Randall C. Budge (ISB #1949)
Candice M. McHugh (ISB #5908)
Thomas J. Budge (ISB # 7465)
RACINE OLSON NYE BUDGE &
BAILEY, CHARTERED
201 E. Center Street
P.O. Box 1391
Pocatello, ID 83201
Telephone: (208) 232-6101
Facsimile: (208) 232-6109

Attorneys for Plaintiffs

**BEFORE THE IDAHO DEPARTMENT OF WATER RESOURCES
OF THE STATE OF IDAHO**

IN THE MATTER OF DISTRIBUTION OF WATER TO WATER RIGHTS NOS. 36-02356A, 36-07210, AND 36-07427 (Blue Lakes Delivery Call)	)	**AFFIDAVIT OF CHARLES M. BRENDECKE**
IN THE MATTER OF DISTRIBUTION OF WATER TO WATER RIGHTS NOS. 36-04013A, 36-04013B, AND 36-07148 (SNAKE RIVER FARM); AND TO WATER RIGHTS NOS. 36-07083 AND 36-07568 (CRYSTAL SPRINGS FARMS) (Clear Springs Delivery Call)	)	

STATE OF COLORADO)
ss:
County of Boulder)

I, CHARLES M. BRENDECKE, being first duly sworn, hereby declare the following:

1. I am President of Hydrosphere Resource Consultants, 1002 Walnut, Suite 200, Boulder, Colorado 80302. I am a licensed professional engineer in Idaho, Colorado, Wyoming and Oklahoma. I

have a Bachelor of Science degree in civil engineering from the University of Colorado and Master of Science and Doctor of Philosophy degrees in civil engineering from Stanford University.

2. My educational and professional experience is summarized in my resume which is attached hereto as Exhibit A. I have over 30 years of experience in hydrology, water resources engineering and water resources planning and management. I have directed or contributed to several river-basin-scale water management studies that involved analysis of basin hydrology and water uses and the development of computer models to investigate implications of changes in hydrology, system operations and water uses. My experience includes historical consumptive use analysis, evaluation of surface and ground water interactions, development of protective terms and conditions for water users, settlement negotiations and expert witness testimony.

3. I have been admitted as an expert witness in hydrology, hydrologic modeling and statistical hydrology before the Colorado Water Court and before the U.S. Supreme Court.

4. I have specific experience with modeling hydrologic interconnections between ground and surface water systems in the context of water administration. The following are some representative examples:

a. Hydrologic analysis and review of ground water models simulating effects of specific ground water withdrawals on reach gains on the Pecos River, New Mexico in connection with satisfying New Mexico's interstate surface water delivery obligations to Texas.

b. Hydrologic analysis of natural flow, storage and ground water supplies in the North Platte River Basin in Colorado, Wyoming and Nebraska with emphasis on the effects of ground water withdrawals and changes in irrigation methods on return flows and reach gains in surface streams.

c. Consultant to ground water users concerning development of plans of augmentation (similar to mitigation plans) pursuant to Colorado administrative rules concerning the maintenance of certain Arkansas River flows under the interstate compact between Colorado and Kansas for the Arkansas River.

5. My professional experience also includes study and modeling in the Snake River basin of Idaho. Since 1998 I have served as a technical advisor to the Idaho Ground Water Appropriators, Inc. (IGWA) in various matters including studies of historical irrigation practices and modeling of surface and ground water interactions on the eastern Snake River Plain. Since 2000 I have participated as a member of the Eastern Snake Hydrologic Modeling Committee (Modeling Committee) in technical review of the development, by the Idaho Department of Water Resources, of a new ground water model of the Eastern Snake Plain Aquifer (ESPA).

6. In the course of my work for IGWA I have become familiar with historical data and studies pertaining to the water resources of the upper Snake River basin and the ESPA. These data and studies have been gathered or prepared by various entities including, among others, the U.S. Geological Survey (USGS), the Idaho Department of Water Resources (IDWR, formerly the Idaho Department of Reclamation), and the U.S. Bureau of Reclamation (USBR).

7. The USGS has issued a number of professional papers, maps and atlases prepared as part of the Regional Aquifer-System Analysis (RASA) of the Snake River Plain. Large portions of the RASA are devoted to the eastern Snake River plain and information developed for the RASA was foundational in the development of the new ESPA model.

8. USGS Professional Paper 1408-E (PP 1408-E; Goodell, 1988) was prepared as part of the RASA and describes the historical water resources development on the Snake River plain. Exhibits B, C and D are reproduced from PP 1408-E and show the historical development of surface water irrigation on the plain. The Eastern Snake River Plain is generally considered to be that portion of the plain lying upstream and to the east of King Hill.

9. From Exhibits B through D it can be seen that early (19th century) irrigation development on the Eastern Snake River Plain was concentrated in the upper portions of the basin, above Blackfoot. Extensive irrigation development in the lower portion of the plain, in the vicinity of Twin Falls, began in earnest in 1905 with the development of the Twin Falls Project. Diversions by the Twin Falls North Side Land & Water Company (predecessor to the North Side Canal Company and hereafter referred to as the North Side Canal Company) to the north side portion of the Project began in 1908. By 1915 more than 300,000 acres were being irrigated north and south of the Snake River from diversions to the Project at Milner Dam.

10. According to Goodell, ground water development on the Eastern Snake River Plain did not become significant until the late 1940s. Thus observations of water levels on and spring flows from the ESPA prior to that time are largely unaffected by ground water pumping.

11. In 1927 the USGS published Water Supply Paper 557 (WSP 557; Meinzer, 1927), an inventory and description of large springs in the United States. A portion of WSP 557 is devoted to springs in the reach of the Snake River between Milner Dam and King Hill, commonly known as the Thousand Springs Reach.

12. In WSP 557, Meinzer states that the total discharge of the large springs on the north side of the Snake River between Milner and King Hill was 3,885 cubic feet per second (cfs) in 1902, before any irrigation developments had been made on the north side (this refers to the irrigation project now served by the North Side Canal Company). He states that this discharge averaged 5,085 cfs in 1918, after the development of the north side project.

13. Exhibit E, reproduced from WSP 557, illustrates the close relationship found by Meinzer between the combined spring discharges at Blue Lakes and Clear Lakes and the quantity of irrigation water applied to the Eastern Snake River Plain above the springs via the North Side Canal Company. Notable on Exhibit E is the effect of the dry year of 1919 on spring discharges.

14. In 1938, the USGS published Water Supply Paper 774 (WSP 774; Stearns, et.al., 1938) describing geology and ground water resources of the Snake River basin in Idaho. WSP 774 provides a comprehensive description of the ESPA and contains detailed descriptions of springs in the Thousand Springs Reach. Early records of discharge of Blue Lakes spring, the source of Alpheus Creek, are presented in a table on p. 156 of WSP 774. These data show that the discharge of Blue Lakes spring in August, 1902, was 80 cfs.

15. In 1958, the USGS published Water Supply Paper 1463 (WSP 1463; Nace, et. al., 1958) describing records of springs in the Snake River valley in Jerome and Gooding Counties for the period 1899-1947. WSP 1463 is a compilation of early measurements of spring discharges in the Thousand Springs Reach.

16. Exhibit F is derived from Table 4 of WSP 1463 and shows the reported discharge of selected springs and spring complexes in April, 1902. The total discharge of springs between a point 3 miles above Twin Falls and a point 10 miles below the Malad River is reported in Table 4 to be 3,833 cfs. This total includes discharges of springs on the south side of the river. Note that these discharge measurements were made prior to any irrigation water application on the plain above the springs by the North Side Canal Company.

17. USGS Professional Paper 1408-C (PP 1408-C; Kjelstrom, 1995) was prepared as part of the RASA and describes stream flow gains and losses in the Snake River and ground water budgets for the Snake River Plain, including the ESPA. A significant portion of PP 1408-C is devoted to description and analysis of the spring flows and reach gains to the Snake River in the Thousand Springs Reach.

18. Exhibit G, reproduced from PP 1408-C, shows the estimated ground water discharge (spring flow) to the Thousand Springs Reach for the period 1902-1980. Based on Exhibit G, ground water discharge to the Thousand Springs Reach for the 10-year period 1902-1911 averaged approximately 3.1 million acre-feet (maf) annually, or 4,280 cfs. Elsewhere in PP 1408-C Kjelstrom

estimates that the pre-irrigation (pre-1880) discharge of springs between Milner and King Hill averaged about 3.0 maf, or 4,140 cfs.

19. The IDWR also prepares estimates of the annual spring discharge to the Thousand Springs Reach based on a method originally developed by Kjelstrom and documented in USGS Water-Resources Investigation Report 95-4055 (WRIR 95-4055; Kjelstrom, 1995). Exhibit H is a plot of the discharge estimates prepared by the IDWR for the period 1902-2004. The average of the annual discharge values for the 10-year period from 1902-1911 is 4,207 cfs.

20. From the foregoing reports of historical discharge of springs between Milner and King Hill reach prior to the advent of extensive surface water irrigation on the plain above the springs I would conclude that the total natural discharge of the springs on the north side of the Snake River in the Thousand Springs Reach is approximately 4100 cfs. I would further conclude that the natural discharge of Blue Lakes spring is approximately 80 cfs, that the natural discharge of Crystal Springs is approximately 305 cfs, and that the natural discharge of Clear Lakes spring is approximately 150 cfs.

21. In PP 1408-C, Kjelstrom estimated that incidental recharge from surface water irrigation development (seepage from canals and laterals and percolation beneath farm fields) added 24 million acre-feet (maf) of water to ground water storage in the ESPA between 1880 and 1950, and that this increased ground water storage caused increases in spring flows to the river in the Thousand Springs Reach. Exhibit I, reproduced from PP1408-C, shows the close relationship between incidental recharge and spring discharge in the Thousand Springs Reach found by Kjelstrom.

22. Exhibits J and K are reproduced from PP 1408-E (Goodell, 1988). Exhibit J shows the increase in water levels in three observation wells, the locations of which are shown on Exhibit K. Water levels in observation well 8S-17E-19BBB1 reflect water levels in the aquifer beneath the area irrigated by the North Side Canal Company. It can be seen that aquifer water level in this area rose by approximately 45 feet between 1900 and 1950 as the result of incidental recharge.

23. Exhibit G, reproduced from PP 1408-C, shows that spring discharge in the Thousand Springs Reach increased dramatically between 1902 and the early 1950s.

24. Based on water budget data contained in Table 12 of PP 1408-C, the average annual ground water discharge (spring flow) from the ESPA in the Thousand Springs Reach reached a maximum of 6,940 cfs in 1952. Based on the data in Table 12, the average annual ground water discharge (spring flow) to the Thousand Springs Reach for the 10-year period 1946-1955 was 6,806 cfs, or about 4.9 maf.

25. Based on the estimates prepared by the IDWR (Exhibit H), the peak annual discharge of springs between Milner and King Hill was 6,820 cfs in 1951 and the average for the 10-year period 1946-1955 is 6,700 cfs.

26. From the foregoing facts I would conclude that at the time of the peak spring discharges in the Thousand Springs Reach in the early 1950s, approximately 4,100 cfs of that discharge was natural in origin and approximately 2,600 cfs was the result of incidental losses from surface water irrigation.

27. Data contained in WSP 774 (Stearns, et.al., 1938) show that between August of 1902 and August of 1910, two years after diversions began by the North Side Canal Company, the flow of Blue Lakes spring rose from 80 cfs to 110 cfs. By August of 1914, the flow had risen to 199 cfs.

28. Records contained in WRIR 95-4055 (Kjelstrom, 1995) indicate that the flow of Blue Lakes spring in 1951 was 229 cfs. From this and foregoing facts I would conclude that at the time of the peak spring discharges in the Thousand Springs Reach in the early 1950s, approximately 80 cfs of the discharge of Blue Lakes spring was natural in origin and approximately 150 cfs was the result of incidental losses from surface water irrigation.

29. Data contained in WSP 774 (Stearns, et.al., 1938) show that between 1902 and 1917, nine years after diversions began by the North Side Canal Company, the flow of Crystal Springs rose from 304 cfs to 536 cfs.

30. Records contained in WRIR 95-4055 (Kjelstrom, 1995) indicate that the flow of Crystal Springs in 1951 was 575 cfs. From this and foregoing facts I would conclude that at the time of the peak spring discharges in the Thousand Springs Reach in the early 1950s, approximately 305 cfs of the discharge of Crystal Springs was natural in origin and approximately 270 cfs was the result of incidental losses from surface water irrigation.

31. Data contained in WSP 774 (Stearns, et.al., 1938) show that between 1902 and November of 1917, nine years after diversions began by the Twin Falls North Side Land & Water Company, the flow of Clear Lakes spring rose from 150 cfs to 538 cfs.

32. Records contained in WRIR 95-4055 (Kjelstrom, 1995) indicate that the flow of Clear Lakes spring in 1951 was 533 cfs. From this and foregoing facts I would conclude that at the time of the peak spring discharges in the Thousand Springs Reachin the early 1950s, approximately 150 cfs of the discharge of Clear Lakes spring was natural in origin and approximately 383 cfs was the result of incidental losses from surface water irrigation.

33. Water rights on springs and spring-fed creeks in the Thousand Springs Reach are tabulated by the IDWR. The Department also maintains an on-line database through which members of the public can access information on these water rights.

34. I have extracted from the IDWR water rights database a listing of all water rights having as their source a spring or spring-fed creek on the north side of the Snake River between Milner and King Hill. Exhibit L is derived from this listing of water rights and shows the cumulative appropriation of springs and spring-fed creeks in the Thousand Springs Reach. While the earliest of these water rights has a priority date of 1874, the median priority date of the rights is 1961. Exhibit L reveals that the vast majority of appropriations of spring flows in the Thousand Springs Reach were made beginning in 1950, about the same time that the spring discharges described in preceding paragraphs were at their maximum values.

35. The relative timing of increased water rights appropriations and increased spring discharge indicates that a substantial portion of the appropriations made on springs in the Thousand Springs Reach were appropriations of flows resulting from incidental recharge from surface water irrigation. The cumulative appropriation in the reach exceeded the total natural discharge in the reach by 1955.

36. Cumulative appropriations on Blue Lakes spring and its outlet stream, Alpheus Creek, are shown on Exhibit M, which is derived from the IDWR water rights database. These cumulative appropriations have been adjusted to remove rights I understand to be served by return flows from other rights on the springs. Cumulative appropriations on Blue Lakes spring exceeded the natural discharge of the spring in 1958. From the curves shown on Exhibit M I would conclude that all water rights on Blue Lakes spring with priority dates later than May 29, 1958, are wholly appropriations of flows resulting from incidental recharge from surface water irrigation.

37. Cumulative appropriations on Crystal Springs are shown on Exhibit N, which is derived from the IDWR water rights database. These cumulative appropriations have been adjusted to remove rights I understand to be served by return flows from other rights on the springs. Cumulative appropriations on Crystal Springs exceeded the natural discharge of the spring in 1969. From the curves shown on Exhibit N I would conclude that all water rights on Crystal Springs with priority dates later than July 8, 1969 are wholly appropriations of flows resulting from incidental recharge from surface water irrigation.

38. Cumulative appropriations on Clear Lakes spring and are shown on Exhibit O, which is derived from the IDWR water rights database. These cumulative appropriations have been adjusted to remove rights I understand to be served by return flows from other rights on the springs. Cumulative appropriations on Clear Lakes spring exceeded the natural discharge of the spring in 1966. From the curves shown on Exhibit O I would conclude that all water rights on Clear Lakes spring with priority

dates later than June 23, 1966, are wholly appropriations of flows resulting from incidental recharge from surface water irrigation.

39. At about the same time that spring discharges in the Thousand Springs Reach reached their maximum levels, changes in surface water irrigation practices began to diminish the amount of incidental recharge to the ESPA. Principal among these changes in irrigation practice were the conversion from flood irrigation to sprinklers and the cessation of winter diversions in connection with the Palisades Reservoir project.

40. In PP 1408-C, Kjelstrom notes that by the 1970s about 20 percent of surface water irrigation distribution systems had converted from flood and furrow application methods to sprinkler application methods and that this conversion reduced deep percolation to the aquifer.

41. In 1981 the University of Idaho published (Hamilton, et.al., 1981) the results of a survey of the responses of irrigators to the severe drought of 1977. The survey found that between 18 and 25 percent of irrigators in counties on the Eastern Snake River Plain had installed sprinkler systems, that about 10 percent had added gated pipe, and that between 5 and 9 percent had lined ditches as a result of the 1977 drought. All of these measures could be expected to reduce incidental recharge to the ESPA.

42. Information provided to the IDWR by the North Side Canal Company in connection with the 2005 delivery call of the Surface Water Coalition shows that in 2004 sprinklers were the primary method of water application on 88 percent of the North Side service area.

43. In October of 1946, the U.S. Bureau of Reclamation (USBR) published a planning report for the Palisades Reservoir Project (USBR, 1946). In its submittal of the report to the Secretary of the Interior, the Commissioner of Reclamation stated that the full benefit of the Project could only be realized if surface water users would enter into agreements to stop "wasteful non-irrigation season diversions" thereby saving 435,000 acre-feet for storage in the Project. Winter water savings agreements

were subsequently negotiated with many canal companies that divert from the Snake River, including the North Side Canal Company. Construction of the Palisades Reservoir Project began in 1951.

44. The Palisades Winter Water Savings agreements went into operation in 1961 and generally required participating canal companies to cease diversions in the months of November through March. Exhibit P is derived from diversion records maintained by the IDWR and shows the historical November through March diversions of the North Side Canal Company. The onset of the Winter Water Savings Program is clearly evident in this diversion record.

45. Irrigation requirements on Eastern Snake River Plain are negligible in the months of November through March. Other than minor amounts of consumption for domestic and livestock uses, it is reasonable to assume that nearly all of the historical winter diversions of the North Side Canal Company (and others) contributed to recharge of the ESPA. Based on Exhibit P, the Winter Water Savings of the North Side Canal Company alone may have reduced recharge to the ESPA by more that 150,000 acre-feet per year. The winter diversion reductions of just five canals (North Side, Anderson, Great Western/Porter, Idaho, and Twin Falls) come to approximately 370,000 acre-feet per year. In all, 40 companies hold Palisades Winter Water Savings contracts.

46. In the year 2000, the IDWR embarked on the development of a new ground water model of the ESPA. I have participated in this development process as a member of the Modeling Committee, providing modeling oversight and direction to the IDWR and the IWRRI. A fully calibrated version of this model, known by the acronym ESPAM (Eastern Snake Plain Aquifer Model) became available for use in 2004.

47. The ESPAM is a regional-scale ground water model. While it was developed using accepted scientific and engineering approaches and utilized extensive data sets of water uses, flows, and reach gains, it cannot be relied upon to accurately predict the changes in flows of specific springs that might result from administrative curtailment or other water management activities.

48. In November 2004, the IDWR and IWRRI completed an ESPAM scenario evaluating the hydrologic effects of changes in surface water irrigation practices (Contor, et.al., 2004). In this model scenario, the simulated spring discharges associated with surface water irrigation practices of the 1950s were compared to the simulated spring discharges associated with surface water irrigation practices of the model calibration period, 1980-2002. Under 1950s irrigation practices, the model results showed spring discharges in the Thousand Springs Reach to be 1,019 cfs greater than under the 1980-2002 irrigation practices. In other words, the effect of increased surface water use efficiency and reduced surface water diversions was to reduce overall spring discharge in the Thousand Springs Reach by 1,019 cfs. Roughly two-thirds of this effect was concentrated in the reaches containing Blue Lakes spring, Crystal Springs, and Clear Lakes spring.

49. Exhibit Q is the May, 2006, edition of the Oversight Monitor, a periodical prepared by the INL (Idaho National Laboratory) Oversight and Radiation Control Division of the Idaho Department of Environmental Quality. Exhibit Q, citing USGS and IWRRI sources, states that 6 maf of water was removed from storage in the ESPA between 1950 and 1980 as a result of reduced incidental recharge and ground water pumping. It states that another 6 maf of water was removed between 1980 and 2002, with half of that reduction occurring in just the last year of the period as a result of severe drought. Thus, ground water storage in the ESPA was decreased by approximately 12 maf between 1950 and 2002.

50. Kjelstrom estimated that the additions to ground water storage between 1880 and 1950, due to incidental recharge, totaled 24 maf. Given the reductions described in Paragraph 49, I would conclude that at the end of 2002 the ESPA still contained 12 maf of stored water whose origin was incidental recharge from surface water irrigation.

51. If one assumes that the rate of storage reduction evident between 1980 and 2002 has continued to the present day, the amount of water stored in the ESPA would today still be greater than its natural, pre-development level by approximately 10 maf.

52. The average discharge of springs in the Thousand Springs Reach for the 10-year period 1997-2006, based on Exhibit H, is 5,379 cfs. This is approximately 1,300 cfs lower than the average for the peak 10-year period 1946-1955 (Paragraph 25), but approximately 1,300 cfs greater than the average for the 10-year period 1902-1911 (Paragraph 19). This suggests that springs in the Thousand Springs Reach are still today discharging at greater than natural levels as a result of incidental recharge from surface water irrigation.

DATED this 18th day of June, 2007.

CHARLES M. BRENDECKE

SUBSCRIBED AND SWORN TO before me this 18th day of June, 2007,

Notary Public for State of Colorado
Residing at Boulder, Colorado
My Commission Expires: 11/15/2009
Sylvia Grace

Exhibit "A"

HYDROSPHERE
Resource Consultants

Charles M. Brendecke, Ph.D., P.E.

Education:

Ph.D., Civil Engineering, Stanford University, 1979.

M.S., Civil Engineering, Stanford University, 1976.

B.S., Civil Engineering, University of Colorado, 1971.

Public Policy Mediation Training – CDR Associates, 2004.

Years Experience:

With this Firm: 20
With Other Firms: 15

Registration(s) and Membership(s):

Registered Professional Engineer:

State of Colorado, #17578

State of Wyoming, #6960

State of Oklahoma, #21265

State of Idaho, #11896

American Society of Civil Engineers

American Water Resources Association

American Geophysical Union

EXPERIENCE NARRATIVE

Dr. Brendecke has more than 35 years of diverse experience in hydrology, water resources engineering and water resources planning and management. He has directed or contributed to several river-basin water management studies that involved detailed inventories of basin hydrology and water demands, as well as development of planning models to investigate implications of reservoir systems operations and growth in basin water demands. Several of these studies have involved instream flow and endangered species issues. His work as the project manager and lead expert in a variety of water rights proceedings has included historical consumptive use analysis, evaluation of surface/groundwater interactions, stream depletion analysis, development of protective terms and conditions, settlement negotiations, and expert witness testimony.

As a researcher, he has supervised investigations of rainfall and snowmelt frequency in alpine watersheds, comparative applications of rainfall/runoff models, and hydraulic evaluations of stream habitat enhancement measures. Dr. Brendecke was the project manager and principal author for the development of *Achieving Efficient Water Management, A Guidebook for Preparing Agricultural Water Conservation Plans,* for the U.S. Bureau of Reclamation. He has served as a testifying expert in numerous judicial and administrative proceedings including before the U.S. Supreme Court in *Nebraska v. Wyoming* and *Kansas v. Colorado.*

RECENT PROJECT EXPERIENCE

<u>Conjunctive Administration of Ground Water Rights</u>. Project manager and testifying expert for Idaho Ground Water Appropriators, Inc., in proceedings related to administration of surface and ground water rights. Work has involved oversight of regional ground water model development of the Eastern Snake Plain Aquifer, ground water modeling in support of management and mitigation plans, and analysis of historical water use data.

<u>Rio Grande Basin Confined Aquifer Use Rules</u>. Testifying expert for the State of Colorado regarding the use of the RGDSS ground water model in developing rules governing withdrawals from the confined aquifer system of the San Luis Valley.

<u>Columbia River Basin Reservoir Operations.</u> Project manager for studies of the impact of modified reservoir operations on agricultural interests in the Kootenai River basin.

<u>New Mexico Surface Water Studies</u>. Project manager for a program of surface and ground water studies on the Pecos River in support of State initiatives.

<u>Interstate Compact Litigation</u>. Expert witness in litigation between Kansas and Colorado regarding Arkansas River water uses.

<u>Interstate Compact Litigation</u>. Project manager and expert witness in litigation between Nebraska and Wyoming regarding storage project operations and water deliveries to agricultural users on the North Platte River.

Snake River Water Rights. Project manager for studies of historical irrigation practices and modeling of surface/ground water interaction on the eastern Snake River Plain, Idaho.

Rio Grande Decision Support System. Quality assurance officer on development of comprehensive surface water model of the Rio Grande River basin in Colorado.

Agricultural Water Conservation. Project manager for development of a water conservation guidebook for use by irrigation districts. The guidebook describes planning approaches and methods for evaluating specific conservation measures.

Colorado City Metropolitan District. Project manager for water supply planning studies and water rights litigation support for municipal water provider.

Gunnison Basin Planning Model. Project manager for development of an interactive PC-based computer model of the Gunnison River basin. The model uses a network solution algorithm and incorporates a Windows™-based interface.

Boulder Creek Water Rights. Lead expert in a variety of water rights proceedings for the City of Boulder related to applications, changes, and transfers of agricultural rights in the Boulder Creek basin.

Yampa River Basin Planning Studies. Project manager for comprehensive water supply planning study that included demand forecasting, development of a basin computer model, and evaluation of potential water storage project operations.

Snake River Basin Water Supply Study. Project manager for a comprehensive review of water use in the Snake River basin and computer model evaluation of potential water management strategies, including agricultural water conservation, to enhance anadromous fisheries.

Columbus Ditch Transfer. Performed engineering analysis of the historical use of irrigation rights located on the Blue River, determining the portion of consumptive use made possible by Green Mountain Reservoir releases.

Muddy Creek Water Rights. Analyzed the historical consumptive use of the irrigation water rights associated with the Gary Hill Ranch on Muddy Creek, in support of water rights acquisition associated with the construction of Muddy Creek Reservoir.

Summit County Small Reservoir Study. Project manager for a Blue River basin water management study involving development of a hydrologic model and evaluation of new storage facilities for instream flow maintenance.

Gunnison Basin Planning Study. Project manager for development of a detailed hydrology and water rights model of the 8000 square mile Gunnison River basin as part of a comprehensive river basin planning study.

Windy Gap Delivery Study. Developed detailed computer models of Colorado-Big Thompson Project operations to support analysis of the yields of the Windy Gap Project, which shares common facilities.

Superconducting Super Collider Water Supply. Determined industrial water needs and developed the water supply strategy for a proposed Department of Energy physics research facility.

Boulder Raw Water Master Plan. Prepared a comprehensive report concerning water rights holdings and water supply system operating policies for a Front Range municipality of 100,000 persons.

Standley Lake Pollutant Loading. Developed hydrologic and pollutant loading model of Standley Lake to assess relative effects of non-point sources and a proposed effluent exchange by a major industrial water user.

Pecos River Compact. Consultant to the Special Master of the U.S. Supreme Court on technical issues in a lawsuit between Texas and New Mexico concerning river depletions and water deliveries.

Rocky Ford Ditch Transfer. Performed engineering analyses of historic irrigation practices and Arkansas River depletions associated with a 4100-acre tract in southeastern Colorado.

Buena Vista Water Rights. Analysis of the historic use of irrigation water rights and development of engineering data supporting their transfer to municipal use.

Dillon Clean Lakes Study. Development of a comprehensive hydrologic monitoring network to determine lake inflow patterns and non-point source pollutant loadings from various land uses.

Restoration of West Tenmile Creek. Performed hydrologic and hydraulic analysis and design of comprehensive stream habitat improvements at Copper Mountain ski area.

EMPLOYMENT HISTORY

1986-present Principal and President (1990 to present), Hydrosphere Resource Consultants, Inc. Responsible for management of engineering studies, company development and management, consultant on water rights and water resources planning projects.

1985-1986 Senior Project Engineer, Wright Water Engineers Inc. Responsible for engineering analysis and report preparation on water rights and hydrologic studies.

1979-1985 Assistant Professor of Civil Engineering, University of Colorado. Responsible for teaching and research in areas of water resources and systems analysis.

Faculty Research Associate, Institute for Arctic and Alpine Research. Directed various research studies in alpine hydrology and meteorology.

Consultant, U.S. Army Corps of Engineers; Western Environmental Analysts, Inc.; Dietze & Davis, P.C.; Copper Mountain, Inc.; Hydrologic Consulting Engineers, Inc.; Westfork Investments, Ltd.

1975-1979 Research Assistant and Lecturer, Stanford University. Responsible for conducting research and lecturing for undergraduate courses in civil engineering.

1973-1975 Design Engineer, Wright-McLaughlin Engineers, Inc. Performed engineering design of water supply and wastewater collection systems.

1971-1973 Design Engineer, Ministry of Agriculture, Government of Kenya (U.S. Peace Corps). Performed planning and design of rural domestic water supply systems.

REPORTS AND PUBLICATIONS

Brendecke, C., 2004, "Toward Conjunctive Management of the Eastern Snake Plain Aquifer," poster presentation at Natural Resources Law Center 25th Summer Conference Groundwater in the West, June 16-18, Boulder, CO.

Brendecke, C., 2004, "Interstate Water Conflict: Compacts, Adjudications and Decrees," presentation at Water Policy Seminar: Freshwater Conflicts in the United States, May 19, Stanford, CA.

Brendecke, C., and R.D.Tenney, 2001, "Water Rights, Compact Entitlements and Endangered Fishes of the Yampa River Basin," Proceedings of the Annual Water Resources Conference, American Water Resources Association, November 12-15, Albuquerque, NM.

Brendecke, Charles M., 2001, "Conjunctive Management: Science or Fiction?" presentation to Idaho Water Users Association 18th Annual Water Law and Resource Issues Seminar, November 8-9, Boise, ID.

Tenney, Ray D., and C.M. Brendecke, 1998, "Planning for Water Development and Endangered Species Recovery in the Yampa River Basin." Proceedings of the Wetlands Engineering & River Restoration Conference, 1998, American Society of Civil Engineers, March 26th, 1998, Denver, CO.

Payton, E., C. Brendecke, B. Harding, E. Armbruster, T. McGuckin and C. Huntley. 1997. "Agricultural Water Conservation Planning & Pricing-Tools & Technologies." Proceedings of the Irrigation Association's 18th International Conference, Nov. 2, 1997, Nashville, TN.

Hydrosphere Resource Consultants, Inc., 1996, "Achieving Efficient Water Management: Agricultural Water Conservation Planning," workshop for U.S. Bureau of Reclamation staff, Dec. 16 - 18, Las Vegas, NV.

Brendecke, C., B. Harding and E. Payton, 1996, "PC-Based Decision Support Tools: Lessons from a Dozen Applications," Proceedings of the Fifth Water Resources Operations Management Workshop, Water Resources Planning and Management Division (ASCE). March 4, Arlington, Virginia.

Howe, C.W., M. Smith, L. Bennett, C. Brendecke, J. Flack, R. Hamm, R. Mann, L. Rozaklis, and K. Wunderlich, 1994, "The Value of Water Supply Reliability in Urban Water Systems," Journal of Environmental Economics and Management, 26, 19-30.

Brendecke, C., 1993, "Managing Snake River Operations for Juvenile Salmon Migration," Proceedings of the ASCE Water Resource Planning and Management Conference Division 20th Anniversary Conference, Seattle, Washington, May.

Brendecke, C., 1992, "The Hydrosphere Snake River Operations Model", 9th Annual Water Law and Resource Issues Seminar, Idaho Water Users Association, Boise, Idaho.

Brendecke, C., and B. Harding, 1990, "Logical Intransitivities and Other Administrative Nightmares: Can Models Help?," Proceedings of the 26th Annual AWRA Conference and Symposium, November 4-9, Denver, Colorado.

Harding, B., C. Brendecke, and R. Kerr, 1990, "Legal and Economic Disincentives in the Transfer of Models to Users," Proceedings of the 26th Annual AWRA Conference and Symposium, November 4-9, Denver, Colorado.

Brendecke, C., W. DeOreo, E. Payton, and L. Rozaklis, 1989, "Network Models of Water Rights and System Operations," Journal of the Water Resources Planning and Management Division (ASCE).

Rozaklis, L., E. Payton, C. Brendecke, and B. Harding, 1988, "Modeling Water Allocation Problems Under Complex Hydrologic and Institutional Settings," paper presented at the 24th Annual AWRA Conference and Symposium, November 8, Milwaukee, Wisconsin.

Brendecke, C., W. DeOreo, and L. Rozaklis, 1987, "Water Rights Analysis and System Operation Using Network Optimization Models," paper presented at the 14th Annual ASCE Water Resources Planning and Management Division Conference, March 16-18, Kansas City.

Brendecke, C., E. Payton, and R. Wheeler, 1987, "Network Optimization Models for Water Rights Analysis and System Operating Studies for the City of Boulder," Proceedings of the Colorado Water Engineering and Management Conference, February 17-18, Ft. Collins, Colorado.

Payton, E., and C. Brendecke, 1985, "Rainfall and Snowmelt Frequency in an Alpine Watershed," Proceedings of the 53rd Western Snow Conference, April 16-18, Boulder, Colorado, pp. 25-36.

Brendecke, C., and J. Sweeten, 1985, "A Simulation Model of Boulder's Alpine Water Supply," Proceedings of the 53rd Western Snow Conference, April 16-18, Boulder, Colorado, pp. 63-71.

James, E., and C. Brendecke, 1985, "The Redistribution and Sublimation Loss of Snowpack in an Alpine Watershed," Proceedings of the 53rd Western Snow Conference, April 16-18, Boulder, Colorado, pp.148-151.

Brendecke, C., D. Laiho, and D. Holden, 1985, "Comparison of Two Daily Streamflow Simulation Models of an Alpine Watershed," Journal of Hydrology, 77, pp. 171-186.

Brendecke, C., D. Laiho, and J. Sweeten, 1984, "Management of a Municipally Owned Alpine Watershed Using Continuous Simulation," Proceedings of the 11th International Symposium on Urban Hydrology, Hydraulics, and Sediment Control, July 23-26, Lexington, Kentucky, pp. 79-87.

Lewis, W., D. Crumpacker, J. Saunders, and C. Brendecke, 1984, Eutrophication and Land Use, Ecological Studies Vol. 46, Springer-Verlag, New York, 202 pp.

Brendecke, C., D. Laiho, and D. Holden, 1984, "A Comparative Evaluation of Streamflow Simulation Models in a Colorado Alpine and Subalpine Environment," Proceedings of the American Geophysical Union Front Range Branch Hydrology Days, April 24-26, Ft. Collins, Colorado, pp. 40-55.

Baker, F., and C. Brendecke, 1983, "Seepage from Oilfield Brine Disposal Ponds in Utah," Groundwater, 21(3), pp. 317-324.

Brendecke, C., and L. Ortolano, 1981, "Environmental Considerations in Corps Planning," Water Resources Bulletin, 17(2), pp. 248-254.

Exhibit "B"

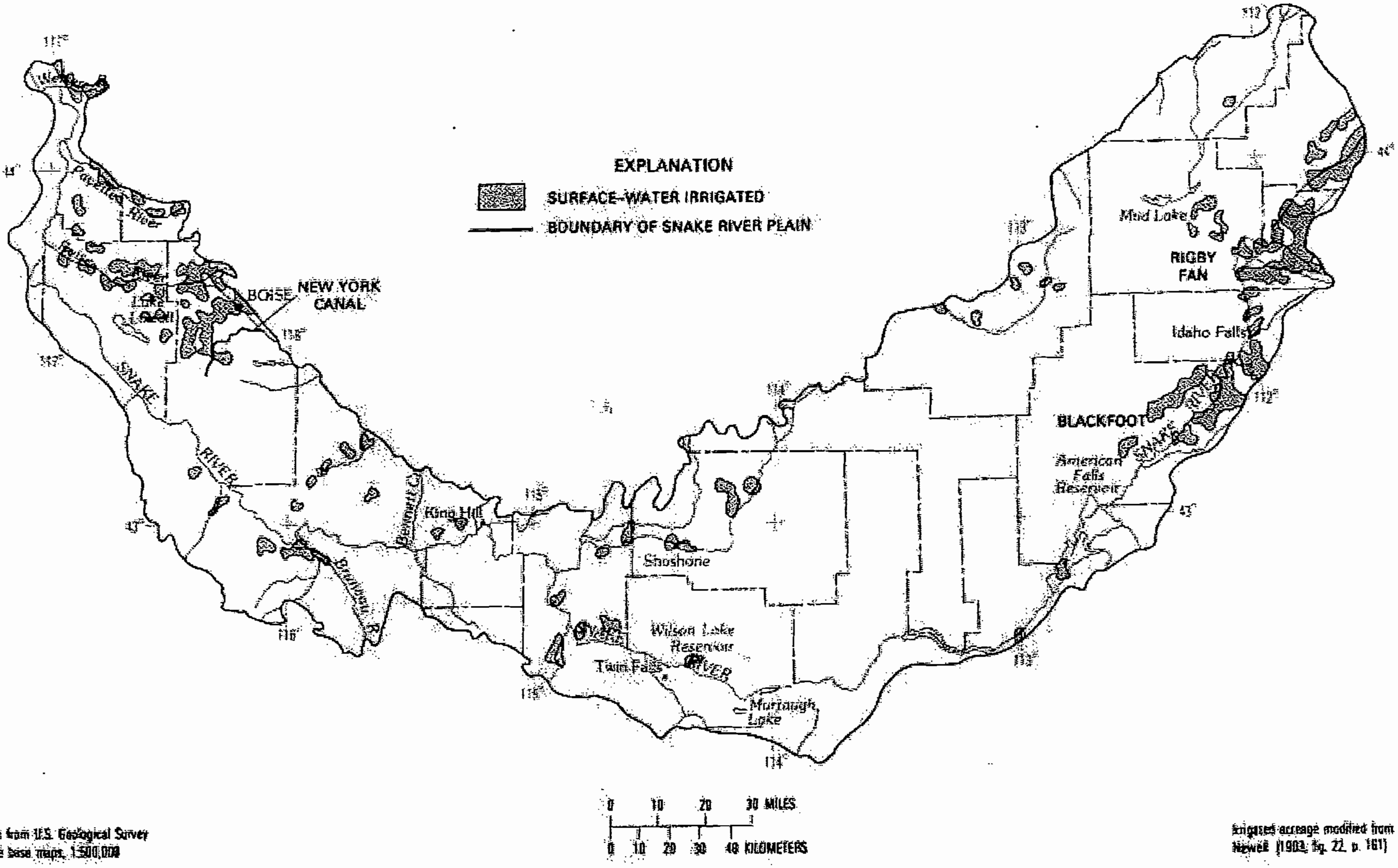


FIGURE 7.—Irrigated acreage, 1899.

Source: Goodell, 1988

Exhibit No. B

Exhibit "C"

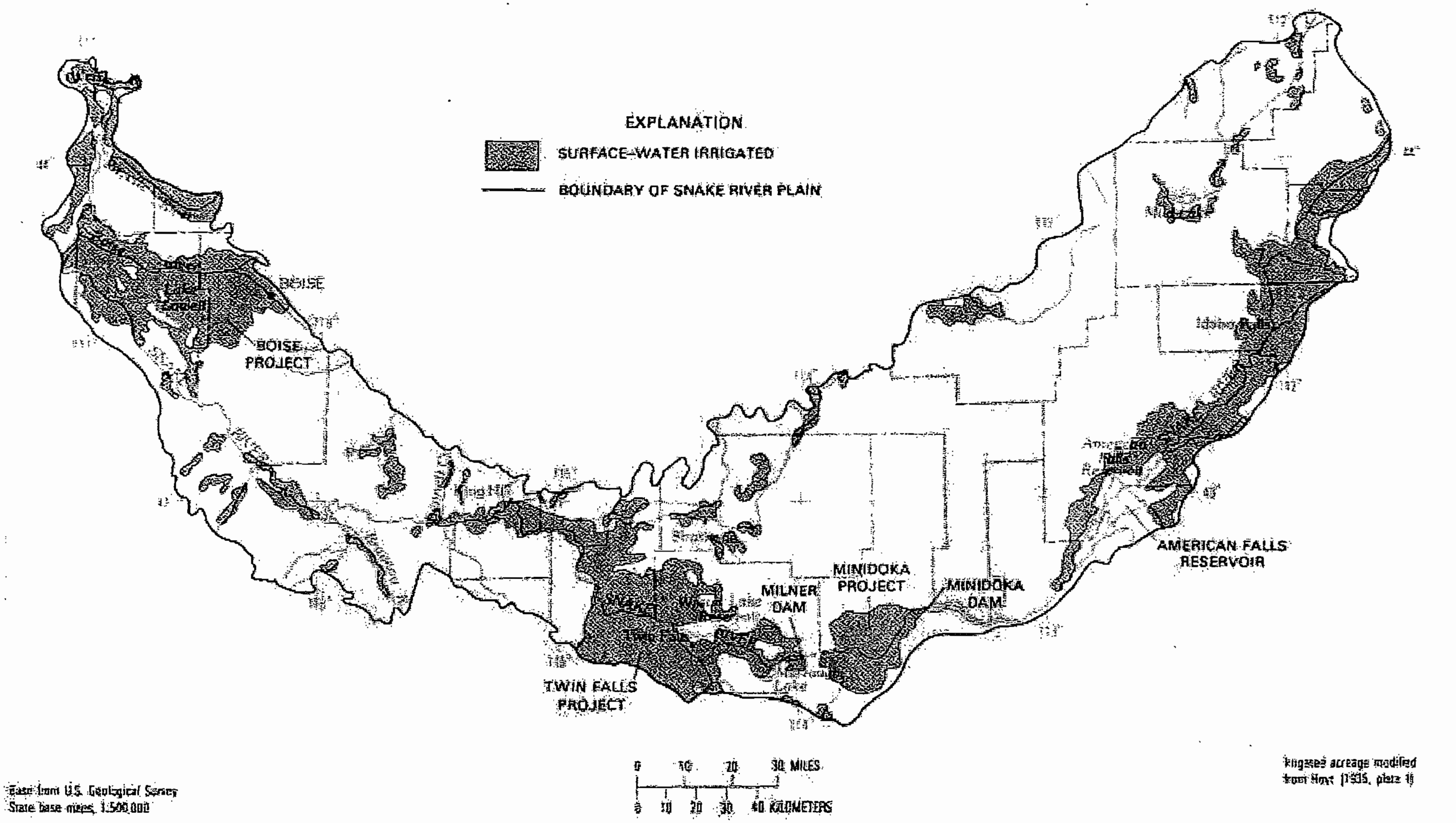


FIGURE 8.—Irrigated acreage, 1929.

Source: Goodell, 1988

Exhibit No. C

Exhibit "D"

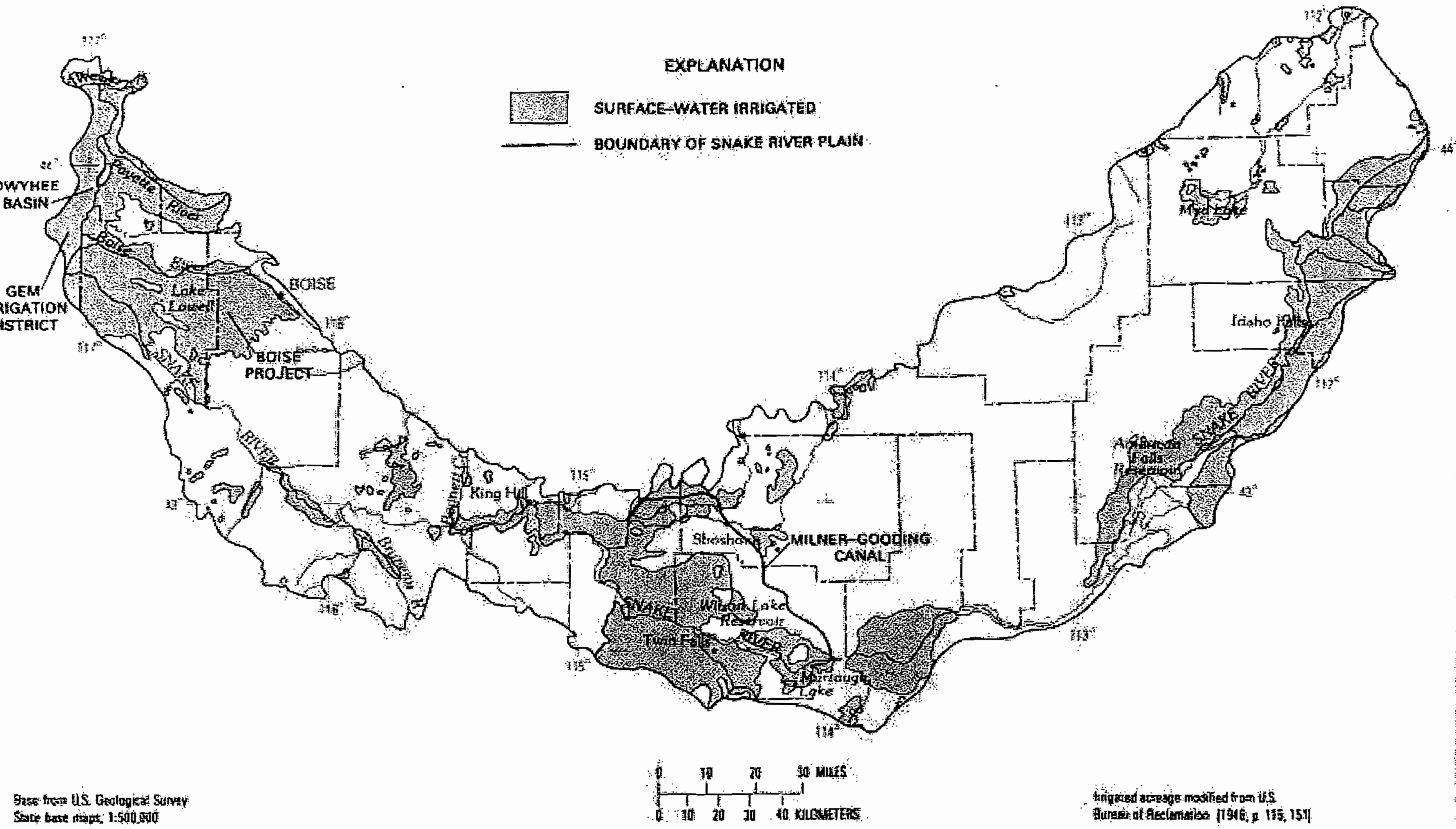


FIGURE 9.—Irrigated acreage, 1945.

Source: Goodell, 1988

Exhibit No. D

Exhibit “E”

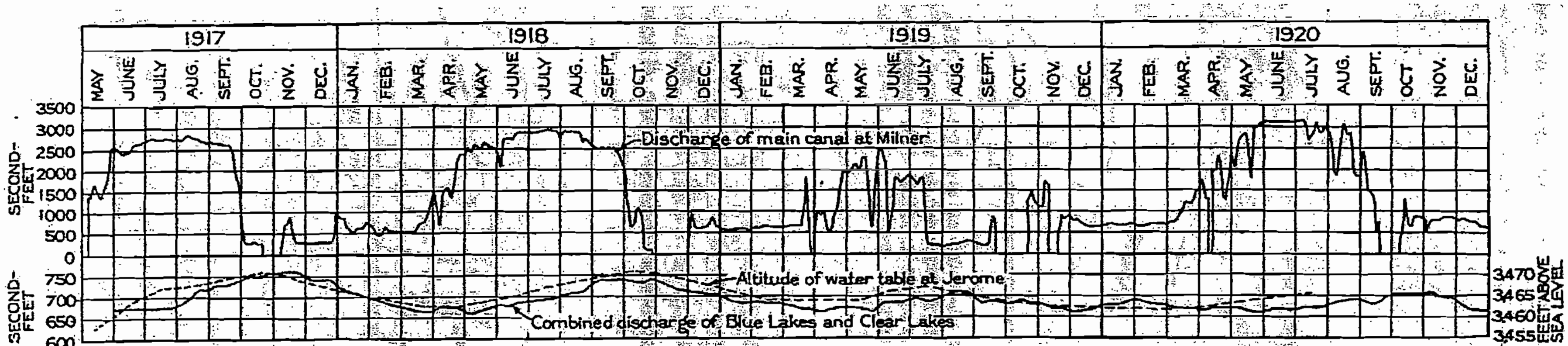


FIGURE 13.—Fluctuations in the discharge of two large springs on Snake River, Idaho (Blue and Clear Lakes), in relation to the quantity of irrigation water placed upon the upland back of these springs and to the fluctuations of the water table at Jerome, Idaho, on the upland. Diagram prepared by the engineering department of the Twin Falls North Side Land & Water Co.

Source: Meinzer, 1927

Exhibit No. E

Exhibit "F"

Spring Discharges Observed April 15-28, 1902

Spring	Discharge (cfs)
Blue Lakes	86.37
Crystal	306.7
Clear Lakes	150
Grand Total*	3832.6

* all observations, includes south side springs

Source: Nace, et.al, 1958

Exhibit No. F

Exhibit "G"

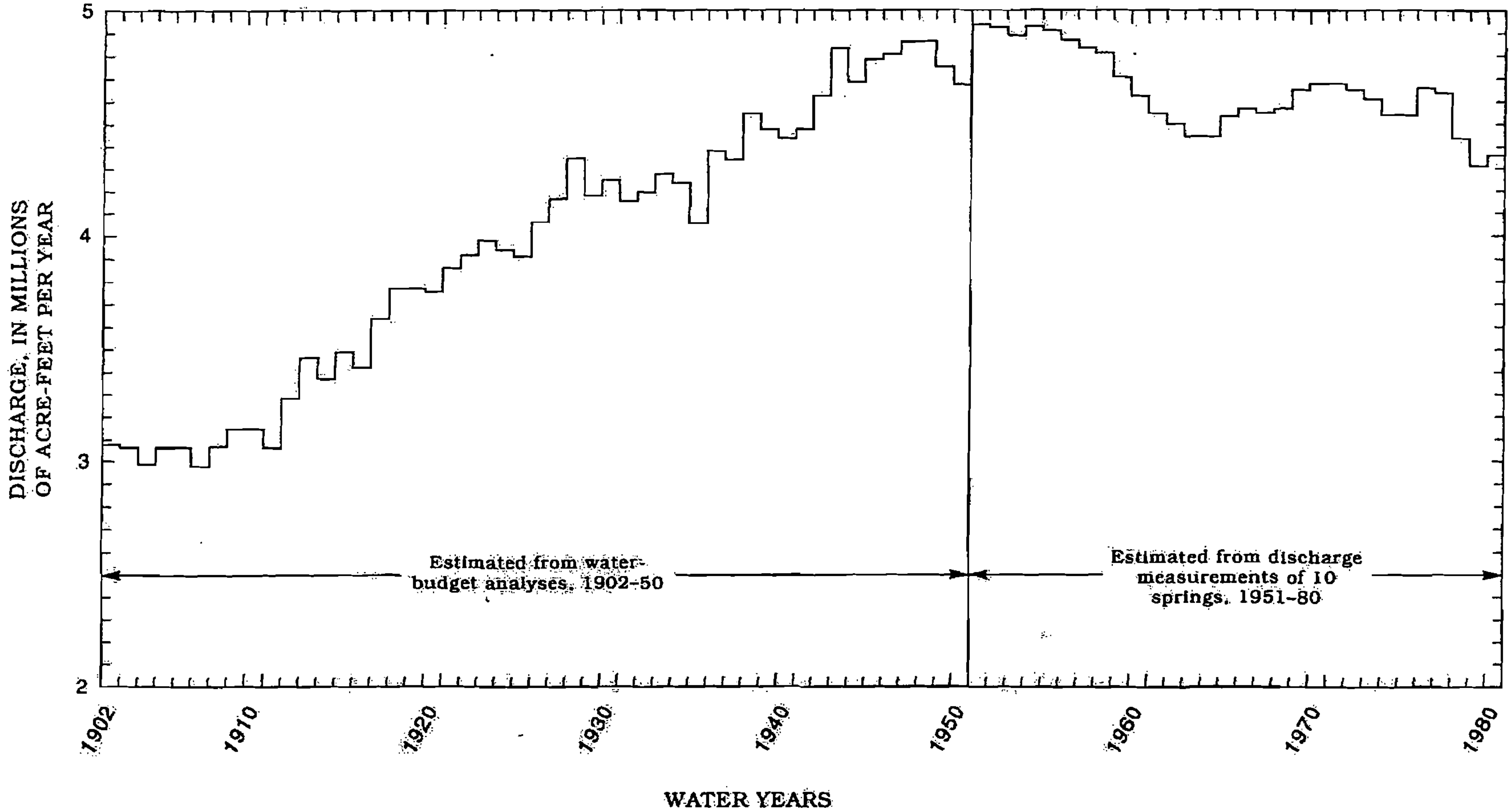


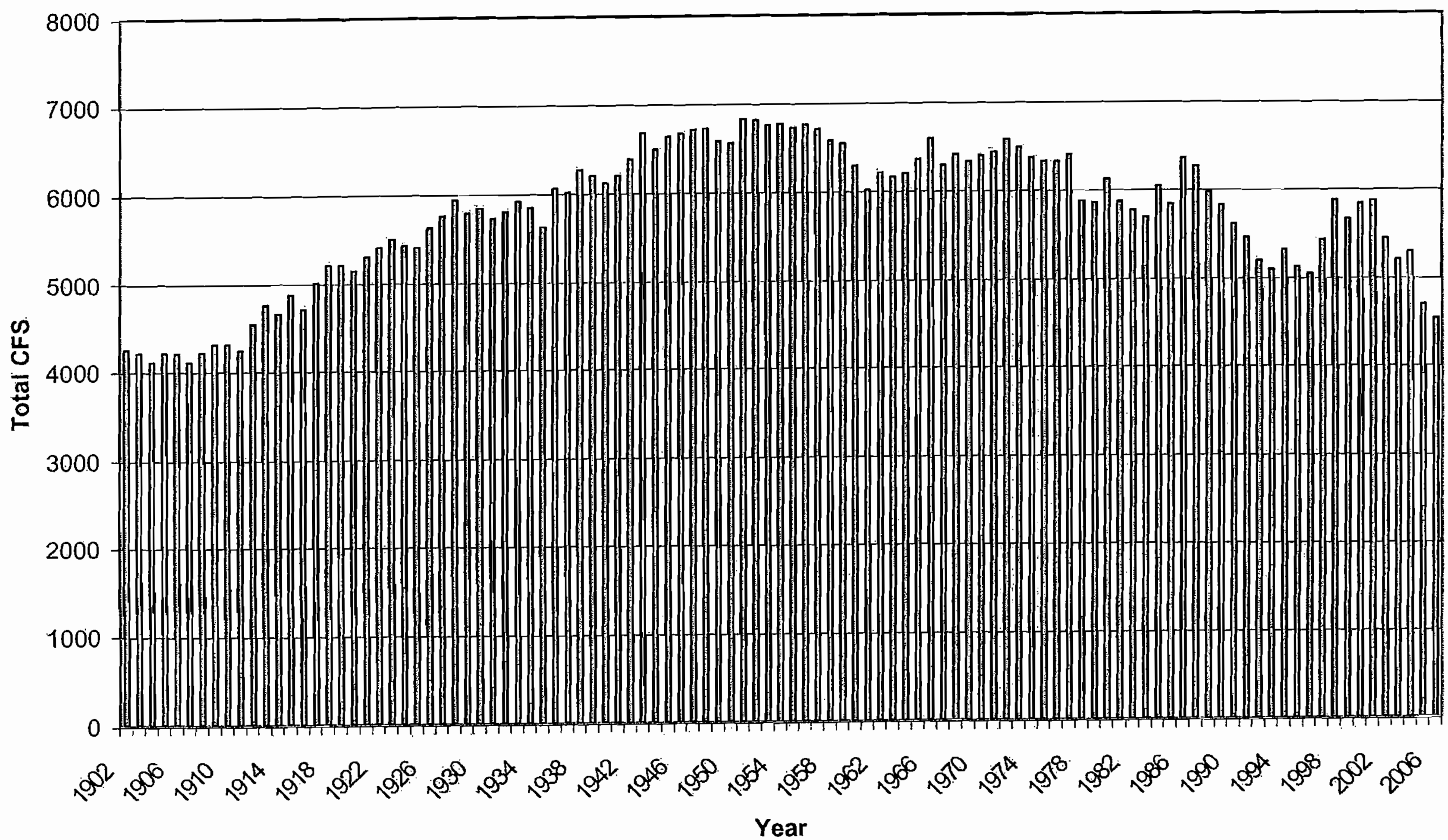
FIGURE 27.—Annual ground-water discharge from the north side of the Snake River between Milner (site 9) and King Hill (site 13), water years 1902–80.

Source: Kjelstrom, 1995

Exhibit No. G

Exhibit "H"

Average Annual Spring Discharge to Snake River Between Milner and King Hill



Source: IDWR

Exhibit No. H

Exhibit "I"

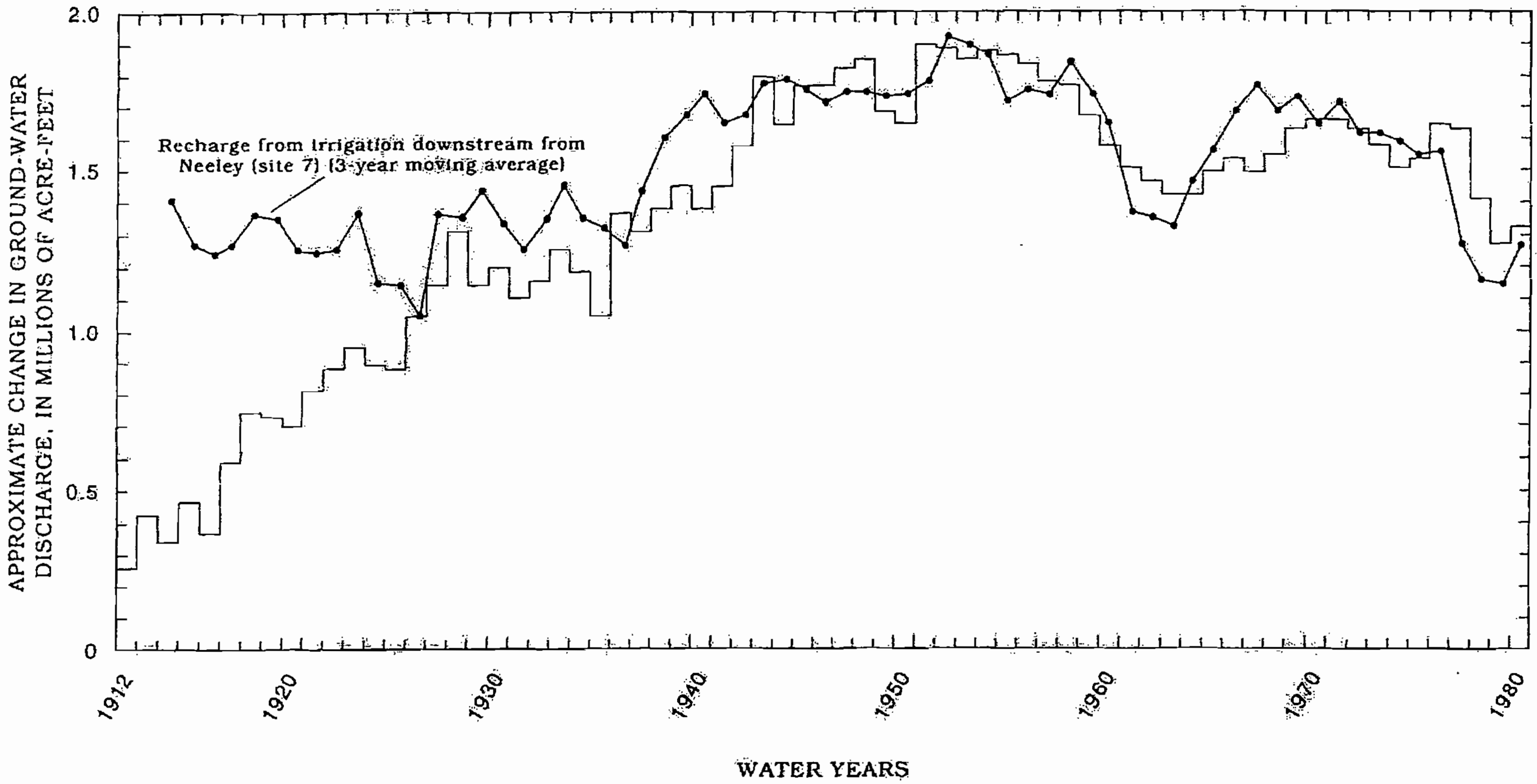


FIGURE 41.—Approximate change in ground-water discharge to the north side of the Snake River, from estimates in 1911, between Milner (site 9) and King Hill (site 13), water years 1912–80.

Source: Kjelstrom, 1995

Exhibit No. I

Exhibit “J”

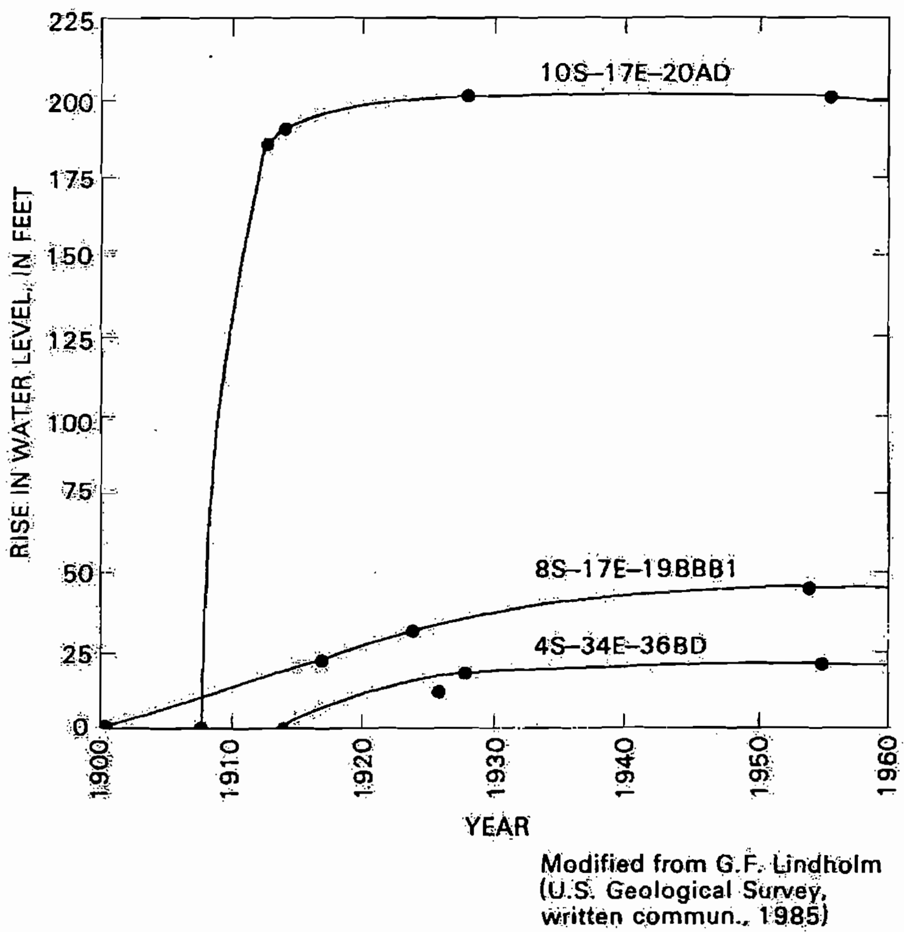


FIGURE 23.—Water-level rises in three wells, 1900–1960.

Source: Goodell, 1988

Exhibit No. J

Exhibit "K"

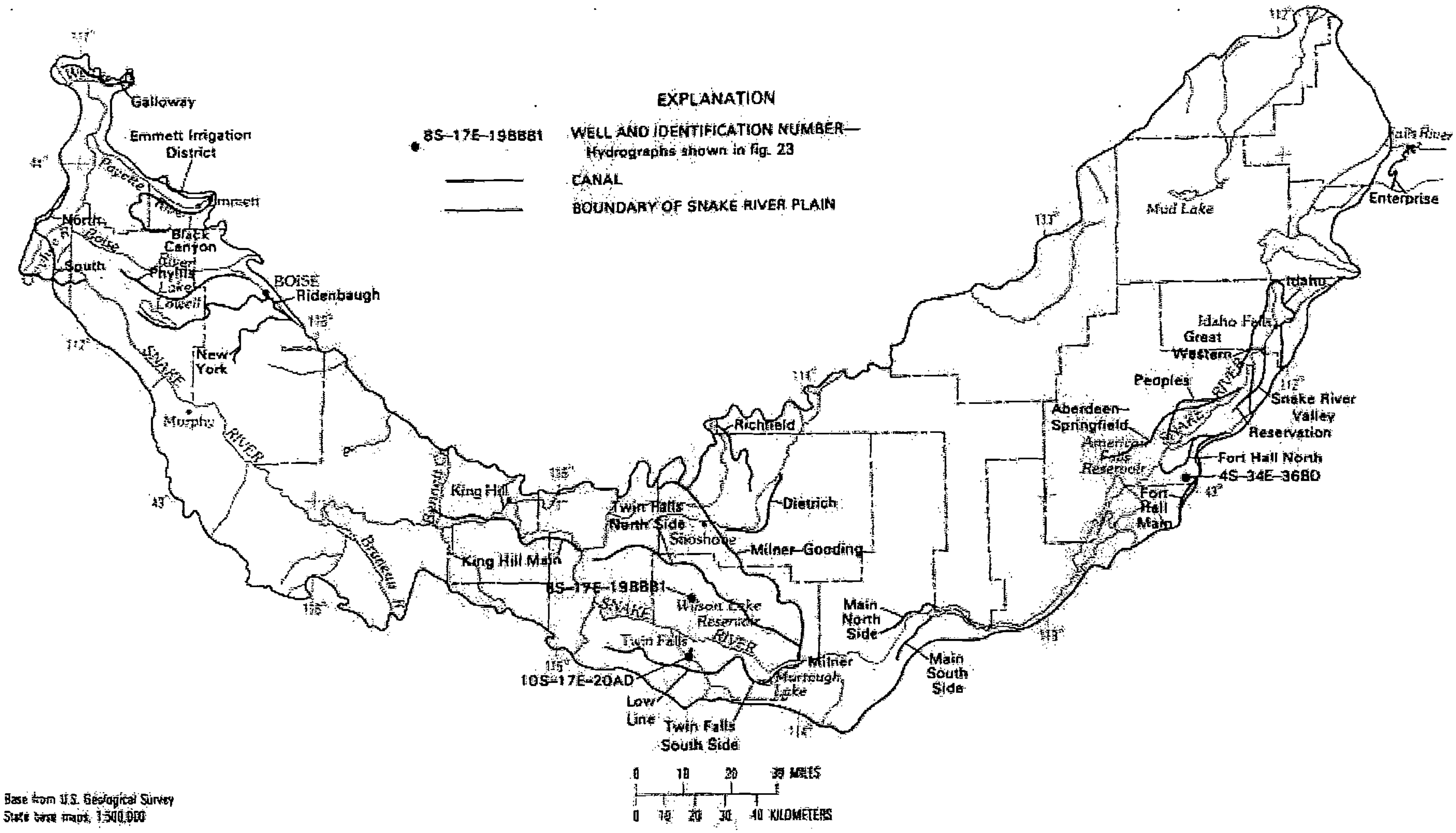


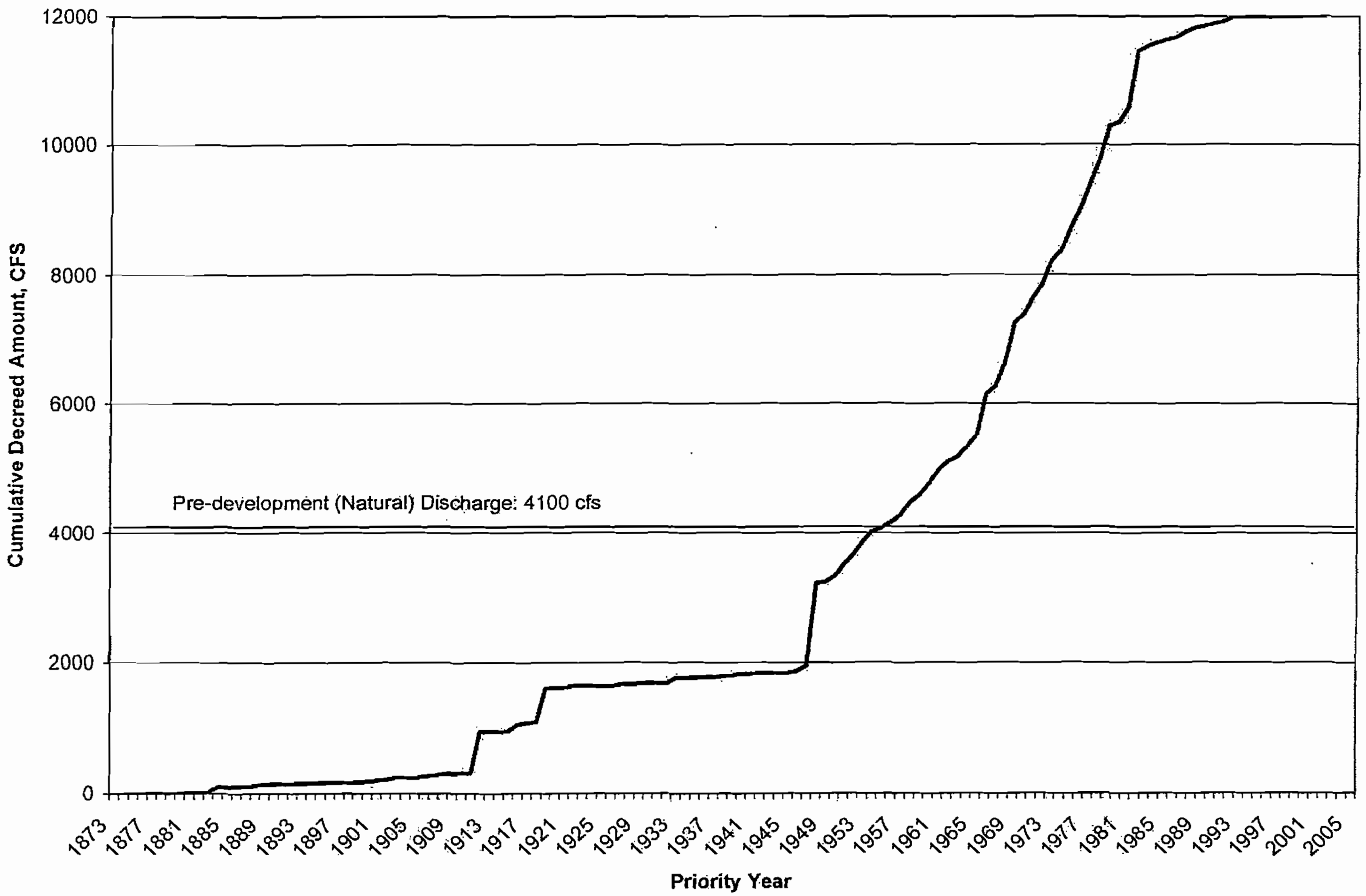
FIGURE 15.—Locations of major canals.

Source: Goodell, 1988

Exhibit No. K

Exhibit "L"

Cumulative Appropriations on Spring Sources
North Side of Snake River
Milner to King Hill

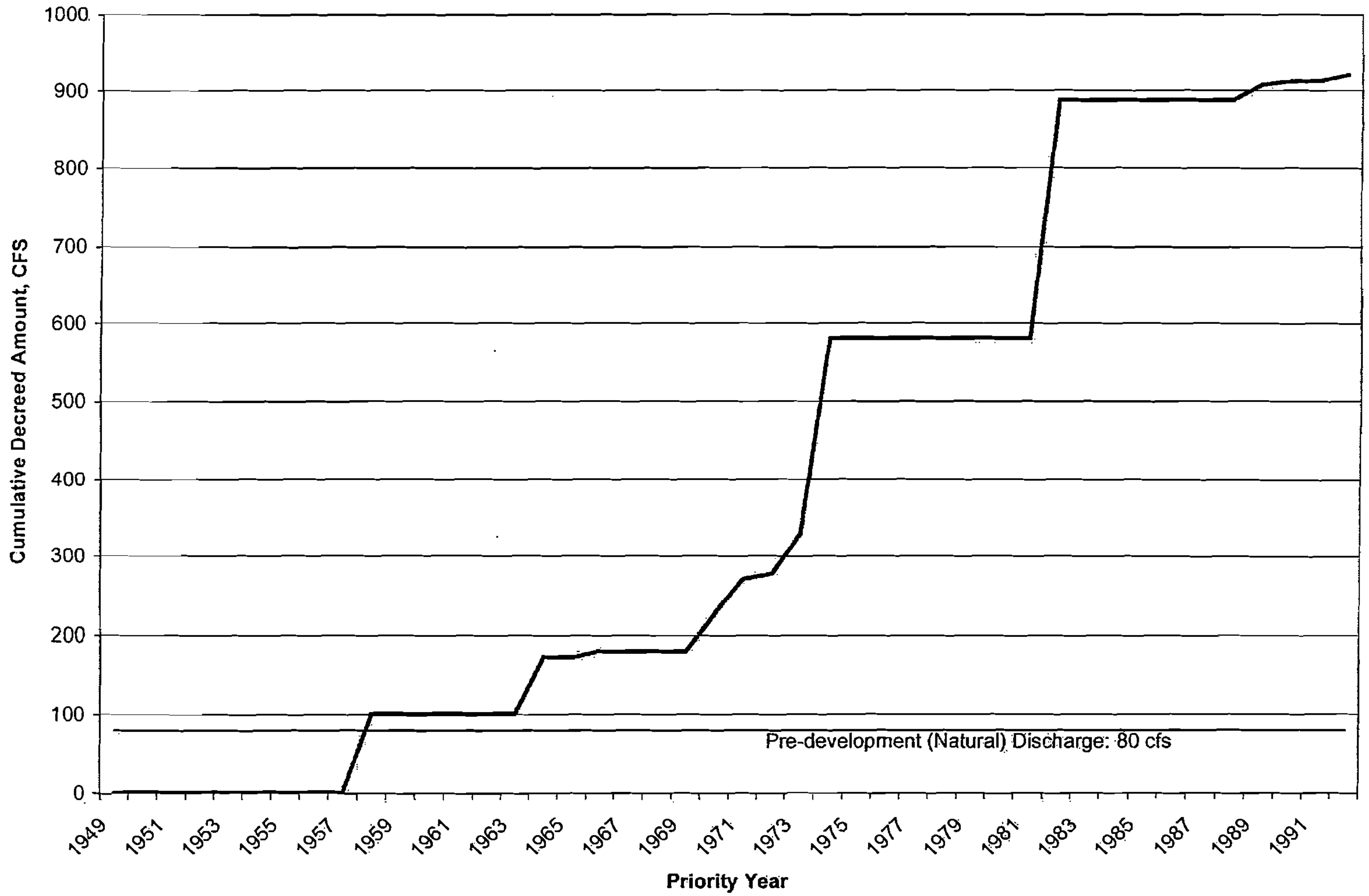


Source: IGWR; USGS

Exhibit No. L

Exhibit "M"

Cumulative Appropriations on Blue Lake Springs

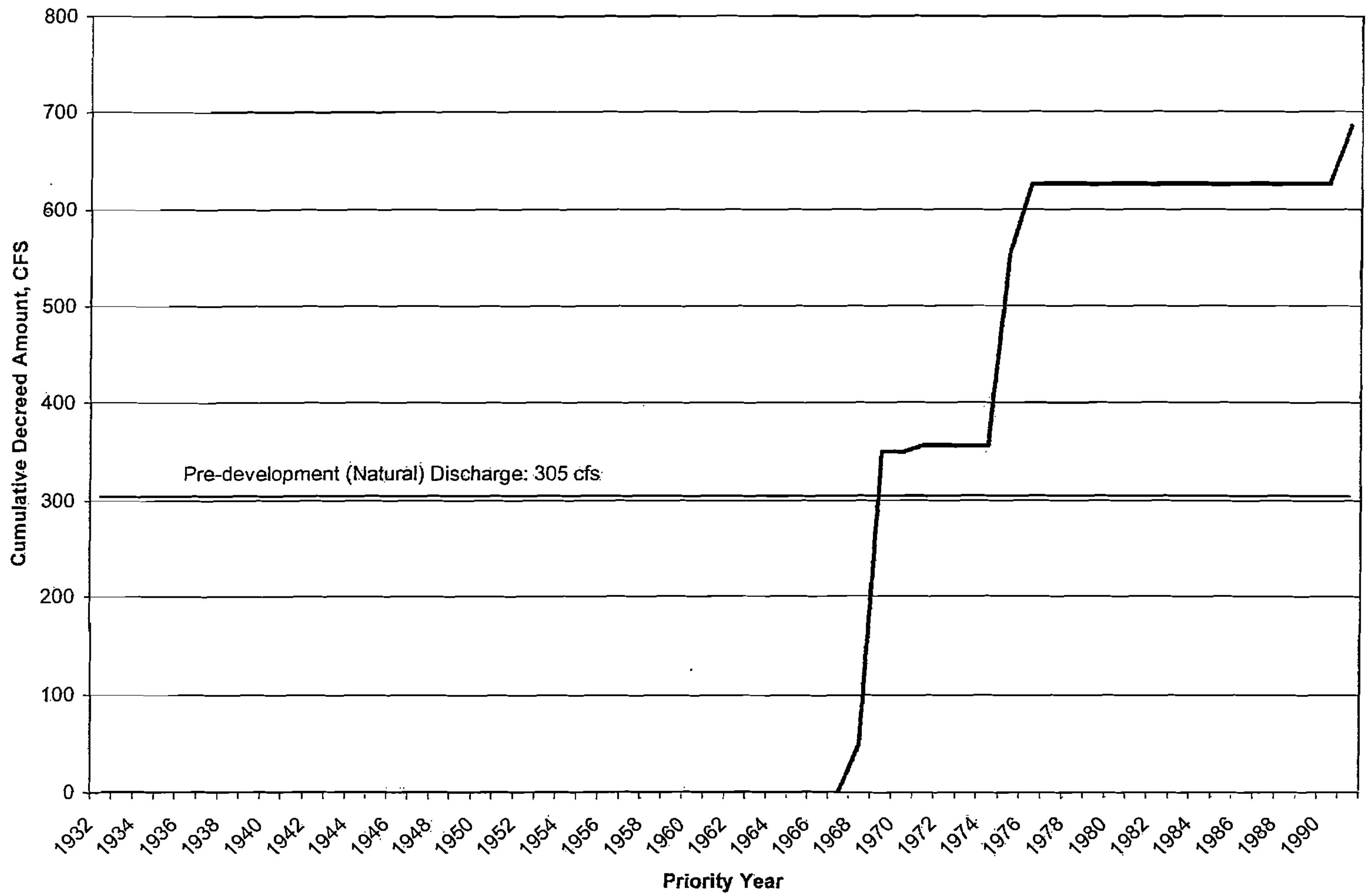


Source: IGWR; USGS

Exhibit No. M

Exhibit "N"

Cumulative Appropriations on Crystal Springs

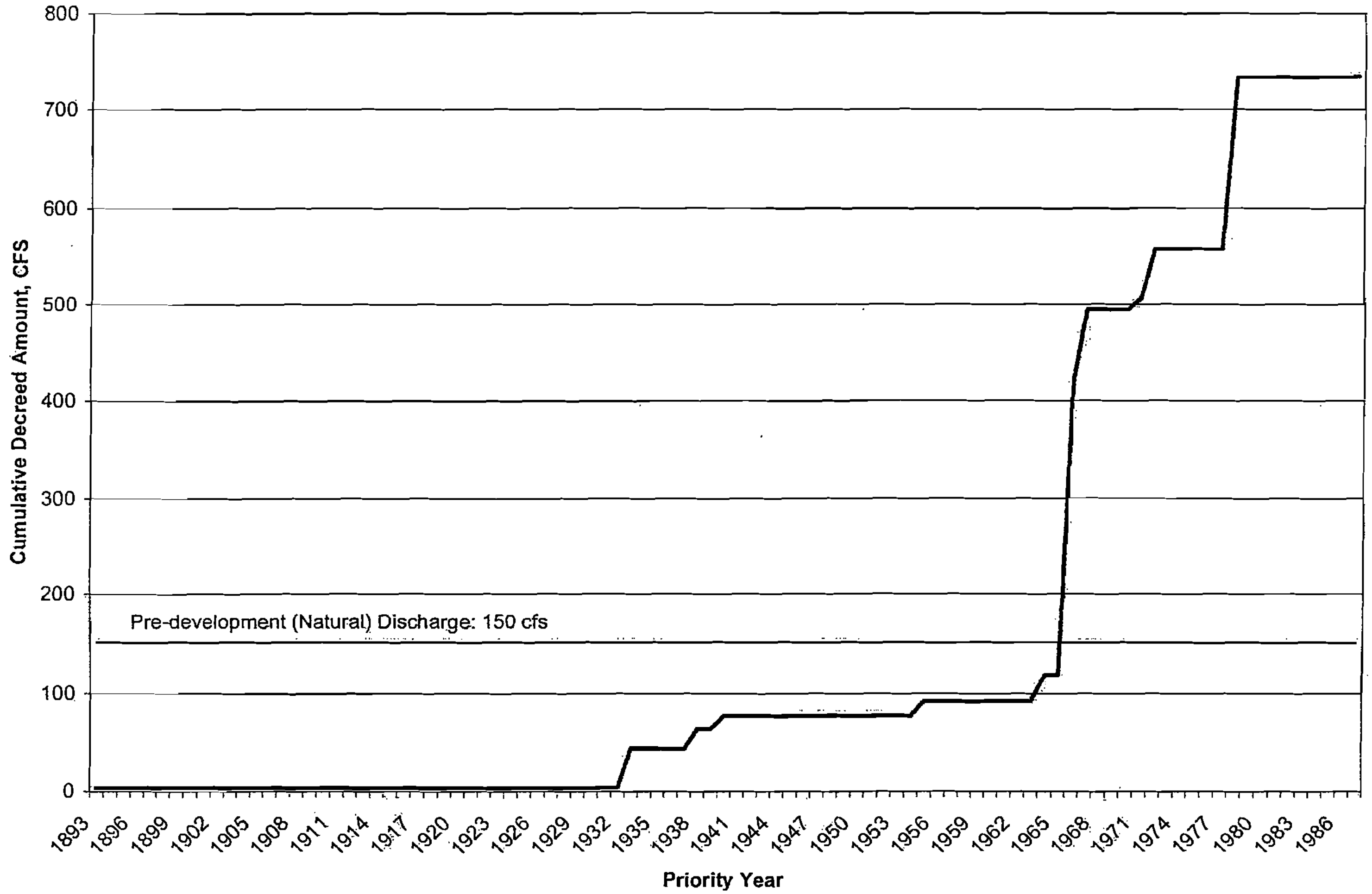


Source: IGWR; USGS

Exhibit No. N

Exhibit "O"

Cumulative Appropriations on Clear Springs

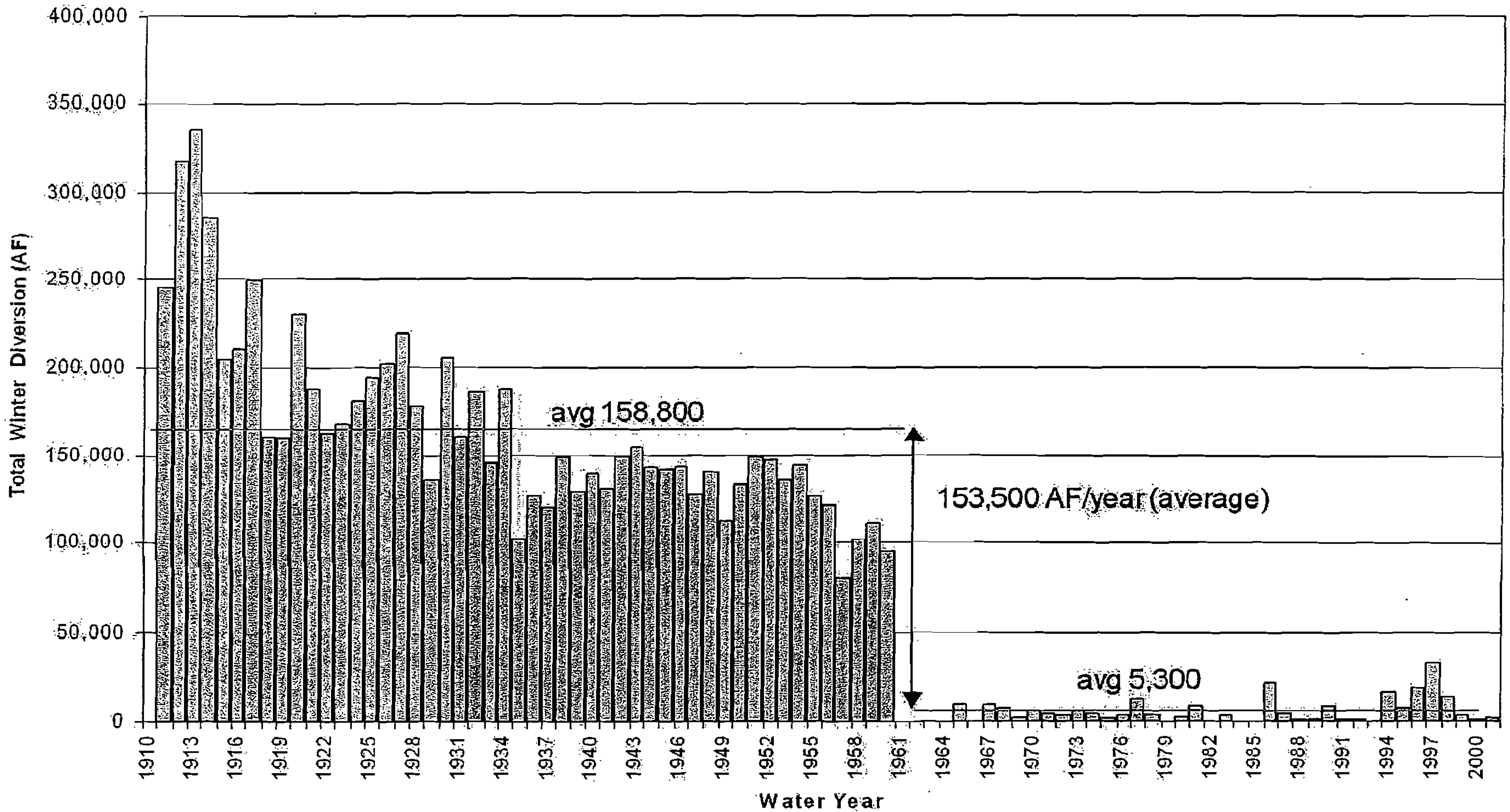


Source: IGWR; USGS

Exhibit No. O

Exhibit "P"

Historical Winter (Nov-Mar) Diversions, North Side Canal at Milner



Source: IGWR data

Exhibit No. P

Exhibit "Q"

State of Idaho Oversight Monitor

The Eastern Snake River Plain Aquifer
March 2006

our changing AQUIFER

On the volcanically unique Eastern Snake River Plain, just like elsewhere, water flows from high country to low, channeled into streams, lakes, and rivers. But in the portion of the plain occupied by the Idaho National Laboratory (INL), rivers don't all flow to the ocean. Instead, something dramatically different happens. Streams like the Big and Little Lost Rivers simply disappear.

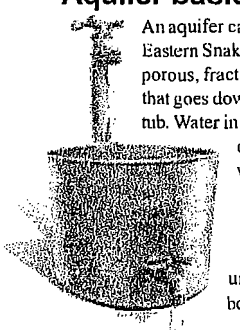
Here, where sediments deposited by the actions of wind and water overlay porous layers of basalt, rivers and streams disappear, losing their water to the Eastern Snake River Plain Aquifer. Decades later, the same water will reappear in the Magic Valley, issuing from the "Thousand Springs" stretch of the Snake River along the north canyon wall between Milner and King Hill.

The Lost River and the fascinating springs of the Magic Valley are but two features of the remarkable Eastern Snake River Plain Aquifer, which is not only the focus of this issue of the Oversight *Monitor*, but the primary reason that the INL Oversight Program exists.

Concern about how activities conducted at Idaho's nuclear laboratory affect the aquifer was the driving force behind the formation of a state oversight program. No matter what issue we're considering, we're thinking about the aquifer—when we're talking about building a nuclear reactor at the site, removing waste buried in pits and trenches, closing buildings that aren't needed any more—whatever it is, to Oversight, it is about Idaho's precious resource, the Eastern Snake River Plain Aquifer.

As we struggle to find the appropriate balance between competing demands for our state's finite water resources, it makes sense to begin with the source of much of Idaho's water: the Eastern Snake River Plain Aquifer.

Aquifer basics: the bathtub concept



An aquifer can be thought of as a bathtub—a bathtub that, in the case of the Eastern Snake River Plain Aquifer, consists of thousands of cubic miles of porous, fractured basalt. Water from the faucet **recharges** the tub, water that goes down the drain (or is splashed on the floor) is **discharged** from the tub. Water in the tub is stored until the drain is opened or water is splashed out. When more water is recharged to the tub than drains, the water level in the tub increases and more water is in **storage**.

The Water Balance for an aquifer is:

Recharge – Discharge = Change in storage

We'll first talk about changes in storage because it helps us understand where the recharge to the aquifer stays before it can become discharge.

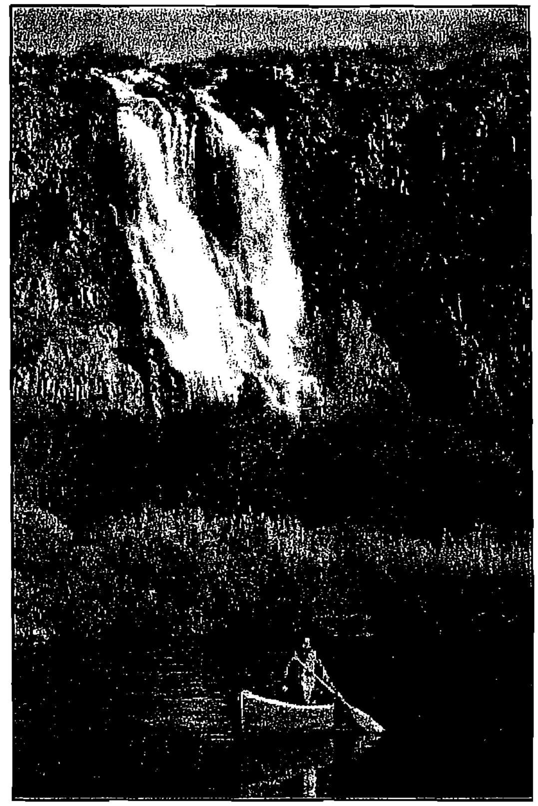
Aquifer Storage

The broken basalt and sediments of the Eastern Snake River Plain Aquifer contain a tremendous amount of water, as much as 1 billion acre-feet. This is enough water to cover the entire 10,800 square miles of the plain with nearly 145 feet of water, about the same amount of water as in Lake Erie.

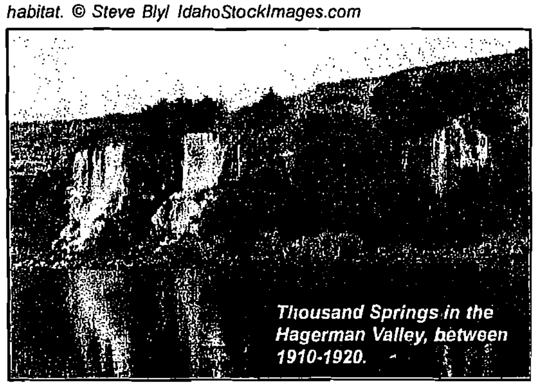
Though the aquifer can be compared to the volume of Lake Erie, the aquifer is not at all like an underground lake. Water is stored between the grains of sediments and in the open fractures between pieces of basalt of the Eastern Snake River Plain. The water-holding rocks of the aquifer are as much as 4000 - 5000 feet thick. However, not all of that water can be easily used. Only 100 to 220 million acre-feet stored in the top few hundred feet of the aquifer can be easily pumped and used.

Flood irrigation practices (the only way to get water to crops before sprinklers and electric pumps) add much more water to the crop than growing plants can use. The extra water soaks into the ground to add to storage in the aquifer, increasing the aquifer level beneath irrigated areas. An estimated 24 million acre-feet of water was added to the aquifer from 1880s to 1950s, with some places seeing water levels rise more than 100 feet.

But the longer we irrigated, the better we got at moving water to the places we wanted it. Irrigation methods changed from "flood" irrigation to more efficient sprinkler irrigation, and using only surface water to an increasing portion of pumped ground water. Increased pumping took more water out of the aquifer, and flood irrigation no longer provided as much recharge water. About 6 million acre-feet of water came out of



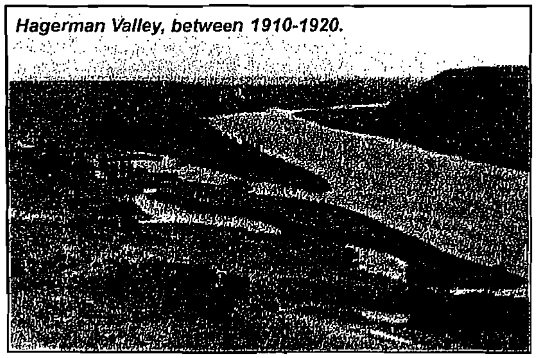
Lost river found: Above and below, some of the "thousand" springs in Idaho's Magic Valley. Most are along the north bank of the Snake River between Milner and King Hill. Spring water is used in fish hatcheries, for power production, drinking water, and habitat. © Steve Blyl IdahoStockImages.com



Thousand Springs in the Hagerman Valley, between 1910-1920.

Idaho State Historical Society, Bisbee collection.

Hagerman Valley, between 1910-1920.

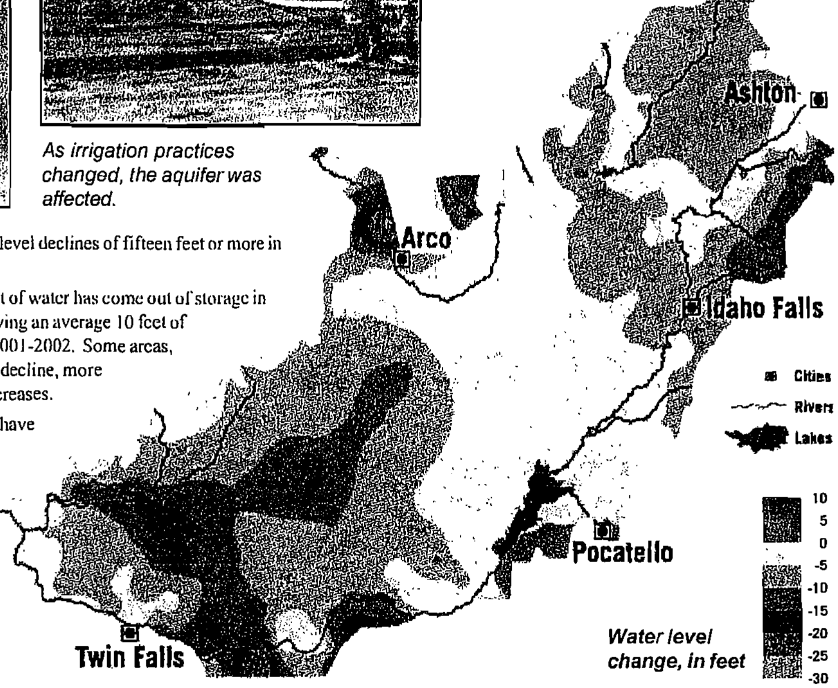


Irrigation ditch, southwest of Jerome, August 1912. Idaho State Historical Society.

Bean crop under irrigation from well, September 1950. Idaho State Historical Society.

As irrigation practices changed, the aquifer was affected.

Changes in aquifer level: 1980-2002



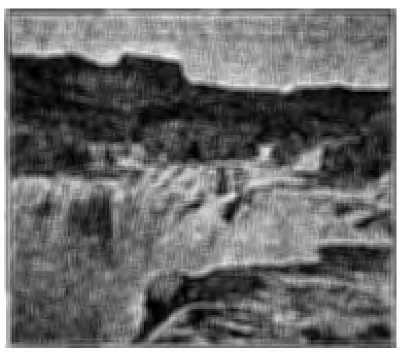
storage from the 1950s to 1980, leading to aquifer level declines of fifteen feet or more in some areas.

From 1980 to 2002, another 6 million acre-feet of water has come out of storage in the aquifer, with aquifer-wide measurements showing an average 10 feet of decline since 1980, with half of that occurring in 2001-2002. Some areas, such as near Arco, have experienced even greater decline, more than 60 feet, while other areas have seen slight increases.

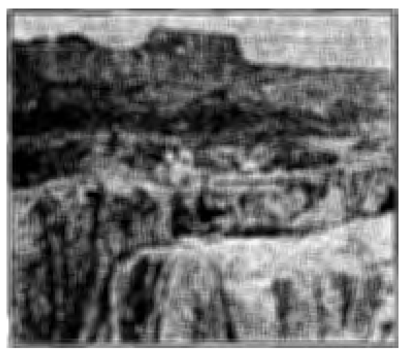
Water level measurements from 2001 to 2002 have shown decreases in aquifer levels, largely due to the current drought. Less snow in the mountains means less water in the river to irrigate with, less water to recharge the aquifer, and greater reliance on ground water. In many years the demand for surface water consumes most, if not all, of the flow of the Snake River above Shoshone Falls during the irrigation season. The result, first seen in 1905, is a dry "Twin Falls."

Shoshone Falls: *Nicknamed "the Niagra of the West," Shoshone Falls drops 50 feet farther than Niagra-- 212 feet. It is 1200 feet wide. You'll note in the historical and present day photos of Shoshone Falls on this page and the next that the flow of water over the falls varies. Like the water in the aquifer, it is affected by the amount of water used for irrigation.*

Drawing from REPORT OF THE GEOLOGICAL EXPLORATION OF THE 40TH PARALLEL, 1870-1880. Idaho State Historical Society.



1871. Settlers are arriving in Idaho, but few acres are irrigated. Surface water irrigation began to increase in the 1880s.



Irrigation diversions temporarily dried up the Falls for the first time in 1905. This photo was taken in 1941. Idaho State Historical Society

Aquifer Recharge

The water that fills the aquifer comes from a number of sources. The amount of water recharging the aquifer varies from year to year; however, the proportion of recharge from each source stays about the same. An estimated 8.06 million acre-feet of water recharged the Eastern Snake River Plain Aquifer in water year 1980. Because a great deal of measuring and sampling took place that year, it provides a good benchmark for comparison.

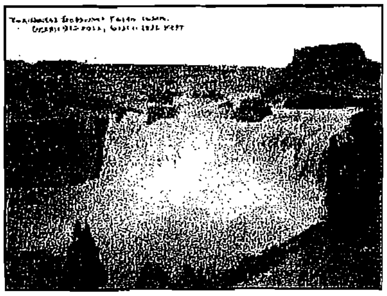
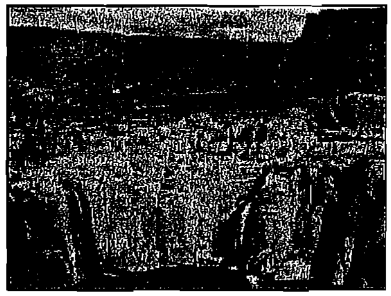
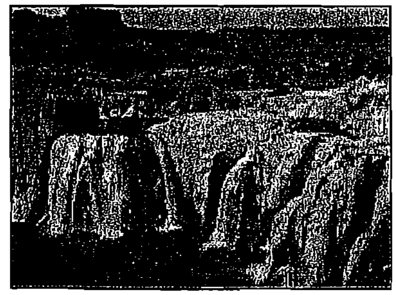
The largest source of water recharging the aquifer is irrigation. This leftover water seeps into the ground, and works its way to the aquifer. For the 1980 water year, this was 4.84 million acre-feet, or 60% of all recharge.

The next largest source of recharge to the aquifer is tributary basin underflow. That's ground water that flows to the aquifer from the tributary valleys along the margins of the plain. This includes recharge from the Henry's Fork and South Fork of the Snake River, and the valleys of Birch Creek, Big and Little Lost Rivers, Big and Little Wood Rivers, Portneuf and Raft River valleys, and other smaller valleys. This source added 1.44 million acre-feet, or 18% of recharge.

While the climate of the Eastern Snake River Plain Aquifer is semiarid, with less than 10 inches of precipitation each year, the timing of the rain and snow (snow cover melting and rain occurring in times of the year when there is less evaporation), and the scant soil cover over much of the basalts of the plain allows a significant amount of precipitation to recharge the aquifer in some areas. Direct precipitation on the plain accounts for 0.70 million acre-feet, or 9% of recharge.

Water infiltrating from the bed of the Snake River is also a significant source of recharge. Along some lengths ("reaches") of the Snake River, the riverbed is above the aquifer level; and therefore, water from the river seeps through the river bed to recharge the aquifer. These are called "losing reaches." Since aquifer levels can change during the year, some reaches of the river can "lose" during times of the year that the aquifer level is lower, and "gain" when the aquifer level is above the bed of the river.

In 1980, 0.69 million acre-feet, or 9% of recharge was from Snake River losses. Just like the Snake River, other rivers and streams, as well as canals, that flow out on to the Eastern Snake River Plain can recharge the aquifer. This recharge from tributary stream and canal losses added 0.39 million acre-feet, about 5% of the recharge for the 1980 water year.

This postcard published in 1909 and these two pictures taken in 2005 show how the level of water going over Shoshone Falls rises and falls.

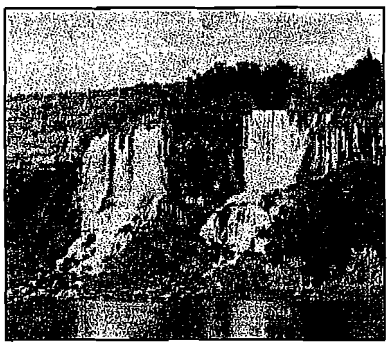
Aquifer discharge

Just like the bathtub metaphor, what goes into an aquifer as recharge is reflected in changes in aquifer levels and in water discharged. Water can be discharged as springs in the walls of the Snake River Canyon, or seep into the bed of the Snake River in "gaining reaches," or be pumped out of the aquifer for use on the land.

In 1980, 8.22 million acre-feet were estimated to have been discharged from the aquifer. Most of this discharge, 7.1 million acre-feet or 86%, occurred as seepage and spring flow to the Snake River. Major springs occur along three stretches of the Snake River, near St. Anthony, from Blackfoot to American Falls, and Milner to King Hill.

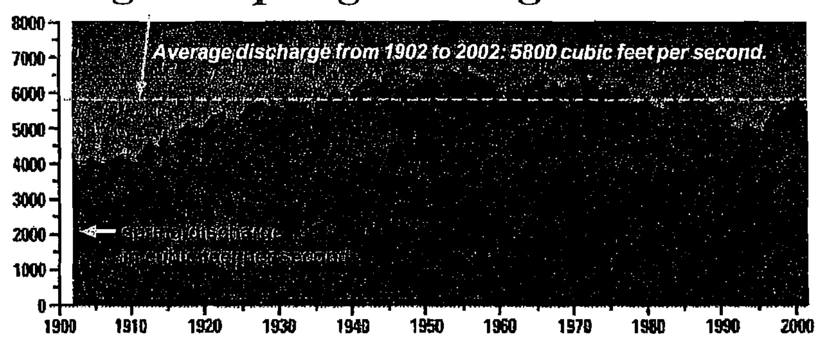
Most of the spring flow and seepage occurs from Milner to King Hill, often called the Thousand Springs reach. Here, 4.83 million acre-feet or 68% of the spring flow and seepage occurs. Seepage and springs from Blackfoot to American Falls account for 1.99 million acre-feet, or 28% of discharge. The remaining 0.28 million acre-feet, or 4% occurs near St. Anthony.

Ground water pumped from the aquifer accounts for 1.14 million acre-feet, or 14% of discharge. Nearly all of this ground water is pumped for irrigation (95%), about 3% is pumped for drinking water for cities and rural homes. The remaining 2% is pumped for industrial and livestock use.



Thousand Springs photo from an old postcard negative, date unknown. Idaho State Historical Society.

Changes in spring discharge: 1900-2000



The pulse of the aquifer

Spring discharge is like the pulse of the aquifer; changes in aquifer levels result in changes in spring flow. Measurements in some of the springs between Milner and King Hill began as early as 1902.

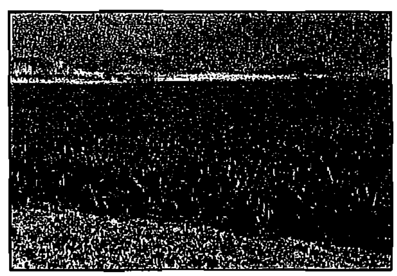
As irrigation began in the Eastern Snake River Plain, spring flows from springs along the north side of the canyon increased. Estimates of spring flow (based on analyzing the water budget for years prior to 1951) were 4,200 cubic feet per second or about 3 million acre feet per year in 1902, and continued to grow until the early 1950s. At the peak flow in 1951, the discharge was estimated at 6820 cubic feet per second, and 4.94 million acre-feet.

Between 1902 and the 1950s, irrigation with surface water spread across the Eastern Snake River Plain. The increased recharge and aquifer levels resulted in a substantial increase in discharge from these springs. From the 1950s through 1980, the measured discharge from these ten springs decreased to about 6000 cubic feet per second, or 4.42 million acre-feet per year.

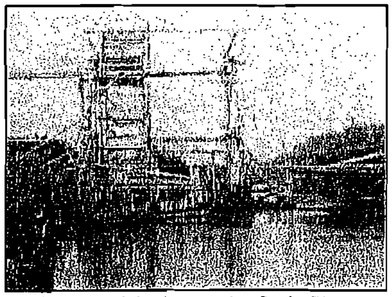
Flow measurements made through 2002 show a continued decline to about 5400 cubic feet per second and 3.9 million acre-feet per year. The average spring flow from 1902 through 2002 is about 5800 cubic feet per second, or 4.2 million acre-feet of discharge.

The increase in spring discharge from 1902 through 1951 appears to be relatively constant, however, the decline from 1951 through 2002 is not. The fluctuations correspond to drought years that had less water available for surface water irrigation and wet years of higher flows in the Snake River, while the overall trend of decreasing flow from the springs is due to more acres being watered from sprinklers and less by traditional flood irrigation.

Water users who designed their spring-dependent fish farms when flows were at their highest are now being affected by the decline in spring flows. However, the decline in spring flows, outside of weather patterns that can't be changed, is due to the irrigators on the Eastern Snake River Plain becoming more efficient with their water in some portions of the aquifer, and in other areas by irrigators pumping ground water for their crops.

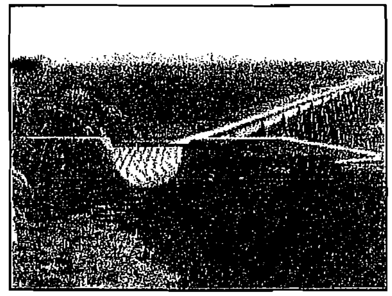



An **acre-foot** is the amount of water which would cover one acre of land with water one foot deep. An acre is a little less than a football field from goal line to goal line. To be precise, from one goal line to within a football-length from the nine yard line at the other end of the field. This is 326,000 gallons. Discharge of one **cubic foot per second** is the same as 449 gallons per minute. One cubic foot per second would fill a foot-ball field one foot deep in 12 hours and 8 minutes. One cubic foot per second flowing from a spring for a year is 724 acre-feet.



***Moving water:** irrigation wheel on Snake River about 8 miles below Montgomery Ferry. July 1908. Idaho State Historical Society.*

Moving water for irrigation in the Magic Valley, between 1910-1920. Idaho State Historical Society, Bisbee collection.



***Improved:** over time, we got better at getting water where we wanted it. Idaho State Historical Society, Bisbee collection, around 1910-1920.*

Irrigation *on the Eastern Snake River Plain Aquifer*

In the century and a half since Idaho water was first used to water crops, irrigation has changed the landscape of the Eastern Snake River Plain. Water in its many forms shapes Idaho's economy, culture, politics, and society. In recent years it has come to dominate the state's legal landscape as well.

It's not surprising that much of Idaho's concern relating to the INL centers around the Eastern Snake River Plain Aquifer. If activities at the lab were to result in irreparable harm to the aquifer, it could be a devastating blow to Idaho's economy and way of life.

The history of the aquifer is inexorably tied to the history of irrigation. A prime example is the difference between the Magic Valley being a semi-arid desert with farms along the river, and the extraordinarily productive agricultural area it is today. Because irrigation is the primary agent of change to the Eastern Snake River Plain Aquifer, the history of irrigation on the Eastern Snake River Plain provides vital insight into the factors that shape Idaho's concern over operations at the Idaho National Laboratory.

Agricultural "Growth"

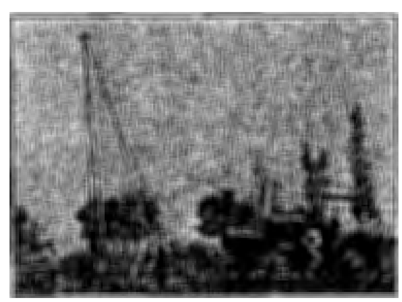
In 1890, the newly-admitted state of Idaho feared that all the land that could be developed for agriculture was already under the plow. Many miles of canals were already being used to take the natural flow of Idaho's waterways to fields. But serious and expensive efforts were needed to store and transfer the huge volumes of water that flowed down the Snake and other rivers throughout the year to the many acres of rich volcanic soils that were beyond the reach of canals or could be supplied with just the low river flows during southern Idaho's dry summers. It was feared that without these great efforts, Idaho's growth would run out of momentum. It could not have been imagined that just ten years later, total irrigated acres across the State topped 550,000, more than double that at the time of Idaho's statehood.

Development of the arid Snake River Plain was encouraged by the Carey Act (1894) and other federal legislation that provided government land at bargain prices to those that could bring that land under irrigation and into production. Private investment provided the capital to buy the lands and build canals. Among the first projects were canals near American Falls, and Milner Dam and associated canals near Burley and Rupert. Familiar landmarks such as Milner Dam, Perrine Bridge, Buhl, and Kimberly remind us of those that helped to finance these early projects. Still, the limiting factor for further development was how to store the melting snows and high spring flows for irrigation in the hot, dry Idaho summers.

Even with the help of wealthy investors, it became clear that the astronomical cost of building dams required more assistance from the federal government. The 1902 Newlands Reclamation Act allowed the Federal Government to finance the work of constructing dams and irrigation works beyond the ability of private investment. From this grew the Minidoka Project that eventually resulted in the Minidoka, American Falls, Palisades, Jackson Lake, and other major dams of the Upper Snake River Valley, as well as dams on other southeast Idaho streams. In addition to storing water for irrigation, these dams helped to tame the floods that often came with spring's melting snow.

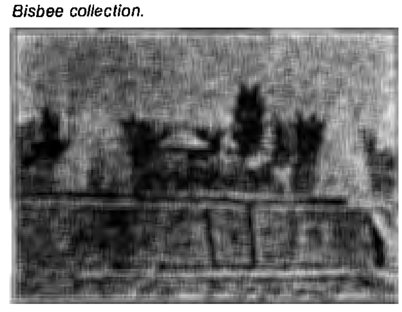
Irrigation on the Eastern Snake River Plain was underway by 1880, on lands immediately adjacent to the Snake River and other eastern Idaho streams. By 1899-1900, about 330,000 acres were under irrigation. From 1903 through 1938 Mindoka, Jackson Lake, Milner, American Falls, Henrys Lake, Island Park, and Grassy Lake Dams were constructed. Acres irrigated increased to about 1.54 million in 1929, and 1.7 million acres by 1945.

From 1945 to 1959, acres irrigated increased to 1.83 million acres. Although ground water had been used for irrigation since the 1920s in some areas on the Eastern Snake River Plain, the development of powerful and efficient electric pumps allowed significant ground water usage, with 400,000 acres irrigated from this "new" source. Surface water irrigation accounted for 1.43 million acres. By 1966, acres irrigated by ground water grew to 640,000, and by surface water, to 1.56 million acres, for a total of 2.20 million acres. Irrigated acres totaled 2.27 million in 1979. The source for irrigation water for some lands switched from surface water to ground water, with surface water the source for irrigation of 1.23 million acres, and ground water the source for 930,000 acres. Both surface and ground water resources were used to irrigate 110,000 acres.



***From surface water to ground water:** Core drilling for weter at an Idaho farm in 1916. Idaho State Historical Society.*

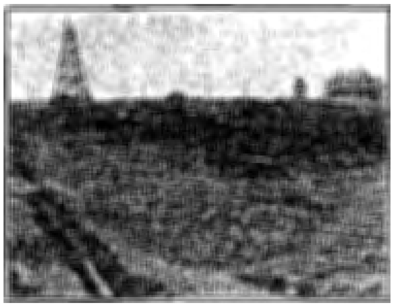
Irrigation wells at Artesian City in Twin Falls County, around 1910-1920. Idaho State Historical Society, Bisbee collection.



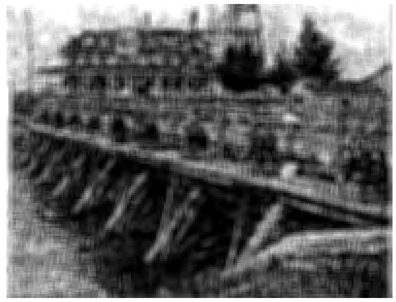
Resource from "Waste"

Flooding fields with water is a relatively inefficient means of providing water to crops. The amount of water applied to the fields and furrows prior to more modern irrigation methods was sometimes as much as 7 times what the crop could use. All that extra water, as much as 12 feet of water applied during the course of an irrigation season,
recharged the aquifer. This "waste" became water stored for later use, just like water stored behind a dam.

Water levels rose substantially in some areas, for example, ground water levels rose 60-70 feet from 1907 to 1959 in areas near Kimberly and Bliss, and as much as 200 feet in areas near Twin Falls. Across the whole of the aquifer, the average aquifer rise was about 50 feet. This rise in aquifer levels became most evident by the increases in discharge from the major springs along the Snake River. With the transition to irrigating with ground water and more efficient means of applying surface water to fields, less water was added to storage.



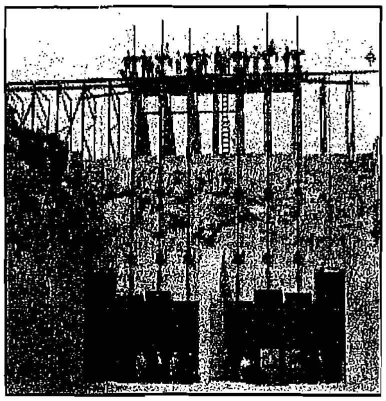
Breaking ground: *Early stages of construction at the Milner Dam, June 1903. Idaho State Historical Society,*

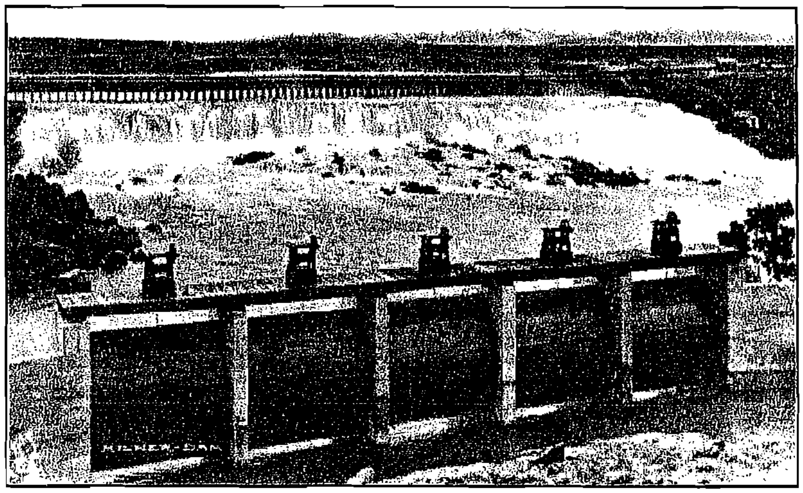


Diversion at Milner. Milner water first reached crops in 1905.

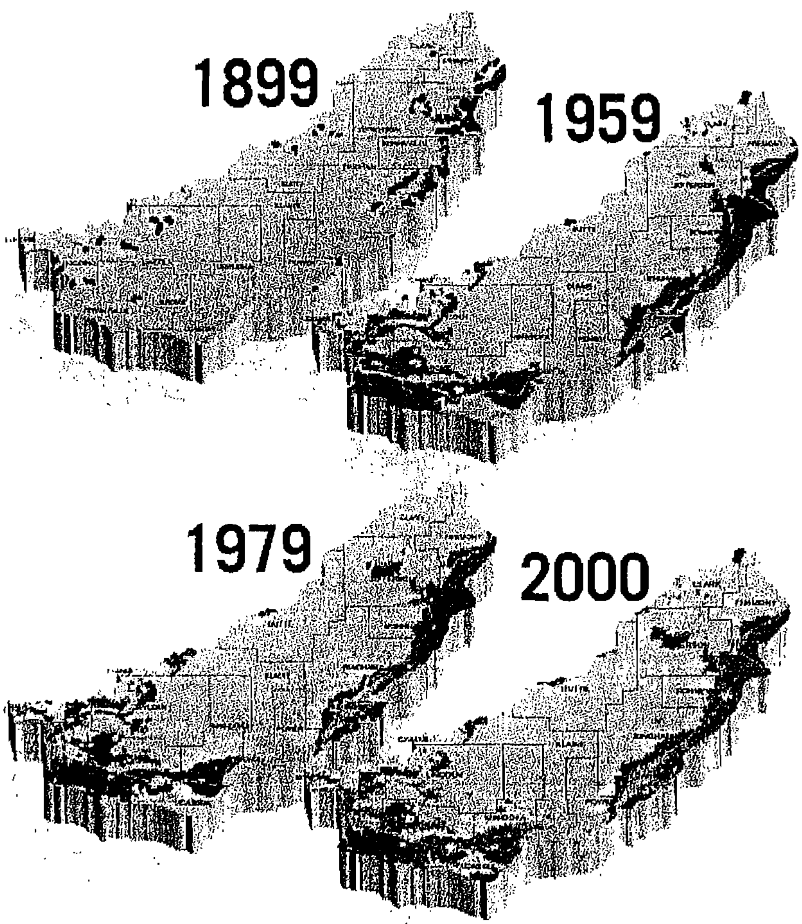
Building wood pipeline, *March, 1912. Part of the Milner project. Idaho State Historical Society.*

Below, late stages of construction on the Milner project. Idaho State Historical Society, Bisbee collection. Right, Milner Dam from old postcard negative. Idaho State Historical Society.





A century of irrigation on the Eastern Snake River Plain

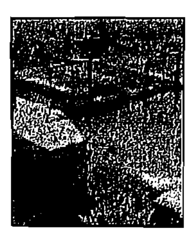


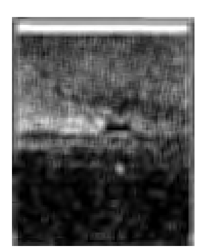
surface water ground water both surface and ground water

Prize-winning potatoes: *in 1910, this farm a mile east of Twin Falls produced 645 bushels per acre, winning $500.00. Idaho State Historical Society.*

Over time, the primary source of irrigation water changed from diverted surface water to pumped ground water.

The primary method of irrigation also changed, from flooding fields to sprinkling. This allowed more acres to be farmed, but also resulted in less water available for recharge.





Modern agricultural methods deliver precise amounts of water at carefully timed intervals

our changing AQUIFER

It's said that biology is destiny. For humans, that may be true. But for Idaho, geology is destiny, and much of that destiny is defined by the presence of the Eastern Snake River Plain Aquifer.

Rich mineral deposits brought miners to the area. Abundant water and fertile soil attracted homesteaders and farmers. Dams—many built in canyons—provide the hydroelectric power that fuels our homes, businesses, and economy. Majestic mountains and stunning landscapes lure those whose souls are fed by beauty. Idaho's history, and its destiny, have been shaped by these resources.

Lured west with the false promise that "the rain follows the plow," homesteaders traveling the Oregon Trail crossed the Snake River Plain. Some decided to stop, gravitating to the areas where water was plentiful—next to the Snake River and its tributary streams.

In time, Idahoans developed the technology and the infrastructure to thrive whether the rain followed or not. With the addition of pumps, canals, and dams, they tapped the aquifer and farms spread out. No longer tethered to just those areas adjacent to surface water, land was cultivated throughout the Eastern Snake River Plain, molding the arid stretch into one of the most productive agricultural regions in the world.

Today, the pure, cold spring water that flows from Thousand Springs supports a thriving aquaculture (fish-farming) industry; sixty-nine percent of the trout farmed in the United States come from Idaho. Twenty-nine percent of the nation's potatoes are grown in Idaho, and the state ranks sixth in the number of cattle produced. The Eastern Snake River Plain, once little more than a dry passage to the west, now helps feed people all over the world.

Balancing Water

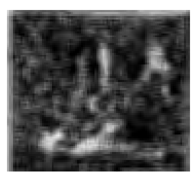
Unfortunately, the rain still doesn't follow the plow. Nor does it follow the increasing demands for drinking water, habitat, agriculture, industry, production of electricity, fishing and boating, landscaping, or water left in rivers and lakes for its beauty. Demands on this vital resource continue to grow, but the amount of water available, much of it stored up in the aquifer, does not.

Some want more water for consumptive uses, such as industry, agriculture, or drinking. Others want water for production of electricity, for habitat, for recreation, or for other downstream uses.

The demands for water continue, defining Idaho's political landscape now just as surely as geology and hydrology have always defined the Gem State's destiny. An understanding of the way the aquifer gains and loses water can help us understand the conflicts inherent in the use of water and help define that balance.

Whether you are going to define the right balance for water users or understand the complexities of contamination, it is helpful to know how the aquifer works: the principles of storage, recharge, and discharge.

Demands on this vital resource continue to grow, but the amount of water available, much of it locked up in the aquifer, doesn't grow...



The Oversight Monitor is published by the State of Idaho's INL Oversight & Radiation Control Division, part of the Department of Environmental Quality. More information is available at www.deq.idaho.gov/inl_oversight. Contact Oversight through this web site, by e-mailing AskOversight@deq.idaho.gov, or by calling 1-800-232-4635.

Idaho Department of Environmental Quality
INL Oversight & Radiation Control Program
1410 North Hilton Street
Boise, Idaho 83706