

Chapter 2

Background

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A variety of available information was reviewed and compiled for this updated and expanded study of the Snake/Salt River Basin groundwater resources. The updated data were obtained from regional and area-specific studies conducted by state and federal agencies in Wyoming and Idaho. This chapter discusses the data sources, approach, organization, and computer-based mapping used in this study and compares them to the previous Groundwater Resource Investigations contained within the 2003 Snake/Salt River Basin Water Plan (Sunrise Engineering and others, 2003).

The 2003 Snake/Salt River Basin Water Plan (Sunrise Engineering and others, 2003) and associated technical memoranda constitute one of the earlier studies for Wyoming's seven major drainage basins completed by the Wyoming Water Development Commission (WWDC) between 2000 and 2011. The 2003 plan provides extensive information about the cultural and physical settings of the basin, both generally and as they relate to groundwater resources. In order to avoid repetition, the 2003 Snake/Salt River Basin plan (Sunrise Engineering and others, 2003) and 2007 Wyoming Framework Water Plan (WWC and others, 2007) are cited frequently in this study, and where appropriate, links are provided to online information.

2.1 Sources of data

Agencies that contributed data and information for this study include:

BLM	U.S. Bureau of Land Management
EPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
	University of Wyoming Libraries
WRDS	University of Wyoming Water Resources Data System
WDEQ	Wyoming Department of Environmental Quality
WyGISC	Wyoming Geographical Information Science Center
WOGCC	Wyoming Oil and Gas Conservation Commission

WRRI	Wyoming Water Resources Research Institute
SEO	State Engineer's Office (Wyoming)
WSGS	Wyoming State Geological Survey
WWDC	Wyoming Water Development Commission
WWDO	Wyoming Water Development Office

2.2 Previous regional-scale investigations

Several surface water and groundwater management studies have been previously conducted for areas contained wholly or partly within the Snake/Salt River Basin. The geographic scale of the earlier projects varies considerably. This study builds on these previous compilations. The primary hydrogeologic studies and associated supporting geologic investigations of the basin area are listed below in approximate chronologic order by agency and author(s):

- *U.S. Geological Survey Hydrologic Investigation Atlases*

1968 – Whitcomb, H.A and Lowry, M.E., 1968, Groundwater resources and geology of the Wind River Basin area, central Wyoming; U.S. Geological Survey Hydrologic Investigations Atlas HA-270, map scale 1:250,000, 2 sheets.

1975 – Lines, G.C., and Glass, W.R., 1975, Water resources of the Thrust Belt of western Wyoming; U.S. Geological Survey Hydrologic Investigations Atlas HA-539, map scale 1:250,000, 3 sheets.

1976 – Cox, E.R., 1976, Water resources of northwestern Wyoming; U.S. Geological Survey Hydrologic Investigations Atlas HA-558, map scale 1:250,000, 3 sheets.

1994 – Whitehead, R.L., 1994 Groundwater

- atlas of the United States, Segment 7, Idaho, Oregon, Washington: U.S. Geologic Survey Hydrologic Investigations Atlas HA-730-H, 31 p.
- 1996 – Whitehead, R.L., 1996 Groundwater atlas of the United States, Segment 8, Montana, North Dakota, South Dakota, Wyoming: U.S. Geologic Survey Hydrologic Investigations Atlas HA-730-I, 24 p.
- *Basin studies by the University of Wyoming, Water Resources Research Institute, and the Wyoming Natural Resource Board*
- 1962 – Dana, G.F., 1962, Groundwater reconnaissance study of the State of Wyoming, Introduction and seven basin reports: Prepared for Wyoming Natural Resource Board, Cheyenne, Wyoming, 355 p.
- 1981 – Ahern, J., Collentine, M., and Cooks, S., 1981, Occurrence and characteristics of ground water in the Green River Basin and Overthrust Belt, Wyoming: Report to U.S. Environmental Protection Agency, contract number G-008269-79, by Water Resources Research Institute, Laramie, Wyoming, 123 p.
- 1985 – Sando, S.K., Borrelli, John, and Brosz, D.J., 1985, Hydrologic impacts on the Salt River due to changes in irrigation systems: Wyoming Water Research Center, Water Resource Publication 85-16, 73 p.
- 1990 – Blanchard, M.R., Drever, J.I., and Huntoon, P.W., 1990, Discrimination between flow-through and pulse-through components of an alpine carbonate aquifer, Salt River Range, Wyoming: Wyoming Water Research Center, Water Resource Publication 90-31, 77 p.
- *Wyoming State Geological Survey publications*
- 1993 – Love, J.D., Christiansen, A.C., and Ver Ploeg, A.J., 1993, Stratigraphic chart showing the Phanerozoic nomenclature for the state of Wyoming: Geological Survey of Wyoming Map Series MS-41, no scale, 1 sheet.
- Royse, F., Jr., 1993, An overview of the geologic structure of the thrust belt in Wyoming, northern Utah, and eastern Idaho: in Snoke, A.W., Steidtmann, J.R., and Roberts, S.M., Eds., *Geology of Wyoming: Laramie, Wyoming*, Geological Survey of Wyoming Memoir No. 5, p. 272-311.
 - *U.S. Geological Survey Water Supply Papers, Professional Papers, Scientific Investigation Reports, Scientific Investigation Maps, Water Resource Investigations Open-File Reports, Water Resource Investigations Reports, and Circulars.*

1951 – Love, J.D., Keefer, W.R., Duncan, D.C., Gergquist, H.R., Hose, R.K., 1951, Geologic map of the Spread Creek-Gros Ventre River area, Teton County, Wyoming: U.S. Geological Survey Oil and Gas Investigation Map, map scale 1:48,000, 1 map.

1961 – Rubey, W.W., Oriel, S.S., and Tracey, J.I., Jr., 1961, Age of the Evanston Formation, western Wyoming: U.S. Geological Survey Professional Paper 424-B in *Short papers in the geologic and hydrologic sciences*, Article 64, p. B153-B154.

Gardner, L.S., 1961, Preliminary geologic map, columnar sections, and trench sections of the Irwin quadrangle, Caribou and Bonneville counties, Idaho, and Lincoln and Teton counties, Wyoming: U.S. Geological Survey Open-File Report

- OF-61-53, map scale 1:48,000, 4 plates.
- 1964 – Lowry, M.E., and Gordon, E.D., 1964, Ground-water investigations in Yellowstone National Park, October 1960 to October 1963: U.S. Geological Survey Open-File Report 64-105, 39 p.
- McGreevy, L.J., and Gordon, E.D., 1964, Ground water east of Jackson Lake, Grand Teton National Park, Wyoming: U.S. Geological Survey Circular 494, 27 p., 1 pl.
- 1965 – Albee, H.F., 1965, Preliminary geologic map of the Poker Peak and Palisades Reservoir quadrangles, Bonneville County, Idaho and Lincoln County, Wyoming: U.S. Geological Survey Open-File Report OF-65-2, map scale 1:24,000, 1 plate.
- Jobin, D.A., 1965, Preliminary geologic map of the Palisades Peak quadrangle, Bonneville County, Idaho and Teton County, Wyoming: U.S. Geological Survey Open-File Report OF-65-80, map scale 1:24,000, 1 map.
- Kilburn, C., 1965, Groundwater in the upper part of the Teton Valley, Teton counties, Idaho and Wyoming: U.S. Geological Survey Water Supply Paper 1789, 60 p., 4 maps.
- Walker, E.H., 1965, Ground water in the upper Star Valley, Wyoming: U.S. Geological Survey Water-Supply Paper 1809-C, 27 p., 1 pl.
- 1967 – Pampeyan, E.H., Schroeder, M.L., Schnell, E.M., and Cressman, E.R., 1967, Geologic map of the Driggs quadrangle, Bonneville and Teton counties, Idaho and Teton County, Wyoming: U.S. Geological Survey Miscellaneous Field Studies Map 300, map scale 1:31,680, 1 map.
- 1968 – Albee, H.F., 1968, Geologic map of the Munger Mountain quadrangle, Teton and Lincoln counties, Wyoming: U.S. Geological Survey Geologic Quadrangle GQ-705, map scale 1:24,000, 1 plate.
- Rohrer, W.L., 1968, Geologic map of the Fish Lake quadrangle, Fremont County, Wyoming: U.S. Geological Survey, Geologic Quadrangle Map GQ-724, 1 sheet, scale 1:24,000.
- 1969 – Cox, E.R., 1969, Results of water-resources investigations through 1968 in Yellowstone National Park, Wyoming: U.S. Geological Survey Open-File Report 69-60, 87 p.
- Rohrer, W.L., 1969, Preliminary geologic map of the Sheridan Pass quadrangle, Fremont and Teton counties, Wyoming, U.S. Geological Survey Open-File Report OF-69-228, map scale 1:24,000, 1 map.
- Schroeder, M.L., 1969, Geologic map of the Teton Pass quadrangle, Teton County, Wyoming: U.S. Geological Survey Geologic Quadrangle 793, map scale 1:24,000, 1 map.
- 1971 – Reed, J.C., Jr., and Love, J.D., 1971, Preliminary geologic map of the Mount Bannan quadrangle, Teton County, Wyoming: U.S. Geological Survey Open-File Report OF-71-233, map scale 1:24,000, 1 map.
- 1972 – Lindsey, D.A., 1972, Sedimentary petrology and paleocurrents of the Harebell Formation, Pinyon Conglomerate, and associated coarse clastic deposits, northwestern Wyoming: U.S. Geological Survey Professional Paper 734-B, 68 p.

- Love, J.D., and Albee, H.F., 1972, Geologic map of the Jackson quadrangle, Teton County, Wyoming: U.S. Geological Survey IMAP-769-A, map scale 1:24,000, 1 map.
- Love, J.D., and Keefer, W.R., 1972, Geology of sedimentary rocks in southern Yellowstone National Park, Wyoming: U.S. Geological Survey Professional Paper 729-D, p. D1-D60, 1 pl.
- Reed, J.C., Jr., and Love, J.D., 1972, Preliminary geologic map of the Granite Basin quadrangle, Teton County, Wyoming: U.S. Geological Survey Open-File Report OF-72-309, map scale 1:24,000, 1 map.
- Schroeder, M.L., 1972, Geologic map of the Rendezvous Peak quadrangle, Teton County, Wyoming: U.S. Geological Survey Geologic Quadrangle GQ-980, map scale 1:24,000, 1 plate.
- 1973 – Albee, H.F., 1973, Geologic map of the Observation Peak quadrangle, Teton and Lincoln counties, Wyoming: U.S. Geological Survey Geologic Quadrangle GQ-1081, map scale 1:24,000, 1 plate.
- Cox, E.R., 1973, Water resources of Yellowstone National Park, Wyoming, Montana, and Idaho: U.S. Geological Survey Open-File Report 73-53, 161 p.
- Love, J.D., 1973, Preliminary geologic map of the Two Ocean Lake quadrangle, Teton County, Wyoming: U.S. Geological Survey Open-File Report OF-73-158, map scale 1:24,000, 5 leaves, 1 map.
- Love, J.D., and Reed, J.C., Jr., 1973, Preliminary geologic map of the Coulter Bay quadrangle, Teton County, Wyoming: U.S. Geological Survey Open-File Report OF-73-160, map scale 1:24,000, 1 map.
- Reed, J. C., Jr., Love, D. W., and Love, J. D., 1973, Preliminary geologic map of the Rammel Mountain quadrangle, Teton County, Wyoming: U.S. Geological Survey Open-File Report OF-73-231, map scale 1:24,000, 1 map.
- Rubey, W.W., 1973a, Geologic map of the Afton quadrangle and part of the Big Piney quadrangle, Lincoln and Sublette counties, Wyoming: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-686, map scale 1:62,500, 2 sheets.
- Rubey, W.W., 1973b, New Cretaceous formations in the western Wyoming Thrust Belt: U.S. Geological Survey Bulletin 1372-I, Contributions to stratigraphy, 35 p.
- Schroeder, M.L., 1973, Geologic map of the Clause Peak quadrangle, Lincoln, Sublette, and Teton counties, Wyoming: U.S. Geological Survey Geologic Quadrangle GQ-1092, 1 plate.
- 1974 – Cox, E.R., 1974, Water resources of Grand Teton National Park, Wyoming: U.S. Geological Survey Open-File Report 74-1019, 114 p.
- Love, J.D., 1974a, Geologic map of the south half of the Huckleberry Mountain quadrangle, Teton County, Wyoming: U.S. Geological Survey Open-File Report OF-74-54, map scale 1:24,000, 1 map.
- Love, J.D., 1974b, Geologic map of the south half of the Mount Hancock quadrangle, Teton County, Wyoming:

- U.S. Geological Survey Open-File Report OF-74-127, map scale 1:24,000, 1 map.
- Schroeder, M.L., 1974, Geologic map of the Camp Davis quadrangle, Teton County, Wyoming: U.S. Geological Survey Geologic Quadrangle GQ-1160, scale 1:24,000, 1 map.
- 1975 – Albee, H.F., and Cullins, H.L., 1975, Geologic map of the Alpine quadrangle, Bonneville County, Idaho and Lincoln County, Wyoming: U.S. Geological Survey Geologic Quadrangle GQ-1259, map scale 1:24,000, 1 plate.
- Cox, E.R., 1975, Discharge measurements and chemical analyses of water in northwestern Wyoming: Wyoming State Engineer's Office, Wyoming Water Planning Program Report no. 14, 21 p.
- Love, J.D., 1975a, Geologic map of the Whetstone Mountain quadrangle, Teton County, Wyoming: U.S. Geological Survey Open-File Report OF-75-138, map scale 1:24,000, 1 map.
- Love, J.D., 1975b, Geologic map of the Gravel Mountain quadrangle, Teton County, Wyoming: U.S. Geological Survey Open-File Report OF-75-220, map scale 1:24,000, 1 map.
- Love, J.D., 1975c, Geologic map of the Gros Ventre Junction quadrangle, Teton County, Wyoming: U.S. Geological Survey Open-File Report OF-75-334, map scale 1:24,000, 1 map.
- Love, J.D., 1975d, Geologic map of the Teton Village quadrangle, Teton County, Wyoming: U.S. Geological Survey Open-File Report OF-75-335, map scale 1:24,000, 1 map.
- 1976 – Schroeder, M.L., 1976, Geologic map of the Bull Creek quadrangle, Teton and Sublette counties, Wyoming: U.S. Geological Survey Geologic Quadrangle GQ-1300, scale 1:24,000, 1 map.
- 1978 – Christiansen, R.L., Blank, H.R., Love, J.D., and Reed, J.C., 1978, Geologic map of the Grassy Lake Reservoir quadrangle, Yellowstone National Park and vicinity, Wyoming: U.S. Geological Survey, Geologic Quadrangle Map GQ-1459, map scale 1:62,500, 1 sheet.
- Love, J.D., and Love, C.M., 1978, Geologic map of the Turquoise Lake quadrangle, Teton County, Wyoming: U.S. Geological Survey Open-File Report OF-78-481, map scale 1:24,000, 1 map.
- Love, J.D., and Love, C.M., 1978, Geologic map of the Cache Creek quadrangle, Teton County, Wyoming: U.S. Geological Survey Open-File Report OF-78-480, map scale 1:24,000, 1 plate.
- Love, J.D., Leopold, E.B., and Love, D.W., 1978, Eocene rocks, fossils, and geologic history, Teton Range, northwestern Wyoming: U.S. Geological Survey Professional Paper 932-B, p. D1–D40, 5 pl.
- 1979 – Schroeder, M.L., 1979, Preliminary geologic map of the Pickle Pass quadrangle, Lincoln County, Wyoming: U.S. Geological Survey Open-File Report OF-79-1630, map scale 1:24,000, 1 plate.
- 1980 – Oriel, S.S., and Platt, L.B., 1980, Geologic map of the Preston 1° x 2° quadrangle, southeastern Idaho and western Wyoming: U.S. Geological

- Survey Miscellaneous Investigations
Series I-1127, scale 1:250,000, 1
sheet.
- 1981 – Craig, G.S., Jr., Ringen, B.H., and
Cox, E.R., 1981, Hydrologic data
for the Cache Creek-Bear Thrust
Environmental Impact Statement near
Jackson, Wyoming: U.S. Geological
Survey Open-File Report 81-410, 46
p.
- Goetze, P.R., 1981, Regional geologic
map for the Cache Creek-Bear Thrust
environmental impact statement,
Teton and Sublette counties,
Wyoming: U.S. Geological Survey
Open-File Report OF-81-856, map
scale 1:48,000, 2 plates.
- Schroeder, M.L., 1981, Geologic map
of the Pine Creek quadrangle, Lincoln
and Teton counties, Wyoming:
U.S. Geological Survey Geologic
Quadrangle GQ-1549, 1 plate.
- Schroeder, M.L., Albee, H.F., and
Lunceford, R.A., 1981, Geologic map
of the Pine Creek quadrangle, Lincoln
and Teton Counties, Wyoming:
U.S. Geological Survey, Geologic
Quadrangle Map GQ-1549, 1 sheet,
scale 1:24,000.
- 1984 – Hopkins, R.T., Antweiler, J.C.,
Campbell, W.L., and Fox, J.P., 1984,
Analytical results and sample locality
maps of stream-sediment, panned-
concrete, rock, and water samples
from the West and East Palisades
Roadless Areas, Idaho and Wyoming:
U.S. Geological Survey Open-File
Report 84-284, 54 p., 1 pl.
- Moore, D.W., Woodward, N.B., and
Oriel, S.S., 1984, Preliminary geologic
map of the Mount Baird quadrangle,
Bonneville County, Idaho and Teton
and Lincoln counties, Wyoming:
USGS Open-File Report OF-84-776,
map scale 1:24,000, 12 p., 1 plate.
- 1985 – Love, J.D., and Christiansen, A.C.,
1985, Geologic Map of Wyoming:
USGS Unnumbered Series, map scale
1:500,000, 3 sheets.
- Lowham, H.W., Peterson, D.A.,
Larson, L.R., Zimmerman, E.A.,
Ringen, B.H., and Mora, K.L.,
1985, Hydrology of Area 52, Rocky
Mountain Coal Province, Wyoming,
Colorado, Idaho, and Utah: U.S.
Geological Survey Water-Resources
Investigations/Open-File Report OF-
83-761, 96 p.
- Oriel, S.S. and Moore, D.W., 1985,
Geologic map of the West and East
Palisades Roadless Areas, Idaho and
Wyoming: U.S. Geological Survey,
Miscellaneous Field Studies Map MF-
1619-B, 2 sheets, scale 1:50,000.
- 1987 – Schroeder, M.L., 1987, Geologic map
of the Bailey Lake quadrangle, Lincoln
and Teton counties, Wyoming:
U.S. Geological Survey Geologic
Quadrangle GQ-1608, map scale
1:100,000, 2 p., 1 plate.
- 1989 – Smedes, H.W., M'Gonigle, J.W., and
Prostka, H.J., 1989, Geologic map
of the Two Ocean Pass quadrangle,
Yellowstone National Park and
vicinity, Wyoming: U.S. Geological
Survey, Geologic Quadrangle Map
GQ-1667, 1 sheet, scale 1:62,500.
- 1992 – Love, J.D., Reed, J.C., Jr.,
Christiansen, A.C., 1992, Geologic
map of Grand Teton National Park,
Teton County, Wyoming: U.S.
Geological Survey IMAP-2031, map
scale 1:62,500, 1 map.
- M'Gonigle, J.W., and Dover, J.H.,
1992, Geologic map of the Kemmerer
30' x 60' quadrangle, Lincoln, Uinta,

- and Sweetwater counties, Wyoming: U.S. Geological Survey Miscellaneous Investigations Series Map I-2079, map scale 1:100,000, 1 sheet.
- 1995 – Ogle, K.M., Eddy-Miller, C.A., and Busing, C.J., 1996, Estimated use of water in Lincoln County, Wyoming, 1993: U.S. Geological Survey Water-Resources Investigations Report WRIR-96-4162, 13 p.
- Nolan, B. T., Miller, K. A., 1995, Water resources of Teton County, Wyoming, exclusive of Yellowstone National Park: USGS Water-Resources Investigations Report WRIR-95-4204, 76 p., 3 maps.
- 1996 – Eddy-Miller, C.A., Plafcan, M., and Clark, M.L., 1996, Water resources of Lincoln County, Wyoming: U.S. Geological Survey Water-Resources Investigations Report WRIR-96-4246, 131 p., 3 plates.
- Ogle, K.M., Eddy-Miller, C.A., and Busing, C.J., 1996, Estimated use of water in Lincoln County, Wyoming, 1993: U.S. Geological Survey Water-Resources Investigations Report WRIR-96-4162, 13 p.
- 1998 – Ball, J.W., Nordstrom, D.K., Cunningham, K.M., Schoonen, M.A., Xu, Yong, and DeMonge, J.M., 1998, Water chemistry and on-site sulfur-speciation data for selected springs in Yellowstone National Park, Wyoming, 1994-1995: U.S. Geological Survey Open- File Report 98-574, 35 p.
- Ball, J.W., Nordstrom, D.K., Jenne, E.A., and Vivit, D.V., 1998, Chemical analyses of hot springs, pools, geysers, and surface waters from Yellowstone National Park, Wyoming, and vicinity, 1974-1975: U.S. Geological Survey Open-File Report 98-182, 45 p.
- 2000 – Eddy-Miller, C.A., and Norris, J.R., 2000, Pesticides in groundwater – Lincoln County, Wyoming, 1998-99: U.S. Geological Survey Fact Sheet FS-033-00, 1 sheet, 4 p.
- 2001 – Ball, J.W., Nordstrom, D.K., McCleskey, R.B., Schoonen, M.A., and Xu, Yong, 2001, Water-chemistry and on-site sulfur-speciation data for selected springs in Yellowstone National Park, Wyoming, 1996-1998: U.S. Geological Survey Open-File Report 01-49, 42 p.
- Love, J.D., 2001a, Geologic map of the Moose Quadrangle, Teton County, Wyoming: Wyoming State Geological Survey, J. David Love Map Series LMS 3, 1 sheet, scale 1:24,000.
- Love, J.D., 2001b, Geologic map of the Blue Miner Lake Quadrangle, Teton County, Wyoming: Wyoming State Geological Survey, J. David Love Map Series LMS 6, 1 sheet, scale 1:24,000.
- Love, J.D., 2001c, Geologic map of the Shadow Mountain Quadrangle, Teton County, Wyoming: Wyoming State Geological Survey, J. David Love Map Series LMS 7, 1 sheet, scale 1:24,000.
- 2002 – Back, William, 1966, Hydrochemical facies and ground-water flow patterns in northern part of Atlantic Coastal Plain: U.S. Geological Survey Professional Paper 498-A, 42 p.
- Ball, J.W., McCleskey, R.B., Nordstrom, D.K., Holloway, J.M., and Verplanck, P.L., 2002, Water-chemistry data for selected springs, geysers, and streams in Yellowstone National Park, Wyoming, 1999-2000, with a section on Activity of thermal features of Norris Geyser Basin, 1998, by S.A. Sturtevant: U.S. Geological

- Survey Open-File Report 02–382, 104 p.
- Love, J.D., 2002, Geologic map of the Two Ocean Lake Quadrangle, Teton County, Wyoming: Wyoming State Geological Survey, J. David Love Map Series LMS 8, 1 sheet, scale 1:24,000.
- 2003 – Love, J.D., 2003a, Geologic map of the Colter Bay Quadrangle, Teton County, Wyoming: Wyoming State Geological Survey, J. David Love Map Series LMS 10, 1 sheet, scale 1:24,000.
- Love, J.D., 2003b, Geologic map of the Moran Quadrangle, Teton County, Wyoming: Wyoming State Geological Survey, J. David Love Map Series LMS 11, 1 sheet, scale 1:24,000.
- Love, J.D., 2003c, Geologic map of the Jackson Quadrangle, Teton County, Wyoming: Wyoming State Geological Survey, J. David Love Map Series LMS 9, 1 sheet, scale 1:24,000.
- 2004 – Eddy-Miller, C.A., and Remley, K. J., 2004, Pesticides in groundwater – Teton County, Wyoming, 2001 – 2002: U.S. Geological Survey Fact Sheet FS-2004 – 3080, 4 p.
- O'Neill, J.M., and Christiansen, R.L., 2004, Geologic map of the Hebgen Lake quadrangle, Beaverhead, Madison, and Gallatin counties, Montana, Park and Teton counties, Wyoming, and Clark and Fremont counties, Idaho: U.S. Geological Survey Scientific Investigations Map 2816, map scale 1:100,000, 1 sheet.
- 2007 – Gemery-Hill, P.A., Shanks, W.C., III, Balistrieri, L.S., and Lee, G.K., 2007, Geochemical data for selected rivers, lake waters, hydrothermal vents, and subaerial geysers in Yellowstone National Park, Wyoming and vicinity, 1996–2004, in Morgan, L.A., editor, Integrated geoscience studies in the Greater Yellowstone Area - volcanic, tectonic, and hydrothermal processes in the Yellowstone Geoccosystem: U.S. Geological Survey Professional Paper 1717, chapter L, p. 365-426.
- 2008 – Wheeler, J.D., and Eddy-Miller, C.A., 2005, Seepage investigation on selected reaches of Fish Creek, Teton County, Wyoming, 2004: U.S. Geological Survey Scientific Investigations Report 2005–5133, 15 p.
- 2009 – Eddy-Miller, C.A., Wheeler, J.D., and Essaid, H.I., 2009, Characterization of interactions between surface water and near-stream groundwater along Fish Creek, Teton County, Wyoming, by using heat as a tracer: USGS Scientific Investigations Report 2009-5160, 53 p.
- 2010 – Eddy-Miller, C.A., and Wheeler, J.D., 2010, Chloride concentrations and stable isotopes of hydrogen and oxygen in surface water and groundwater in and near Fish Creek, Teton County, Wyoming, 2005-2006: U.S. Geological Survey Data Series 518, 12 p.
- Wright, P.R., 2010, Hydrogeology and water quality in the Snake River alluvial aquifer at Jackson Hole Airport, Jackson, Wyoming, September 2008–June 2009: U.S. Geological Survey Scientific Investigations Report 2010–5172, 54 p.
- 2013 – Eddy-Miller, C.A., Peterson, D.A., Wheeler, J.D., Edmiston, C.S., Taylor, M.L., and Leemon, D.J., 2013b, Characterization of water quality and biological communities, Fish Creek, Teton County, Wyoming,

- 2007–2011: U.S. Geological Survey Scientific Investigations Report 2013–5117, 76 p., <http://pubs.usgs.gov/sir/2013/5117/>.
- Wright, P.R., 2013, Hydrogeology and water quality in the Snake River alluvial aquifer at Jackson Hole Airport, Jackson, Wyoming, water years 2011 and 2012: U.S. Geological Survey Scientific Investigations Report 2013–5184, 56 p.
- *Wyoming Water Development Commission Studies*
 - 1973 – Wyoming Water Planning Program, 1973, Wyoming's groundwater supplies: Wyoming State Engineer's Office, Wyoming Water Planning Program Report, Cheyenne, Wyoming, [variously paged].
 - 1984 – Nelson Engineering, 1984, Jackson water feasibility study, groundwater exploration program: prepared for the Wyoming Water Development Commission, Cheyenne, Wyoming, [variously paged].
 - 1986 – Forsgren-Perkins Engineering, 1986, Bedford water supply study, level 1 final report: prepared for the Wyoming Water Development Commission, Cheyenne, Wyoming, [variously paged].
 - Lageson, D.R., 1986, Geologic map of the Stewart Peak Quadrangle, Lincoln County, Wyoming: Wyoming State Geological Survey, Map Series 22, 1 sheet, scale 1:24,000.
 - 1987 – Forsgren-Perkins Engineering, 1987, Bedford water supply study Level II final report: prepared for the Wyoming Water Development Commission, Cheyenne, Wyoming, [variously paged].
 - 1989 – Forsgren Associates, 1989, Star Valley municipal water supply, level I study: prepared for the Wyoming Water Development Commission, Cheyenne, Wyoming, [variously paged].
 - 1990 – Forsgren Associates, 1990, Afton municipal water supply Level II study, final report: prepared for the Wyoming Water Development Commission, Cheyenne, Wyoming, [variously paged].
 - Forsgren Associates (in association with Weston Engineering), 1990, Star Valley Ranch master plan: prepared for the Wyoming Water Development Commission, Cheyenne, Wyoming, [variously paged].
 - 1991 – AVI Professional Corporation (in association with Lidstone and Anderson, Inc.), 1991, level I study - Squaw Creek water supply project: prepared for the Wyoming Water Development Commission, Cheyenne, Wyoming, [variously paged].
 - Forsgren Associates, 1991a, Star Valley municipal water supply, level II Study- report of the Etna water supply system, final report: prepared for the Wyoming Water Development Commission, Cheyenne, Wyoming, [variously paged].
 - Forsgren Associates, 1991b, Star Valley municipal water supply, level II Study- report of the Freedom water supply system, final report: prepared for the Wyoming Water Development Commission, Cheyenne, Wyoming, [variously paged].
 - Forsgren Associates, 1991c, Star Valley municipal water supply, level II Study- report of the Grover water

- supply system, final report: prepared for the Wyoming Water Development Commission, Cheyenne, Wyoming, [variously paged].
- Forsgren Associates, 1991d, Star Valley municipal water supply, level II Study- report of the Osmond water supply system, final report: prepared for the Wyoming Water Development Commission, Cheyenne, Wyoming, [variously paged].
- Forsgren Associates, 1991e, Star Valley municipal water supply, level II Study- report of the Smoot water supply system, final report: prepared for the Wyoming Water Development Commission, Cheyenne, Wyoming, [variously paged].
- Forsgren Associates, 1991f, Star Valley municipal water supply, level II Study- report of the Fairview water supply system, final report: prepared for the Wyoming Water Development Commission, Cheyenne, Wyoming, [variously paged].
- Nelson Engineering, 1991, Teton Village water supply study level I: prepared for the Wyoming Water Development Commission and the Town of Jackson, [variously paged].
- Sunrise Engineering Inc., 1991, Alpine Junction water level I study: prepared for the Wyoming Water Development Commission, Cheyenne, Wyoming [variously paged].
- 1992 – Forsgren Associates, 1992, Freedom Water and Sewer District water supply system – part of the Star Valley level II study, final report (revised): prepared for the Wyoming Water Development Commission, Cheyenne, Wyoming, [variously paged].
- 1993 – Forsgren Associates (in association with Weston Engineering), 1993a, Etna Water and Sewer District water supply system – part of the Star Valley level II study, final report (revised): prepared for the Wyoming Water Development Commission, Cheyenne, Wyoming [variously paged].
- Nelson Engineering, 1993, Town of Jackson groundwater exploration program, final report: prepared for the Wyoming Water Development Commission, Cheyenne, Wyoming, [variously paged].
- TriHydro Corporation, 1993, Construction and testing report Freedom No. 2 test well, Freedom, Wyoming: prepared for the Wyoming Water Development Commission, Cheyenne, Wyoming, [variously paged].
- 1994 – Lidstone and Anderson, Inc., (in association with AVI Professional Corporation), 1994, Squaw Creek water supply project – level II: prepared for the Wyoming Water Development Commission, Cheyenne, Wyoming, [variously paged].
- 1995 – Forsgren Associates, 1995, Thayne area water supply, level I study: prepared for the Wyoming Water Development Commission, Cheyenne, Wyoming, [variously paged].
- TriHydro Corporation, 1995, Level I groundwater reconnaissance investigation, Thayne, Wyoming: prepared for Forsgren Associates, [variously paged].
- 1996 – Jorgensen Engineering and Land Surveying, PC, (in association with Hinckley Engineering), 1996, Final – Buffalo Valley level I – water

- supply project report: prepared for the Wyoming Water Development Commission, Cheyenne, Wyoming, [variously paged].
- 1997 – Forsgren Associates, 1997, Thayne water supply, level II study: prepared for the Wyoming Water Development Commission, Cheyenne, Wyoming, [variously paged].
- Jorgensen Engineering and Land Surveying, PC, (in association with Hinckley Engineering), 1997, Final report– Buffalo Valley water supply project level II – Teton County: prepared for the Wyoming Water Development Commission, Cheyenne, Wyoming, [variously paged].
- TriHydro Corporation, 1997, Well construction and testing report, level II feasibility study, Thayne, Wyoming: prepared for the Wyoming Water Development Commission and Forsgren Associates, [variously paged].
- 1998 – Jorgensen Engineering and Land Surveying, PC, (in association with Gordon-Prill-Drapes and Hinckley Engineering) 1998, Final – Rafter J water supply level II study: prepared for the Wyoming Water Development Commission, Cheyenne, Wyoming, [variously paged].
- Forsgren Associates, 1998, Turnerville water supply system, Thayne area water supply level II study, final report: prepared for the Wyoming Water Development Commission, [variously paged].
- 1999 – BRS, Inc., 1999, in association with Lidstone and Associates, Afton water supply project level II, final report: prepared for the Wyoming Water Development Commission, Cheyenne, Wyoming, [variously paged].
- 2001 – Rio Verde Engineering, 2001, Final report for the Alpine Spring irrigation supply project: prepared for the Wyoming Water Development Commission, Cheyenne, Wyoming, [variously paged].
- 2002 – Rendezvous Engineering, PC, (in association with Hinckley Engineering) 2002, Final report - level I - Alta master plan: prepared for the Wyoming Water Development Commission, Cheyenne, Wyoming, [variously paged].
- Rendezvous Engineering, PC, (in association with Hinckley Consulting and Sunrise Engineering), 2002, Final report for level II North Alpine water supply study: prepared for the Wyoming Water Development Commission, [variously paged].
- 2003 – Keller Associates, Inc., 2003, Kennington Springs Pipeline Company level I water system reconnaissance study, final report: prepared for the Wyoming Water Development Commission, Cheyenne, Wyoming, [variously paged].
- Sunrise Engineering, Inc., (in association with Boyle Engineering, Inc., BBC Consulting, Inc., Hinckley Consulting, Fassett Consulting, Rendezvous Engineering, and Nelson Engineering), 2003, Snake/Salt River Basin Plan, final report and technical memoranda: prepared for the Wyoming Water Development Commission, Cheyenne, Wyoming, [variously paged].
- 2006 – Nelson Engineering, 2006, in

- association with Lidstone and Associates, Inc., Hoback Junction water supply study level I, final report: prepared for the Wyoming Water Development Commission, [variously paged].
- Sunrise Engineering, Inc., 2006, Siting, construction, and testing of the Town of Afton new municipal East Alley Well: prepared for the Wyoming Water Development Commission, Cheyenne, Wyoming, [variously paged].
- 2007 – Rendezvous Engineering, PC, (in association with Hinckley Engineering), 2007, Final report - level II - Alta groundwater supply study: prepared for the Wyoming Water Development Commission, Cheyenne, Wyoming, [variously paged].
- WWC Engineering, Inc., (in association with Hinckley Consulting, Collins Planning Associates, Greenwood Mapping, Inc., and States West Water Resources Corporation), 2007, Wyoming framework water plan level II): prepared for the Wyoming Water Development Commission, Cheyenne, Wyoming, [various pagination] [Available at: <http://waterplan.state.wy.us/>].
- 2008 – Forsgren Associates, 2008, in association with Weston Engineering, Star Valley Ranch master plan, final report: prepared for the Wyoming Water Development Commission, [variously paged].
- 2009 – Rendezvous Engineering, PC, (in association with Hinckley Engineering), 2009a, Alpine master plan update level II, final report: prepared for the Wyoming Water Development Commission, Cheyenne, Wyoming, [variously paged].
- Rendezvous Engineering, PC, (in association with Hinckley Consulting), 2009b, Final report, level II North Alpine water supply study: prepared for the Wyoming Water Development Commission, Cheyenne, Wyoming, [variously paged].
- Sunrise Engineering, Inc., 2009a, Star Valley regional master plan - Town of Afton – water system investigation and evaluation: prepared for the Wyoming Water Development Commission, Cheyenne, Wyoming, [variously paged].
- Sunrise Engineering, Inc., (in association with Boyle Engineering, Harvey Economics, Rendezvous Engineering and Collins Planning Associates), 2009b, Star Valley regional master plan final report: prepared for the Wyoming Water Development Commission, Cheyenne, Wyoming, [variously paged].
- Weston Engineering and Forsgren Associates, 2009, Star Valley Ranch groundwater level II study, final report: prepared for the Wyoming Water Development Commission and Town of Star Valley Ranch, [variously paged].
- 2012 – AVI Professional Corporation (in association with Dahlgren Consulting, Pierson Land Works, Stockdale Consulting), 2012, Squaw Creek water supply level II study: prepared for the Wyoming Water Development Commission, Cheyenne, Wyoming, [variously paged].

2.3 Current WWDC and USGS hydrogeologic investigations in the Snake/Salt River Basin

In addition to these existing studies, the WWDO is updating the previous Snake /Salt River Basin Water Plan (Sunrise Engineering, 2003) and constructing a hydrological model for surface flows in the basin. The U.S. Geological Survey (USGS) is currently conducting specific hydrogeologic investigations of Fish Creek near Wilson, Wyoming and the Snake River Alluvial aquifer in the vicinity of the Jackson Hole Airport. Reports of these investigations can be obtained from the USGS publications website: <http://pubs.er.usgs.gov/>. Additionally, the USGS continues to collect real time streamflow data and periodic water quality at 16 USGS gaging stations located in the basin: <http://waterdata.usgs.gov/wy/nwis/current/?type=flow>.

2.4 Current Available Groundwater Determination

The previous investigations, noted above, examined the hydrogeology of geographic areas of varying scale that fall partly or entirely within the Snake/Salt River Basin. The study area of this and the previous memorandum (Sunrise Engineering, 2003) include the surface drainages of the Snake/Salt River that lie within the borders of the state of Wyoming as well as watersheds in Idaho that are tributary to the Wyoming Snake Salt River Basin (**fig. 3-1**).

A detailed hydrostratigraphy of the Snake Salt River Basin was developed by the USGS for this study based on stratigraphic regions by Love and others (1993). Development of the updated hydrostratigraphy is described in **chapter 7** and summarized on hydrostratigraphic nomenclature charts (**pls. 4-6**), and on **plate 2**.

This Available Groundwater Determination provides expanded information on several topics, to more fully characterize the groundwater resources of the Snake Salt River Basin:

- Effects of structure on groundwater

distribution and flow (**section 5.4** and **chapter 7**),

- Potential hydrothermal resources (**chapter 4**),
- Aquifer vulnerability and potential sources of groundwater contamination (**section 5.6**),
- Comparisons of calculated aquifer(s)-specific recharge volumes with updated precipitation data, and current and projected beneficial uses (**section 6.2**),
- A basinwide water balance (**chapter 8**),
- A detailed listing and summary of historic groundwater development studies by the WWDC in the Snake Salt River Basin (**appendix B**).

2.5 Maps

Progressive improvements in geographic information system (GIS) technology have greatly enhanced the geologist's ability to process and present large, complex geospatially linked datasets for natural resource evaluations. To meet the objectives of this updated Available Groundwater Determination, the WSGS and USGS developed a series of maps to present and evaluate the extensive digital data resources available on Snake/Salt River Basin groundwater resources. Several maps were generated wholly or primarily from existing GIS databases compiled specifically for this study. Some of the maps and layers were supplemented with information scanned or digitized from existing hard copy maps into GIS-supported formats.

The accuracy of any map or figure depends on the accuracy of the original data and the methods used to process it. Frequently, data processing for large compilations requires correlations between multiple, disparate datasets. The limitations of the data used in digital mapping make it necessary for the analyst to provide the reader with interpretive qualifications regarding the reliability of the produced maps and figures. This memorandum provides discussions of data limitations and cites data sources for each map and figure presented.

Additionally, metadata (qualifying information on the GIS datasets) is commonly furnished

along with the GIS data. Metadata provides structured and detailed descriptive information about the data resources used to develop GIS map layers. Metadata facilitates the understanding, use, and management of the data by defining its sources, locations, formats, attributes, processing, limitations, disclaimers, etc. Where appropriate, the metadata includes contact information to obtain additional information. The metadata associated with the Snake/Salt River Basin maps are provided online at <http://waterplan.state.wy.us/plan/>.

WSGS and USGS generated the maps for this study in two formats. Plate-scale maps use 1:380,000 scale (1 inch = 6 miles). Figure-scale maps use variable scales that allow the maps to fit either 8½ × 11-inch, or 11 × 17-inch sheets depending on readability considerations.

