURT IN 1936 RECOGNIZED THAT THE ECONOMY OF THE LOWER VALLEY WAS DEPENDENT ON A SYSTEM OF WATER RIGHT ROTATION AND PUMPING WITHIN THE BIG LOST BIG LOST RIVER IRRIGATION DISTRICT THEN AND IT CONTINUES TO HOLD TRUE TODAY.

THE ROTATION OF DECREED AND STORAGE WATER HAS BEEN THE ONE THING THAT HAS ENABLED THE DISTRICT FARMERS IN THE LOWER VALLEY TO HAVE SUFFICIENT WATER TO AT LEAST PRODUCE SOME KIND OF CROP IN EVEN A DROUGHT YEAR.

THE STORAGE WATER, PUMP WATER AND NATURAL FLOW MUST REMAIN IN THE IRRIGATION DISTRICT IN ORDER TO HAVE SUFFICIENT WATER AND HAVE ANY KIND OF PROSPERITY.

Compiled from the records of the Big Lost River Irrigation District, the records of the Watermaster's, the ASCS snow Forecast, Court records.



Assistant Secretary-treasurer

Rita M. Lundy

BIG LOST RIVER IRRIGATION DISTRICT

wells were carried on downstream to reduce the slight head so that the wells in this area would no longer flow.

To obtain a substantial supply of water from wells or infiltration ditches it would doubtless be necessary to lower the water table until the flow of the springs would be diminished. Thus the total water supply would be increased but the flow from the springs would be diminished. Gaging stations should be established on the spring-fed creeks to determine their normal discharge in order that any diminution of their flow as a result of future withdrawals from wells or infiltration ditches can be determined and prior rights can be fully protected.

BIG LOST RIVER VALLEY ²⁰

GEOGRAPHY

The Big Lost River rises in the high mountainous region included in the Lemhi National Forest, Custer County, Idaho. On the rim of its drainage basin are Hyndman Peak, 12,078 feet above sea level, for many years considered to be the highest mountain in Idaho, and Mount Borah, which during 1929 was found by Lee Morrison, of the United States Geological Survey, to be 12,655 feet above sea level. The upper valley of the East Fork, known as "Copper Basin," is parallel to the main Big Lost River Valley and about 15 miles west of it, being separated from it by the White Knob Mountains (pl. 31). Below the East Fork the stream enters a gravel-filled valley averaging about 4 miles in width. Through this valley, known as the "Big Lost River Valley," it flows in a southeasterly direction for about 60 miles to the edge of the Snake River Plain below Arco. Thence it continues for about 40 miles, first in an easterly and then in a northeasterly and northerly direction to the Lost River "sinks," a shallow depression in the surface of the Snake River Plain, where the surplus waters in years of heavy run-off accumulate until they are lost by evaporation or by percolation into the underlying lava rocks. In the valley are the towns of Mackay (population 1,482 in 1930), Arco (population 834), and Moore (population 336), and the smaller settlements of Darlington, Leslie, and Chilly. (See pl. 31.)

In the section of the valley above Mackay the irrigated area, comprising about 10,000 acres, consists principally of wild-hay meadow lands devoted to raising livestock. Below Mackay about 40,000 acres has been irrigated, including the 6,000 acres of Carey Act lands lying at the mouth of the valley. This lower portion of the valley is used for general farm crops, principally hay and grain. The irrigated acreage, however, has been decreasing in recent years, owing to deficient run-off and decreasing precipitation. The altitude of the valley floor ranges from 5,300 feet at Arco to 6,300 feet at Chilly, 50 miles

²⁰ A more detailed report was released to the public in mimeograph form on June 23, 1930.

IDWR12

upstream. At Mackay, at an altitude of 5,900 feet, the mean annual precipitation is 9.74 inches and the mean annual temperature 42.1° F., according to the Weather Bureau records.

SURFACE WATER

The productive run-off of the Big Lost River comes principally from a relatively small area on its headwaters. The drainage area above the Howell ranch gaging station, in sec. 30, T. 8 N., R. 21 E., at an altitude of 6,600 feet, where the river first enters the enlarged valley, is 430 square miles. During the period 1921-29 the average annual discharge of the river at this station was 191,700 acre-feet. The drainage area above the gaging station below the Mackay Dam, 24 miles downstream from the Howell ranch station, is 790 square miles, and the average annual discharge at this station during 1921-29 was 207,900 acre-feet, a net gain between the two stations of only 16,200 acre-feet. If the crops on irrigated lands in the section between these stations consumed 1.7 acre-feet of water to the acre, a total of about 17,000 acre-feet was annually consumed on the tract of about 10,000 acres in the section.

The average annual run-off from the drainage area of 360 square miles between the two stations may have been more or less than the 33,200 acre-feet represented by the sum of the gain in flow and the water consumed on irrigated land, according as underflow at the Mackay station was greater or less than that at the Howell station. The actual run-off would also be greater than 33,200 acre-feet by the amount of water consumed by vegetation along the Thousand Springs Slough. (See p. 246.)

Below the Mackay Dam the river dwindles downstream through irrigation diversions and seepage losses. During the 3 years 1921-23, there was an average annual discharge of 47,000 acre-feet past the lowest canal diversion below Arco, but with this exception, there was no appreciable outflow from the valley during the 11 years 1919-29, although at Arco the river has a drainage area of 1,560 square miles.

The contributions from the Big Lost River to the ground-water flow of the Snake River Plain have been estimated by computing the total supply available from stream flow and deducting from it the quantity of water consumed on the irrigated land below the dam. The total supply available from stream flow was obtained by adding to the annual discharge of the river at the Mackay Dam the inflow from tributary streams below the dam. About 40,000 acres of land below the Mackay Dam was irrigated from the Big Lost River and tributaries below the points where they were measured during the years considered. The consumption of water by transpiration and evaporation of 1.7 acre-feet to the acre for the season, exclusive of precipitation, was assumed for the crops on these lands where water was available

throughout the season. Many of the lands, however, have inferior water rights, which are filled only during part of the irrigation season, and on such lands a smaller consumption was assumed, the amount varying from year to year with the water supply in accordance with the record of water deliveries on the stream furnished by the water-master.

Estimated contributions, in acre-feet, to the ground water of the Snake River Plain by Big Lost River, years ending Sept. 30, 1920-27

	Discharge of Big Lost River at Mackay Dam (acre-feet)	Tributary inflow below Mackay Dam ¹ (acre-feet)	Total supply (acre-feet)	Estimated crop con- sumption and evaporation losses (acre-feet)	Contribution to supply of ground water of Snake River Plain (acre-feet)
1920.....	168,000	45,000	213,000	46,000	167,000
1921.....	268,000	102,000	370,000	64,000	306,000
1922.....	279,000	97,000	376,000	64,000	312,000
1923.....	235,000	80,000	315,000	58,000	267,000
1924.....	145,000	40,000	185,000	32,000	153,000
1925.....	237,000	61,000	298,000	58,000	240,000
1926.....	144,000	39,000	183,000	32,000	151,000
1927.....	212,000	65,000	277,000	56,000	221,000
Average.....					220,000

¹ Includes lower Cedar, Alder, Pass, and Antelope Creeks.

NOTE.—All records from unpublished data supplied by water commissioner for the Big Lost River, Mackay, Idaho.

GROUND WATER

The ground water is stored mainly in the alluvial valley fill. Some of this material is cemented, at least on the surface, and this is much older than the rest. Wells 80 feet deep fail to reach bedrock. From the size of the valley and the profiles of the exposed bedrock, the alluvium at some places may be 500 feet or more in thickness.

The alluvium is in part derived from the Big Lost River, but broad alluvial fans flank the mountains on each side of the valley. Most of the streams descending from the mountains sink into these fans and fail to join the Big Lost River except in times of cloudbursts or spring freshets. The river has been unable to maintain its course through the axis of the valley because these fan deposits have forced it first to one side and then to the other. Basalt flows from the Snake River Plain intermittently blocked or partly dammed the mouth of the valley thus causing the river to aggrade its floor. One of these flows issued in sec. 33, T. 4 N., R. 26 E., near Arco and forced the river to the east side of the valley. The main underflow of the valley escapes through the lava and follows the present surface channel only about 5 miles below Arco (pl. 19). As is shown below, the relation between the water table and the land surface differs from place to place in response to the geology.

Since the earliest days of settlement in the valley the river has been noted for the "sinks" along its channel, and it no doubt takes its name

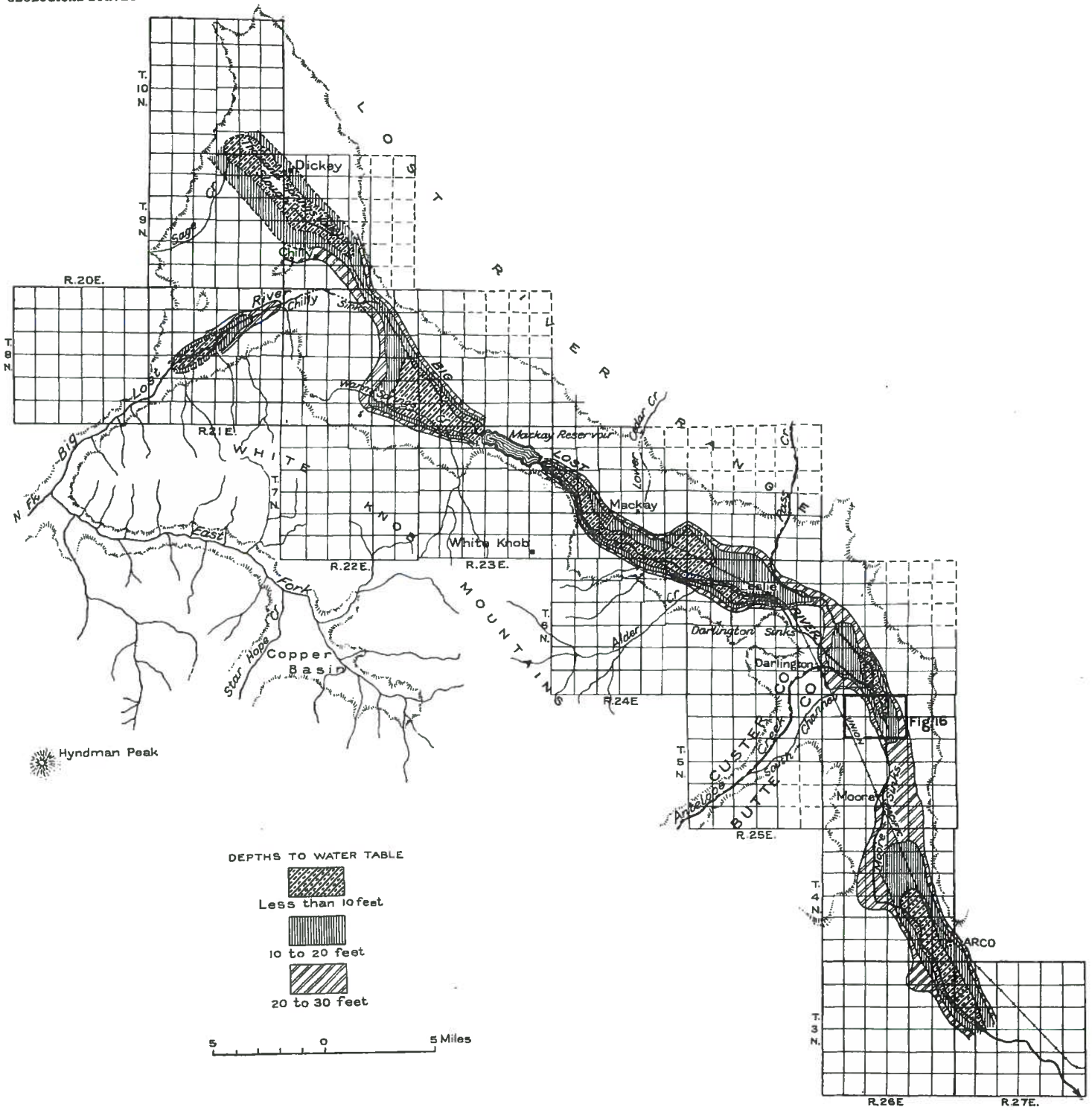
from these features. Five sinks have been recognized and named. The uppermost one in sec. 15, T. 8 N., R. 21 E., consists of four small depressions in the land surface alined in a northeasterly direction. The southernmost of these depressions is the largest and has a width of about 50 feet and a depth of about 25 feet. It is thought that they may record the presence beneath the alluvial cover of a collapsed limestone cavern and that water entering this cavern may give rise to Thompson Spring, 5 miles to the southeast. The river losses in the section that contains the depressions are known to average about 30 second-feet; moreover, there is some contribution to the supply of ground water from irrigated land in the tributary drainage area.

The next three sinks downstream are not depressions but merely places where the river loses heavily in gravel and at times disappears. The lowest sink is a shallow basin or playa, where the river spreads out and is dissipated by evaporation and deep percolation.

The Chilly Sinks begin at a point in sec. 6, T. 8 N., R. 22 E., southwest of the village of Chilly, and extend thence about 9 miles downstream. The river has to attain a flow of about 750 second-feet at the Howell ranch before it is able to cross these sinks in the spring. However, once started, it will continue to flow at the surface in this stretch until it declines to a flow of about 300 second-feet at the Howell ranch. The river usually flows across the sinks for a period of 1 to 3 months in the spring and early summer of each year, and the channel is dry for the remainder of the year. During the spring, when the stream is first making its way across the sinks, the ground water in the adjacent gravel rises several feet daily, and water appears in wells and depressions a quarter of a mile or more from the river, keeping pace with the downstream advance of the water in the surface channel. Evidently there is much permeable alluvium in this stretch.

Thousand Springs Creek, which enters the Big Lost River about midway on the Chilly Sinks, has its source in springs that rise at the head of Thousand Springs Slough, about 10 miles from the point where it discharges into the river. The natural flow of these springs is largely absorbed during the summer by transpiration and evaporation on about 5,000 acres of swampy meadow. One of the largest springs feeding this creek rises in alluvium about half a mile from a limestone hill and discharges about 20 second-feet of water. During years of plentiful water supply the flow of the creek is augmented by seepage from the irrigated lands in the vicinity of Chilly, and at such times it may discharge as much as 75 second-feet into the Big Lost River. The creek usually dries up at its mouth early each winter, owing to the lowering of the adjacent water table.

Below the Chilly Sinks the river receives a considerable ground-water inflow, augmented by the flow of Warm Spring Creek. This creek has its source in two springs that rise on the west side of the valley



1

2

3

4

5

6

7

8

9

about 100 feet above the adjacent river level. The upper spring, which is Thompson Spring, in sec. 29, T. 8 N., R. 22 E., gushes forth from a fissured cherty limestone, overlain by Challis volcanics. The temperature of the water on October 9, 1929, was 46° F. The flow of this spring reaches a low point of about 22 second-feet during March of each year. It starts to rise during May and reaches a maximum of about 36 second-feet around August 1.

The lower spring, known as Boone Creek, in sec. 34, T. 8 N., R. 22 E., is about 15 feet lower in altitude than the upper spring. It issues from alluvium near a ridge capped with Challis volcanics. The water temperature on October 9, 1929, was 54° F. The lower spring reaches its minimum flow of about 26 second-feet during May and reaches a maximum of 33 second-feet during September.

Warm Spring Creek enters the main valley several miles above its mouth. The creek receives inflow from the ground water of the main valley, and at its mouth it usually discharges about 125 second-feet during low stages and considerably more during periods of high ground-water levels.

Below the mouth of Warm Spring Creek and 4 miles above Mackay is the Mackay Dam, a gravel-fill structure about 70 feet in height, which impounds 40,000 acre-feet. This dam is at the lower end of a stretch in which the river receives ground-water inflow. It abuts at both ends on hills of Paleozoic limestone, those on the northeast being mantled by the gravel sediments of upper Cedar Creek. Numerous minor faults with trends transverse to the valley appear to be present in the limestone in the southwest abutment, a fact which suggests that the limestone exposed farther northeast may be related to cross faulting. To the northeast the broad expanse of the valley is interrupted by hills composed largely of old alluvium, which dips gently westward. At the surface this alluvium is so thoroughly cemented as to be nearly impermeable but in the zone of saturation it may not be cemented. Whatever the precise structure or character in the underlying material, it seems clear that the hills which constrict the valley here, although far lower than the mountains on both sides, correspond to a restriction in the flow of ground water beneath them. This is believed to be the principal cause of the area of shallow ground water at and immediately above the Mackay Reservoir. (See pl. 31.)

The underground conditions are such that much water escapes under and around the dam. That this water returns to the river above the narrows, a mile below the dam, where the valley floor is greatly constricted by abrupt limestone spurs on each side, is proved by measurements at a station about 1½ miles below the dam and just below the narrows during periods when the gates at the dam are closed, as shown by the table following:

Discharge, in second-feet, of Big Lost River 1½ miles below Mackay Dam with the gates at dam closed

Gage height of reservoir (feet)	1918- 19	1919- 20	1920- 21	1921- 22	1922- 23	1923- 24	1924- 25	1925- 26	1926- 27	1927- 28	1928- 29
10.....	(1)	(1)	43	50	(1)	(1)	30	(1)	30	30	28
15.....	(1)	(1)	47	52	(1)	(1)	42	(1)	40	38	36
20.....	68	(1)	59	63	(1)	60	50	(1)	47	46	46
25.....	76	(1)	69	75	(1)	65	64	(1)	53	63	55
30.....	87	85	85	84	(1)	71	76	59	67	76	66
35.....	94	94	100	95	97	77	87	69	78	85	78
40.....	111	(1)	122	103	102	89	101	85	90	89	98
45.....	121	(1)	135	112	106	105	115	96	108	112	113
50.....	137	(1)	(1)	135	113	112	(1)	108	(1)	130	130
55.....	(1)	(1)	(1)	(1)	123	131	(1)	135	(1)	(1)	(1)

¹No record.

Between the narrows below the Mackay Dam and the village of Leslie, a distance of 10 miles, the ground water under the valley floor holds up to a level equal to or higher than the river level. During the irrigation season of the dry year of 1920 the river sustained an average loss of 15 second-feet in this section, but in years of plentiful supply it shows an average gain of about 20 second-feet during the irrigation season. Apparently the rate of underflow is nearly in equilibrium with the supply of water. Nearby spurs of limestone constrict the valley, and it is thought that bedrock may be closer to the surface under the alluvium here than in most other sections. These factors aid in maintaining the water close to the surface in the area between this point and Mackay.

Downstream from Leslie the valley again widens, and the ground-water level drops rapidly below the river level, and in the Darlington Sinks the river sustains losses ranging from 30 to 75 second-feet. About 2½ miles east and 1 mile south from Darlington water again rises and flows into the river channel, but all of it is diverted during low-water periods at the Moore diversion dam, in sec. 4, T. 5 N., R. 26 E. The rise here is aided by the constriction of the valley caused by Antelope Ridge, near Moore.

The average annual flow of the Big Lost River at the gaging station below the Mackay Dam in 1921-29 was about 208,000 acre-feet, to which may be added 64,000 acre-feet as the average annual inflow to the valley from Lower Cedar, Alder, Pass, and Antelope Creeks and minor tributaries between the Mackay Dam and the Moore Dam, making a total average annual supply of about 272,000 acre-feet. If there were no seepage loss and the consumption of water on the 17,000 acres of irrigated lands in this area is taken as 30,000 acre-feet annually, the average annual flow of the river at the Moore Dam should be about 242,000 acre-feet. However, during this period the average annual flow at the Moore Dam was only about 96,000 acre-feet, in addition to which there was an annual average of about 37,000 acre-feet carried by the Blaine Canal past the Moore Dam.

lower than the river level. This fact and the ground-water contours (pl. 19 and fig. 16) indicate that part of this underflow leaves the valley under the land of the Utah Construction Co., west of Arco, at great depth. The ground water may follow an old buried channel from which the river was diverted by basalt flows.

Between the Moore Dam and a point about a mile above Arco, a distance of 9 miles, the river flows across the Moore Sinks. In years of plentiful water supply, when the river runs through this section for several months and large volumes of water are used in the irrigation

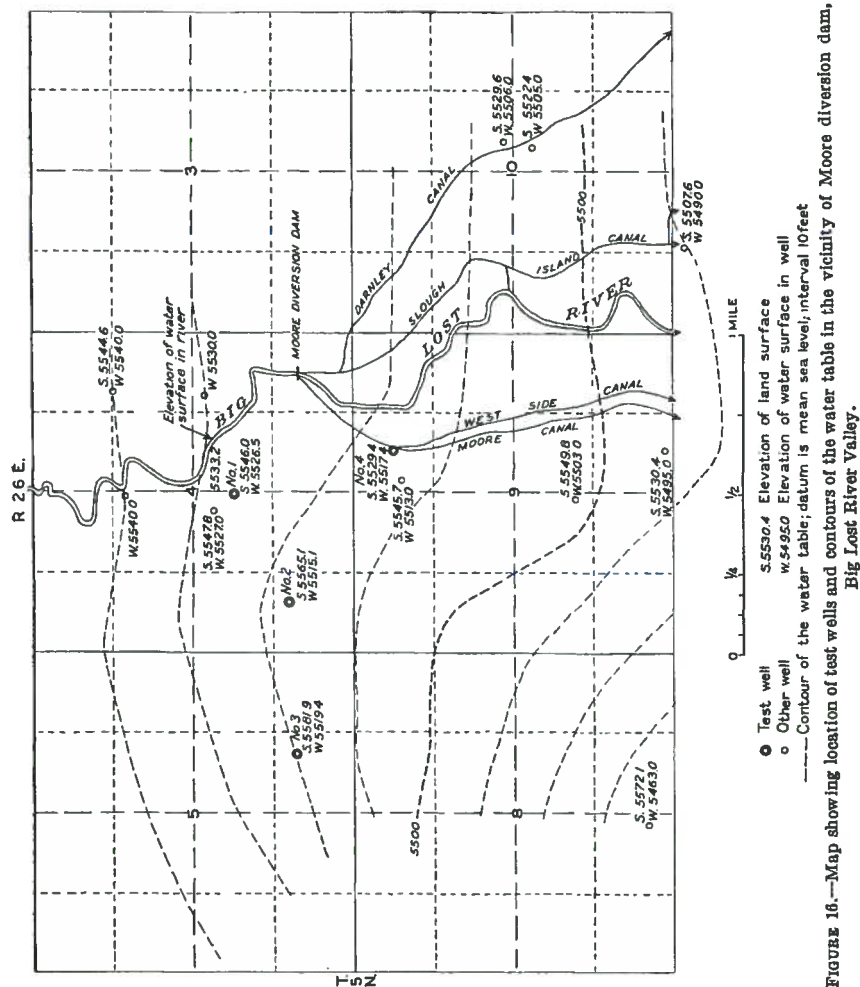


FIGURE 16.—Map showing location of test wells and contours of the water table in the vicinity of Moore diversion dam, Big Lost River Valley.

of adjacent lands, as much as 75 second-feet of return flow rises in the river channel and in several spring-fed creeks a mile or two above Arco. In dry years, however, this return flow decreases to practically nothing. When the ground-water levels are low in this section more than 200 second-feet must be discharged past the Moore Dam in order for any water to reach Arco.

At a point about 5 miles south of Moore the Big Lost River turns to the east and thence continues southeastward near the edge of a basalt flow for several miles. The main ground-water flow, however, continues southward beneath the lavas, its course being fairly well defined by the ground-water contours at the mouth of the valley (pl. 19). The area of shallow ground water in the vicinity of Arco appears to be supplied chiefly from the eastern side of the valley and the supply for this area is apparently not large.

TEST WELLS

WELLS NEAR MOORE DAM

During the winter of 1929-30 four test wells 4 inches in diameter were drilled in the valley in the vicinity of the Moore diversion dam, 3 miles upstream from the village of Moore. (See fig. 16.) A percussion drill was used, and the casing was carried down with the drilling. The casing was salvaged from all the wells except well 4. In the spring of 1930 a test well 20 inches in diameter was drilled in the vicinity of Arco and was pumped with a deep-well turbine centrifugal pump. The logs and descriptive notes of these wells follow:

Log of test well 1, NE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 4, T. 5 N., R. 26 E.

[Altitude of surface 5,546.0 feet]

	Thickness (feet)	Depth (feet)
Sandy loam soil.....	3	3
Sandy silt; sample at 20 feet, sandy silt.....	17	20
Sand and fine gravel; sample at 25 feet, medium sand with a little $\frac{1}{8}$ -inch gravel.....	5	25
Clayey silt; sample at 27 feet, clayey silt with a little gravel as large as $\frac{1}{4}$ inch in diameter; looks nearly impermeable.....	5	30
Sandy silt with a little gravel; sample at 30 feet, sandy silt with a little gravel as large as $\frac{1}{4}$ inch in diameter; the gravel is subangular and mostly dark like the sand.....	5	35
Silty sand; sample at 35 feet, sand with a little silt and no gravel; sample at 36 feet, fine sandy silt containing mica flakes.....	2	37
Sand and gravel; sample at 37 feet, sharp coarse clean dark sand and considerable subangular $\frac{1}{8}$ -inch gravel, probably a good aquifer; sample at 39 feet, like that at 37 feet but a little less clean and contains some gravel $\frac{1}{4}$ inch in diameter; sample at 40 feet like that at 37 feet.....	5	42
Fine dirty sand.....	1	43
Sand and fine gravel; sample at 44 feet like that at 37 feet but not quite so clean.....	1	44
Fine sand with a little clay; sample at 45 feet fine sand containing a little clay.....	1	45
Sand and gravel; sample at 46 feet clean, dark gravel as large as $\frac{1}{2}$ inch in diameter; should be an excellent aquifer.....	1	46
Clayey silt; sample at 47 feet yellow clayey silt.....	1	47
Gravel and sand; sample at 48 feet clean, well-rounded dark gravel like that at 46 feet; samples from 49 to 63 feet and at 68 feet clean sand and gravel as large as $\frac{1}{4}$ inch in diameter.....	24	71
Sandy silt; sample of material that rose 10 feet in the pipe at 72 feet is sandy silt; sample at 72 feet after cleaning pipe is fine sand with many of the grains rounded.....	1	72

Water was first encountered in this well at a depth of 19 feet. At 25 feet the water was cased off in a silty clay. Water was again encountered at the depth of 36 feet and rose in the casing to a level 13 feet below the surface. At 40 feet, in coarse sand, the water rose at the rate of 1 foot in 15 seconds when bailed down 6 feet. At 42 feet, in fine dirty sand, the hole was bailed dry, but water was struck again at 44 feet. At 45 feet the water was cased out, but water in small quantity was again struck at 45.5 feet. The low yield at this depth is indicated by the fact that the water rose very slowly and when left over night reached only a level 36 feet below the surface. At 48 feet a more plentiful supply of water was found in a sandy gravel, and the water rose to a level 18 feet below the surface. Between 48 and 70 feet several bailing tests showed that the water rose at the rate of 1 foot in 22 seconds when bailed down 4 feet. At 61 feet the water stood 19.5 feet below the surface. At 72 feet fine sand was encountered that rose 10 feet in the casing.

The formations encountered in this hole to the depth tested are not favorable for large yields by pumping, on account of the interbedded strata of sandy clay, which evidently prevent the free movement of water through the gravel beds. In all probability these gravel beds are lens-shaped and terminate in the sandy clay.

Log of test well 2, SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 4, T. 5 N., R. 26 E.

[Altitude of surface 5,565.1 feet]

	Thickness (feet)	Depth (feet)
Clayey soil with a few $\frac{1}{4}$ -inch pebbles; sample at 40 feet silty clay with a few pea-sized pebbles; samples at 44, 45, and 48 feet have texture like that at 40 feet; sample at 53 feet dirty $\frac{1}{4}$ -inch gravel; sample at 61 feet shot-sized gravel and silt. Sand and fine gravel; sample at 64 feet clean sand and gravel as large as $\frac{1}{4}$ inch in diameter; sample at 71 feet similar to sample at 64 feet but more sand; sample at 74 feet, sand and gravel 1 inch in maximum diameter.....	61	61
Sand; samples at 76 feet clean, coarse sand.....	14	75
Sand and fine gravel; sample at 80 feet clean, coarse sand with a little $\frac{1}{4}$ - to $\frac{1}{2}$ -inch gravel.....	3	78
	2	80

Water was first struck in this well at 61 feet, at the bottom of a stratum of gravelly clay, and rose to a level 47 feet below the surface. At 70 feet the water was cased off in clay. Below 72 feet an abundant supply of water that could not be lowered by repeated bailing was encountered in gravel. Between 72 and 77 feet the water stood 50 feet below the surface. Regular measurements on another well at this point were made during 1920-22 and are tabulated on page 252.

Measurements of depth to water in well in SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 4, T. 5 N., R. 26 E.

[Martha Jones, owner]

	<i>Feet</i>		<i>Feet</i>		<i>Feet</i>
Nov. 24, 1919.....	39.3	Oct. 12, 1920.....	38.7	Oct. 21, 1921.....	25.7
Dec. 2, 1919.....	39.2	Nov. 1, 1920.....	37.7	Nov. 22, 1921.....	34.6
Feb. 19, 1920.....	40.2	Nov. 24, 1920.....	38.8	Dec. 16, 1921.....	36.4
Mar. 13, 1920.....	40.4	Dec. 30, 1920.....	40.7	Feb. 8, 1922.....	37.7
Mar. 23, 1920.....	40.7	Feb. 4, 1921.....	41.1	May 3, 1922.....	34.8
Mar. 29, 1920.....	40.2	Mar. 5, 1921.....	40.7	June 5, 1922.....	24.4
Apr. 12, 1920.....	40.2	Mar. 30, 1921.....	39.3	July 8, 1922.....	18.7
Apr. 28, 1920.....	40.5	Apr. 25, 1921.....	39.1	Aug. 2, 1922.....	23.4
May 24, 1920.....	38.4	May 23, 1921.....	28.8	Aug. 26, 1922.....	26.0
July 2, 1920.....	28.0	June 24, 1921.....	25.0	Oct. 2, 1922.....	26.7
July 22, 1920.....	34.1	July 26, 1921.....	22.1	Jan. 9, 1930.....	50.0
Aug. 28, 1920.....	38.3	Aug. 24, 1921.....	29.1		
Sept. 24, 1920.....	37.8	Sept. 26, 1921.....	29.7		

During the high-water year of 1932 the water table at this place rose to a level 18.7 feet below the surface. A well at this site would furnish a good yield if pumped, but the lift might be too great for economical operation.

Log of test well 3, SW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 5, T. 5 N., R. 26 E.

[Altitude of surface 5,581.9 feet]

	<i>Thickness (feet)</i>	<i>Depth (feet)</i>
Clayey soil with a little shot-sized gravel; samples at 26, 28, 35, 40, 45, 50, 55, 60, and 65 feet, clayey soil with a little $\frac{1}{8}$ -inch gravel.....	65	65
Sandy silt; sample at 67 feet, sandy silt.....	2	67
Clay; sample at 70 feet clay.....	3	70
Sand and fine gravel; sample at 75 feet, clean sand and $\frac{1}{4}$ -inch gravel.....	5	75
Silty clay; sample at 80 feet, silty clay.....	5	80
Sand; sample at 84 feet, fairly clean sand.....	4	84
Sand and fine gravel; sample at 85 feet clean sand and $\frac{1}{4}$ -inch gravel; should be an excellent water bearer.....	1	85

Water was found in this hole at a depth of 61 feet, and it rose to a level 55 feet below the surface. At 70 feet the water was shut off in clay. At 75 feet water was again encountered but rose only to a level 63 feet below the surface. A free yield of water was obtained in this well, and it was impossible to lower the water level appreciably by bailing.

In well 4, in the NW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 9, T. 3 N., R. 26 E., water was first found at a depth of 12 feet. Owing to the perforated casing used, water and sand came in at all depths, making it impossible to identify the water-bearing characteristics of the different formations. A plentiful supply of water was apparent, however, as the water level could not be lowered by bailing. When the hole was ended at 40 feet the water level stood 9.9 feet below the surface. This reading may have been affected by seepage inflow from an adjoining canal.

The test wells were drilled in the vicinity of the Moore diversion dam to determine the feasibility of an attempt to recover the water

known to be passing through this part of the valley. Over half of the irrigated area in the valley below the Mackay Dam could be served by the canals that divert water at the Moore Dam. Hence, if the ground water could be recovered and discharged into the canals its distribution to the land would be greatly facilitated. The results of the drilling, however, were discouraging, as the main ground-water flow was found to occur west of the river, mostly at depths below the surface probably too great for economical pumping under present conditions and at a lower altitude than the river level. The portion of the ground-water flow that passes the Moore Dam adjacent to the river for a distance of half a mile or so downstream from the dam could be recovered by pumping at relatively low cost, as the depth to the ground-water level does not exceed 10 to 15 feet. The results of the drilling and the ground-water contours (see fig. 16) indicate, however, that the largest flow down the valley occurs from three-quarters of a mile to a mile west of the river channel, beneath an overburden of 50 feet of alluvial fill of the Antelope fan.

During the spring of 1929 a sump was excavated in gravel by A. W. Bell in the SW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 4, T. 5 N., R. 26 E., 500 feet west of the river, which yielded 1.6 second-feet with a 4-foot draw-down when pumped. A test of the municipal well of the village of Arco in 1922 showed a yield of 0.24 second-foot for each foot of draw-down. Several other plants pumping 1 to 2 second-feet at different places in the valley in past years are reported to have yielded from 0.16 to 0.30 second-foot to the foot of draw-down, and it appears probable from a study of such well logs as are available that similar yields can be obtained at many places in the valley.

WELL NEAR ARCO

On May 7, 1930, through local financial aid, a test well was sunk in the vicinity of Arco. The choice of the site was determined by the presence of a canal and a power line that were already built and not by the geologic structure. The site selected was close to the edge of the alluvial fan on the east side of the valley. Probably more productive gravel would have been found if the well had been located nearer the axis of the valley.

The first 57 feet of the well was sunk by Thomas Stephenson, of Burley. When the well had reached this depth it was cased to the bottom with 10-gage butt-welded casing 20 inches in diameter. On June 14, 1930, the casing had been perforated between 45 and 54 feet with 150 slits 2 inches long and about three-fourths of an inch wide in the middle. It is estimated that these perforations have an area of about 150 square inches. By removing the sand and gravel with a vacuum-type bailer and weighting the casing the well was constructed without the use of a drill. Water was encountered at

8 feet in the upper gravel bed. It is the so-called "sub" water and fluctuates considerably with the flow of the river. This water was cased out of the hole at 27 feet, and the second water was encountered at 31 feet. It rose almost to the level of the first water. On June 8, when the casing was 46 feet below the surface, it was perforated from 34 to 42 feet, and a centrifugal pump was installed. The depth to the water on the inside of the casing from the top of the north side of the wood curb at ground surface on this date was 8.4 feet and the depth to the "sub" water outside of the casing was 0.3 foot higher. When the pump was started the water was drawn down to 14.7 feet below the top of the wood curb, or 17 feet below the center of the pump, which was essentially the suction limit. A yield of only about 90 gallons a minute (0.2 second-foot) was obtained. After pumping a short time the well filled up with about 3.5 feet of sand.

Log of test well in SW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 25, T. 4 N., R. 26 E., to depth of 57 feet

	Thickness (feet)	Depth (feet)
Silty loam soil.....	2	2
Light-yellow sandy clay.....	3	5
Fairly clean gravel and sand; 4-inch streak of $\frac{1}{4}$ - to $\frac{1}{4}$ -inch gravel and sand at 7 feet.....	2	7
Clean sand and gravel; pebbles fairly well rounded and some of them 4 inches in diameter.....	1	8
Coarse subangular gravel in silty sand; approaching hillside wash in character.....	1	9
Dirty gravel; hillside wash with 2-inch streak of clay at 11 feet.....	2	11
Dirty gravel; gravel fairly well rounded.....	1	12
Fine clean sand; mostly quartz and gravel as large as 3 inches in diameter; the gravel is mostly porphyry and not derived from the adjacent limestone mountain, but one large angular limestone cobble was found in it.....	1	13
Clean sand with pea- to apple-sized gravel; at 16.5 feet a number of subangular limestone blocks, some of them 6 inches in diameter.....	4	17
Fine sand, mostly quartz grains.....	10	27
Silty clay.....	4	31
Fine clean sand.....	5	36
Coarse dirty gravel; hillside wash.....	10	46
Coarse clean gravel and coarse sand; mostly $\frac{1}{4}$ inch in diameter but some as large as 3 inches.....	11	57

As it was impossible to develop the well effectively by pumping out the sand with this equipment, the well was drilled 10 feet deeper and clean water-bearing gravel was encountered. The perforated casing was driven down into this gravel. On June 13 an 18-inch deep-well turbine pump was installed and operated with electric power. It delivered over 0.5 second-foot, and considerable coarse sand was discharged. However, after a few minutes of operation a fuse blew out, causing the motor to stop. Before the pump could be started again 5 feet of sand had settled into the well, choking the screen intake at the bottom of the suction pipe and considerably reducing the discharge. A few minutes after the pump was started again it ceased to throw out any sand. If all the sand had been pumped out it would have left a gravel wall through which water could enter the well more readily.

The pump was then pulled, the well was sunk 15 feet deeper, and the casing was perforated at all water-bearing beds. The local co-operators report that the bottom of the gravel aquifer was reached before the well had been sunk the additional 15 feet and that the well yielded about 3 second-feet of water.

CONSERVATION AND RECOVERY OF WATER

Plans to save a part of the water that will normally be lost underground from the Big Lost River Valley may be directed either toward the prevention of seepage losses in the river bed or toward the recovery of the water by pumping from wells after it has reached the water table. Practically any plan will modify to some extent the existing ground-water situation and will thus affect certain existing rights adversely. In view of the fact that at the present time the land-owners in the valley have individual water rights of varying dates of priority, a consolidation of these water rights would probably have to precede any large-scale attempt at further conservation of the water supply. Several plans are discussed below.

Chilly Sinks bypass.—It is apparent from a study of the run-off records at Howell's ranch and Mackay Dam that very little if any water is lost in the section between these points, taking the year as a whole. The large losses that now occur on the Chilly Sinks during the flood period feed the ground water that supplies the inflow to the Mackay Reservoir during the late summer, fall, and winter. Hence a bypass canal would result only in a seasonal redistribution of the present annual inflow to that reservoir. This, however, might be well worth while, as the water supply for users below the reservoir in very dry years could be augmented at the expense of the reservoir inflow the following winter. Inasmuch as the reservoir, with the gates closed during the winter, is able to retain only about 50 percent of the winter inflow, this would result in a net saving of water, provided the reservoir and natural-flow interests were consolidated or could agree on some kind of a joint program.

Leslie bypass.—It has been long suggested that a canal be constructed to divert from the river below Leslie, extending to the east side of the valley and returning to the river about a mile above the Moore diversion dam. This canal would bypass the gravelly section of the river known as the "Darlington Sinks", where about 50 second-feet is now lost at normal stages, and would probably effect a conservation of about half this amount of water, besides expediting the delivery of water to the Moore Dam.

Antelope channel improvement.—Considerable quantities of water are now lost by seepage during the spring floods in the several channels of Antelope Creek on the fan where the creek enters the Big Lost River Valley. A saving of several thousand acre-feet annually could

be made by cleaning and enlarging the south channel of the creek from a point in sec. 21, T. 5 N., R. 25 E., to the Big Lost River, so that it would carry the waters of that stream quickly and with minimum loss to the river.

Moore Sinks bypass.—The water supply for lands near Arco in dry years could be carried from the Moore diversion dam in a canal that could be constructed along the east side of the valley to a point 3 miles above Arco, where the water could be discharged into James Creek, a spring-fed stream that enters the river at the diversion dam a mile north of Arco.

It is suggested that in years of plentiful supply it would be best to carry the water from Leslie to Arco in the present river channel, because the large losses that occur under such conditions build the water table up beyond the height required to supply the capacity of the underground outlets from the valley, and the surplus water then appears as ground-water inflow into the river and adjacent channels and provides a substantial addition to the supply available late in the season. In dry years, however, the available supply is inadequate to build the water table to this height, and most of the water contributed to the water table in such years is a total loss to the valley.

Increased supply for Thompson Spring.—A suggested inexpensive test would be to conduct floodwaters by means of a short canal into the sinkholes at the head of the Chilly Sinks. If this water reappears in Thompson Spring and there is sufficient underground storage and a long enough time interval while the water is passing under the intervening ridge, it may offer a way to save some water for use later in the season.

Increased supply for Mackay Reservoir.—The amount of water stored behind the Mackay Dam during the winter could be substantially increased if the leakage under and around the dam could be reduced. This might be accomplished by grouting through drill holes along the axis of the dam and extending into the adjacent hill-sides or by a heavy blanket of fine material on the upper face of the dam, extending for some distance upstream along each shore of the reservoir. This work, however, to be effective would involve a considerable expenditure, and the matter should be carefully considered before being undertaken.

Thousand Springs Reservoir.—There is a reservoir site at the Thousand Springs, near Chilly, but the area flooded would be large in proportion to the volume of water that would be stored, and the land that would be flooded is valuable for winter grazing on account of the luxuriant grass now produced naturally. The damage to the livestock industry of the Big Lost River Valley by the destruction of this grazing area would probably more than offset any benefits that would result from the use of the stored water.