APPENDIX A

DATA COMPILATION

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APPENDIX A-1

BIBLIOGRAPHY

Spokane Watershed Bibliography Appendix A1

1. Adema, G. W. Bedrock Depth and Morphology of the Rathdrum Prairie, Idaho: University of Idaho; c1999. 67 pages.
   Notes: Master of Science Thesis

2. Adema, G. W.; K.F.Sprenke., and R.M. Breckenridge. Bed Morphology of the Spokane Valley/Rathdrum Prairie Aquifer from a Detailed Gravity Survey [abstract]. Geological Society of America. 1998; 30(6).

3. Ader, M. J. Hydrogeology of the Green Bluff Plateau Spokane County. Washington State Department of Ecology, Shorelands and Water Resources Program; 1996; Open File Technical Information Report 96-03. 27 pages.

4. Allen, D. R. Latah Creek, Washington, Watershed: 1995-1996 Water Year Water Quality Assessment [abstract]. Inland Northwest Water Resources Conference, Program and Abstracts; 1997.

5. Amerigian, C.; J. Toth, and S.P. Reidel. Paleomagnetism of the Columbia River Basalt Group [abstract]. Geological Society of America Abstracts With Programs. 1987; 19(6):354.

6. Ames, K. C.; N.P. Matson.; D.M. Suzuki., and P.B. Sak. Inventory, Characterization, and Water Quality of Springs, Seeps, and Streams near Midnite Mine, Stevens County, Washington. U.S. Geological Survey; 1996; U.S. Geological Survey Open-File Report 96-115. 53 pages.

7. Anderson, A. M.; K. Bloudek.; P.O. Hyde; O. O'Connor, and N. Ogren. Evaluation of Urban Runoff Treatment in Swales. Spokane, Washington: Gonzaga University, School of Engineering, Center for Engineering Design; 1996; Senior Design Project 95-5. 44 pages.

8. Anderson, M. P. and Woessner, W. W. Applied Groundwater Modeling: Simulation of Flow and Advective Transport. San Diego: Academic Press; 1992.

9. Anderson, R. Hydrogeologic Study of the Deer Park, Washington Aquifer System: Eastern Washington University; 1986 80 pages, 7 plates.
   Notes: Master of Science Thesis

10. Andres, G. E. and Harrar, W. G. Groundwater Modeling at the Colbert Superfund Site, Washington [abstract]. Geological Society of America Abstracts With Programs. 1992; 24(5):3.

11. Ashlock, D.; W.J. Burns.; K.E. Hartz; M.Q. Luther., and M. Kennedy. What Can Communities Do to Preserve and Protect Their Aquifers? A Panel Discussion. in Washington Water Research Center. Protection and Management of Aquifers with Emphasis on the Spokane-Rathdrum Aquifer; 1985: pages 95-105.

12. Avista Corporation. 1997 - 1999 Upper Spokane River Rainbow Trout Spawning and Fry Emergence Study. Spokane, Washington; 2000 Jun 26 pages.

13. Aziz, N. M. A Baseline Water Quantity Investigation of the West Medical Lake Drainage Basin, Spokane County, Washington: Eastern Washington University; 1995 90 pages.
    Notes: Master of Science Thesis

14. Bailey, Gary C. and Jack Saltes. Fishery Assessment of the Upper Spokane River. Pullman, WA 99164-3002: State of Washington, Water Esearch Center, Washington State University; 1982 Jun; Report 46. 110 pages.

15. Baker, V. R. Palaeohydrology and Sedimentology of Lake Missoula Flood in Eastern Washington. Boulder,

Colorado; 1973; Geological Society of America Special Paper 144. 79 pages.

16. Barker, V. R. and R.D. MacNish. Digital Model of the Gravel Aquifer, Walla Walla River Basin, Washington and Oregon. U.S. Geological Survey; 1976; U.S. Geological Survey Water Supply Bulletin 45. 49 pages.

17. Bauer, H. H. and J.J. Vaccaro. Documentaton of a Deep Percolation Model for Estimating Ground-Water Recharge: A Contribution of the Regional Aquifer-System Analysis Program. Tacoma, Washington: U.S. Geological Survey; 1987; OFR 86-536. 180 (Open-File Reports).

18. Beard, L. D. Design and Construction of Deep Groundwater Monitoring Wells. Nielsen, D. M. Sara M. N., Editors. Current Practices in Ground Water and Vadose Zone Investigations. American Society for Testing and Materials; 1992; pp. 256-269.

19. Beckwith, M. A. Concepts for Monitoring Water Quality in the Spokane River Basin, Northern Idaho and Eastern Washington: U.S. Geological Survey; 1998; U.S. Geological Survey Open-File Report 98-534. 25 pages.

20. Bennett, David H. and Tevis J. Underwood (Department of Fish and Wildlife Resources, College of Forestry, Wildlife, and Range Sciences, University of Idaho, Moscow, Idaho 83843). Population Dynamics and Factors Affecting Rainbow Trout (Salmo gairdneri) in the Spokane River. Spokane, Washington: The Washington Water Power Company; 1988 Feb; Completion Report No. 3. 70 pages, appendices.

21. Bentley, R. D. Angular Unconformity and Thrust Fault in the Umtanum Anticlinal Uplift near Priest Rapids Dam, Central Washington . Eos (American Geophysical Union Transactions). 1980; 61(46):1108.

22. Bentley, R. D. and N.P. Campbell. Miocene-Pliocene Stratigraphy of Western Columbia Plateau, Washington [abstract]. Geological Society of America Abstracts With Programs. 1982; 14(4):149.

23. Berenbrock, C.; M.D. Bassick/T.L. /Rogers, and S.P. Garcia. Depth to Water, 1991, in the Rathdrum Prairie, Idaho; Spokane River Valley, Washington; Moscow-Lewiston-Grangeville Area, Idaho; and Selected Intermontaine Valleys, East-Central Idaho. Boise, Idaho: U.S. Geological Survey; 1995; U.S. Geological Survey Water-Resources Investigations Report 94-4087.

24. Boese, R.; S. Miller, and B. Lackaff. The Comparison of Ground Water Susceptibility Modeling Results with Measured Ground Water Quality in Spokane County, Washington. 1998.
Notes: Presented at: Groundwater Protection Council Annual Meeting, Sacramento California

25. Boese, R. M. Aquifer Delineation and Baseline Groundwater Quality Investigation of a Portion of North Spokane County, Washington: Eastern Washington University; 1996 224 pages.
Notes: Master of Science thesis

26. Boese, R. M. and J.P. Buchanan. Aquifer Delineation and Baseline Groundwater Quality Investigation of a Portion of North Spokane County. 1996 200 pages.
Notes: Final Project Report Prepared for Spokane County, Department of Geology, Eastern Washington University, Cheney, WA

27. Boleneus, D. E. The Peone Uranium Target: Evaluation of Drilling Information and Recommendations for Exploration. 1978.
Notes: Prepared for Teton Exploration Drilling Company, Inc.

28. Boleneus, D. E. and R.E. Derkey. Geohydrology of Peone Prairie, Spokane County, Washington. Washington Geology. 1996; 24(1):Pages 30-39.

29. Bolke, E. L. and J.J. Vaccaro. Digital-Model Simulation of the Hydrologic Flow System, with Emphasis on Ground Water, in the Spokane Valley, Washington and Idaho. U.S. Geological Survey; 1981; U.S. Geological Survey Water-Resources Investigations Open-File Report 80-1300. 43 pages.

30. Bolke, E. L. J. J. Vaccaro. Selected Hydrologic Data for the Spokane Valley, Spokane, Washington, 1977-78. Tacoma, WA : United States Geological Survey; 1979; United States Geological Survey Open File Report 79-333. 98 pages.
Notes: Prepared in cooperation with the Spokane County Engineers Office

31. Bond, J. G.; J.D. Kauffman; D.A.Miller.; W. Barrash.; J.C. Brown.; J.H. Bush Jr.; W.B. Hall; et al, and Geoscience Research Consultants. Geology of the Southwestern Pasco Basin. 1978; Rockwell Hanford Operations RHO-BWI-C-25. 217 pages, in folder with 43 plates.

32. Bonneville Power Administration . FY 2001 Provincial Review Project. 2001.
Notes: Form for Middle/Little Spokane River IFIM Study

33. Bonneville Power Administration; Northwest Power Planning Council; Columbia Basin Fish and Wildlife Authority, and Independent Scientific Review Panel. Columbia River Basin Fish and Wildlife Program Guide to Fiscal Year 2001 Project Peer Reviews in the Columbia Gorge and Inter-Mountain Provinces. 2000 Jul 27 pages.

34. Box, Stephen and John C. Wallis. Surficial Geology Along the Spokane River, Washington and It's Relationship to the Metal Content of Sediments. U.S. Geological Survey; 2002(USGS Open-File Report 02-126).

35. Brandstoettner, E. Petrified Wood at Expo of Gems. Jewelry Making, Gems and Minerals. 1983; 54934.

36. Breckenridge, R. M.; K.L. Othberg; J.H. Welhan.; C.R. Knowles., and P.A. McDaniel. Geologic Characteristics of the Rathdrum Prairie Aquifer, Idaho [abstract]. Inland Northwest Water Resources Conference, Program and Abstracts; 1930.

37. Bretz, J. H. Lake Missoula and the Spokane Floods. Geological Society of America Bulletin. 1930; 41:92-93.

38. Bretz, J. H. Washington's Channeled Scabland. Washington Division of Mines and Geology; 1959; Washington Division of Mines and Geology Bulletin 45. 57 pages.

39. Briggs, T. D. and L.L. Conner. A Hydrogeologic Investigation to Evaluate Flood Control Remedies in North Spokane County [abstract]. Program and Abstracts from the 3rd Symposium on the Hydrogeology of Washington State: Washington Department of Ecology; Washington Hydrologic Society; U.S. Geological Survey; 2000 36 pages.

40. Broom, H. C. Gaging Station Records in Spokane River Basin, Washington, from Post Falls, Idaho to Long Lake, Washington, Including Little Spokane River, Water Years 1948 to 1950. Tacoma, Washington; 1951; U.S. Geological Survey Open-File Rport. 29 pages.

41. Buchanan, J. P. Evaluation of Proposed Municipal Wells Sites for the City of Coeur d'Alene, Idaho with Emphasis on Potential TCE Contamination. 1999.
Notes: Report submitted to Welch Comer & Associates, Inc. and the City of Coeur d'Alene

42. --. Ground Water and Surface Water Hydrology of the Sullivan Road Gravel Pit. Spokane, WA ; 1998 40 pages.
Notes: Prepared for: Central Pre-Mix Concrete Company and Acme Materials and Construction Company

43. --. Groundwater Flow Simulation in the Vicinity of the Burlington Northern/Santa Fe Railroad Refueling

site, Rathdrum Prairie, Idaho. 1999 9 pages plus computer files.
Notes: Report submitted to Kennedy/Jenks Consultants

44. ---. The Rathdrum Prairie-Spokane Valley Aquifer Connection: How Much Ground Water is Crossing the State Line (Does Anybody Really Know)? . IN Washington Department of Ecology. The First Symposium on the Hydrogeology of Washington State: Washington State Department of Ecology; 1995: page 50.

45. Buchanan, J. P. Unified Groundwater Flow Model of the Rathdrum Prairie: Spokane Valley Aquifer System. 2000.
Notes: Prepared for the Spokane County Water Quality Management Program and Idaho Division of Environmental Quality.

46. Buchanan, J. P. and I.A. Olness. Groundwater Flow Model of the Spokane Valley Portion of the Spokane Valley - Rathdrum Prairie Aquifer System.
Notes: Report submitted to the Water Quality Management Program, Spokane County Engineers. 1994.

47. Buchanan, J. P. and K. McMillan. Investigation of the Hangman Valley Aquifer and its Continuity with the "Lower" Spokane Aquifer: Seismic Reflection Profiling and Groundwater Flow Estimates [abstract]. Inland Northwest Water Resources Conference, Program and Abstracts; 1997.

48. Burkett, S. E. Groundwater and Water and Nutrient Budget Studies of Newman Lake, Washington: Washington State University; 1991 159 pages.
Notes: Master of Science Thesis

49. Campbell, M. C.; S.J. Bennett, and P.S. Cocks. Above and Below Ground: A Comparative Study of the Root and Shoot Growth of Pasture Legumes [Web Page]. 1998. Available at: http://life.csu.edu.au/agronomy/papers/297/297.html.

50. Carey, B. M. Vadose Zone Monitoring at Deer Park, Washington--A Municipal Land Application Site. . Washington Department of Ecology, Abstracts from the 1st Symposium on the Hydrogeology of Washington State: Washington Department of Ecology; 1995: page 29.

51. Cassem, B. R. and J.D. Fancher. Plume Delineation using a Cone Penetrometer System [abstract]. Washington Department of Ecology, Abstracts from the 1st Symposium on the Hydrogeology of Washington State: Washington Department of Ecology; 1995: page 30.

52. Celto, E. and D.R. Allen. Spokane River Watershed Web Site [abstract]. Inland Northwest Water Resources Conference, Program and Abstracts; 1997.

53. CH2M-Hill. Citizens Wellhead Committee Issues. 1999 May.
Notes: Prepared for Spokane Aquifer Joint Board and City of Spokane Wellhead Protection Program

54. ---. City of Spokane Wellhead Protection Program Phase I Technical Assessment Report. 1998.
Notes: Unpublished technical report to the City of Spokane

55. --. City of Spokane Wellhead Protection Program, Spokane Valley Aquifer Conceptual Model. 1994.
Notes: Prepared for City of Spokane Planning and Engineering Services

56. --. Spokane Aquifer Joint Board Wellhead Protection Plan, Management Plan and Report Appendix. 2000 3 Volumes.
Notes: Prepared for: Spokane Aquifer Joint Board

57. Choiniere, S. R. and D.A. Swanson. Magnetostratigraphy and Correlation of Miocene Basalts of the Northern

Oregon Coast and Columbia Plateau, Southeast Washington. American Journal of Science. 1979; 279(7):755-777.

58. Christenson, D. H. Hydrology of Urban Watersheds in Cheney, Washington with an Emphasis on Stormwater Runoff and Water Quality: Eastern Washington University; 1997 139 pages.
Notes: Master of Science Thesis

59. ---. Surface Runoff Water Quality and Hydrology Assessments for a Stormwater Management Plan for the City of Cheney, Washington [abstract]. Inland Northwest Water Resources Conference, Program and Abstracts; 1997.

60. Chung, S. K. Water Resources Management Program - Little Spokane River Basin WRIA 55. Olympia, Washington: Department of Ecology, Policy Development Section, Water Resources Division; 1975 83 pages.

61. City of Spokane. Spokane Wastewater Treatment Plant River Metals Study.

62. Cline, D. R. Ground-Water Resources and Related Geology, North Central Spokane and Southeastern Stevens Counties. Olympia, WA: Department of Water Resources; 1969; Water Supply Bulletin No. 27. 195 pages.
Notes: Prepared in cooperation with U.S. Geological Survey

63. Cochran, M. P. Geophysical Investigation of a Segment of the Rattlesnake Hills Lineament [abstract]. Eos (American Geophysical Union Transactions). 1982; 63(8):173.

64. ---. Geophysical Investigation of Eastern Yakima Ridge, South-Central Washington: Washington State University; 1982 132 pages, 4 plates.
Notes: Master of Science Thesis

65. Collins, B. The Development of a Detailed Data Base for Informed Decision Making . Proceedings from the Conference, Protection and Management of Aquifers with Emphasis on the Spokane-Rathdrum Aquifer: Washington Water Research Center; 1985: pages 35-38.

66. Cook, J. R. Spokane NTSM 1 Degree by 2 Degree Quadrangle Area, Washington-Idaho-Montana; Data Report (abbreviated); Hydrogeochemical and Stream-Sediment Reconnaissance; 1980; U.S. Department of Energy GJBX-211(80), DPST-80-146-15. 17 pages.

67. Covert, J. J. Water Rights/Water Availability in the Little Spokane River Watershed Water Resource Inventory Area 55, Washington [abstract] . Inland Northwest Water Resources Conference, Program and Abstracts; 1997.

68. Cox, S. E.; W.T. Foreman; G.Cortleson, and K.A. Green. Distribution of Selected Trace Elements and Chlorinated Dioxins in Water and Suspended Sediment of the Columbia River at Northport, Washington. Proceedings of the Canada/United States Technical Workshop on the Upper Columbia River Basin, Spokane, Washington. 1994.

69. Crosby III, J. W. Preliminary Investigation of the Garden Springs Ground Water Problem, Spokane County, Washington. Washington State University College of Engineering; 1963; Washington State University College of Engineering Research Division Research Report 63/9-33.

70. Crosby III, J. W.; D.L. Johnstone; C.H. Drake, and R.L. Fenton. Migration of Pollutants in a Glacial Outwash Environment. Water Resources Research. 1968; 4(5):1095-1114.

71. Crosby III, J. W.; D.L. Johnstone, and R.L. Fenton. Migration of Pollutants in a Glacial Outwash Environment, 3. Water Resources Research. 1971; 7(3):713-720.

72. Crosby III, J. W.; D.L. Johnstone; R.L. Fenton.; C.H. Drake.; W.J. Purves.; J.P. Kiesler.; C.A. Ko., and E.C. Weakly. Investigation of Techniques to Provide Advance Warning of Ground-Water Pollution Hazards with Special Reference to Aquifers in Glacial Outwash. Washington State University College of Engineering Research Division; 1971.

73. Crosby III, J. W.; J.C. Brown., and R.W. Tucker. Geophysical Investigations of Cheney City Well 5: Washington State University College of Engineering; 1977; Washington State University College of Engineering Research Division Research Report 77/15-24.

74. Crosby III, J. W.; T.L. Weber, and J.A. Anderson. Geological and Geophysical Interpretations, Cheney City Well Number 5. Washington State University College of Engineering; 1974; Washington State University College of Engineering Research Division, Research Report 75/15-1.

75. Cunningham, R. and R.E. Pine. Preliminary Investigation of the Low Dissolved Oxygen Concentrations that Exist in Long Lake Locate Near Spokane, Washington. Olympia, WA: Washington State Water Pollution Control Commission; 1969; Washington State Water Pollution Control Commission Technical Report No. 69-1.

76. Cusimano, Bob. Spokane River and Long Lake Total Maximum Daily Load Study Data Summary Report. Review Draft ed.; Washington State Department of Ecology; 2002 Dec; Publication No. 02-03-001. 35 pages.

77. Daly, C.; G.H. Taylor, and W.P. Gibson. The PRISM Approach to Mapping Precipitation and Temperature. 10th Conference of Applied Climatology; Reno, Nevada. American Meteorological Society; 1997: pages 10-12.

78. Daly, C.; R.P. Neilson, and D.L. Phillips. A Statistical-Topographic Model for Mapping Climatological Precipitation over Mountain Terrain. Journal of Applied Meteorology. 1994; 33:140-158.

79. Dames and Moore Inc. and Cosmopolitan Engineering Group. Draft Initial Watershed Assessment Water Resources Inventory Area 55, Little Spokane River Watershed. 1995; Open-File Technical Report 95-15. 33 pages.
Notes: Prepared in cooperation with the Washington State Department of Ecology

80. Danish Hydraulic Institute. Mike SHE Water Movement User Manual (for Version 2001b). 2001.

81. Deobald, W. B. and J.P. Buchanan. Hydrogeology of the West Plains Area of Spokane County, Washington: Spokane County, Department of Geology, Eastern Washington University, Cheney, WA ; 1995.

82. Deobald, W. B.; J.P. /Buchanan., and F.E. Durham. Hydrogeology of the Northeastern Columbia Plateau: The Wanapum and Grande Ronde Hydrostratigraphic Units in Lincoln and Spokane Counties, Washington [abstract]. Abstracts from the 1st Symposium on the Hydrogeology of Washington State: Washington Department of Ecology; 1995.

83. Derkey, R. E. Geologic Map of the Mead 7.5. Minute Quadrangle, Spokane County, Washington. Washington State Department of Natural Resources, Division of Geology and Earth Resources; 1997 Jun; Open File Report 97-3.

84. Derkey, R. E.; C.W. Gulick; S.P. Palmer, and W.J. Gerstel. An Interdisciplinary Approach to Sole-Source Aquifer Management Planning--Subsurface Investigation of Missoula Flood Deposits that Form the Sole Source Aquifer for Spokane, Washington [abstract]. Geological Society of America Abstracts With Programs. 1994; 26(7): A-100 - A-101.

85. Derkey, R. E.; W.J. Gerstel, and R.L. Logan. Geologic Map of the Dartford 7.5. Minute Quadrangle, Spokane County, Washington. Washington State Department of Natural Resources, Division of

Geology and Earth Resources; 1998 Jun; Open File Report 98-6.

86. Derkey, Robert E. and Michael M. Hamilton. Unpublished Data. 2000: Washington State Department of Natural Resources, Division of Geology and Earth Resources.

87. Dion, N. P. Geohydrologic Reconnaissance of a Ground-Water Contamination Problem in the Argonne Road Area near Spokane, Washington. U.S. Geological Survey with the cooperation of Washington State Department of Ecology; 1987; U.S. Geological Survey Water-Resources Investigations Report 86-4173. 37 pages.

88. Dion, N. P.; G.C. Bortleson; J.B. McConnell, and L.N. Nelson. Reconnaissance Data on Lakes in Washington. Washington State Department of Ecology; 1976; Water-Supply Bulletin 43. 267 pages. Notes: Volume 7: Pend Oreille, Spokane, and Stevens Counties

89. Dion, N. P. and S.S. Sumioka. Extent and Source of Organic Solvents in Ground Water in the Argonne Road Area near Spokane, Washington. U.S. Geological Survey; 1991; U.S. Geological Survey Water-Resources Investigations Report 89-4121. 39 pages.

90. Dobratz, W. and R.L. Wubbena./J.M. /Maxwell. Spokane County Protection and Management Plan for a Sole Source Aquifer. American Water Well Association, Annual Conference Proceedings; 1984: pages 561-587.

91. Doorenbos, J. and W.O. Pruitt. Crop Water Requirements. Food and Agricultural Organization of the United Nations; 1977(Irrigation and Drainage Paper).

92. Driscoll, F. G. Groundwater and Wells. St. Paul, MN: Johnson Screens; 1986.

93. Drost, B. W. and H.R. Seitz. "Sole-Source" Study [abstract]; 1978; U.S. Geological Survey Professional Paper 1100.

94. --. Spokane Valley - Rathdrum Prairie Aquifer - Washington and Idaho. Tacoma, WA : United States Geological Survey; 1978; United States Geological Survey Open File Report 77-829. 79 pages, 10 plates.

95. Drost, B. W. and K.J. Whiteman. Surficial Geology, Structure, and Thickness of Selected Geohydrologic Units in the Columbia Plateau, Washington. U.S. Geological Survey; 1986; U.S. Geological Survey Water-Resources Investigations Report 84-4326. 11 sheets.

96. Drost, B. W.; K.J. Whiteman, and J.B. Gonthier. Geologic Framework of the Columbia Plateau Aquifer System, Washington, Oregon, and Idaho. U.S. Geological Survey; 1990; U.S. Geological Survey Water-Resources Investigations Report 87-4238. 10 pages, 10 plates.

97. Duwelius, R. F. Hydraulic Conductivity of the Streambed, East Branch Grande Calumet River, Northern Lake County, Indiana. U.S. Geological Survey; 1996; U.S. Geological Survey Water Resources Investigations Report 96-4218. 37 pages.

98. Eastern Washington University and EWU Department of Urban and Regional Planning. A Resource Inventory for Little Spokane Scenic River Area. Cheney, WA; 1991.

99. Eaton, L. G.; B.F. Butler.; L.D. Beard., and J.S. Paul. Hydrologeology of the Colbert Landfill Superfund Site, Spokane County, Washington. Geological Society of America Abstracts With Programs. 1992; 24(5):22.

100. Economic & Engineering Services, Inc. Guide to Watershed Planning and Management. 1999.

101. Eddy, P. A. Ground Water Conditions in the Vicinity of Plaza, Spokane County, Washington: Washington State Department of Ecology; 1973; Washington State Department of Ecology Technical Report 73-8. 9 pages.

102. Embrey, S. S. Ground-Water Resources of Selected Areas of the Spokane and Kalispel Indian Reservations, Northeastern Washington. Wayenberg, J. A. and V. F. Renslow, Compilers. Summary of Water-Resources Activities of the U.S. Geological Survey in Washington--Fiscal Year 1991. U.S. Geological Survey; 1992; pp. 47-48.

103. Embrey, S. S.; A.J. Hansen., Jr., and D.R. Cline. Ground-Water Resources of Three Areas on the Spokane and Kalispel Indian Reservations, Northeastern Washington. U.S. Geological Survey; 1997; U.S. Geological Survey Water-Resources Investigations Report 94-4235. , 67 pages., 1 plate.

104. EMCON Northwest. Deer Park Ground Water Characterization Study, Draft Hydrogeologic Summary Report. 1992 Jun.
Notes: Report to Spokane County, Emcon Northwest, Bothell, WA. Project X22-01.02

105. --. Deer Park Ground Water Characterization Study Draft Hydrologic Report. 1992; Project X22-01.02.
Notes: Prepared for Spokane County, Emcon Northwest, Bothell, WA

106. Environmental Simulations. Groundwater Vistas . Version 2.0. Herndon, VA; 1998.

107. Esvelt, L. A. Spokane Aquifer Cause and Effect Report, Summary Report of '208' Water Quality Results and Cause and Effect Relationships for Water Quality in the Spokane - Rathdrum Aquifer. 1978 74 pages.
Notes: Spokane Water Quality Management Program, Spokane County Engineers Office, Spokane WA

108. ---. Water Quality of the Rathdrum Prairie-Spokane Valley Aquifer System. , Proceedings from the Conference, Protection and Management of Aquifers with Emphasis on the Spokane-Rathdrum Aquifer: Washington Water Research Center; 1985: pages 7-22.

109. Esvelt, L. A. and S.A. Miller. 208 Cause and Effect Report 1983 Update. Spokane, WA; 1983 16 pages.
Notes: Prepared for Spokane County Engineers Office

110. Fenneman, N. M. Physiography of Western United States. New York: McGraw-Hill ; 1931. 534 pages .

111. Flaherty, L. Restoration Measures at Newman Lake, Washington [abstract]. Inland Northwest Water Resources Conference, Program and Abstracts; 1997.

112. Freeze, R. A. and J.A. Cherry. Groundwater. Prentice-Hall, Inc.; 1979.

113. Frink, J. F. Spokane Valley Project - Geology and Groundwater Factors Controlling Design and Construction of Water Wells. U. S. Bureau of Reclamation; 1962; : U. S. Bureau of Reclamation Open File Report.

114. Frink, J. W. An Appraisal of Potential Ground Water Supply for Avondale and Hayden Lake Irrigation Districts, Rathdrum Prairie Project, Idaho. U. S. Bureau of Reclamation; 1968.

115. Funk, W. H.; F.W. Rabe; R. Filby, and et al. Biological Impact of Combined Metallic and Organic Pollution in the Coeur d'Alene - Spokane River Drainage System. Washington State University - University of Idaho, Joint Project Completion Report: Washington State University, University of Idaho; 1973 188 pages.
Notes: Washington State University and the University of Idaho, Joint Project Completion Report

116. Funk, W. H.; F.W. Rabe.; R. Filby, and et al. An Integrated Study on the Impact of Metallic Trace Element Pollution in the Coeur d'Alene - Spokane Rivers - Lake Drainage System: Washington State University, University of Idaho; 1975 332 pages.
Notes: Joint Project Completion Report

117. Funk, W. H. and L.K. Bucy. Restoration and Maintenance of Liberty Lake, Washington, Water Quality [abstract]. Inland Northwest Water Resources Conference, Program and Abstracts; 1997.

118. Garrett, A. A. and C.J. Londquist. Feasibility of Artificially Recharging Basalt Aquifers in Eastern Washington. U.S. Geological Survey; 1972; U.S. Geological Survey Open-File Report 72-127. 42 pages, 1 plate.

119. Gearhardt, C. and J. Buchanan. The Hydraulic Connection Between the Spokane River and the Spokane Aquifer: Gaining and Losing Reaches of the Spokane River From State Line, Idaho to Spokane, Washington, Final Project Report. Eastern Washington University, Department of Geology; 2000 Oct.

120. Geo-Slope International Ltd. SEEP/W Version 5 User's Guide. Calgary, Alberta, Canada: 2001.

121. Gerstel, W. J. Geologic Map of the Dartford 7.5-minute Quadrangle, Spokane County, Washington. Washington State Department of Natural Resources, Division of Geology and Earth Resources; June 1998 (Washington State Department of Natural Resources Open File Report 98-6).
Notes: 7.5-minute quadrangle.

122. Gerstel, W. J.; C.W. Gulick., and R.E. Derkey. Mapping Missoula Flood Deposits in the Spokane Valley--An Interdisciplinary Approach to Sole-Source Aquifer Management, Spokane County, Washington [abstract]. Washington Department of Ecology, Abstracts from the 1st Symposium on the Hydrogeology of Washington State: Washington Department of Ecology; 1995: Page 143.

123. Gerstel, W. J. and S.P. Palmer. Geologic and Geophysical Mapping of the Spokane Aquifer: Relevance to Growth Management. Washington Geology. 1994; 22(2):18-24.

124. Gifford Consultants, Inc.Letter To: Dr. John Buchanan, Eastern Washington University. 1995. 2 pages.
Notes: Technical Memorandum

125. Gilbert, J. Spokane River Metals Reduction Project Report--Actions Taken and Lessons Learned. Washington State Department of Ecology; 1997; Washington State Department of Ecology Publication 97-01. 25 pages.

126. Gilmour, E. H. and M. Bacon. Groundwater Resources and Potential Sewage Pollution in Southern Spokane County. Eastern Washington State College; 1974 58 pages.

127. Glasoe, S.; Steiner, F.; Budd, W., and Young, G. Assimilative Capacity and Water Resource Management--Four Examples from the United States. Landscape and Urban Planning. 1990; 19(1):17-46.

128. Golder Associates. Compilation of Review Comments for Draft Phase II, Level 1 Technical Assessment. 2002 Feb.

129. Golder Associates. Level I Technical Assessment . 2001.

130. Golder Associates. Phase I Remedial Investigation of the North Market Street Site, Spokane, Washington; Volume II--Final Report to State of Washington Department of Ecology. 1985.

131. Graham, W. A. Hydrogeologic Characterization and Reconnaissance Water Quality Study of the Chilco Channel Area, Kootenai County, Idaho: Eastern Washington University; 1994 127 pages.

Notes: Master of Science Thesis

132. Greene, K. E.; J.C. Ebbert., and M.D. Munn. Nutrients, Suspended Sediment, and Pesticides in Streams and Irrigation Systems in the Central Columbia Plateau in Washington and Idaho, 1959-1991. U.S. Geological Survey; 1994; U.S. Geological Survey Water-Resources Investigations Report 94-4215. 125 pages.

133. Greene, K. E.; M.D. Munn, and J.C. Ebbert. Nutrients, Benthic Algae, and Stream Quality during Low Streamflow in the Palouse River Basin, Washington and Idaho. U.S. Geological Survey; 1997; U.S. Geological Survey Water-Resources Investigations Report 96-4078. 38 pages.

134. Gruenenfelder, C. R. Evidence of a Deep Confined Aquifer System in the Hillyard Trough and Little Spokane River Valley of North Spokane [abstract]. Inland Northwest Water Resources Conference, Program and Abstracts; 1997.

135. Gulick, C. W. Agency Studies Aquifer Thickness. Groundwater Guard. 1993; 3(2):3.

136. Hall, T. L. Effects of Hillslope Development on Quantity and Quality of Recharge to the Spokane Aquifer, Spokane, Washington: Eastern Washington University; 1991 133 pages.
Notes: Master of Science Thesis

137. ---. Is Urban Runoff Water Quality Deleterious to Recharge of the Spokane Aquifer in Northeastern Washington? [abstract]. Geological Society of America Abstracts With Programs. 1989; 21(5):89.

138. Hansen, A. J. Jr.; J.J. Vaccaro, and H.H. Bauer. Ground-Water Flow Simulation of the Columbia Plateau Regional Aquifer System, Washington, Oregon, and Idaho. U.S. Geological Survey; 1994; U.S. Geological Survey Water-Resources Investigations Report 91-4187. 81 pages, 15 plates.

139. Hart-Crowser, Inc.Letter To: Kaiser Aluminum and Chemical Corporation. 1994 Feb 16.

140. Hathhorn, W. E. and T.R. Wubbena. Groundwater Risk Assessment Score Sheet for the Spokane Valley Aquifer. 1994; Washington Water Research Center Report A-181-WASH. 82 pages.

141. ---. Site Vulnerability Assessment for Wellhead Protection Planning. Journal of Hydrologic Engineering. 1996; 1(4):152-160.

142. Hattenburg, T. G. Geology and Hydrology of the Minnie Creek Drainage Basin with an Emphasis on Queen Lucas Lake, Spokane County, Washington: Eastern Washington University; 1994 198 pages.
Notes: Master of Science Thesis

143. Helz, R. T. and Wright, T. L. A Model for the Origin of the Yakima Basalt Subgroup, NW USA [abstract]. Geological Society of America Abstracts With Programs. 1987; 19(6):388.

144. Hendron, L. H. Wellhead Protection Program for the City of Spokane, Washington [abstract]. Inland Northwest Water Resources Conference, Program and abstracts; 1997.

145. Henry, M. Recent Hydrogeologic Investigations of the Spokane Aquifer [abstract]. Inland Northwest Water Resources Conference, Program and Abstracts; 1997.

146. Hooper, P. R. A Case of Simple Magma Mixing in the Columbia River Basalt Group: The Wilbur Creek, Lapwai, and Asotin Flows, Saddle Mountains Formation. Contributions to Mineralogy and Petrology. 1985; 91(1):66-73.

147. Hooper, P. R. and C.J. Hawkesworth. Isotopic and Geochemical Constraints on the Origin and Evolution of the Columbia River Basalt. Journal of Petrology. 1993; 34(6):1203-1246.

148. Hubbs, D.; A. Mencke., and C. Sullivan. Stormwater Sampling Device Development and Testing, Interim Report . Spokane Washington: Gonzaga University, School of Engineering Center for Engineering Design; 2000; Senior Design Project 2000 CE-4. 31 pages.
Notes: Project in process

149. Igloria, R. V.; W.E. Hathhorn., and D.R. Yonge. NOM and Trace Metal Attenuation during Storm-Water Infiltration. Journal of Hydrologic Engineering. 1997; 2(3):120-127.

150. Ikramuddin, M. and Miller, S. A. The Use of Lead 207/206 Isotope Ratios as an Indicator of the Source of Lead in Surface and Ground Water [abstract]. Inland Northwest Water Resources Conference, Program and Abstracts; 1997.

151. Ikramuddin, M.; S.E. Box.; A.A. Bookstrom., and S.A. Miller. Lead Isotopic Composition of Sediments and Water Downstream from the Coeur d'Alene Mining District [abstract]. Geological Society of America Abstracts With Programs. 1997; 29(6):386.

152. Illsley, C. T. Evaluation of Hydrogeochemical Techniques in the Mt. Spokane Area, Washington. 1957; U.S. Atomic Energy Commission RME-1098. 25 pages.

153. James, L. G.; J.M. Erpenbeck; D.L. Bassett, and J.E. Meddleton. Irrigation Requirements for Washington - Estimates and Methodology, EB1513. Pullman, WA: Washington State University Cooperative Extension; 1989 37 pages.

154. Jensen, J. R. and C.M. Eckart. The Spokane Aquifer. Washington Division of Geology and Earth Resources Bulletin. 1987; 78(II):975-981.

155. Jensen, M. E.; R.D. Burman, and R.G. Allen. Evapotranspiration and Irrigation Water Requirements. ASCE; 1990.

156. JISAO and SMA Climat Impacts Group. Impacts of Climate Change. Seattle Washington: University of Washington; 2001.

157. Johnson, A. Reconnaissance Survey on Metals, Semivolatiles, and PCBs in Sediment Deposits behind Upriver Dam, Spokane River. 2000; Washington Department of Ecology Publication 00-03-021. 18 pages.

158. Johnson, Eric (Washington Water Power). Upper Spokane River Trout Spawning and Emergence Study for 1995 and 1996. 1997 Nov 21 pages.
Notes: Prepared for the Spokane River Management Team

159. Johnson, M. S. Hydrology and Hydrogeology of Long Lake, Spokane and Stevens Counties, Washington: Eastern Washington University; 1992 222 pages.
Notes: Master of Science Thesis

160. Johnstone, D. L. and G.C. Bailey. Comparative Quality of Water Samples Collected from the Sand Pit and Adjacent Wells. Spokane County Planning Commission, Draft Environmental Impact Statement for Sullivan Road sand and Gravel Operation--Bacteriological Chemical and Physical Aspects. Spokane County Planning Commission; 1975 15 pages.

161. Juul, S. T. J.; W.H. Funk., and B.C. Moore. The Effects of Nonpoint Pollution on the Water Quality of the West Branch of the Little Spokane River. 1990; Washington Water Research Center Report 76. 156 pages.

162. Kaiser-Hill Company, L. L. C. Model Code and Scenario Selection Report Site-Wide Water Balance, Rock Flats Environmental Technology Site. 2001 Feb; Document 01-RF-00337.

163. Kiesler, J. P. Earth Resistivity as a Technique for Monitoring Drainfield Pollution in Spokane Outwash: Washington State University; 1973 36 pages.
Notes: Master of Science Thesis

164. King, M.; Palmer, S. P.; Gruenenfelder, C. R.; Miller, S. A., and Hendron, L. H. The Application of Reflection Seismology and Hydrogeology in an Interdisciplinary Approach to Sole-Source Aquifer Management Planning: Subsurface Investigation of Missoula Flood Deposits that Form the Sole Source Aquifer for Spokane, Washington. Bell, R. S, Compiler. Proceedings of the Symposium on the Application of Geophysics to Engineering and Environmental Problems: Environmental and Engineering Geophysical Society; 1995: pages 877-881.

165. King, M. and S.P. Palmer. Vertical Seismic Reflection Profiling: A New Tool for Hydrogeologists [abstract]. Washington Department of Ecology, Abstracts from the 1st Symposium on the Hydrogeology of Washington State: Washington Department of Ecology; 1995: page 35.

166. Kiver, E. P. and D.F. Stradling. Periodic Jokulhlaups from Pleistocene Glacial Lake Missoula: New Evidence from Varved Sediments in Northern Idaho and Washington. Comments. Quarternary Research. 1985; 24:354-356.

167. Kleist, Todd R., Investigator. An Evaluation of the Fisheries Potential of the Lower Spokane River: Monroe Street Dam to Nine Mile Falls Dam. Environmental Affairs Department, The Washington Water Power Company and the Washington State Department of Wildlife; 1987 Sep29 pages, tables, figures, appendices.

168. Kresch, D. L. Equations for Estimating Fish Passage Design Flows at Ungaged Streams in Eastern Washington. Tacoma Washington: U.S. Geological Survey; 1999; WRIR 99-4186. 26 pages(Water-Resources Investigation Reports).

169. Lackaff, B.; J. Blake., and S. Miller. Recent Studies of Surface and Groundwater in the Spokane Area. Inland Northwest Water Resources Conference, Spokane Convention Center; Spokane, WA. 1997.
Notes: From a Poster Session

170. Lackaff, B. B.; Hunt, B. J., and Von Essen, I. E. The Development and Implementation of a GIS-Based Contaminant Source Inventory over the Spokane Aquifer, Spokane County, Washington. Water Resources Bulletin. 1993; 29(6):949-955.

171. Landau Associates, Inc. Eaglewood Hydrogeologic Study Spokane, Washington. 1997: nonpaginated.
Notes: Report to Spokane County

172. Landau Associates, Inc. Final Phase I Engineering Report; Colbert Landfill Remedial Design; Remedial Action, Spokane County, Washington. 1991.
Notes: Report to Spokane County. From the Executive Summary: A detailed study of the hyrogeology and contaminated ground water cleanup methods around the Colbert Landfill. The study identified a faily complex ground water system with six hydrostratigraphic units. The study focused on the upper sand/gravel aquifer, the basalt aquifer, and the lower sand/gravel aquifer. Most of the text focuses on the the ground water contamination and its treatment.

173. Landau Associates, Inc. and and others. Colbert Landfill Remedial Design/Remedial Action, Spokane County, Washington. Volume I of III--Final Phase I Engineering Report. 1991.
Notes: Prepared under contract for Spokane County

174. Lane, R. C. and K.J. Whiteman. Ground-Water Levels, Spring 1985, and Ground-Water Level Changes, Spring 1983 to Spring 1985, in Three Basalt Units Underlying the Columbia Plateau, Washington and Oregon. U.S. Geological Survey; 1989; U.S. Geological Survey Water-Resources Investigations Report 88-4018. 4 sheets, scale 1:500,000.

175. League of Women Voters of the Spokane Area. The Spokane - Rathdrum Aquifer, Spokane, WA. 1983.

176. Lindsay, C. S.; J.B. Harakas, and S.M. Worley. Shallow Ground Water Recharge Evaluation, Mead, Washington [abstract]. Inland Northwest Water Resources Conference, Program and Abstracts; 1997.

177. Long, P. E. Horizontal vs. Vertical Cooling Joint Frequency (or Spacing) in the Pomona Flow at the Near Surface Test Facility. 1987; Rockwell Hanford Operations DER-CB-0021. 3 pages.

178. Long, P. E.; M.T. Murphy., and S. Self. Time Required to Emplace the Pomona flow, Columbia River basalt [abstract]. Eos (American Geophysical Union Transactions). 1991; 72(44, Supplement):602.

179. Lum, W. E.; G.L. Turney, and R.C. Alvord. A Preliminary Evaluation of the Geohydrology and Water Quality of the Greenacres Landfill Area, Spokane County, Washington. U.S. Geological Survey in cooperation with Washington State Department of Ecology; 1986; U.S. Geological Survey Open-File Report 85-496.

180. Luzier, J. E. and R.J. Burt, R. J. Hydrology of Basalt Aquifers and Depletion of Ground Water in East-Central Washington. Washington State Department of Ecology; 1974; Washington State Department of Ecology Water-Supply Bulletin 33. 53 pages, 3 plates.

181. MacInnis, J. D.; J. Blake; B. Painter; J.P. Buchanan; B.B. Lackaff, and R. Boese. The Spokane Valley-Rathdrum Prairie Aquifer Atlas. Spokane County Utilities Department and Idaho Department of Environmental Quality; 2000.

182. MacInnis, J. D. Jr. and B.D. Painter. Using a Community-Based Technical Advisory Committee to Develop Aquifer Protection Guidelines: Wastewater Land Application in Idaho over the Spokane Valley-Rathdrum Prairie Aquifer [abstract]. Inland Northwest Water Resources Conference, Program and Abstracts; 1997.

183. Maddox, G. E. Geologic Controls of Ground-Water Movement, Spokane Aquifer. Spokane, Wash.: George Maddox and Associates, Inc; 1989 6 pages, 1 plate.

184. Maidment, David R. Handbook of Hydrology. New York: McGraw-Hill, Inc.; 1993.

185. Marcy, A. D.; B.J. Scheibner.; K.L. Toews, and C.M.K. Boldt. Hydrogeology and Hydrochemistry of the Midnite Mine, Northeastern Washington. U.S. Bureau of Mines; 1994; U.S. Bureau of Mines Report of Investigations 9484. 40 pages.

186. Maret, T. R. and D.M. Dutton. Summary of Information on Synthetic Organic Compounds and Trace Elements in Tissue of Aquatic Biota, Clark Fork-Pond Oreille and Spokane River Basins, Montana, Idaho, and Washington, 1974-96. Boise, Idaho: United States Geologic Survey, National Water Quality Assessment Program; 1999; Water Resources Investigations Report 98-4254.

187. Marti, P. and R. Garrigues. Spokane River/Aquifer Interaction Project Results, May-November 1999. Washington State Department of Ecology; 2001 38 pages (Washington State Department of Ecology Report 01-03-024).

188. Martin, L. J. Ground Water in Washington. , Pullman, WA: Washington State University/University of Washington; 1983; State of Washington Water Research Center, Report No. 40.

189. Martindale, D. The Rathdrum Prairie Aquifer Policy Advisory Committee: Aquifer Protection at the Local Level [abstract]. Inland Northwest Water Resources Conference, Program and Abstracts; 1997.

190. Matt, V. J. Hydrology and Hydrogeology of the Spokane Indian Reservation, Northeastern Washington State:

Eastern Washington University; 1994 209 pages.
Notes: Master of Science Thesis

191. McDonald, C. C. and H.C. Broom. Analysis of Increments of Discharge in Spokane River, Post Falls, Idaho, to Long Lake, Washington. Tacoma, Washington: U. S. Geological Survey with the cooperation of Washington State Department of Ecology; 1951; U. S. Geological Survey Open-File Report. 19 pages.

192. McDonald, M. G. and A.W. Harbaugh. A Modular Three-Dimensional Finite-Difference Ground-Water-Flow Model. U.S. Geological Survey; 1988; U.S. Geological Survey, Techniques of Water-Resources Investigations 06-A1. 576 pages.

193. McKiness, Paul. The Quarternary System of the Eastern Spokane Valley and the Lower, Northern Slopes of the Mica Peak Uplands, Eastern Washington and Northern Idaho. Idaho: University of Idaho; 1988 May; c1988.

194. McMacken, J. G. Geological Implications of Wells in Spokane Rathdrum Valleys - Permafrost. Northwest Science. 1949; 23 (1):37-38.

195. Miles, Edward L.; Amy K. Snover; Alan F. Hamlet; Bridget Callahan, and David Fluharty. Pacific Northwest Regional Assessment: The Impacts of Climate Variability and Climate Change on the Water Resources of the Columbia River Basin. Journal of the American Water Resources Association. 2000 Apr; 36(2):21 .

196. Miller, S. A. The Accumulation of Toxics in Storm Runoff Infiltration Area Soil. Abstracts and Program Rocky Mountain Ground Water Conference and 6th Annual New Mexico Section, American Water Resources Association, Ground Water Technology and Tasks in the 90's; Albuquerque, New Mexico. 1993.

197. Miller, S. A. The Impact of Stormwater Runoff on Groundwater Quality and Potential Mitigation. Proceedings from the Conference, Protection and Management of Aquifers with Emphasis on the Spokane-Rathdrum Aquifer: Washington Water Research Center; 1985: 55-76.

198. Miller, S. A. Monitoring Contaminant Removal and Migration Beneath Grass Lined, Storm Runoff Infiltration Basins. Proceedings of the Focus Conference on Regional Ground Water Issues, National Ground Water Association; Boston Marriott Newton, Newton MA. State of Maine Department of Environmental Protection and Maine Geological Survey; 1992: 395-409.

199. ---. Using Chemical Indicators to Identify and Quantify Groundwater: Surface Water Interactions. Inland Northwest Water Resources Conference; Spokane Convention Center, Spokane, WA. 1997.

200. ---. Water Quality Impacts of Aquifer Discharges on the Spokane River. 1996: 54 pages.

201. Miller, S. A.; B. Lackaff., and B. Galle. Identification of Ground Water Impacts from Storm Water Injection and Infiltration Using Direct and Indirect Methods. Proceedings 1996 Ground Water Protection Council Annual Forum, Radisson St. Paul, St. Paul Minnesota. Ground Water Protection Council, U. S. Environmental Protection Agency; 1996.

202. Miller, Stan A.; Reanette Boese; Erin Cunningham, and Bea Lackaff (Spokane County Utulities, Spokane County Information Systems). A Conceptual Model of the Interaction between the Spokane Valley-Rathdrum Prarie Aquifer and the Spokane River in the East Spokane River Valley, Washington and Idaho. 2002.

203. Mohl, Gregory B. Refraction Seismic Investigation of the North Argonne Road Area, Spokane, Washington. Pullman, Washington; undated.

Notes: Submitted to the Water Resources Division of the U.S. Geological Survey

204. Molenaar, D. The Spokane Aquifer Washington: Its Geologic Origin and Water-Bearing and Water-Quality Characteristics. Tacoma, Washington: U S. Geological Survey; 1988; U S. Geological Survey Water Supply Paper 2265. 74 pages.

205. Moore, J. E. and C.T. Jenkins. An Evaluation of the Effect of Groundwater Pumpage on the Infiltration Rate of a Semiporous Streambed. Water Resources Research. 1966; Volume 2(Number 4):691-696.

206. Moos, D. W. The State Viewpoint. Washington Water Research Center. Proceedings from the Conference, Protection and Management of Aquifers with Emphasis on the Spokane-Rathdrum Aquifer; 1985: 49-54.

207. Nassar, E. G. and K.L. Walters. Water in the Palouse River Basin, Washington. 1975; Washington State Department of Ecology Water-Supply Bulletin 39. 246 pages, 1 plate.

208. National Resource Conservation Service. National Soil Survey Handbook, Title 430-V. Washington D.C.: U.S. GPO Printing Office; 1996 Nov.

209. Nelson, D. O. Strontium Isotopic and Trace Element Geochemistry of the Saddle Mountains and Grande Ronde Basalts of the Columbia River Basalt Group: Oregon State University; 1980 224 pages.
Notes: Doctor of Philosophy Thesis

210. Nelson, D. O.; Cocker, J. D., and Dasch, E. J. Strontium and Oxygen Isotopic Studies of Radiogenic Basalts of the Saddle Mountain Basalt: A Case for Contamination [abstract]. Geological Society of America Abstracts With Programs. 1980; 12(3):144 pages.

211. Newcomb, R. C. Seismic Cross Sections across the Spokane River Valley and the Hillyard Trough, Idaho and Washington. U.S. Geological Survey ; 1953; U.S. Geological Survey Open-File Report 53-199. 16 pages, 18 plates.

212. --. Underground Water of the Upper Spokane River Valley. State College of Washington; 193316 pages, 3 plates.
Notes: State College of Washington Contest Paper

213. Northwest Power Planning Council. Compilation of Information on Salmon and Steelhead Losses in the Columbia River Basin. Portland, OR: Northwest Power Planning Council; 1986.
Notes: Appendix D of the 1987 Columbia River Basin Fish and Wildlife Program

214. Ogden, A. E.; Kirk, K. G., and Thompson, S. D. Factors Affecting Spatial and Temporal Water Quality Changes in the Spokane-Rathdrum Prairie Aquifer in Idaho [abstract]. Geological Society of America Abstracts With Programs. 1988; 20(6):460.

215. Oliver, Chadwick D. and Bruce C. Larson. Forest Stand Dynamics. McGraw Hill, Inc.; 1990.

216. Olness, I. A. Formulation of a Finite-Difference Groundwater Flow Model for the Spokane Valley Aquifer, Washington: Eastern Washington University; 1993101 pages.
Notes: Master of Science Thesis

217. Olson, T. M. The Geology and Groundwater Resources of Part of the Hangman and Marshall Creek Drainage Basins, Spokane County, Washington: Eastern Washington State College; 1975 70 pages, 1 plate.
Notes: Master of Science Thesis

218. Olson, T. M. Ground Water, Resources of Five Mile Prairie Spokane County, Washington. Olympia, WA, Washington State Department of Ecology, Water Resources Information System; 1979 Aug; WRIS

Technical Bulletin Number 23. 30 pages, 2 plates.

219. Olson, T. M.; E.H. Gilmour.; M. Bacon.; J.L. Gaddy.; G.A. Robinson., and O.J. Parker. Geology, Groundwater, and Water Quality of Part of Southern Spokane County, Washington. Washington State Department of Ecology; 1975; Washington State Department of Ecology Water Resources Information System, WRIS Technical Bulletin 15. 146 pages, 2 plates.

220. Olson, T. M. et al. Geology, Groundwater, and Water Quality of a Part of Southern Spokane County, Washington. Olympia, WA ; 1975; Technical Information Bulletin 15. 146 pages, 2 plates.
Notes: Water Resources Information System, Washington State Department of Ecology

221. Othburg, K. L. Surficial Geologic Map of the Rathdrum Quadrangle and Part of the Newman Lake Quadrangle, Kootenai County, Idaho. Moscow, ID: Idaho Geological Survey; 1998 (Surficial Geologic Map 6).

222. Pacific Northwest River Basin Commission. Water Resources, Appendix V. Columbia North-Pacific Region Comprehensive Framework Study. Vancouver, WA: PNRBC; 1970 Apr.

223. Painter, B. D. An Estimate of Recharge to the Rathdrum Prairie Aquifer in Idaho from All Sources. Idaho Department of Health and Welfare, Division of Environmental Quality, Water Quality Bureau ; 1991 6 pages.

224. ---. A Finite-Difference Flow Model of the Rathdrum Prairie Aquifer. 1992 to present, written communication.
Notes: Computer model

225. Palmer, S. P. and D.E. Derkey. Seismic Reflection Profiling and Well Velocity Surveying Along Colbert Road and Shady Slope Road. Olympia, WA: Washington Department of Natural Resources, Geology and Earth Resources Division; 1996.

226. Palmer, S. P.; M. King; C.R. Gruenenfelder.; S.A. Miller., and L.H. Hendron. Application of Reflection Seismology to the Hydrogeology of the Spokane Aquifer. Washington Geology. 1995; 23(2):27-30.

227. Palmer, S. P. and W.J. Gerstel . Preliminary Report on Seismic Reflection Profiling of the Spokane Valley, Spokane County, Washington. Washington Division of Geology and Earth Resources; 1994 12 pages.

228. Pardee, J. T. and K. Bryan. Geology of the Latah Formation in Relation to the Lavas of the Columbia Plateau near Spokane, Washington. United States Geological Survey; 1926; United States Geological Survey Professional Paper 140.
Notes: Pages 1 - 16

229. Patmont, C. R.; G.J. Pelletier; L.R. Singleton; Dr. R.A. Soltero; Dr. W.T. Trial, and Dr. E.B. Welch. The Spokane River Basin: Allowable Phosphorus Loading. Final Report ed.; Washington State Department of Ecology; 1987 Sep178 pages.

230. Patmont, C. R.; G.J. Pelletier; M.E. Harper., and et al. Phosphorus Attenuation in the Spokane river, Project Completion Report. 1985; Contract C84-076. 144 pages.
Notes: Prepared by Harper-Owes, Seattle, Washington, for the Washington State Department of Ecology

231. Pelletier, G. J. and K. Merrill. Cadmium, Lead, and Zinc in the Spokane River. 1998; Washington State Department of Ecology Publication 98-329. 26 pages.

232. Pend Oreille Conservation District. Little Spokane Water Quality Assessment, Final Report for Washington

Department of Ecology Grant G-99-00036. 2000.
Notes: Prepared in cooperation with Spokane County Conservation District and Spokane County Public Works Department

233. Piper, A. M. Washington. Meinzer, O. E. L. K. Wenzel et al. Water Levels and Artesian Pressure in Observation Wells in the United States in 1939. U.S. Geological Survey; 1940; U.S. Geological Survey Water-Supply Paper 886.
Notes: pages 915 - 928

234. Piper, A. M. and G.A. La Rocque, Jr. Excerpts from Advance Report on Water-Table Fluctuations in the Spokane Valley and Contiguous Areas, Washington-Idaho: U.S. Geological Survey; 1940; U.S. Geological Survey Open-File Report. 12 pages.
Notes: Published as U.S. Geological Survey Water-Supply Paper 889-B

235. --. Water-Table Fluctuations in the Spokane Valley and Contiguous Area, Washington-Idaho. U. S. Geological Survey ; 1944; Water Supply Paper 889-B. 137 pages.

236. --. Wells Used for Public Water Supply at Spokane, Washington. U.S. Geological Survey; 1939; U.S. Geological Survey Open-File Report. 3 pages.

237. Piper, A. M. and L.C. Huff. Some Ground-Water Features of Rathdrum Prairie-Spokane Valley Area, Idaho-Washington, with Respect to Seepage Loss from Pend Oreille Lake. U.S. Geological Survey; 1943; U.S. Geological Survey Open-File Report. 13 pages.

238. Pluhowski, E. J. and C.A. Thomas. A Water-Balance Equation for the Rathdrum Prairie Ground-Water Reservoir, near Spokane, Washington. U.S. Geological Survey ; 1968; Professional Paper 600-D. D75-D78.

239. Pollack, D. W. Documentation of Computer Programs to Complete and Display Pathlines using Results from the U.S. Geological Survey Modular Three-Dimensional Finite-Difference Ground-Water Model. U.S. Geological Survey; 1989; U.S. Geological Survey Open File Report 89-381. 81 pages.

240. Porcello, J. J. Development and Use of a Regional Finite-Element Groundwater Flow Model for Wellhead Protection Planning in the Spokane Area, Washington [abstract] . Inland Northwest Water Resources Conference, Program and Abstracts; 1997.

241. Purves, W. J. Stratigraphic Control of the Ground Water through Spokane Valley: Washington State University; 1969 213 pages.
Notes: Master of Science Thesis

242. R&A Technical Consultants; Buchanan, J. P., and Hydrometrics. Wellhead Protection Plan for Fairchild Air Force Base 1977.
Notes: Project completion report to Fairchild Air Force Base, Washington

243. Ravan, J. E. Keynote Address. Washington Water Research Center, Proceedings from the Conference, Protection and Management of Aquifers with Emphasis on the Spokane-Rathdrum Aquifer; 1985: pages 1-6.

244. Rawlings, G. Community efforts--Origin and development of the Spokane-Rathdrum aquifer management plans (Washington). Proceedings from the Conference, Protection and Management of Aquifers with Emphasis on the Spokane-Rathdrum Aquifer: Washington Water Research Center; 1985: pages 27-30.

245. Reidel, S. P. Emplacement of Columbia River Flood Basalt. Journal of Geophysical Research. 1998; 103(B11):393-410.

246. --. Geology of the Saddle Mountains between Sentinel Gap and 119 Degrees 30 Minutes Longitude. 1978; Rockwell Hanford Operations RHO-BWI-LD-4. 75 pages, 4 plates.

247. ---. The Saddle Mountains--The Evolution of an Anticline in the Yakima Fold Belt. American Journal of Science. 1984; 284(8):942-978.

248. Reidel, S. P. and Fecht, K. R. Wanapum and Saddle Mountains Basalts of the Cold Creek Syncline Area. Myers, C. W. and S. M. Price , Editors. Subsurface Geology of the Cold Creek Syncline. 1981; Rockwell Hanford Operations RHO-BWI-ST-14.
Notes: pages 3-1 and 3-45

249. Reidel, S. P.; R.K. Ledgerwood; C.W. Myers.; M.G. Jones., and R.D. Landon. Rate of Deformation in the Pasco Basin during the Miocene as Determined by Distribution of Columbia River Basalt Flows [abstract]. Geological Society of America Abstracts With Programs. 1980; 12(3):149.

250. Reidel, S. P.; T.L. Tolan; P.R. Hooper; M.H. Bison; K.R. Fecht; R.D. Bently, and J.L. Anderson. The Grande Ronde Basalt, Columbia River Basalt Group; Stratigraphic Descriptions and Correlations in Washington, Oregon, and Idaho - Volcanism and Tectonism in the Columbia River Flood-Basalt Province. Spokane County, Washington; 1989 pp. 21-53 (Geologic Society of America Special Paper 239).
Notes: Spokane County Comprehensive Plan. Adopted November, 2001. Chapters one through twelve including Appendix A-Plan Implementation

251. Rieber, F. R. and Turner, D. S. Drilling and Completion Report of the Hillyard Trough Well No. 1. Denver, CO: Ball Associates, Ltd.; 1963 33 pages.
Notes: , Report to the Washington Water Power Company, Spokane, Washington,

252. Robinson, J. D. Stratigraphy and Sedimentology of the Latah Formation, Spokane County, Washington: Eastern Washington University; c1991. 113 pages.

253. Robison, D. L. and Funk, W. H. Comprehensive Plan of Development for Stormwater Control in the Newman Lake Watershed. Washington Water Research Center; 1997; Washington Water Research Center Report 101. 102 pages.

254. Roe, R. B. Release of Chloride from Basalt: Implications for the Chloride Mass-Balance Approach to Estimating Groundwater Recharge: Washington State University; c1995. 90 pages.
Notes: Master of Science Thesis

255. Ross, M. E. Stratigraphic Relationships of Subaerial, Invasive, and Intracanyon Flows of Saddle Mountains Basalt in the Troy Basin, Oregon and Washington Reidel, S. P. and Hooper, P. R., Editors. Volcanism and Tectonism in the Columbia River Flood-Basalt Province. 1989; Geological Society of America Special Paper 239.
Notes: pages 131-142

256. Rushton, Clifford D. (Water Resources Program, Washington State Department of Ecology). Instream Flows in Washington State of Washington Past, Present and Future. Draft ed.. Olympia WA 98504-7600; 2000 Jul.

257. Ryker, S. J. and Jones, J. L. Nitrate Concentrations in Ground Water of the Central Columbia Plateau: U.S. Geological Survey; 1995; U.S. Geological Survey Open-File Report 95-445. 4 pages.

258. Ryker, S. J. and Williamson, A. K. Pesticides in Public Supply Wells of the Central Columbia Plateau. U.S. Geological Survey ; 1996; U.S. Geological Survey Fact Sheet 205-96. 4 pages.

259. Saxton, K. E. and et al. Estimating Generalized Soil-Water Characteristics From Texture. Soil Science

Society of America Journal. 1986; 50(4):1031-1036.

260. Sceva, J. E. Ground Water in the Vicinity of Geiger Field, Spokane County, Washington. 1953; U.S. Geological Survey Open-File Report. 25 pages, 4 plates.

261. Scherer, K. Monitoring the Status of Heavy Metals in Grass Lined Storm Runoff Infiltration Basins.
Notes: Unpublished Project Paper, Soil Science Department, Washington State University, Pullman WA

262. Scott, D. M.; Dobratz, W., and Maxwell, J. M. Wastewater Treatment: A Sewer plan . Proceedings from the Conference, Protection and Management of Aquifers with Emphasis on the Spokane-Rathdrum Aquifer: Washington Water Research Center; 1985: pages 39-46.

263. Scurlock, J. M. O.; G.P. Asner, and S.T. Gower. Worldwide Historical Estimates of Leaf Area Index, 1932-2000. 2001.

264. SeisPulse Development Corp.; Excel Geophysical Services, I., and Washington State Department of Natural Resources. A Report of Geophysical Activities Conducted for: The County of Spokane, Washington of the Spokane Valley - Rathdrum Prairie Aquifer. 1993.

265. Selde, V. Saddle Mountain Wood. Rock and Gem. 1980; 10(11):20-24.

266. Simons, W. D. Spokane-Coeur d'Alene River Basin, Washington-Idaho. Subsurface Facilities of Water Management and Patterns of Supply: Type Area Studies. U.S. Congress, House, Interior and Insular Affairs Committee; 1953(The Physical and Economic Foundation of Natural Resources; Part 4).
Notes: Pages 162-185

267. Sims, B. Watershed Planning--Everybody Cares [abstract] . Inland Northwest Water Resources Conference, Program and Abstracts: Inland Northwest Water Resources; 1997.

268. Singleton, L. R. Spokane River Wasteland Allocation Study - Supplemental Report for Phosphorus Allocation. Olympia, WA : Washington State Department of Ecology, Water Quality Investigations Section; 1981; Washington State Department of Ecology Report #81-15. 37 pages.

269. Snyder, Daniel T.; David S. Morgan, and Timothy S. McGrath. Estimation of Ground-Water Recharge from Precipitation, Runoff into Drywells, and On-Site Waste-Disposal Systems in the Portland Basin, Oregon and Washington. U.S. Geological Survey ; 1994; U.S. Geological Survey Water-Resources Investigations Report 92-4101.

270. Soden, D. L.; N.P. Lovrich, Jr., and J.C. Pierce. City/Suburb Views on Groundwater Issues. Schmidt, K. D., Editor. Symposium on Groundwater Contamination and Reclamation: Proceedings: American Water Resources Association; 1985: pages 81-86.

271. Spane, Jr. F. A. Hydrogeologic Properties and Hydrochemistry for the Levey Interbed at Well 699-S11-E12A; 1981; Rockwell Hanford Operations RHO-BWI-LD-27. 40 pages.

272. Spokane County. Deer Park Basin Groundwater Management Plan: Water Quality Addendum. 1995 Mar.
Notes: Completed in cooperation with the City of Deer Park

273. --. Spokane Aquifer Water Quality Management Plan: Final Report and Water Quality Management Framework Recommendations for Policies and Actions to Preserve the Quality of the Spokane-Rathdrum Aquifer. Spokane, WA: Spokane County Washington 208 Program, County Engineers Office; 1979 Apr 127 pages, 6 plates.

274. ---. Spokane River Low Flow Water Quality Reconnaissance.
Notes: Unpublished data

275. ---. Spokane Water Quality Management Program. 1996.
Notes: Unpublished data

276. Spokane County Growth Management Steering Committee and Buchanan, J. Ground Water Flow Model of the Spokane Valley Portion of the Spokane Valley-Rathdrum Prairie Aquifer System. Cheney, Washington; 1993 98 pages.
Notes: Final Report Prepared for Water Quality Management Program, Spokane County Engineers, Department of Geology, Eastern Washington University

277. Spokane County Growth Management Water Quality and Water Quantity Technical Committee. Spokane County, Water Quality and Water Quantity Report, Spokane, Washington. 1996 Nonpaginated.

278. Spokane County, Washington. Critical Areas Ordinance for the Protection of Wetlands, Fish and Wildlife Habitats and Geo-hazard Areas, Chapter 11.20. Approved March 26, 1996 by Resolution No. 96-0302, executed July 9, 1996 and effective August 1, 1996. 1996.

279. --. Spokane County Shoreline Program. 1975.
Notes: Accessed at: http://www.spokanecounty.org/planning/documents/shorelines/Toc.pdf

280. Spokane County Water Quality Management Program Staff. Aquifer Quality Status Report: September 1996. Spokane, Washington : Spokane County Public Works Department, Spokane Regional Health District; 1996 45 pages.

281. --. Spokane Valley Aquifer Monitoring Network: Sentinel Well Siting, Installation and Sampling, Supplement to the FY 1998 4th Quarter Report. Spokane, Washington : Spokane Water Quality Management Program, Spokane County Utilities Division; 1998; Spokane Valley Aquifer Demonstration Grant X-000-425-05. 8 pages, appendices.

282. --. Spokane Valley - Rathdrum Prairie Aquifer Water Quality Report for the Period January 1999 - March 2000. Spokane, Washington: Spokane Water Quality Management Program, Spokane County Utilities Division; 2000 22 pages, appendices.

283. Spokane County Water Quality Management Team. Spokane Valley Aquifer Monitoring Network: Sentinel Well Siting, Installation and Sampling. Spokane Washington: Spokane County Water Quality Management Program; 1998 Sep.
Notes: Supplement to FY 1998 4th Quarter Report, Spokane Valley Aquifer Demonstration Grant

284. St. Godard, E. N. J. In-situ Vapor Extraction as Rapid Remedial Response to a Hydrocarbon Release over the Rathdrum Prairie Aquifer [abstract] . Inland Northwest Water Resources Conference, Program and Abstracts: Inland Northwest Water Resources; 1997.

285. Swanson, D. A. and Helz, R. T. Bedrock Geologic Map of the Vent System for the Ice Harbor Member of the Saddle Mountains Basalt, Ice Harbor Dam-Basin City Area, Southeast Washington. 1979; U.S. Geological Survey Open-File Report 79-292. 8 sheets.

286. Swanson, D. A.; T.L. Wright.; P.R. Hooper., and R.D. Bentley. Revisions in Stratigraphic Nomenclature of the Columbia River Basalt Group. U.S. Geological Survey; 1979; U.S. Geological Survey Bulletin 1457-G. 59 pages, 1 plate.

287. Taylor, C. L. Unrecognized Active and Potentially Active Faults Identified During Seismotectonic Studies of Northwestern United States [abstract]. Seismological Research Letters. 1992; 63(1):22.

288. Taylor, T. L. The Basalt Stratigraphy and Structure of the Saddle Mountains of South-Central Washington: Washington State University; 1976116 pages, 1 plate.
Notes: Master of Science Thesis

289. Tennant, Donald Leroy. Stream Flow Regimens for Fish, Wildlife, Recreation and Related Environmental Resources. Fisheries. 1976; 1(4):6-10.

290. Thomas, C. A. Investigation of the Inflow to the Rathdrum Prairie: Spokane Valley Aquifer. Boise, Idaho: U. S. Geological Survey; 1963; U. S. Geological Survey Water Resource Division Open-File Report. 46 pages.

291. Thomas, Sean C. and William E. Winner. Leaf Area Index of an Old-Growth Douglas-Fir Forest Estimated From Direct Structural Measurements in the Canopy. Canadian Journal of Forest Resources. 2000; 30:1922-1930.

292. Thoms, R. E.; J.L. Anderson, and R.D. Bentley (Shannon and Wilson, Inc.). Geologic Studies of the Saddle Mountains-Manastash Ridge and Umtanum Ridge Structures. Analysis Report. Geologic Evaluations of Structures in the Columbia Plateau. Washington Public Power Supply System; 1977; WPPSS Nuclear Project No. 1: Preliminary Safety Analysis Report. 12 pages.

293. Tomlinson, S. A. Estimating Actual Evapotranspiration using Bowen Ratio and Penman Combination Methods--Phase II Wayenberg, J. A. and V.F. Renslow, Compilers. Summary of Water-Resources Activities of the U.S. Geological Survey in Washington--Fiscal Year 1991. 1992; U.S. Geological Survey Open-File Report 92-92. 52 pages.

294. --. Evaluating Evapotranspiration for Grasslands on the Arid Lands Ecology Reserve, Benton County, and Turnbull National Wildlife Refuge, Spokane County, Washington, May 1990 to September 1991. U.S. Geological Survey ; 1995; Water-Resources Investigations Report 95-4069. 72 pages.

295. --. Evaluating Evapotranspiration for Six Sites in Benton, Spokane, and Yakima Counties, Washington. 1996; U.S. Geological Survey Water-Resources Investigations Report 96-4002. 84 pages.

296. Trimmer, W. and H. Hansen. Irrigation Scheduling. Oregon State University; 1994 Oct.

297. Twiss, S. N. Stratigraphy of Saddle Mountains: State College of Washington; 1933 35 pages, 1 plate.
Notes: Master of Science Thesis

298. U.S. Army Corps of Engineers and Kennedy-Tudor Engineers. Appendix B, Geology and Ground water. Metropolitan Spokane Region Water Resources Study. Seattle, Washington: U.S. Army Corps of Engineers; 1976; 227 pages.

299. U.S. Department of Agriculture. Irrigation Water Requirements. U.S. Department of Agriculture, Soil Conservation Service Engineering Division; 1970 Sep; Technical Release Number 21 (revision 2).

300. U.S. Department of Agriculture and Soil Conservation Service. Soil Survey of Pend Oreille County Area, Washington. 1980.

301. --. Soil Survey of Stevens County, Washington. 1978.

302. --. Soil Survey: Spokane County, Washington. 1968.

303. U.S. Department of Agriculture and Soil Survey Division Staff. Soil Survey Manual. U.S. Department of Agriculture; 1993. (U.S. Department of Agriculture Handbook 18.

304. U.S. Geological Survey. Data Collected From Web, www.usgs.gov. 2000.

305. --. Streamflow Statistics and Drainage Basin Characteristics, Washington. 1984; U.S. Geological Survey Open File Report 84-145-B. (; II).

306. --. Water Resources Data for Washington, Water Year 1992. 1992; U.S. Geological Survey Water Data Report WA-92-1.
Notes: Prepared in cooperation with the State of Washington and other agencies

307. U.S. Geological Survey. Water Resources Data for Washington, Water Year 2000. 2001(Water-Data Report WA-00-1).
Notes: Prepared in cooperation with the State of Washington and with other agencies

308. U.S. Weather Bureau, Office of State Climatologist U. S. Department of Agriculture Soil Conservation Service. Evapotranspiration Maps for the State of Washington. 1962.

309. Unattributed. Conceptual Models of Flow and Transport in the Fractured Vadose Zone. Washington, D.C.: National Academy Press; 2001.

310. CorpsconUnattributed. Corpscon Reference: U.S. Army Topographic Engineering Center//Geospatial Applications Branch//Engineer Research and Development Center; No Date.

311. --. Province Management Plan. 9 pages.

312. --. Spokane NPPC Summary . 2000? 14 pages.

313. --. Summary of Activities and Recommendations Related to Watershed and Sub-basin Planning in the Inter-Mountain Province, Implementing the Northwest Power Planning Council's Colombia River Basin Fish and Wildlife Program. 2000? 3 pages.

314. Unattributed. Wildlife Population Estimates [Paper Tally Sheets]. 1990.

315. URS Company. Spokane River Wasteload Allocation Study: Phase I1981.
Notes: Prepared for the Washington State Department of Ecology, Olympia, Washington

316. Vaccaro, J. J. Summary of the Columbia Plateau Regional Aquifer-System Analysis, Washington, Oregon, and Idaho. 1999; U.S. Geological Survey Professional Paper 1413-A. 51 pages.

317. Vaccaro, J. J. and E.L. Bolke. Evaluation of Water-Quality Characteristics of Part of the Spokane Aquifer, Washington and Idaho, using a Solute-Transport Digital Model; 1983; U.S. Geological Survey Open-File Report 82-769. 69 pages.

318. Vigg, Steven, Compiler. Upper Columbia River United Tribes Blocked Area Natural Resources Management Plan Integrated into a Fish, Wildlife, Watershed Management, and Cultural Resources Framework: Phase II. Draft Report ed.; 1999 Jul.
Notes: Developed by the Natural Resource Managers of:
The Confederated Tribes of the Colville Indian Reservation
The Coeur d' Alene Tribe
The Kalispel Tribe of Indians
The Kootenai Tribe of Idaho
The Spokane Tribes

319. Wagner, R. J. and L.M. Roberts. Pesticides and Volatile Organic Compounds in Surface and Ground Water of the Palouse Subunit, Central Columbia Plateau, Washington and Idaho, 1993-95. U.S. Geological Survey; 1998; U.S. Geological Survey Water-Resources Investigations Report 97-4285. 53 pages.

320. Wagstaff, W. H. and R.A. Soltero. The Cause(s) of Continued Hypolimnetic Anoxia in Long Lake,

Washington Following Advanced Wastewater Treatment by the City of Spokane. 1982; Final Progress Report Contract No. 82-031. 71 pages.
Notes: Prepared by Eastern Washington University Department of Biology, Cheney, Washington, for the Washington State Department of Ecology

321. Walton, W. C.; D.L. Hulls, and G.M. Grundeen. Recharge from Increased Streambed Infiltration under Varying Groundwater Level and Stream Stage Conditions. Minneapolis, Minnesota: Minnesota University; 1967; Water Resources Research Center Bulletin 6. 42 pages.

322. Waquar, R. Finite-Difference Groundwater Flow Model of the Sand Aquifer in Minnie Creek and Marshall Creek Valleys, Spokane County, Washington: Eastern Washington University; 1994 112 pages.
Notes: Master of Science Thesis

323. Ward, A. W. Jr. Chemistry and Petrology of the Huntzinger Flow, Columbia River Basalt, Washington [abstract]. Geological Society of America Abstracts With Programs. 1976; 8(3):48-419.

324. Waring, Richard H. and William H. Schlesinger. Forest Ecosystems Concepts and Management. 1985.

325. Washington State Department of Ecology. 2000 Washington State Water Quality Assessment Section 305(b) Report. Olympia, WA; 2000 Aug; Publication # 00-10-058.

326. Washington State Department of Ecology. Ecology's 1998 Section 303(d) List of Impaired and Threatened Waterbodies [Web Page]. 1998; Accessed 2001 Oct. Available at: http://www.ecy.wa.gov/programs/wq/303d/index.html#introduction.

327. Washington State Department of Ecology. Final 1998 Section 303(d) List - WRIA 55 [Web Page]. 1998; Accessed 1911 Jun 1.
Notes: Deadman Creek

328. Washington State Department of Ecology. Final 1998 Section 303(d) List - WRIA 57 [Web Page]. 1998; Accessed 1911 Jun 1.
Notes: Liberty Lake

329. --. Setting Instream Flows in Washington State. Olympia, WA; 1998 Aug; Publication #98-1813-WR. 4 pages.

330. --. Spokane River and Long Lake TMDL Study for Biochemical Oxygen Demand and Update of the Phosphorus Attenuation Model. Olympia, WA; 1999 Jul(Quality Assurance Project Plan).

331. --. Spokane River Basin Bibliography; 1973; Washington State Department of Ecology Basin Bibliography 4. 6 pages.

332. --. Spokane River Dissolved Metals Total Maximum Daily Load. Olympia, WA; 1999 May; Publication # 99-49-WQ.

333. --. Statewide Water Quality Assessment. Olympia, WA
: Washington State Department of Ecology Water Quality Program; 1992; Report #92-04.

334. Washington State Department of Natural Resources. Preliminary Aeromagentic Survey Map of Northeastern Washington. 1992.

335. --. Seispulse Seismic Reflection Profiles. 1993.

336. --. Seispulse Seismic Reflection Profiles. 1994.

337. Washington State Department of Natural Resources. Thompson Creek Watershed Analysis: Washington Department of Natural Resources; 1997.

338. Washington State Department of Wildlife. Washington Rivers Information System: Resident and Andromous Fish Data. 1995.

339. Washington Water Research Center. Proceedings from the Conference, Protection and Management of Aquifers with Emphasis on the Spokane-Rathdrum Aquifer; 1985 118 pages.

340. Weeks, E. P.; D.W. Ericson, and C.L. Holt. Hydrology of the Little Plover Basin, Portage County, Wisconsin, and the Effects of Water Resources Development. U.S. Geological Survey; 1965; U.S. Geological Survey Water Supply Paper 1811. 78 pages.

341. Weigle, J. M. and M.J. Mundorff. Records of Wells, Water Levels, and Quality of Ground Water in the Spokane Valley, Spokane County, Washington. U.S. Geological Survey; 1952; U.S. Geological Survey Ground-Water Report 2. 102 pages.

342. Weisenborn, A. E. and P.L. Weiss. Geologic Map of the Mount Spokane Quadrangle, Spokane County, Washington and Kootenai and Bonner Counties, Idaho. 1976: U.S. Geological Survey (GQ-1336).
Notes: 1:62,500 Quadrangle Map

343. Welch, Comer and Associates Inc. and J.A. Riley. Idaho Wellhead Protection Plan, Phase I. City of Newport, Washington, West bonner Water district No. 1; 1994 May.

344. West, M. W. A Continuation of a "Pilot" Study of Quarternary Surface Deformation, Saddle Mountains Anticline, Northern Pasco Basin, Washington [Web Page]. 1998; Accessed 12/2/98 . Available at: http://erp-web.er.usgs.gov/reports/VOL39/pn/pn{Ivol39htm .
Notes: In U.S. Geological Survey, Annual Project Summaries -- Volume 39, Pacific Northwest: U.S. Geological Survey, p. 49-54.

345. West, M. W.; Ashland, F. X.; Busacca, A. J.; Berger, G. W., and Shaffer, M. E. Paleoseismological Study of Late Quaternary (Holocene) Faulting, Saddle Mountains Anticline, Yakima Foldbelt, Washington [abstract]. Geological Society of America Abstracts With Programs. 1994; 26(7): A-189-190.

346. West, M. W.; Busacca, A. J.; Berger, G. W.; Shaffer, M. E., and Ashland, F. X. A Pilot Study of Late Quaternary Surface Deformation, Saddle Mountains Anticline, Northern Pasco Basin, WashingtonJacobson, M. L, Compiler. National Earthquake Hazards Reduction Program Annual Project Summaries--XXXVI . U.S. Geological Survey; 1995; U.S. Geological Survey Open-File Report 95-210.

347. West, M. W.; F.X. Ashland.; A.J. Busacca.; G.W. Berger., and M.E. Shaffer. Late Quaternary Deformation, Saddle Mountains Anticline, South-Central Washington. Geology. 1996; 24(12):1123-1126.

348. West, M. W. and M.E. Shaffer. Late Quaternary Tectonic Deformation in the Smyrna Bench and Saddle Gap Segments, Saddle Mountains Anticline, Yakima fold Belt, Central Columbia Basin, Washington [abstract]. Geological Society of America Abstracts With Programs. 1989; 21(5):157-158.

349. Whalen, John, Subbasin Team Leader (Washington Department of Fish and Wildlife). Spokane River Subbasin Summary. Draft ed.; 2000 Jun 28 pages.
Notes: Prepared for the Northwest Power Planning Council

350. Whiteman, K. J. Ground-water Levels in Three Basalt Hydrologic Units Underlying the Columbia Plateau in Washington and Oregon, Spring, 1984. U.S. Geological Survey; 1986; U.S. Geological Survey Water-Resources Investigations Report 86-4046. 4 sheets.

351. Wick, T. Spokane Aquifer Protection: The Spokane Aquifer Joint Board Perspective [abstract.]Inland Northwest Water Resources Conference, Program and Abstracts: Inland Northwest Water Resources; 1997.

352. Wiggins, W. D.; G.P. Ruppert; R.R. Smith.; L.E. Hubbard., and M.L. Counts. Water Resources Data Washington Water Year 1998. U.S. Geological Survey, U.S. Department of Interior; 1998; U.S. Geological Survey Water-Data Report WA-98-1.

353. Williamson, A. K.; Munn, M. D.; Ryker, S. J.; Wagner, R. J.; Ebbert, J. C., and Vanderpool, A. M. Water Quality in the Central Columbia Plateau, Washington and Idaho, 1992-95. U.S. Geological Survey ; 1998; U.S. Geological Survey Circular 1144. 35 pages.

354. Winter, T. C.; J.W. Harvey; O.L. Franke, and W.M. Alley. Ground Water and Surface Water: A Single Resource. 1998; U.S. Geological Survey Circular 1139. 79 pages.

355. Wolcott, Ernest E. Lakes of Washington, Volume II, Eastern Washington. Washington State Department of Ecology; 1973.

356. Woods, P. F. and M.A. Beckwith. Nutrient and Trace-Element Enrichment of Coeur d'Alene Lake, Idaho. 1997; U.S. Geological Survey Water-Supply Paper 2485. 93 pages.

357. Wright, T. L.; M.T. Mangan., and D.A. Swanson. Chemical Data for Flows and Feeder Dikes of the Yakima Basalt Subgroup, Columbia River Basalt Group, Washington, Oregon, and Idaho, and their Bearing on a Petrogenetic Model. U.S. Geological Survey; 1989; U.S. Geological Survey Bulletin 1821. 71 pages.

358. Wyman, S. The Potential for Heavy Metal Migration From Sediments of Lake Coeur d'Alene into the Rathdrum Prairie Aquifer, Kootenai County, Idaho. Moscow, ID: Idaho Water Resources Research Institute, University of Idaho; 1993; Research Technical Completion Report. 139 pages.

359. Yager, R. M. Estimation of the Hydraulic Conductivity of a Riverbed and Aquifer System on the Susquehanna River in Broome County, New York. U.S. Geological Survey; 1993; U.S. Geological Survey Water Supply Paper 2387. 49 pages.

360. Yanggen, D. A. and S.M. Born. Protecting Groundwater Quality by Managing Local Land Use. Groundwater and Public Policy. 1991; 6:1-6.

361. Zheng, Y. Distribution of Major and Trace Metals in Groundwater of the Spokane Aquifer, Northeastern Washington: Water Quality and River/Aquifer Interaction: Eastern Washington University; 1995 123 pages.
Notes: Master of Science Thesis

362. Zheng, Y.; M. Ikramuddin., and S.A. Miller. Distribution of Major and Trace Metals in the Groundwater of the Spokane Aquifer: Water Quality and River/Aquifer Interaction [abstract]. Geological Society of America Abstracts With Programs. 1995; 27(6):A-103.

APPENDIX A-2

NON-GIS DATA DIRECTORY

Data Directory

File Name	Original Source - blank if unknown	Source	Brief Description	Full Description
12422500 real time data 2000-prsnt	USGS	Golder	Water Quantity - Real Time Stream Data	Spokane River at Spokane, WA
12422500 real time data 95-99	USGS	Golder	Water Quantity - Real Time Stream Data	Spokane River at Spokane, WA
12424000 real time data 2000-prsnt	USGS	Golder	Water Quantity - Real Time Stream Data	Hangman Creek At Spokane, Wash.
12424000 real time data 95-99	USGS	Golder	Water Quantity - Real Time Stream Data	Hangman Creek At Spokane, Wash.
12431000 real time data 95-prsnt	USGS	Golder	Water Quantity - Real Time Stream Data	Little Spokane River At Dartford, Wash
aa1.dwg	DNR	Spokane Co	Geology - Cross Sections	Autocad cross section files.From DNR, 2001. Draft x-sections for the new Spokane draft 1:100,000 geology map
airport1961-1990.doc		Spokane Co	Meteorological Data	same as spokaneapclimate.xls but formated
b1.dwg	DNR	Spokane Co	Geology - Cross Sections	Autocad cross section files.From DNR, 2001. Draft x-sections for the new Spokane draft 1:100,000 geology map
barkercenttrailndailyaverage.xls		Spokane Co	Groundwater	well levels 11/98-9/00 daily avg
barkercenttrailsouthdailyaverage.xls		Spokane Co	Groundwater	well levels 11/98-9/00 daily avg
barkereucliddailyaverage.xls		Spokane Co	Groundwater	well levels 5/99-8/00 daily avg
barkermissiondailyaverage.xls		Spokane Co	Groundwater	well levels 5/99-9/00 daily avg
barkernorthdailyaverage.xls		Spokane Co	Groundwater	well levels 11/98 - 9/2000 well levels
bb1.dwg	DNR	Spokane Co	Geology - Cross Sections	From DNR, 2001. Draft x-sections for the new Spokane draft 1:100,000 geology map.

Data Directory

File Name	Original Source - blank if unknown	Source	Brief Description	Full Description
BOD and TP study QAPP Spokane 7-99.doc		Spokane Co	Water Quality	Spokane River and Long Lake TMDL Study for Biochemical Oxygen Demand and Update of the Phosphorus Attenuation Model 7/99
BPR-4 - Water Quality and Water Resources - 2nd Draft.doc		Spokane Co	Water Quality	reviews key water resources that may be impacted by the County's wastewater management program – the Spokane Valley - Rathdrum Prairie Aquifer, and the Spokane and Little Spokane Rivers.
c1.dwg	DNR	Spokane Co	Geology - Cross Sections	From DNR, 2001. Draft x-sections for the new Spokane draft 1:100,000 geology map.
cc1.dwg	DNR	Spokane Co	Geology - Cross Sections	From DNR, 2001. Draft x-sections for the new Spokane draft 1:100,000 geology map.
cda elev 04_94.xls		Spokane Co	Water Quantity - lake elevations	Lake Couer D'Alene Elevations from 1904-1994, from USGS?
cda elevations 80-00.xls		Spokane Co	Water Quantity - lake elevations	Lake Couer D'Alene Elevations from 1980-2000 at midnight
census folder	US Census Bureau	Golder	Population	2000 Census Data for Spokane, Stevens and Pend Orielle
Chapter BPR-4 Figures.ppt		Spokane Co	Water Quality	figure for BPR-4 document
chatteroyobswell.xls		Spokane Co	Groundwater	78-00 obs well levels
ChehalisBasinLevel1	Grays Harbor Dept. Public Services	Spokane Co	Bibliography	All files for the Level 1 Assessment - December 2000 for the Chelhalis Basin Partnership
chew_geo_071301	DNR	Bryony Hansen	Geology	Table for geology coverage and Figure 4.10
cid11_idahoroaddailyaverage.xls		Spokane Co	Groundwater	well levels 5/99-9/00
Citations Template.xls		Spokane Co	Bibliography	Gives fields that are recorded for tech reports, maps and other
citydatadailyaverages.xls	NCDC	Spokane Co	Meteorological Data	Water elevation at the wastewater treatment plant for 1995-2001
coeur d alene 1 eclimate.xls	NCDC	Spokane Co	Meteorological Data	9/1895-9/1998, met data from NCDC including, temp, precip, snow, evap and wind. Data summarized in different forms
coeurdalene1edaily.xls	NCDC	Spokane Co	Meteorological Data	daily met data including temp, precip and snow. 10/60 - 8/86
coeurd'alenedaily.xls	NCDC	Spokane Co	Meteorological Data	daily met data including temp, precip and snow. 1985 - 2000
Cross Section budget.doc		Spokane Co	Communcation - Geology	Memo to Stan Miller, Reanette regarding costs to get Cross sections in the Spokane Basin
d1.dwg		Spokane Co	Geology - Cross Sections	Autocad cross section files.From DNR, 2001. Draft x-sections for the new Spokane draft 1:100,000 geology map
DakotaWellDailyAverage.xls		Spokane Co	Groundwater	well levels 5/98-8/99
dams.xls	DOE and National Inve	Golder	Dam Information	Dam Locations (GIS coverage), basic srorage, use and ownership info.
DATA FOR WATERSHED MODEL - Reanette's list.doc		Spokane Co	Summary	Summary of Data sent by Spokane County to Golder
dd1.dwg		Spokane Co	Geology - Cross Sections	Autocad cross section files.From DNR, 2001. Draft x-sections for the new Spokane draft 1:100,000 geology map
deer park master.xls		Spokane Co	Water Quality	Ground water quality data for the Deer Park Basin
deerpark2eclimate.xls	NCDC	Spokane Co	Meteorological Data	summarized met data from NCDC including, temp, precip, snow, evap and wind. 7/48-3/77
deerpark2edaily.xls	NCDC	Spokane Co	Meteorological Data	daily met data prcip,temp,snow data. 1960-1977
deerparkobswell.xls		Spokane Co	Groundwater	well levels 4/78-3/00 (not daily levels)

Data Directory

File Name	Original Source - blank if unknown	Source	Brief Description	Full Description
depth2GW.tif		Spokane Co	Groundwater - images	Graphics from the Spokanr Valley- Rathdrum Prarie Aquifer
DNR cross section fix budget.xls		Spokane Co	Communcation - Geology	excel table of budget
dnr-xsec Buchanan memo.doc		Spokane Co	Communcation - Geology	Memo re: Buchannan's review of DNR Cross Sections
e1.dwg	DNR	Spokane Co	Geology - Cross Sections	Autocad cross section files.From DNR, 2001. Draft x-sections for the new Spokane draft 1:100,000 geology map
f1.dwg	DNR	Spokane Co	Geology - Cross Sections	Autocad cross section files.From DNR, 2001. Draft x-sections for the new Spokane draft 1:100,000 geology map
FeltsFieldDailyAverages.xls	NCDC	Spokane Co	Meteorological Data	1973 - 2000 daily avg, max and min temperature
g1.dwg	DNR	Spokane Co	Geology - Cross Sections	Autocad cross section files.From DNR, 2001. Draft x-sections for the new Spokane draft 1:100,000 geology map
gary071301	Golder (B.H.)	Golder (B.H.)	Geology	Instructions for preparation of Figure 4.10
geography.tif		Spokane Co	Groundwater - images	Graphics from the Spokanr Valley- Rathdrum Prarie Aquifer
geology_map.tif		Spokane Co	Groundwater - images	Graphics from the Spokanr Valley- Rathdrum Prarie Aquifer
geology-map-key.tif		Spokane Co	Groundwater - images	Graphics from the Spokanr Valley- Rathdrum Prarie Aquifer
great floodatlas6_21.tif		Spokane Co	Groundwater - images	Graphics from the Spokanr Valley- Rathdrum Prarie Aquifer
GW_SW_Interaction.xls		USGS	Water Quantity	Contains Well Elevations and River flows? Not sure of units or where the measured stations are. Or where this came from
GW_SW_Interactions	USGS	USGS - Rodney R Caldwell	Groundwater and Surface Water Interactions	Summary of selected wells that have been field inventoried and utilized for our project and wells that have continuous water-level (pressure transducers) and temperature recorders.
h1.dwg	DNR	Spokane Co	Geology - Cross Sections	Autocad cross section files.From DNR, 2001. Draft x-sections for the new Spokane draft 1:100,000 geology map
hangmanusgsq.xls		USGS	Water Quantity - Streams	# USGS 12424000 HANGMAN CREEK AT SPOKANE, WASH. (1948-1999)
i1.dwg	DNR	Spokane Co	Geology - Cross Sections	Autocad cross section files.From DNR, 2001. Draft x-sections for the new Spokane draft 1:100,000 geology map
iceage.tif		Spokane Co	Groundwater - images	Graphics from the Spokanr Valley- Rathdrum Prarie Aquifer
idaho_pipelinedailyaverage.xls		Spokane Co	Groundwater	well levels 5/99-9/00 daily avg
inland50.xls		Spokane Co	Water Quantity - Discharge	Inland Paper Company Discharges 95-00
inlandpaperusgswell.xls		Spokane Co	Groundwater	well levels 2/98-6/99 at four hour intervals
InlandpaperWellUSGS.xls		Spokane Co	Groundwater	well levels 7/29-1/01 random well level samples
j1.dwg	DNR	Spokane Co	Geology - Cross Sections	Autocad cross section files.From DNR, 2001. Draft x-sections for the new Spokane draft 1:100,000 geology map
k1.dwg	DNR	Spokane Co	Geology - Cross Sections	Autocad cross section files.From DNR, 2001. Draft x-sections for the new Spokane draft 1:100,000 geology map
kaiser50.xls		Spokane Co	Water Quantity - Discharge	Kaiser Trentwood Discharges from 94-99
kaisermead.xls		Spokane Co	Water Quantity - Discharge	Kaiser Mead Discharges to Deadmans Creek 94-99
l1.dwg	DNR	Spokane Co	Geology - Cross Sections	Autocad cross section files.From DNR, 2001. Draft x-sections for the new Spokane draft 1:100,000 geology map
lake-miz.tif		Spokane Co	Groundwater - images	Graphics from the Spokanr Valley- Rathdrum Prarie Aquifer
lawn irrigation.xls	Assorted Purveyors	Spokane C	Water Use	Water Use for City or Spokane and Whitworth Water. Also includes estimates of lawn irrigation needs as done by R.B.

Data Directory

File Name	Original Source - blank if unknown	Source	Brief Description	Full Description
libert50.xls		Spokane Co	Water Quantity - Discharge	Liberty Lake Sewer District Discharges 94-99
lsa wy99 q's.xls		Spokane Co	Water Quantity - Streams	Little Spokane River flows from water year 1999 at various locations along river, graphs included
LSR 5 Data Master.xls		Spokane Co	Water Quality	graphs for site 5 water quality data
LSR 6 Data Master.xls		Spokane Co	Water Quality	This seems to be Little Spokane River site 1 graphs, but there are errors in it or something
lsr data master2.xls		Spokane Co	Water Quality	Historic water quality and flow data for Little Spkane and Tributaries
lsr data source bibliography.doc		Spokane Co	Bibliography	Bibliography of Little Spokane Basin Data Source Material
lsr doe random qs.xls	DOE	Spokane Co	Water Quantity - Streams	Stream flow measurements at various points along little Spokane River most from 1986-1990
lsr surface monitoring sites.xls		Spokane Co	Water Quality	Surface Monitoring Locations in the Little Spokane River Basin
lsr wq data 1993 - 1998.xls		Spokane Co	Water Quality	Water Quality Data for the Little Spokane River from 1993-1998
LSR WQ Summary 6-1-01	SCCD	SCCD	Water Quantity - Streams	Summary of data from The Spokane County Conservation District (SCCD) assisting The Pend Oreille Conservation District (POCD) with a one- year water quality assessment of the Little Spokane River Watershed. Sampling began October 1998 and ended September 1999.
LSR, LS3.xls		Spokane Co	Water Quality	graphs for site 3 water quality data
LSR4.xls		Spokane Co	Water Quality	graphs for site 4 water quality data
LSR6 Data Master.xls		Spokane Co	Water Quality	graphs for site 6 water quality data
LSRchattq 97-present.xls	SCCD (C.P.)	SCCD	Water Quantity - Streams	Data obtained from SCC by Charlie Peterson for the Chattaroy gage
lsrchattsccq.xls	Spokane Cmnty Coll. (SCC)	Spokane Co	Water Quantity - Streams	Little Spokane River, Chattaroy Rd., Chattaroy, WA 1976-1996, stn 001
lsrdartfordq.xls	USGS	Spokane Co	Water Quantity - Streams	Station Number 12431000 Little Spokane River At Dartford, Wash. Stream Source Agency USGS (1986-2000)
lsrelkq.xls	USGS	Spokane Co	Water Quantity - Streams	STATION NUMBER 12427000 LITTLE SPOKANE RIVER AT ELK, WASH. STREAM SOURCE AGENCY USGS (1948-1971)
lsrrutterparkwayq.xls	USGS	Spokane Co	Water Quantity - Streams	STATION NUMBER 12431500 LITTLE SPOKANE RIVER NEAR DARTFORD, WASH. STREAM SOURCE AGENCY USGS (1948-1952, 1997-2000)
m1.dwg	DNR	Spokane Co	Geology - Cross Sections	Autocad cross section files.From DNR, 2001. Draft x-sections for the new Spokane draft 1:100,000 geology map
MayfairWellDailyAverage.xls		Spokane Co	Groundwater	well levels 9/97-9/00
MICROFEM review.doc	Golder	Golder	Models	Review of Spokane WHPP by Bryony
More data and a correction.txt		Spokane Co	Groundwater	communication regarding Vera data
mtspokanesummitclimate.xls	NCDC	Spokane Co	Meteorological Data	Summarized met data from NCDC including, temp, precip, snow, evap and wind. 1953-1972
mtspokanesummitdaily.xls	NCDC	Spokane Co	Meteorological Data	1960-1972 daily prcp, snow,tmax and tmin
mtspokanesummitnrcsdaily.xls	NCDC	Spokane Co	Meteorological Data	
n1.dwg	DNR	Spokane Co	Geology - Cross Sections	Autocad cross section files.From DNR, 2001. Draft x-sections for the new Spokane draft 1:100,000 geology map

Data Directory

File Name	Original Source - blank if unknown	Source	Brief Description	Full Description
newportclimate.xls	NCDC	Spokane Co	Meteorological Data	Summarized met data from NCDC inlcuding temp, precip, snow, and wind. 1927-1998
newportdaily.xls	NCDC	Spokane Co	Meteorological Data	same data as newportnrcsdaily.xls but in different format (1960-1998)
newportnrcsdaily.xls	NCDC	Spokane Co	Meteorological Data	1960-1998 daily prcp, temp,snow data
nine mile discharge 86-99q.xls		Spokane Co	Water Quantity - Dam Discharge	Nine Mile Dam Discharge (1986-1999)
NOAA Deer Park.xls	NCDC	Spokane Co	Meteorological Data	Graphs of NOAA/NWS COOP data for Deer Park - historical and cumulative precip and historical temperature graphs
NOAA Fairchild.xls	NCDC	Spokane Co	Meteorological Data	Graphs of NOAA/NWS COOP data for Fairchild - historical and cumulative precip and historical temperature graphs. Real data for this is in noaadata.xls file
NOAA MTSpokane.xls	NCDC	Golder	Meteorological Data	Graphs of NOAA/NWS COOP data - historical and cumulative precip and historical temperature graphs (done by Golder)
NOAA Newport.xls	NCDC	Golder	Meteorological Data	Graphs of NOAA/NWS COOP data - historical and cumulative precip and historical temperature graphs (done by Golder)
NOAA Spokane WFO.xls	NCDC	Golder	Meteorological Data	Spokane Temp and Precip graphs (done by Golder)
NOAA Spokane.xls	NCDC	Golder	Meteorological Data	Spokane historic Temp and Precip graphs (done by Golder)
noaadata.xls	NCDC	NCDC	Meteorological Data	COOP data for all stations including newport, mt spokane, fairchild, deer park, spokane WFO spokane AP, Spokane
noaadatainstructions.xls	NCDC	NCDC	Meteorological Data	Describes data format and what NOAA COOP headings mean
normals data for coeur d alene.doc	NCDC	Spokane Co	Meteorological Data	Gives normal monthly and daily temperatures (max,min), precip and snow
o1.dwg	DNR	Spokane Co	Geology - Cross Sections	Autocad cross section files.From DNR, 2001. Draft x-sections for the new Spokane draft 1:100,000 geology map
p1.dwg	DNR	Spokane Co	Geology - Cross Sections	Autocad cross section files.From DNR, 2001. Draft x-sections for the new Spokane draft 1:100,000 geology map
p14-bnew.tif		Spokane Co	Groundwater - images	Graphics from the Spokanr Valley- Rathdrum Prarie Aquifer
Pend Oreille County population.doc		Spokane Co	Population	regarding communication to receive populations numbers. Contains no actual numbers
prcp_by_section.xls	Oregon State Universit	Golder	Meteorological Data - Modeled	Precipitation outputs from the PRISM model, merged to the section scale (PRISM data purchased includes snow, temp and precip)
q1.dwg	DNR	Spokane Co	Geology - Cross Sections	Autocad cross section files.From DNR, 2001. Draft x-sections for the new Spokane draft 1:100,000 geology map
r1.dwg	DNR	Spokane Co	Geology - Cross Sections	Autocad cross section files.From DNR, 2001. Draft x-sections for the new Spokane draft 1:100,000 geology map
river and well data.xls		Spokane Co	Water Quantity	Contains Well Elevations and River flows? Not sure of units or where the measured stations are. Or where this came from
river and well datarevised.xls		Spokane Co	Water Quantity	Contains Well Elevations and River flows - Updated 6/18/01
s1.dwg	DNR	Spokane Co	Geology - Cross Sections	Autocad cross section files.From DNR, 2001. Draft x-sections for the new Spokane draft 1:100,000 geology map
shadisoil.jpg		Golder	Land Use and Soils	Shadi soild coverage. Also have GIS file
snowpackspokanebasin.xls		Spokane Co	Meteorological Data	1/97-6/2000 snow pack data around spokane basin includes data on snow depth, water equiv and averages
snowstuff.xls		Spokane Co	Meteorological Data	Snotel data for bunchgrass, quartz peak and ragged ridge
Soil Tables.xls	NRCS	Golder	Land Use and Soils	NRCS soil categories for the tri-county area with hydrologic group, map symbol, slope, etc.
Soils of Spokane County.xls		Spokane Co	Land Use and Soils	Soil info from Spokane County

Data Directory

File Name	Original Source - blank if unknown	Source	Brief Description	Full Description
spo_geo_071301		Bryony	Geology	Table for geology coverage and Figure 4.10
spokan50.xls		Spokane Co	Water Quantity - Discharge	Spokane Advanced Waste Water Treatment Plant Discharges 94-99
Spokane Bibliography.pdt		Spokane Co	Bibliography	Procite Bibliography for Spokane Report
Spokane Bibliography.pdx		Spokane Co	Bibliography	Procite Bibliography for Spokane Report
Spokane County WELLOG.xls		Spokane Co	Geology	Describes the geologic material found while drilling for inidividual wells
spokaneapclimate.xls	NCDC	Spokane Co	Meteorological Data	1890-2000 Spokane Airport Climate Data
spokaneapdaily.xls	NCDC	Spokane Co	Meteorological Data	1960-2000 daily climate data at spokane airport from NCDC
spokaneclimate.xls	NCDC	Spokane Co	Meteorological Data	1953-1983 NRCS Spokane Climate Data
spokanedaily.xls	NCDC	Spokane Co	Meteorological Data	1960-1983 daily climate data
spokanenwsdaily.xls		Spokane Co	Meteorological Data	1996-1999 National Weather Service Climate Data, Rambo Road - gage 457941
spokaneunknowdaily.xls		Spokane Co	Meteorological Data	??
spokanewsoairportnrcsdaily.xls		Spokane Co	Meteorological Data	10/60-9/98 nrcs data - temp, precip, wind, evap, etc. for the spokane airport
SpoRiver Data Master.xls		Spokane Co	Water Quality	Historic water quality data for the Spokane River
sporiver data master2.xls		Spokane Co	Water Quality	Same as SpoRiverDatamaster not sure which of these is correct
sr@greenacres(barker)q(revised).xls	USGS	Spokane Co	Water Quantity - Streams	USGS measured flow on Spokane River at Greenacres (stn 12420500) 1948-1952 and 1999-2000. Minor calcs done on flows
sr@harvardusgsq(revised).xls	USGS	Spokane Co	Water Quantity - Streams	USGS measured flow on Spokane River at Liberty Bridge (Harvard) 1929-1984 and 1999-2000. Minor calcs done on flows
sr@harvardusgsq.xls	USGS	Spokane Co	Water Quantity - Streams	USGS measured flow on Spokane River at Liberty Bridge (Harvard) 1929-1984 and 1999-2000 (same as above w/o minor calcs)
sratspokaneq.xls		Spokane Co	Water Quantity - Streams	Spokane River at Spokane flows 1891-2000 - no station number given
srblwtrentbridgeusgsq.xls	USGS	Spokane Co	Water Quantity - Streams	STATION NUMBER 12421500 SPOKANE RIVER BLW TRENT BRG NR SPOKANE, WASH. STREAM SOURCE AGENCY USGS. 1948-1954
srgreene93to98sccq.xls	USGS	Spokane Co	Water Quantity - Streams	SPOKANE RIVER BLW GREEN ST AT SPOKANE WASH. Flows 1993-1998. Stn 12422000
srharvard93to98sccq.xls		Spokane Co	Water Quantity - Streams	93-98 flows on the Spokane River at Liberty Bridge. Stn 12419500. SCC data
srpostfalls13to99q.xls	USGS	Spokane Co	Water Quantity - Streams	Flow in the Spokane River at Post Falls from 1913-1999
sullivanparknorthdailyaverage.xls		Spokane Co	Groundwater	well levels 11/98-9/2000 daily avg
sullivanparksouthdailyaverage.xls		Spokane Co	Groundwater	well levels 11/98-9/00 daily avg
sullivansouthdailyaverage.xls		Spokane Co	Groundwater	well levels 11/98-9/00 daily avg
Summary of Water Quality Data.doc		Spokane Co	Water Quality	Summary of Water Quality Data for Little Spokane River
t1.dwg	DNR	Spokane Co	Geology - Cross Sections	Autocad cross section files.From DNR, 2001. Draft x-sections for the new Spokane draft 1:100,000 geology map

Data Directory

File Name	Original Source - blank if unknown	Source	Brief Description	Full Description
temp_by_section.xls	Oregon State Universit	Golder	Meteorological Data - modeled	Temperature outputs from the PRISM model, mergerd to the section scale (PRISM data purchased includes snow, temp and precip)
trsdischarge.xls		Spokane Co	Water Quantity - Discharge	Total Relases by Month for all dischargers in the basin. Units and year unclear
trswateruse.xls		Spokane Co	Water Use	Trswateruse.xls is meant to be average use for the last few years. For many of the water purveyors, information was obtained on water use for at least 1994 and 1997 because they have high use and low use years. Some water purveyors provided water use for the years 1994 to 1999, or some combination of those years. Numbers entered on the high side of average because it was assumed most water districts are growing. For some, we only knew the number of connections. For businesses, we found out the type of business, number of employees, and number of customers to assign water use. Because we were calling in 2000, most of our business data will reflect that year.
u1.dwg	DNR	Spokane Co	Geology - Cross Sections	Autocad cross section files.From DNR, 2001. Draft x-sections for the new Spokane draft 1:100,000 geology map
usgsspokaneriverdata.xls	USGS	Spokane Co	Water Quantity - Streams	Both water quality and flow data from several USGS Sites on the Spokane River, most measurements done in 1999
v1.dwg	DNR	Spokane Co	Geology - Cross Sections	Autocad cross section files.From DNR, 2001. Draft x-sections for the new Spokane draft 1:100,000 geology map
VeraWaterElevations.xls		Spokane Co	Groundwater	1967-2000 well levels and pumping logs for Vera Water District Wells
Vista3.gwv		Spokane Co	Models	GW model
w1.dwg	DNR	Spokane Co	Geology - Cross Sections	Autocad cross section files.From DNR, 2001. Draft x-sections for the new Spokane draft 1:100,000 geology map
waterqualitydata.mdb		Spokane Co	Water Quality	Organic and Inorganic Water Quality Information for Wells in Spokane
Watershed Model Data 2-23-01.doc	Spokane Co	Spokane Co	Summary	Summary of Data sent from Spokane County to Golder
Watershed Model Data 3-26-01.doc	Spokane Co	Spokane Co	Summary	Updated copy of Data sent from Spokane County to Golder
welllocationyield.xls		Spokane Co	Groundwater	Basic info on well yield, location, elevation etc. For Little Spokane Watershed (I think)
WRATS DATA DICTIONARY.doc	DOE	Golder	Water rights	Describes fields in WRATS table
WRIA Spokane River Water Quality Summary.doc		Spokane Co	Water Quality	Data Summary: Historic Water Quality of the Spokane River from Coeur d'Alene Lake to Long Lake Dam - May 2000
WRIA55-WRATS_TABLES.mdb	DOE	Golder	Water rights	Water Rights Application Tracking System Table for WRIA 57, includes master, purpose and source table
WRIA57-WRATS_TABLES.mdb	DOE	Golder	Water rights	Water Rights Application Tracking System Table for WRIA 56, includes master, purpose and source table
x1.dwg	DNR	Spokane Co	Geology - Cross Sections	Autocad cross section files.From DNR, 2001. Draft x-sections for the new Spokane draft 1:100,000 geology map
xsecmemo.doc			Communcation - Geology	Memo to Stan Miller regarding Buchannans review and additional info needed

Data Directory

File Name	Original Source - blank if unknown	Source	Brief Description	Full Description
Xsect1 extra from reanette.DXF		Spokane Co	Geology - Cross Sections	Autocad cross section files. From Boese&Buchanan, 1996, Aquifer delineation of a part of North Spokane.
Xsect1.DXF		Spokane Co	Geology - Cross Sections	Autocad cross section files. From Boese&Buchanan, 1996, Aquifer delineation of a part of North Spokane.
Xsect10.DXF		Spokane Co	Geology - Cross Sections	Autocad cross section files. From Boese&Buchanan, 1996, Aquifer delineation of a part of North Spokane.
Xsect2.DXF		Spokane Co	Geology - Cross Sections	Autocad cross section files. From Boese&Buchanan, 1996, Aquifer delineation of a part of North Spokane.
Xsect3.DXF		Spokane Co	Geology - Cross Sections	Autocad cross section files. From Boese&Buchanan, 1996, Aquifer delineation of a part of North Spokane.
Xsect4.DXF		Spokane Co	Geology - Cross Sections	Autocad cross section files. From Boese&Buchanan, 1996, Aquifer delineation of a part of North Spokane.
Xsect5.DXF		Spokane Co	Geology - Cross Sections	Autocad cross section files. From Boese&Buchanan, 1996, Aquifer delineation of a part of North Spokane.
Xsect7.DXF		Spokane Co	Geology - Cross Sections	Autocad cross section files. From Boese&Buchanan, 1996, Aquifer delineation of a part of North Spokane.
Xsect8.DWG		Spokane Co	Geology - Cross Sections	Autocad cross section files. From Boese&Buchanan, 1996, Aquifer delineation of a part of North Spokane.
Xsect8.DXF		Spokane Co	Geology - Cross Sections	Autocad cross section files. From Boese&Buchanan, 1996, Aquifer delineation of a part of North Spokane.
Xsect9.DXF		Spokane Co	Geology - Cross Sections	Autocad cross section files. From Boese&Buchanan, 1996, Aquifer delineation of a part of North Spokane.
XsectC.DXF		Spokane Co	Geology - Cross Sections	Autocad cross section files. From Boese&Buchanan, 1996, Aquifer delineation of a part of North Spokane.
y1.dwg		Spokane Co	Geology - Cross Sections	Autocad cross section files.From DNR, 2001. Draft x-sections for the new Spokane draft 1:100,000 geology map
z1.dwg		Spokane Co	Geology - Cross Sections	Autocad cross section files.From DNR, 2001. Draft x-sections for the new Spokane draft 1:100,000 geology map

APPENDIX A-3

GIS DATA DIRECTORY

A-3 GIS Data Directory

Filename	Original Source (blank if unknown)	Brief Description	Full Description	Additional Info
east_dem.e00	Coeur d' Alene Tribe- GIS 11/99	DEM	THis DEM unfortunately does not cover the northern portion of the study area.	
ns_dem.e00	Spokane County Long Range Planning GIS	DEM	This DEM provides data for the northern, and an extention of the southern study area.	
hydro.e00		Hydrology	approx. 1:250,000 regional hydrology, with some over-lay annotation to identify major water features. If built as a polygon, the lakes will function as polys.	DOUBLE precision coverage
hydro24k.e00	WA ST DOE GIS 7/96	Hydrology	Detailed 1:24K coverage of MOST of study area hydrology. There is a lot of coded information as arc attributes.	SINGLE precision coverage
po_lu.e00	PO County Conservation District in 1999-2000 as part of a watershed study	Land use from Pend Oreille County (from a planner's perspective)	This data was derived from aerial photos, and field checks	There is one useful polygon item field that describes the general usage of the polygon.
steve_lu.e00	POCCD as part of the watershed study	Land use		SINGLE precision coverage
spolu83spn.shp	POCCD study	landu_use	They received their data in 1999 from Spokane County Long Range Planners GIS.	This data was created at the parcel level.
log		ArcInfo Log file		
meta-data.doc		Disk 1 file info word document		
meta-data.doc		Disk 1 file info word document		
readme.txt				
q-sites.e00		6 sites where effluent is discharged into surfacewater.		DOUBLE precision coverage discharge
q-metadata.doc		info about q-sites.e00		
log.doc		ArcInfo Log file		
aqtyp.e00	WA ST DNR/USGS 1:100K Digital Geologic Map of Spokane County and Vicinity, 1998	Aquifer types for the extent of Spokane County.	Prepared by Spokane County WQMP as an input layer for SHADI - a GRID based Aquifer Sensitivity Study for Spokane County, Spring, 1998.	DOUBLE precision coverage
aqtyp.doc		info about aqtyp.e00		
water_dist.e00	Boundary Review Board Files + Spokane County Assessor Maps	Digitized GDMS layer	Spokane County water purveyors and associated attribute data. Layers wdpub27 and wdpub83 contain historical and current arcs and labels. Layers wdpub27_poly and wdpub83_poly are the current boundaries only, no historical arcs or labels are maintained on these layers. The dataset contains all of those water purveyors, both public and private, which have participated in Spokane County's Coordinated Water System Plan.	
waterdist_ddict.final.doc		SPOKANE COUNTY GIS DATA DICTIONARY		
monitorsite.e00		WQMP monitor site coverage	Monitoring wells and river sampling sites selected specifically by WQMP staff for Golder and the WRIA study.	DOUBLE precision coverage
monitor_golder.dd		info about monitorsite.e00		
stev_soils.e00		*NO DATA*		
camden.e00	Soil Conservation Service Soil Survey of 1968, with revision in 1975.			This data is for use at the scale of 1:24000 or smaller

Filename	Original Source (blank if unknown)	Brief Description	Full Description	Additional Info
chatt.e00	Soil Conservation Service Soil Survey of 1968, with revision in 1975.			This data is for use at the scale of 1:24000 or smaller
clayton.e00	Soil Conservation Service Soil Survey of 1968, with revision in 1975.			This data is for use at the scale of 1:24000 or smaller
deerlk.e00	Soil Conservation Service Soil Survey of 1968, with revision in 1975.			This data is for use at the scale of 1:24000 or smaller
deerpk.e00	Soil Conservation Service Soil Survey of 1968, with revision in 1975.			This data is for use at the scale of 1:24000 or smaller
drtfrd.e00	Soil Conservation Service Soil Survey of 1968, with revision in 1975.			This data is for use at the scale of 1:24000 or smaller
elk.e00	Soil Conservation Service Soil Survey of 1968, with revision in 1975.			This data is for use at the scale of 1:24000 or smaller
fanlk.e00	Soil Conservation Service Soil Survey of 1968, with revision in 1975.			This data is for use at the scale of 1:24000 or smaller
fremn.e00	Soil Conservation Service Soil Survey of 1968, with revision in 1975.			This data is for use at the scale of 1:24000 or smaller
fthill.e00	Soil Conservation Service Soil Survey of 1968, with revision in 1975.			This data is for use at the scale of 1:24000 or smaller
greenac.e00	Soil Conservation Service Soil Survey of 1968, with revision in 1975.			This data is for use at the scale of 1:24000 or smaller
greenac2.e00	Soil Conservation Service Soil Survey of 1968, with revision in 1975.			This data is for use at the scale of 1:24000 or smaller
lbrtylk.e00	Soil Conservation Service Soil Survey of 1968, with revision in 1975.			This data is for use at the scale of 1:24000 or smaller
lbrtylk2.e00	Soil Conservation Service Soil Survey of 1968, with revision in 1975.			This data is for use at the scale of 1:24000 or smaller
mead.e00	Soil Conservation Service Soil Survey of 1968, with revision in 1975.			This data is for use at the scale of 1:24000 or smaller
micapk.e00	Soil Conservation Service Soil Survey of 1968, with revision in 1975.			This data is for use at the scale of 1:24000 or smaller
mtkc.e00	Soil Conservation Service Soil Survey of 1968, with revision in 1975.			This data is for use at the scale of 1:24000 or smaller

Filename	Original Source (blank if unknown)	Brief Description	Full Description	Additional Info
mtspok.e00	Soil Conservation Service Soil Survey of 1968, with revision in 1975.			This data is for use at the scale of 1:24000 or smaller
nineml.e00	Soil Conservation Service Soil Survey of 1968, with revision in 1975.			This data is for use at the scale of 1:24000 or smaller
nwmnlk.e00	Soil Conservation Service Soil Survey of 1968, with revision in 1975.			This data is for use at the scale of 1:24000 or smaller
soil_disclaim		contains info about source of files in this directory		
soil_disclaim%		contains note about erodible soils		
soildscrp.txt		text document about various soil types		
soils.wpd		machine language		
spo_soils.doc		SPOKANE COUNTY GIS DATA DICTIONARY		
spokne.e00	Soil Conservation Service Soil Survey of 1968, with revision in 1975.			This data is for use at the scale of 1:24000 or smaller
spokne2.e00	Soil Conservation Service Soil Survey of 1968, with revision in 1975.			This data is for use at the scale of 1:24000 or smaller
spoknw.e00	Soil Conservation Service Soil Survey of 1968, with revision in 1975.			This data is for use at the scale of 1:24000 or smaller
spoknw2.e00	Soil Conservation Service Soil Survey of 1968, with revision in 1975.			This data is for use at the scale of 1:24000 or smaller
spokse.e00	Soil Conservation Service Soil Survey of 1968, with revision in 1975.			This data is for use at the scale of 1:24000 or smaller
spoksw.e00	Soil Conservation Service Soil Survey of 1968, with revision in 1975.			This data is for use at the scale of 1:24000 or smaller
tmtm.e00	Soil Conservation Service Soil Survey of 1968, with revision in 1975.			This data is for use at the scale of 1:24000 or smaller
tweed.00.e00	Soil Conservation Service Soil Survey of 1968, with revision in 1975.			This data is for use at the scale of 1:24000 or smaller
Info (Folder)				"info" folder contains "nit" and "dat" files
aq_bndry.e00	IDAHO PANHANDLE HEATH DISTRICT	Extent of the Rathdrum Prairie	Spokane Valley aquifer FROM SOUTH END OF LAKE PEND OREILLE, IDAHO - THRU RAHTDRUM PRAIRIE, THE SPOKANE VALLEY, TO DISCHARGE AT LITTLE SPOKANE RIVER, AND SPOKANE RIVER IN N-S REACH WEST OF CITY OF SPOKANE.	
aq_db.e00		Coverage of Spokane Valley- Rathdrum Prairie drainage basins		
aqbndry_comp.dd		info about aq_bndry.e00		
aqdb_meta.txt		info about aq_db.e00		

Filename	**Original Source** (blank if unknown)	Brief Description	Full Description	Additional Info
county~1	USGS 20 contour data	DEM	This is a elevation DEM for Spokane County, at 20 contour resolution (created from USGS 20 contour data)	name this county.dem or A/I won't be able to read it.
d2_h20.e00	Water table elevation for the county was compiled from various studies and USGS well log data.	depth to groundwater	This data was put in a GRID, then subtracted from a surface elevation GRID, created from DNR elevation data. The resultant "depth to groundwater" GRID was GRIDPOLY'd to produce the d2 coverage.	
d2_meta.txt		info about d2_h20.e00		
golder21501.txt		data log		
log		ArcInfo Log file		
misc_meta.txt		info about various GIS files		
misc_meta.txt%		info about various GIS files		
monitor_sites.dd		info about monitor_sites.e00		
monitor_sites.e00	Reanette Boese, WQMP staff	point coverage of various types of USGS monitoring sites		Locations were derived from lat-long data
po_plss.e00		sections for PO County		
po_res2.e00	windshield survey driven in Autumn, 2000, by WQMP-GIS staff and intern	residential sites in Pend Oreille and Stevens Counties, within WRIA 55	The windshield survy was supported by use of 1995 aerial photography of the area. Many roads were private, or turned out to be undrivable- so the digital ortho photography was used to add #'s in unseen areas. Many clusters of mail boses were counted. This is a rough but representative inventory of residences in the study area.	
po_res2_meta.txt		info about po_res.e00		
po_tr.e00		township range PO County		
region_rds.e00		roads	1:250K or so crude regional major highways -sp NAD83 zone 5601	
rivers.e00		hydrology	1:250K or so crude regional hydrology -sp NAD83 zone 5601	
septic_tnks.e00		*septic systems*		
sew_basn.e00		*sewer boundaries*		
spo_domwells.e00		point coverage of Spokane County Domestic Wells		
spo_plss.e00		sections for Spokane County		
spo_t_r.e00		township range Spokane County		
stev_plss.e00		sections for Stevens County		
steve_tr.e00		township range Stevens County		
ch_geo.pkey		cryptic geo data ie. 0.7 Alluvium		
ch_geomaps.txt		Geology of Washington State text data		large text file listing geology sources
ch_metadata.txt		info about chew_geo.e00		
ch_units.txt		Geologic Map Units data		
chew_geo.e00	USGS	geology maps	1:100,000-scale topographic quadrangle maps as base	SINGLE precision coverage
spo_geo.e00	the USGS -Spokane office ???	no info		
spo_geo.key		cryptic geo data ie. 0.7 Alluvium		
spo_metadata.txt		info about spo_geo.e00??? (Doesn't say which file it is for)		
spo_metadata.txt%		same as spo_metadata.txt		
images (Folder)				This Folder contains "tif" images
d2gw.tif		tif image		
geography.tif		tif image		
geo-map.tif		tif image		
g-map-key.tif		tif image		
great floodatlas6_21.tif		tif image		
iceage.tif		tif image		
lake-miz.tif		tif image		
p14-bnew.tif		tif image		

Filename	**Original Source** (blank if unknown)	Brief Description	Full Description	Additional Info
Info (Folder)				"info" folder contains "nit" and "dat" files
about_data.txt		info about various files in this dir.		
about_data.txt%		info about various files in this dir.		
data22301.txt		log data		
data22301.txt%		log data		
lsr_db.e00	DOE statewide (very crude) WAU (water a? unit) coverage, from Spokane County WQMP data, using 30 meter DEMS as an elevation reference, and from 7.5 min quads	Little Spokane River drainage basins		There are no creek names, or other useful information yet added to basin polygons
lsr_db2_data.txt		info about lsr_db.e00		
lsr_sites.e00		Stan's lsr basin data		
po_soil.e00		Pend Oreille County soils		
strm_basn.e00	Spokane County Utilities Stormwater Department	stormwater basins coverage		
precip (Folder)				This Folder contains GIS data about monthly precipitations
precip_apr.e00	Oregon State University and Oregon Climate Service at Oregon State University	Washington Average Monthly Precipitation, 1961-90	Parameter-elevation Regressions on Independent Slopes Model (PRISM) derived raster data is the underlying data set from which the polygons and vectors were created	
precip_aug.e00	Oregon State University and Oregon Climate Service at Oregon State University	Washington Average Monthly Precipitation, 1961-90	Parameter-elevation Regressions on Independent Slopes Model (PRISM) derived raster data is the underlying data set from which the polygons and vectors were created	
precip_dec.e00	Oregon State University and Oregon Climate Service at Oregon State University	Washington Average Monthly Precipitation, 1961-90	Parameter-elevation Regressions on Independent Slopes Model (PRISM) derived raster data is the underlying data set from which the polygons and vectors were created	
precip_feb.e00	Oregon State University and Oregon Climate Service at Oregon State University	Washington Average Monthly Precipitation, 1961-90	Parameter-elevation Regressions on Independent Slopes Model (PRISM) derived raster data is the underlying data set from which the polygons and vectors were created	
precip_jan.e00	Oregon State University and Oregon Climate Service at Oregon State University	Washington Average Monthly Precipitation, 1961-90	Parameter-elevation Regressions on Independent Slopes Model (PRISM) derived raster data is the underlying data set from which the polygons and vectors were created	
precip_jul.e00	Oregon State University and Oregon Climate Service at Oregon State University	Washington Average Monthly Precipitation, 1961-90	Parameter-elevation Regressions on Independent Slopes Model (PRISM) derived raster data is the underlying data set from which the polygons and vectors were created	
precip_jun.e00	Oregon State University and Oregon Climate Service at Oregon State University	Washington Average Monthly Precipitation, 1961-90	Parameter-elevation Regressions on Independent Slopes Model (PRISM) derived raster data is the underlying data set from which the polygons and vectors were created	
precip_mar.e00	Oregon State University and Oregon Climate Service at Oregon State University	Washington Average Monthly Precipitation, 1961-90	Parameter-elevation Regressions on Independent Slopes Model (PRISM) derived raster data is the underlying data set from which the polygons and vectors were created	

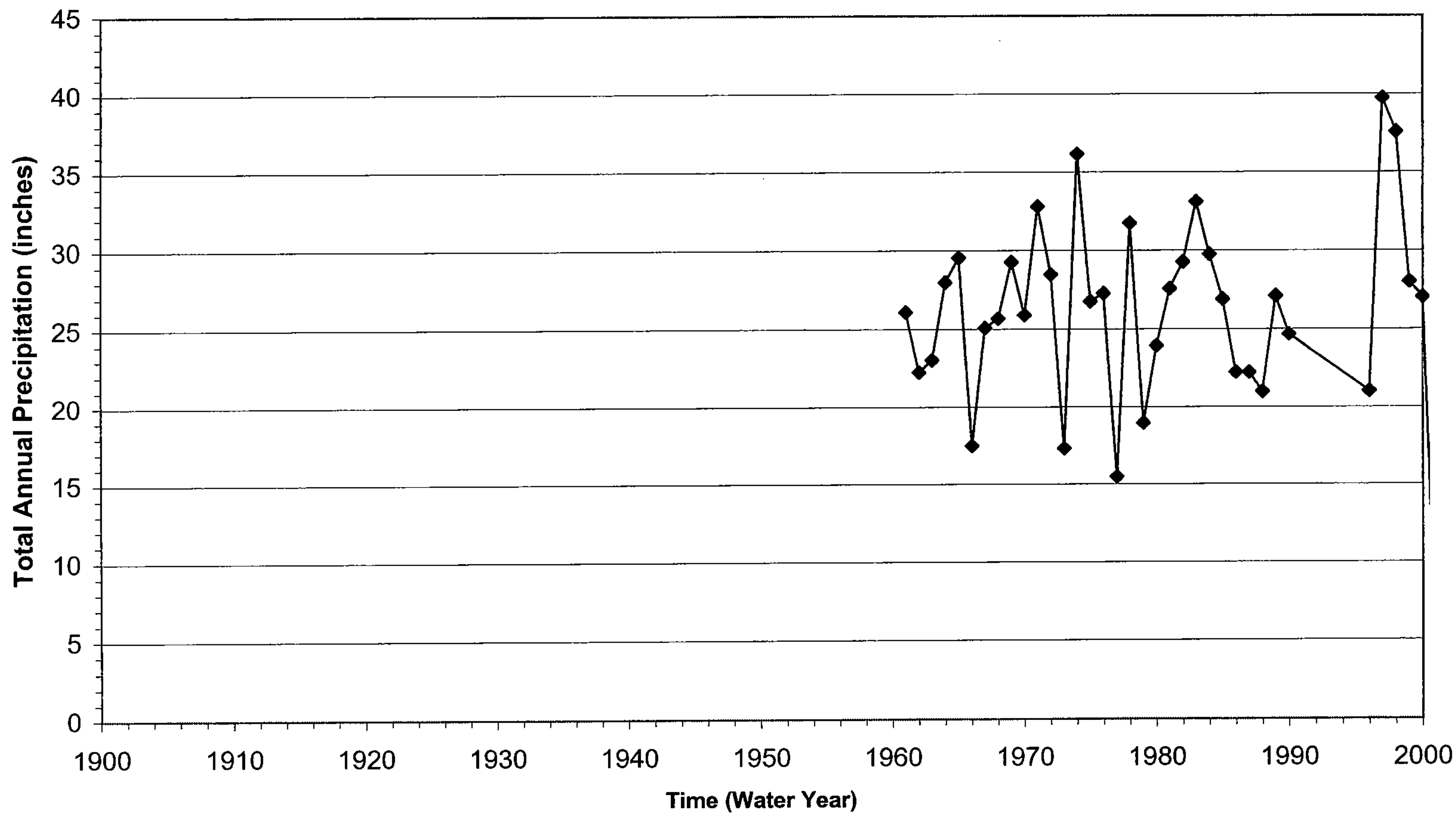
Filename	**Original Source** (blank if unknown)	Brief Description	Full Description	Additional Info
precip_may.e00	Oregon State University and Oregon Climate Service at Oregon State University	Washington Average Monthly Precipitation, 1961-90	Parameter-elevation Regressions on Independent Slopes Model (PRISM) derived raster data is the underlying data set from which the polygons and vectors were created	
precip_nov.e00	Oregon State University and Oregon Climate Service at Oregon State University	Washington Average Monthly Precipitation, 1961-90	Parameter-elevation Regressions on Independent Slopes Model (PRISM) derived raster data is the underlying data set from which the polygons and vectors were created	
precip_oct.e00	Oregon State University and Oregon Climate Service at Oregon State University	Washington Average Monthly Precipitation, 1961-90	Parameter-elevation Regressions on Independent Slopes Model (PRISM) derived raster data is the underlying data set from which the polygons and vectors were created	
precip_sep.e00	Oregon State University and Oregon Climate Service at Oregon State University	Washington Average Monthly Precipitation, 1961-90	Parameter-elevation Regressions on Independent Slopes Model (PRISM) derived raster data is the underlying data set from which the polygons and vectors were created	
washington average monthly or annual precipitationmetadata.doc		info about Precip data	Parameter-elevation Regressions on Independent Slopes Model (PRISM) derived raster data is the underlying data set from which the polygons and vectors were created	
greenac.e00	Soil Conservation Service Soil Survey of 1968, with revision in 1975			
lbrtylk.e00	Soil Conservation Service Soil Survey of 1968, with revision in 1975			data is for use at the scale of 1:24000 or smaller.
soil_disclaim		info about various files in this directory		
soil_disclaim%		sames as soil_disclaim		
soildscrp.txt		textual soil info		
soils.wpd		data form about SOILS coverage		
spokne.e00	Soil Conservation Service Soil Survey of 1968, with revision in 1975			
spoknw.e00	Soil Conservation Service Soil Survey of 1968, with revision in 1975			data is for use at the scale of 1:24000 or smaller.
wdga.e00		Water District Growth Areas.		
c_blk2k.e00		Census Block Boundaries	no population data included, just boundaries	
c_trk2k.e00		Census Tract Boundaries	no population data included, just boundaries	
wria_sewbas.e00		Sewer System Boundaries	use the TYPE item field and reselect for "not_sew_yet" for UNSEWERED areas	
wria_septk.e00	Spokane County Health District	Septic Systems within Spokane County	You will notice that there are many septic tanks still showing upin sewer basins sewered in 2000 and 2001. This is because the residents haveone year to hook up after the sewers are in place.This Septic Tank data from Spokane County Health District is from June 01, 2001(therefore reflecting active septic tanks as of 6/2000).	
gap_lc.e00	USGS National GAP Data Program	GAP Land Cover coverage	based on land - cover data, LANDSAT, from the mid 90's	
lulccode.rtf	USGS National GAP Data Program	Code look up table for gap_lc	based on land - cover data, LANDSAT, from the mid 90's	
datadict.rtf	USGS National GAP Data Program	data dictionary for gap_lc	based on land - cover data, LANDSAT, from the mid 90's	

Filename	Original Source (blank if unknown)	Brief Description	Full Description	Additional Info
WRIA_24k.shp	Washington Dept. of Ecology	WRIA Boundaries	Water Resource Inventory Areas for Washington State	
WAU.shp	Washington Dept. of Ecology	WAU Boundaries	WAU Boundaries for Washington State	
HUC5.shp	National Atlas of the United States	HUC Boundaries	HUC Boundaries for	
streams.shp	Washington Dept. of Ecology	Hydrology	Washington State Streams	
idaho_streams.shp	Idaho Dept. of Water Resources	Hydrology	Idaho Streams	
montana_streams.shp	Montana State Library	Hydrology	Montana Streams	
hydrology.e00 (stream	National Atlas	Hydrology	Large scale streams coverage of Washington	
lakes.shp	Washington Dept. of Ecology	Hydrology	Lakes in close proximity to Spokane County	
idaho_lakes.shp	Idaho Dept of Water Resources	Hydrology	Idaho Lakes	
montana_lakes.shp	Montana State Library	Hydrology	Montana Lakes	
roads_selected.shp	Washington Dept. of Transportation	Roads	Roads in close proximity to Spokane County	
idaho_roads.shp	Idaho Dept of Water Resources	Roads	Idaho Roads	
montana_roads.shp	Montana State Library	Roads	Montana Roads	
roads_24k.shp	Washington Dept. of Transportation	Roads	Large scale roads coverage of Washington	
townships.shp	WAGDA Univeristy of Washington Library	Townships polygons for Washington State		
plss.shp	WAGDA Univeristy of Washington Library	Sections coverage for Washington State		
Us_Snowfall13.asc	Climate Source Ltd	Washington annual snowfall data 1961 - 1990	PRISM Grid data depicting annual snowfall for the Contineneta1 United States	
dams.shp	Washington Dept. of Ecology	Dams	Washington State Dams	
dams_idaho.shp	US Army Corp of Engineers / National Atlas	Dams	Dams of interest falling outside of Washington State (Idaho)	
spo_geo.e00	Spokane County GIS Department	Geology data	Spokane County Geology data	
chew_geo.shp	Spokane County GIS Department	Geology data	Geology data for areas of interst outside Spokane County	
reservations.shp	Washington Dept. of Ecology	Reservations	Current and historic Indian tribal lands	
ancestral_lands	Created with consultation from area tribes	Areas of Cultural significance to First Peoples.	Areas of Cultural significance to First Peoples.	
boundary.shp	Created from HUC4 boundaries	WRIA 57 Contributing Watershed Boundary	WRIA 57 Boundary created from HUC4 boundaries and Map Delineations	
water_districts.shp	Spokane County GIS Department	Water Districts	Water District Polygon coverage for Spokane County, Stevens County and Pend Oreille County	
sewered_areas.shp	Spokane County GIS Department	Sewered Areas	Areas within the Study area that have established sewer systems	
census.shp	US Census Bureau		Tiger population data divided and recalculated for TRS sections boundaries	
303K_sites	Washington Dept. of Ecology Water Quality Program	Impaired & Threatened Waterbodies	303(d) List of Impaired and Threatened Waterbodies	
met_stations.shp	Washington Dept. of Ecology	Meteorlogical Stations	Weather Stations in close proximity to Spokane County	
wells.shp	Washington Dept. of Ecology	Washington State wells		
Aq_bndry.e00	Spokane County GIS Department	Delineated Aquifer Regions	Delineated Aquifer Regions within Washington State and Idaho	
wastewater.shp	Spokane County GIS Department	Wastewater Outfall Regions		
spo_domwells.e00	Spokane County GIS Department	Spokane County Dominant Wells		
monitor_sites.e00	Spokane County GIS Department	Surface Water Quality Monitoring Sites		
irr_land.e00	Spokane County GIS Department	Irrigated lands (Spokane Landuse)		
final.dem	USGS & Washington University Libraries (WAGDA)	DEM	DEM coverage extending throughout study area, comprised of smaller USGS DEMs to capture full area	

APPENDIX B

TOTAL ANNUAL PRECIPITATION GRAPHS

Table of Contents



Legend

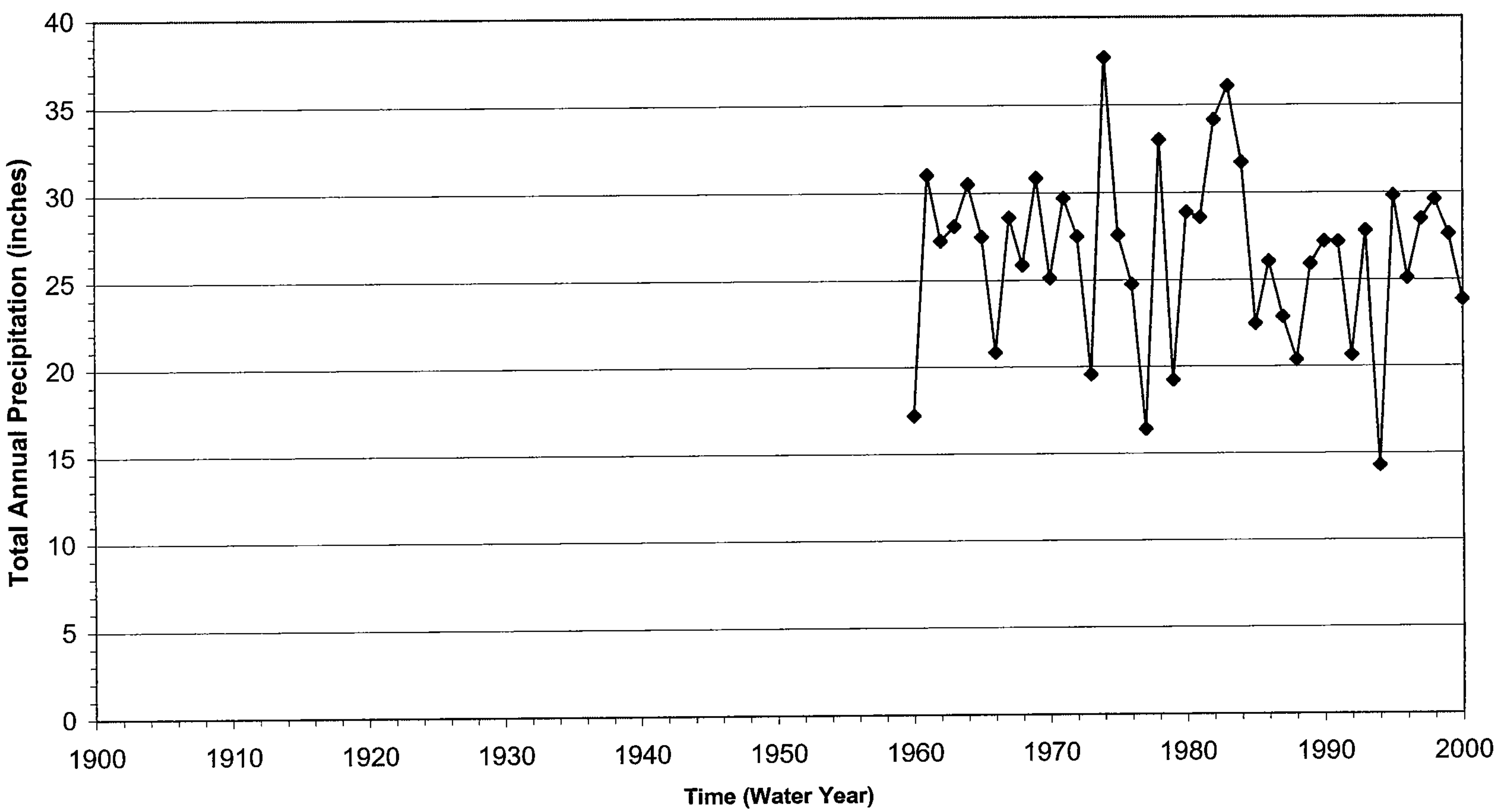
—◆— Total Annual Precipitation

FIGURE B-1a:
Coeur D'Alene 1 E (stn 101956)

Spokane County
Watershed Inventory Assesment

013-1372, 07/23/01, id101956graphs.xls

Golder Associates



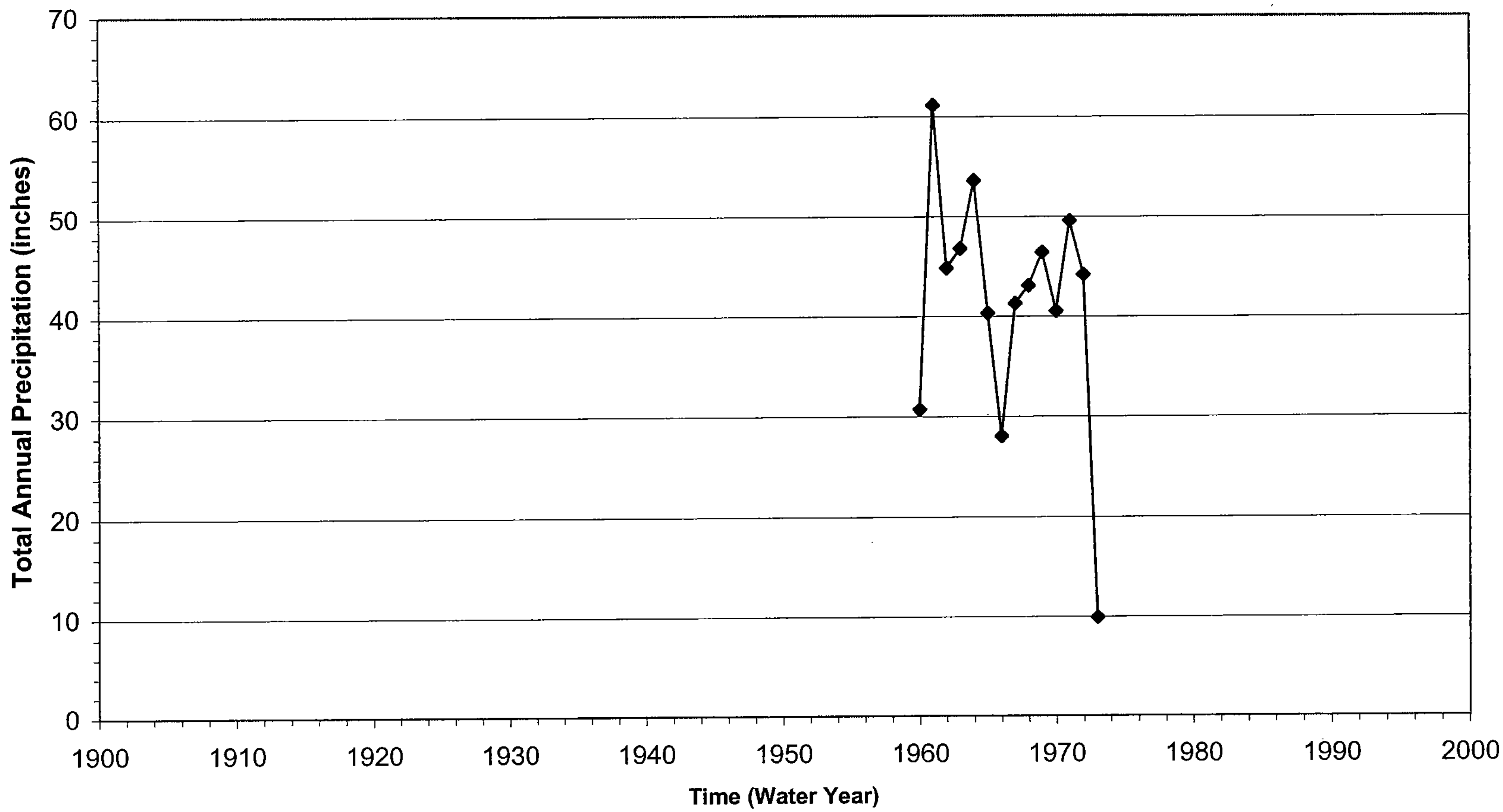
Legend

Total Annual Precipitation

FIGURE B-1b:
Newport (stn 455844)
Spokane County
Watershed Inventory Assesment

013-1372, 07/23/01, id101956graphs.xls

Golder Associates



Legend

—◆— Total Annual Precipitation

FIGURE B-1.c:
Mt. Spokane Summit, WA (stn 455674)
Spokane County
Watershed Inventory Assesment

013-1372, 07/23/01, id101956graphs.xls

Golder Associates

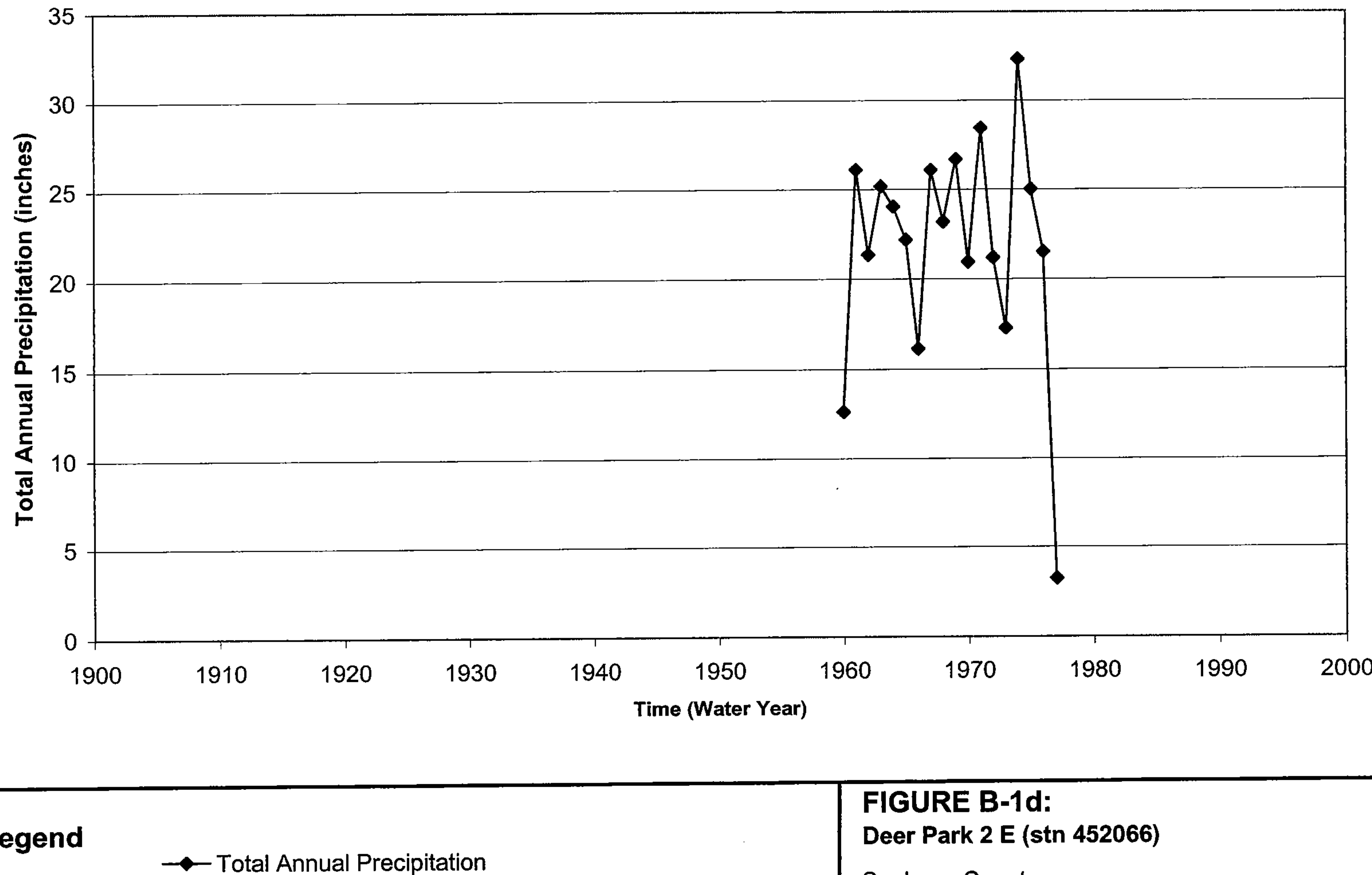
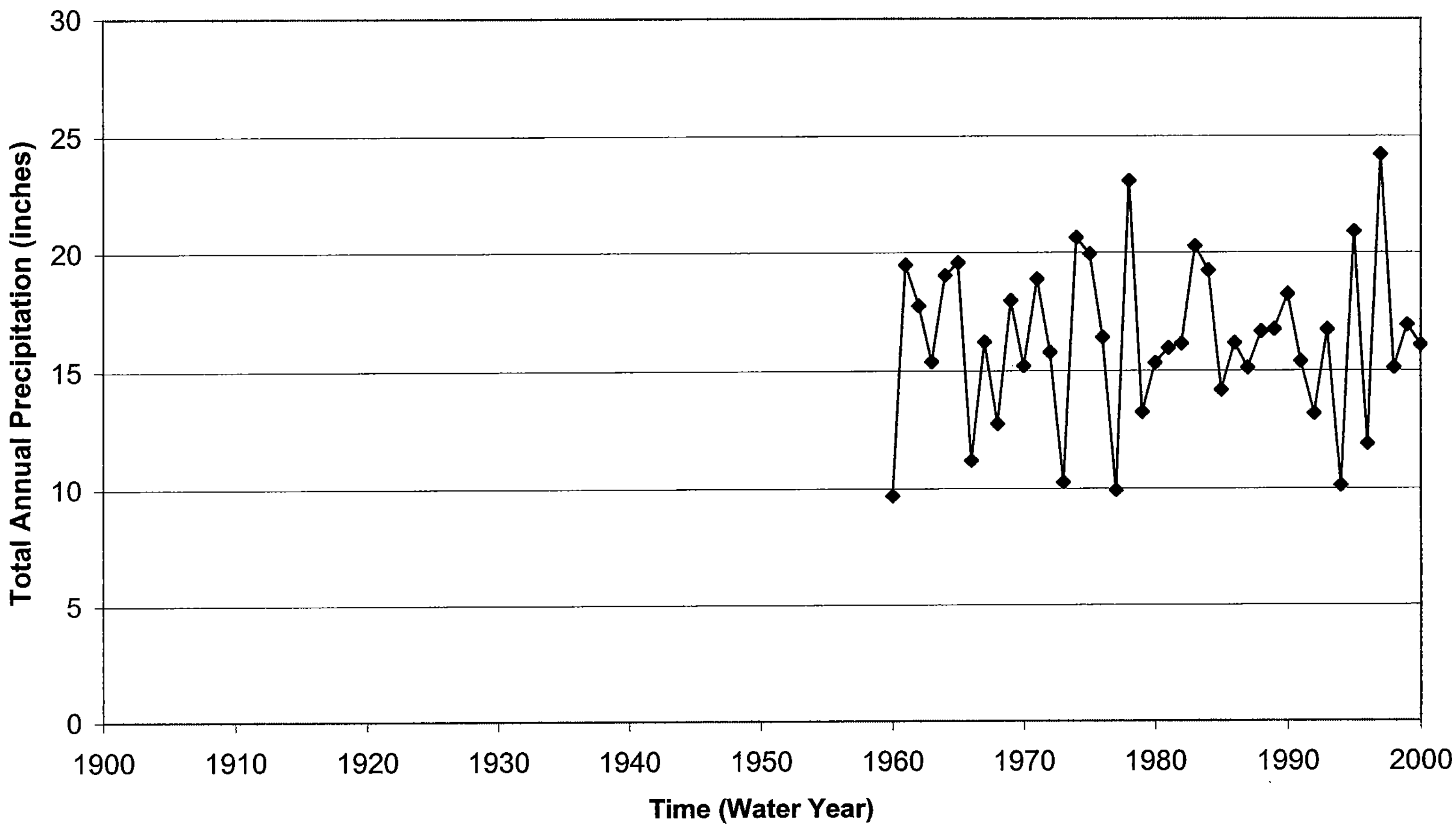


FIGURE B-1d:
Deer Park 2 E (stn 452066)

Spokane County
Watershed Inventory Assesmen
013-1372, 07/23/01, id457938.xls

Golder Associates



Legend

Total Annual Precipitation

FIGURE B-1e:
Spokane International AP (stn 457938)

Spokane County
Watershed Inventory Assesment

013-1372, 07/23/01, id457938.xls

Golder Associates

APPENDIX C

SURFACE WATER INFORMATION

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APPENDIX C-1

STREAM GAGING STATIONS

Table C-1 - List of Stream Gaging Stations

Station Name	Source	Drainage Area (mi^2)	Elevation abv MSL (ft)	Period of Record	Record Length (Years)	County	State	TimeStep	Discharge	Stage	Quality	Peak Flow	USGS ID	WQMP ID	SC-POCD ID	DOE ID
Beaver Ck @ Antler Rd	WQMP			02/28/1992	0	Spokane	WA	single	X		X			8204Q	DRT4A	
Beaver Ck @ Herman Rd	WQMP			06/27/1994-06/12/1995	1	Spokane	WA	monthly	X		X			8204E	DRT4	
Beaver Creek at road, Trib of West Brank LSR	DOE/Dames & Moore			07/09/1986-10/20/1990	4	Spokane	WA	monthly	X		X			0318Q		2
Bigelow Gulch Near Spokane, Wash.	USGS	2. 7		11/06/1950-07/14/1975	15	Spokane	WA	random				X	12430370			
Buck Creek near bridge, Trib of Horseshoe Lk	SCCD			07/09/1986-10/20/1990	4	Pend Orielle	WA	bimonthly	X		X			0306Q		0
Deadman Creek at road (east side)	DOE			06/14/1989-10/19/1991	3	Spokane	WA	monthly	X					7423B		291
Deadman Creek at road (north side)	DOE/Dames & Moore			06/14/1989-10/19/1991	3	Spokane	WA	monthly	X		X			7433Q		293
Deer Creek Near Chattaroy, Wash.	USGS	31.9		00/00/1962-03/02/1975	13	Spokane	WA	random				X	12429600			
Dragoon Ck @ Crawford Rd	POCD- SCCD DOE- 2000			03/18/1992-06/12/1996	4	Spokane	WA	monthly	X		X				DR2	
Dragoon Ck @ Crescent Br	WQMP			06/27/1994-06/12/1995	1	Spokane	WA	monthly	X		X			8333R	DR5	
Dragoon Ck @ Dahl culver	WQMP			03/18/1992	0	Spokane	WA	single	X		X			9234P	DR4A	
Dragoon Ck @ Montgomery	WQMP			02/28/1992-03/18/1992	0	Spokane	WA	random	X		X			9222P	DR1A	
Dragoon Ck @ Old Hwy Br	WQMP			2/28/1992, 3/18/1992	0	Spokane	WA	random	X		X			8331C	DR3	
Dragoon Cr @ Oregon culv	WQMP			02/28/1992-06/12/1995	3	Spokane	WA	monthly	X		X			9205P	DR1	
Fan Lake Outlet	Juul- 1991/ SCCD- 1992			12/15/1988-11/12/1991	3	Pend Orielle	WA	monthly			X			0332G		
Greene St River Sample S	WQMP			02/14/1994-06/15/1999	5	Spokane	WA				X			5310M		
Hangman Creek @ mouth	WQMP			07/17/1984-9/24/1984	0	Spokane	WA	weekly			X			5224E		
Hangman Creek At Spokane, Wash.	USGS	689	1717.42	04/01/1948-09/30/1999	51	Spokane	WA	daily	X		X	X	12424000	5224E01		
Hangman Creek River Sample	WQMP			07/17/1984-09/24/1984	0	Spokane	WA	monthly			X			5224E01		
Harder Pond Outlet	Juul- 1991/ SCCD- 1992			11/22/1988-12/07/1989	1	Pend Orielle	WA	monthly	X		X			0405K		
Heel Creek	Juul- 1991/ SCCD- 1992			11/05/1990-11/12/1991	1	Pend Orielle	WA	monthly	X		X			0304C		
Highway 211	Juul- 1991/ SCCD- 1992			12/15/1988-12/07/1989	1	Pend Orielle	WA	monthly	X		X			0417F		
Huston Ck @ Wildrose cul	POCD- SCCD DOE- 2000			06/27/1994-06/12/1995	1	Spokane	WA	monthly	X		X					
Little Creek At Dartford, Wash.	USGS	11.9		02/03/1963-02/11/1977	14	Spokane	WA	random				X	12431100		DRT8	
Little Deep Creek	Dames & Moore- 1995			06/14/1989-09/11/1990	2	Spokane	WA	monthly	X					7323E		288
Little Deep Creek at access Rd (Splitz)	DOE			06/14/1989-10/19/1991	2	Spokane	WA	monthly	X							289
Little Deep Creek at road (west side)	Dames & Moore- 1995			06/04/1989-09/11/1990	1	Spokane	WA							7407G		287
Little Spokane	POCD- SCCD DOE- 2000			07/29/1996-09/13/1999	3	Spokane	WA	monthly	X		X			7310E	LS5	
Little Spokane @ Milan	POCD- SCCD DOE- 2000			07/29/1996-09/13/1999	3	Spokane	WA	monthly	X		X			9335G	LS4	
Little Spokane @ Scotia	POCD- SCCD DOE- 2000	74.2	2 6	07/29/1996-09/13/1999	3	Pend Orielle	WA	monthly	X		X		12426500	0508N	LS-1	
Little Spokane blw Deadman	POCD- SCCD DOE- 2000	659		07/29/1996-09/13/1999	3	Spokane	WA	monthly	X		X		12430600	7333F	LS-6	
Little Spokane nr Mouth (Hwy 291 Br.)	POCD- SCCD DOE- 2000	6 2	1299	10/05/1993-09/09/1997	4	Spokane	WA	monthly	X		X		12431900	6205E	55B070	

Table C-1 - List of Stream Gaging Stations

Station Name	Source	Drainage Area (mi^2)	Elevation abv MSL (ft)	Period of Record	Record Length (Years)	County	State	TimeStep	Discharge	Stage	Quality	Peak Flow	USGS ID	WQMP ID	SC-POCD ID	DOE ID
Little Spokane R. nr Mouth nr Spokane	USGS	7		11/30/1970-6/11/1980	10	Spokane	WA	random			X		12431900	6203C	55B070	
Little Spokane River at bridge	DOE			06/22/1987-09/12/1990	3	Spokane	WA	monthly	X							
Little Spokane River At Dartford Rd Bridge	WQMP			10/05/1998-09/13/1999	1	Spokane	WA	monthly			X			6305C	55B082	
Little Spokane River At Dartford, Wash.	USGS	665	1585.62	05/01/1929-09/30/1932,01/01/1947-09/30/1999	56	Spokane	WA	daily	X		X	X	12431000	6305C	55B082	
Little Spokane River At Elk, Wash.	USGS	115	187	07/01/1948-10/22/1971	23	Spokane	WA	daily	X		X	X	12427000	9408K	LS2	7
Little Spokane River at USGS Elk Gage	DOE/Dames & Moore			07/02/1987-09/12/1990	12	Spokane	WA	monthly	X		X		12427000	9408K	LS2	7
Little Spokane River Near Dartford, Wash.	POCD- SCCD DOE- 2000			10/12/1998-09/13/1999	1	Spokane	WA	monthly			X			6203E01	55B075	
Little Spokane River Near Dartford, Wash.	USGS	698	155	04/01/1948-03/01/1952,10/01/1997-09/30/1999	51	Spokane	WA	daily	X			X	12431500		55B075	
Little Spokane River, Chattaroy Rd., Chattaroy, WA	SCC			10/01/1975-09/30/1996	21	Spokane	WA	daily	X		X			8327Q	55B200	6
Meenach River Sample Sit	WQMP			05/12/1997-06/15/1999	2	Spokane	WA				X			5212E		
Mud Ck @ Monroe Rd culve	WQMP			02/28/1992-07/10/1995	3	Spokane	WA	monthly	X		X			8222N	DRT5	
N Fork Buck Creek	Juul- 1991/ SCCD- 1992			11/05/1990-11/12/1991	1	Pend Orielle	WA	monthly	X		X			1235G		
N. Fork Little Deep Creek	Dames & Moore- 1995			06/14/1989-09/11/1990	1	Spokane	WA	monthly/seasonal	X					7404C		285
N. Fork Little Deep Creek	Dames & Moore- 1995			06/14/1989-09/11/1990	1	Spokane	WA	monthly/seasonal	X					8433B		284
North Shore Road #2	Juul- 1991/ SCCD- 1992			01/23/1989-05/26/1989	0	Pend Orielle	WA	random			X			0403M		
Otter Creek at highway nr trib of LSR	DOE/Dames & Moore			06/09/1988-10/25/1991	3	Pend Orielle	WA	bimonthly	X					0326C		8
Otter Creek at road (Grange) nr trib of LSR	DOE/Dames & Moore			06/09/1988-10/25/1991	3	Pend Orielle	WA	bimonthly	X					0326F		9
Otter Creek at road (Kopp) nr trib of LSR	DOE/Dames & Moore			06/09/1988-10/25/1991	3	Pend Orielle	WA	bimonthly	X					0335Q		10
Peone Creek at road	DOE/Dames & Moore			06/14/1989-09/11/1990	1	Spokane	WA	monthly	X					6408H		294
Post St River Sample	WQMP			09/15/1998-06/15/1999	1	Spokane	WA	random		X	X			5318L		
S. Fork Little Deep Creek	Dames & Moore- 1995			06/14/1989-09/11/1990	1	Spokane	WA	monthly/seasonal	X					7403D		286
Spokane R Ab Liberty Br Nr Otis Orchard, Wash	USGS/SCC	388	2	01/01/1929-10/01/1983, 01/01/1993-09/30/2000	61	Spokane	WA	daily	X		X	X	12419500			
Spokane R at 7 Mile Bridge Nr Spokane Wash.	USGS	5 2		11/01/1948-09/30/1952	4	Spokane	WA	daily	X		X		12424500			
Spokane R at Sullivan Rd Br NR Trentwood, Wash	USGS			05/11/1978-09/09/1999	21	Spokane	WA	random			X		12420800			
Spokane River - Barker Road Bridge	WQMP			07/17/1984-06/01/1999	15	Spokane	WA	random		X	X			5508M		
Spokane River - Below Nine Mile Falls	WQMP			06/16/1966-09/24/1984	18	Spokane	WA	random			X			6206Q		
Spokane River - Harvard Bridge #2	WQMP			04/02/1999-07/02/1999	0	Spokane	WA	weekly		X				5509A		
Spokane River - Harvard Road Bridge	WQMP			10/10/1971-09/01/1994	23	Spokane	WA	random		X	X			5509A		
Spokane River - Mission Ave Bridge	WQMP			03/12/1972-06/01/1999	27	Spokane	WA	random		X	X			5309N		

Table C-1 - List of Stream Gaging Stations

Station Name	Source	Drainage Area (mi²)	Elevation abv MSL (ft)	Period of Record	Record Length (Years)	County	State	TimeStep	Discharge	Stage	Quality	Peak Flow	USGS ID	WQMP ID	SC-POCD ID	DOE ID
Spokane River - Plantes Ferry	WQMP			01/23/1974-09/19/1997,12/10/1998-07/02/1999	23	Spokane	WA	random		X	X			5404K		
Spokane River - Stateline Bridge	WQMP			09/01/1966-09/01/1999	33	Spokane	WA	random	X	X	X			5606D		
Spokane River - Sullivan Rd	WQMP			07/17/1984-06/01/1999	15	Spokane	WA	random	X	X	X			5412N		
Spokane River - Trent Bridge	WQMP			09/01/1966-09/01/1994	28	Spokane	WA	random	X	X	X			5403M		
Spokane River At Greenacres, Wash	USGS	415		03/01/1948-10/01/1952, 08/11/1999-09/30/1999	3	Spokane	WA	daily	X		X	X	12420500			
Spokane River at Long Lake, Wash	USGS			04/01/1939-09/30/1999	60	Stevens	WA	daily	X		X	X	12433000			
Spokane River At Spokane Wa	USGS	429	1696.6	04/01/1891-09/30/1999	108	Thurston	WA	daily	X		X	X	12422500			
Spokane River Blw Green St at Spokane Wash	USGS/SCC			12/01/1948-09/30/1952, 01/01/1993-12/31/1998	10	Spokane	WA	daily	X		X		12422000			
Spokane River Blw Trent Brg Nr Spokane, Wash.	USGS	42	197.49	01/01/1948-09/30/1954	6	Spokane	WA	daily	X				12421500			
Spokane River near Post Falls, ID	USGS	384	2 3	01/01/1913-09/30/2000	86	Kootenai	ID	daily	X		X	X	12419000			
Spring Ck @ Earl Mix Pk	WQMP			02/28/1992-06/12/1995	3	Spokane	WA	monthly						8303B	DRT3	
Unnamed Creek at road-Deadman Creek Trib.	Dames & Moore- 1995			06/14/1989-05/06/1992	3	Spokane	WA	monthly	X					7430R		290
Unnamed Crk at highway (North side)	DOE/Dames & Moore			02/13/1991-05/06/1992	1	Spokane	WA	bimonthly	X					7420L		290A
Unnamed Crk at road (east side)	DOE/Dames & Moore			06/14/1989-10/19/1991	1	Spokane	WA	monthly	X					7426P		292
Unnamed trib to Peone Crk at Rd (South Side)	DOE/Dames & Moore			06/14/1989-09/11/1990	1	Spokane	WA	monthly	X					6416K		295
Upper Beaver Creek	Juul- 1991/ SCCD- 1992			11/05/1990-11/12/1991	1	Stevens	WA	monthly	X		X			0211Q		
W Br Dragoon Ck @ Monroe	WQMP			02/28/1992-06/12/1995	3	Spokane	WA	monthly	X		X			8222D		
W Br Dragoon Ck @ Wallbr	WQMP			02/28/1992	0	Spokane	WA	single	X		X			8208N		
W Branch LSR @ Circle Moon	Juul- 1991/ SCCD- 1992			11/22/1989-12/07/1999	10	Pend Orielle	WA	monthly			X			1431L		
W Branch LSR @ Diamond Lk Outlet	Juul- 1991/ SCCD- 1992			11/22/1988-12/07/1989	1	Pend Orielle	WA				X			0409Q		
W Branch LSR @ Eloika Outlet	Juul- 1991/ SCCD- 1992			01/19/1987-02/19/1989	2	Spokane	WA	monthly			X			9315L		
W Branch LSR @ Harworth Road	Juul- 1991/ SCCD- 1992			11/22/1988-11/12/1991	4	Pend Orielle	WA	monthly	X		X			1334R		
W Branch LSR @ Horseshoe Lk Inlet	Juul- 1991/ SCCD- 1992			11/12/1988-12/07/1989	1	Pend Orielle	WA	monthly	X		X			0308E		
W Branch of the LSR at Access Rd	Dames & Moore- 1995			09/11/1986-10/20/1990	4	Pend Orielle	WA							0317E		3
W Branch of the LSR at Bridge (Toner's)	DOE			09/11/1986-09/12/1990	4	Pend Orielle	WA	monthly	X							
W Branch of the LSR at Rd (2 culverts)	Dames & Moore- 1995			09/11/1986-10/20/1990	4	Pend Orielle	WA	monthly	X		X			0332B	LS3	4
W Fork Buck Creek	Juul- 1991/ SCCD- 1992			04/15/1991-11/12/1991	0	Pend Orielle	WA	monthly	X		X			1227N		
Wethey Ck @ Crosscut cul	WQMP			02/18/1992-06/12/1995	3	Spokane	WA	monthly	X		X			8235E	DRT8	

APPENDIX C-2

DAM INFORMATION

Table C-2 Dam Summary

Dam Name	WRIA	Federal NID ID	County	Stream	Owner Name	Owner Type	Type of Dam	Dam Purpose	Date Built	Crest Length (ft)	Height (ft)	Max Storage (acre-ft)	Normal Storage (acre-ft)	Surface Area (acres)	Drainage Area (mi^2)	Downstream Hazard	Regulating Authority
Beryl Baker Dam	55	WA01324	Stevens	Tr-Dragoon Creek		Private	Earth	Recreation	1977	390	25	48	22	22	3	Significant	WaDOE
Decie Lake Dam	55	WA01029	Pend Oreille	Tr-Little Spokane River		Private	Earth	Irrigation	1960	190	22	33	25	4	0	Significant	WaDOE
Deer Park Sewage Treatment Lagoon	55	WA01467	Spokane	Tr-Dragoon Creek-Offstream	City of Deer Park	Local Government	Earth	Water Quality	1984	1340	12	25	21	21	0	Significant	WaDOE
Deer Park Waste Water Storage Lagoon	55	WA01468	Spokane	Tr-Dragoon Creek-Offstream	City of Deer Park	Local Government	Earth	Water Quality	1984	3300	12	205	176	176	0	High	WaDOE
Diamond Lake Aeration Lagoon No. 2	55	WA00568	Pend Oreille	Tr-Little Spokane River-Offstream	Diamond Lake Sewer District	Private	Earth	Water Quality	1987	800	16	61	51	51	0	Significant	WaDOE
Diamond Lake Sewage Lagoon No. 1	55	WA01632	Pend Oreille	Tr-Little Spokane River-Offstream	Diamond Lake Sewer District	Private	Earth	Water Quality	1988	500	12	12	10	1	0	Significant	WaDOE
Dragoon Lake Dam	55	WA00342	Spokane	Dragoon Creek	North Park Development Company	Private	Concrete Gravity	Recreation	1913	200	18	157	157	22	17	Low	WaDOE
Gatlin Dam No. 1	55	WA01657	Spokane	Dartford Creek-Offstream		Private	Earth	Irrigation	1988	110	8	50	25	9	0	Significant	WaDOE
Gatlin Dam No. 2	55	WA01658	Spokane	Dartford Creek-Offstream		Private	Earth	Irrigation	1988	100	6	50	25	9	0	Low	WaDOE
Gatlin Dam No. 3	55	WA01659	Spokane	Dartford Creek-Offstream		Private	Earth	Irrigation	1988	100	6	50	25	9	0	Low	WaDOE
Homestead Lake Dam	55	WA00035	Pend Oreille	Tr-Moon Creek		Private	Earth	Recreation	1971	420	18	52	30	7	0	Low	WaDOE
Isabelle Lake Dam	55	WA01028	Pend Oreille	Tr-Little Spokane River		Private	Earth	Irrigation	1960	180	22	16	10	2	0	Significant	WaDOE
Keltwig Wildlife Dam	55	WA00385	Pend Oreille	Spring Heel Creek		Private	Earth	Recreation	1979	550	13	180	100	100	2	Low	WaDOE
Koenig Dam	55	WA01014	Pend Oreille	Tr-Otter Creek		Private	Earth	Recreation	1968	80	12	35	15	15	0	Low	WaDOE
Little Spokane River Dam	55	WA01293	Pend Oreille	West Branch Little Spokane River	Washington Dept. of Wildlife	State	Earth	Recreation	1960	290	8	35	20	20	0	Low	WaDOE
Loon Lake Aeration Lagoon	55	WA01495	Stevens	Tr-Loon Lake-Offstream	Loon Lake Sewer District No. 4	Private	Earth	Water Quality	1986	840	12	18	15	1	0	Significant	WaDOE
Lynda Lake Dam	55	WA01027	Pend Oreille	Tr-Little Spokane River		Private	Earth	Irrigation	1960	170	22	17	9	2	0	Significant	WaDOE
Ponderay Newsprint Mill Settling Lagoon	55	WA00598	Pend Oreille	Pend Oreille River-Offstream	Ponderay Newsprint	Private	Earth	Water Quality	1989	2250	24	105	82	8	0	Low	WaDOE
Ponderosa Lake Dam	55	WA00041	Stevens	Beaver Creek		Private	Earth	Recreation	1969	412	55	710	357	75	8	Significant	WaDOE
Reflection Lake North Dam	55	WA00362	Spokane	Sheets Creek	Reflection Lake Homeowners Assoc.	Private	Earth	Recreation	1955	200	8	440	370	58	1	Significant	WaDOE
Reflection Lake South Dam	55	WA00050	Spokane	Sheets Creek	Reflection Lake Homeowners Assoc.	Private	Earth	Recreation	1955	710	23	570	490	58	1	High	WaDOE
Wandermere Lake Dam	55	WA00304	Spokane	Tr-Little Spokane River		Private	Earth	Recreation	1930	1500	4	70	45	11	0	Low	WaDOE
Nine Mile Dam		WA00068	Spokane	Spokane River	Washington Water Power Company	Public Utility	Concrete Gravity	Recreation	1908	464	68	5275	5210	440	5110	High	FERC
Deruwe Dam	57	WA01023	Spokane	Saltese Creek		Private	Earth	Irrigation	1966	1200	12	39	24	24	0	Low	WaDOE
Dosser Reservoir Dam	57	WA00049	Spokane	Quinnamose Creek		Private	Earth	Irrigation	1959	950	10	55	42	10	6	Low	WaDOE
Martin Dam	57	WA00531	Spokane	Tr-Deadman Creek		Private	Earth	Irrigation	1972	500	15	55	30	10	1	Significant	WaDOE
Monroe Street Dam	57	WA00039	Spokane	Spokane River	Washington Water Power Company	Public Utility	Concrete Gravity	Hydroelectric	1973	217	26	68	30	30	4290	Significant	FERC
Morisson Dam	57	WA01605	Spokane	Saltese Creek	Morrison Cattle Company	Private	Earth	Irrigation	1945	1000	5	50	5	5	0	Low	WaDOE
Newman Lake Flood Control Dam	57	WA00396	Spokane	Thompson Creek	Newnam Lake Flood Control Zone Dist	Private	Earth	Recreation	1976	8400	10	11300	8700	1200	29	Low	WaDOE
Upper Falls Dam	57	WA00038	Spokane	Spokane River	Washington Water Power Company	Public Utility	Concrete Gravity	Hydroelectric	1922	366	25	800	800	135	4290	Significant	FERC
Upriver Station Control Works	57	WA00074	Spokane	Spokane River	City of Spokane	Local Government	Earth	Hydroelectric	1935	725	38	3000	200	160	4215	Significant	FERC
Warner Dam	57	WA01325	Spokane	Thompson Creek-Offstream		Private	Earth	Recreation	1975	240	15	25	20	20	0	Low	WaDOE
Williams Dam	57	WA01520	Spokane	Saltese Creek		Private	Earth	Recreation	1982	1400	10	50	30	30	0	Low	WaDOE
Woods Lake Dam	57	WA01294	Pend Oreille	Tr-Little Spokane River		Private	Earth	Recreation	1930	225	3	35	35	29	0	Low	WaDOE
Albeni Falls		ID00319	BONNER	Pend Oreille River-Offstream	DAEN NPS	Federal	Concrete Gravity	Hydroelectric	1955		180	1155000	1153000	94600	24200	High	
Baker Lake Dam		WA01314	Pend Oreille	Tr-Deer Creek	Alice Congdon	Private	Concrete Butress	Recreation	1966	110	5	61	20	2300	0	Low	WaDOE
Beitey Lake Dam		WA00064	Stevens	Tr-Colville River		Private	Earth	Recreation	1934	40	10	124	100	24	0	Low	WaDOE
Davis Lake Dam		WA00459	Pend Oreille	Deer Creek and Davis Creek	Washington Dept. of Wildlife	State	Rockfill	Recreation	1960	210	10	12622	12000	150	18	Low	WaDOE
Diamond Lake Aeration Lagoon No. 3		WA00567	Pend Oreille	Tr-Little Spokane River-Offstream	Diamond Lake Sewer District	Private	Earth	Water Quality	1987	1570	17	61	51	51	0	Significant	WaDOE
Duncan Dam No. 1		WA00045	Pend Oreille	Tr-Pend Oreille River		Private	Earth	Recreation	1966	176	12	150	96	96	1	Low	WaDOE
Duncan Dam No. 2		WA00044	Pend Oreille	Tr-Pend Oreille River		Private	Earth	Recreation	1966	325	15	150	95	95	1	Low	WaDOE
Emtman Dam No. 2		WA01026	Spokane	Tr-Minnie Creek		Private	Earth	Irrigation	1968	192	13	24	18	18	0	Low	WaDOE

Table C-2 Dam Summary

Dam Name	WRIA	Federal NID ID	County	Stream	Owner Name	Owner Type	Type of Dam	Dam Purpose	Date Built	Crest Length (ft)	Height (ft)	Max Storage (acre-ft)	Normal Storage (acre-ft)	Surface Area (acres)	Drainage Area (mi^2)	Downstream Hazard	Regulating Authority
Jumpoff Jim Lake Dam		WA00060	Stevens	Tr-Colville River		Private	Earth	Recreation	1972	590	11	270	115	61	6	Low	WaDOE
Loon Lake Control Structure		WA01208	Stevens	Tr-Sheep Creek	Washington Dept. of Wildlife	State	Concrete	Recreation	1951	25	5	5590	5590	279	0	Low	WaDOE
Loon Lake Polishing Lagoon		WA00519	Stevens	Tr-Loon Lake-Offstream	Loon Lake Sewer District No.	Private	Earth	Water Quality	1986	1700	12	41	35	4	0	Significant	WaDOE
Loon Lake Waste Storage Lagoon		WA00518	Stevens	Tr-Loon Lake-Offstream	Loon Lake Sewer District No. 4	Private	Earth	Water Quality	1986	1700	10	76	63	7	0	Significant	WaDOE
Marney Lake Dam		WA00046	Pend Oreille	Tr-Deer Creek	Marley Orchards	Private	Earth	Irrigation	1967	280	15	50	21	5	0	Significant	WaDOE
Marshall Lake Dam		WA00353	Pend Oreille	Marshall Creek		Private	Earth	Irrigation	1912	565	10	1919	1292	219	5	High	WaDOE
Mountain Meadows Lake		WA00030	Pend Oreille	Kent Creek	Pend Oreille County	Local	Earth	Recreation	1959	120	10	1000	1000	170	1	Low	WaDOE
Post Falls Earth Dike		ID83065	KOOTENAI	Spokane River	WASHINGTON WATER	Public Utility	Concrete	Hydroelectric	1990		13	1900000	225000	48000	3784	High	
Post Falls Middle Channel		ID00220	KOOTENAI	Spokane River	WASHINGTON WATER PWR	Public Utility	Concrete	Hydroelectric	1906		64	1900000	225000	48000	3784	High	
Post Falls North Channel		ID83001	KOOTENAI	Spokane River	WASHINGTON WATER PWR	Public Utility	Concrete	Hydroelectric	1906		31	1900000	225000	48000	3784	High	
Post Falls South Channel		ID83002	KOOTENAI	Spokane River	WASHINGTON WATER PWR	Public Utility	Concrete	Hydroelectric	1906		25	1900000	225000	48000	3784	High	
Power Lake Dam		WA00010	Pend Oreille	North Fork Calispell Creek	Pend Oreille County, PUD No.	Public Utility	Concrete	Hydroelectric	1922	150	56	1450	1000	62	56	High	WaDOE
Sowers Reservoir Dam		WA00065	Stevens	Tr-Sheep Creek		Private	Earth	Recreation	1958	181	15	51	23	7	8	Low	WaDOE
Willy-O Lake Dam		WA01024	Pend Oreille	Tr-Pend Oreille River		Private	Earth	Recreation	1959	1155	16	42	28	7	0	Low	WaDOE
Yergens & Anselmo Dam No. 1		WA00076	Pend Oreille	Tr-Pend Oreille River		Private	Earth	Recreation	1970	245	15	51	45	45	0	Low	WaDOE
Yergens & Anselmo Dam No. 2		WA01025	Pend Oreille	Tr-Pend Oreille River		Private	Earth	Recreation	1970	150	15	24	16	16	0	Low	WaDOE

APPENDIX C-3

AVERAGE ANNUAL FLOW FOR CONTINUOUS GAGING STATIONS (WRIA 55/57)

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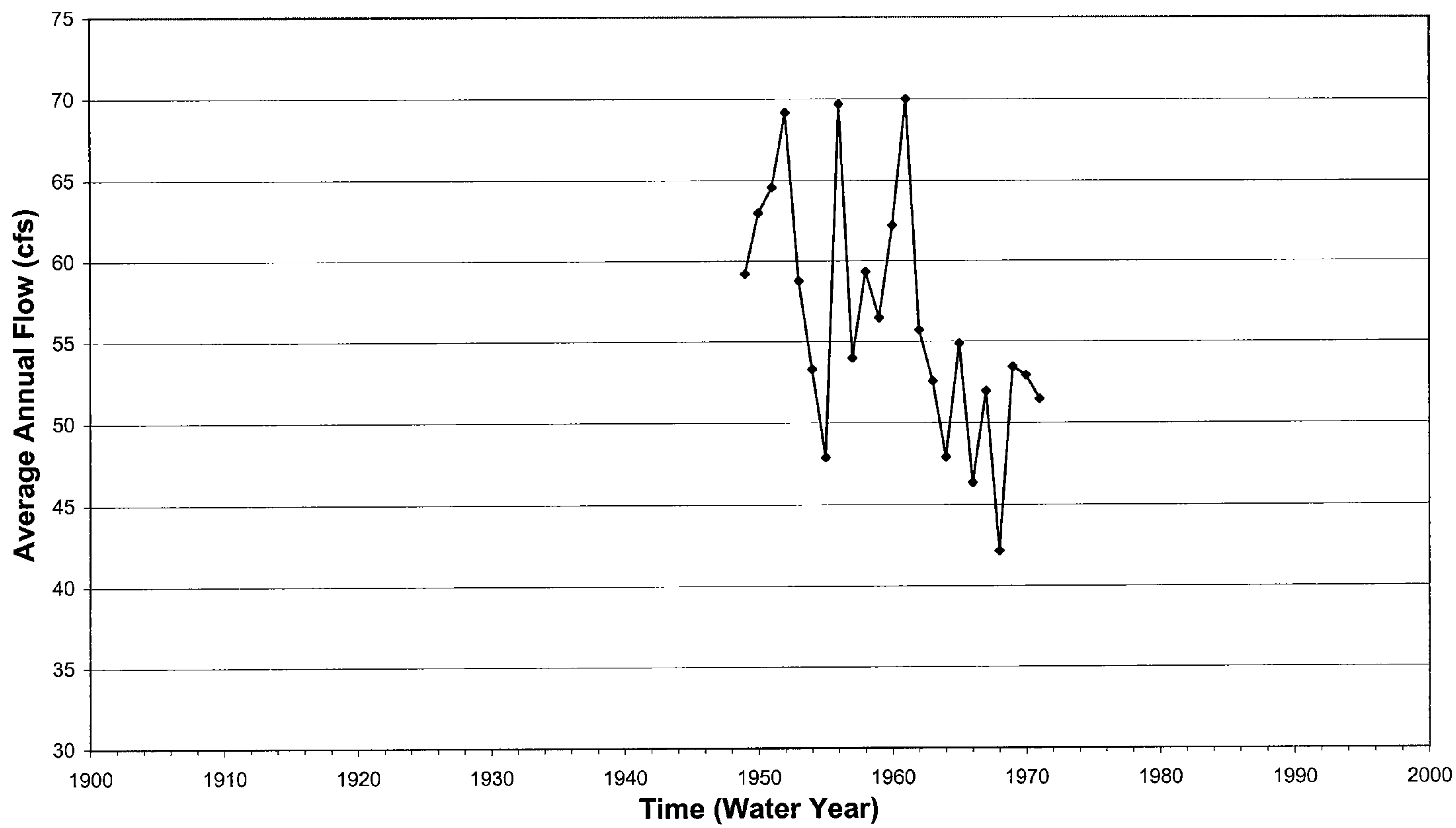

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FIGURE C-3a:
Little Spokane River At Elk, Wash. (USGS stn. 12427000)

Spokane County
Watershed Inventory Assessment
013-1392, id143.xls, 07/23/2001

Golder Associates

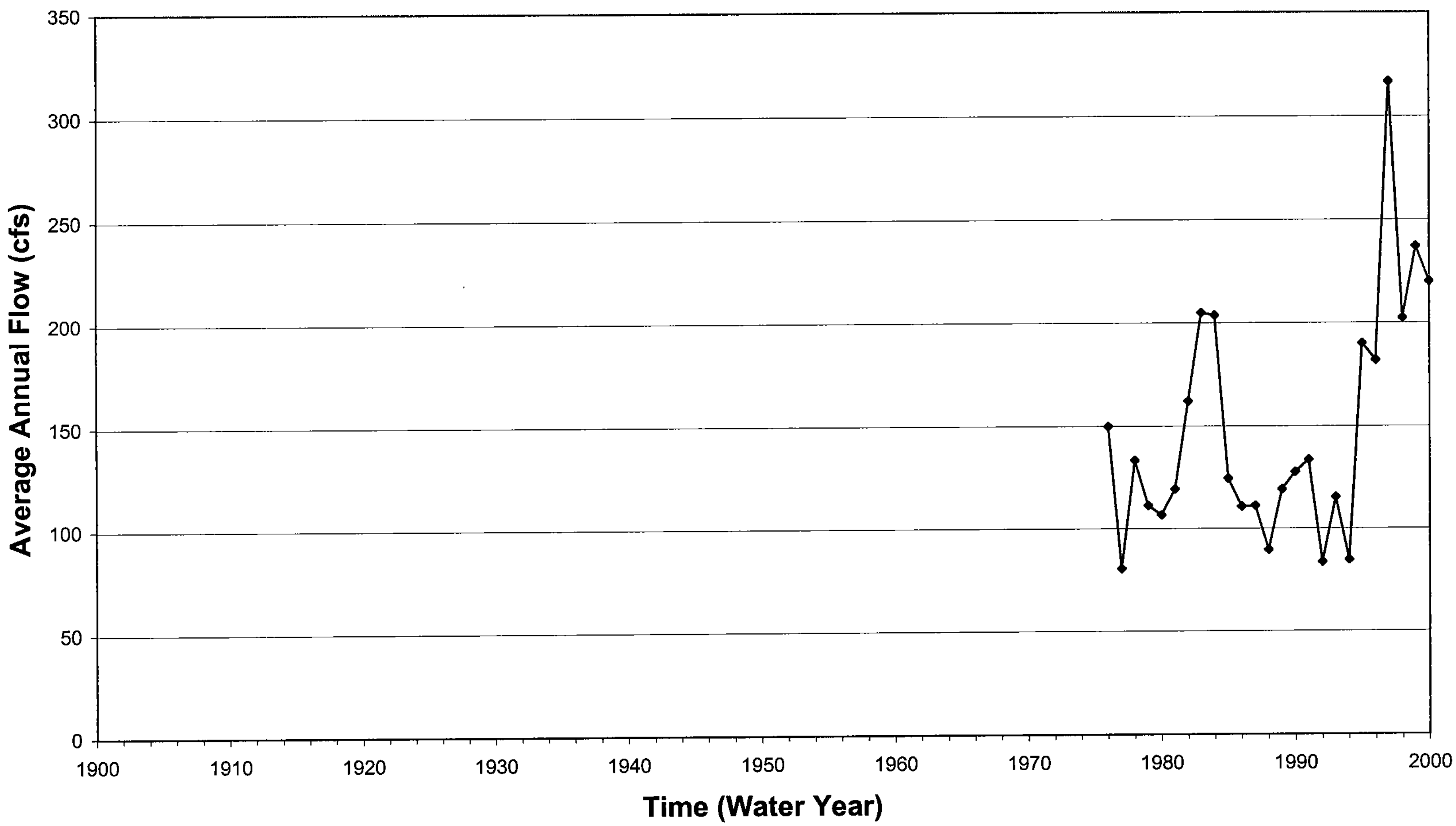

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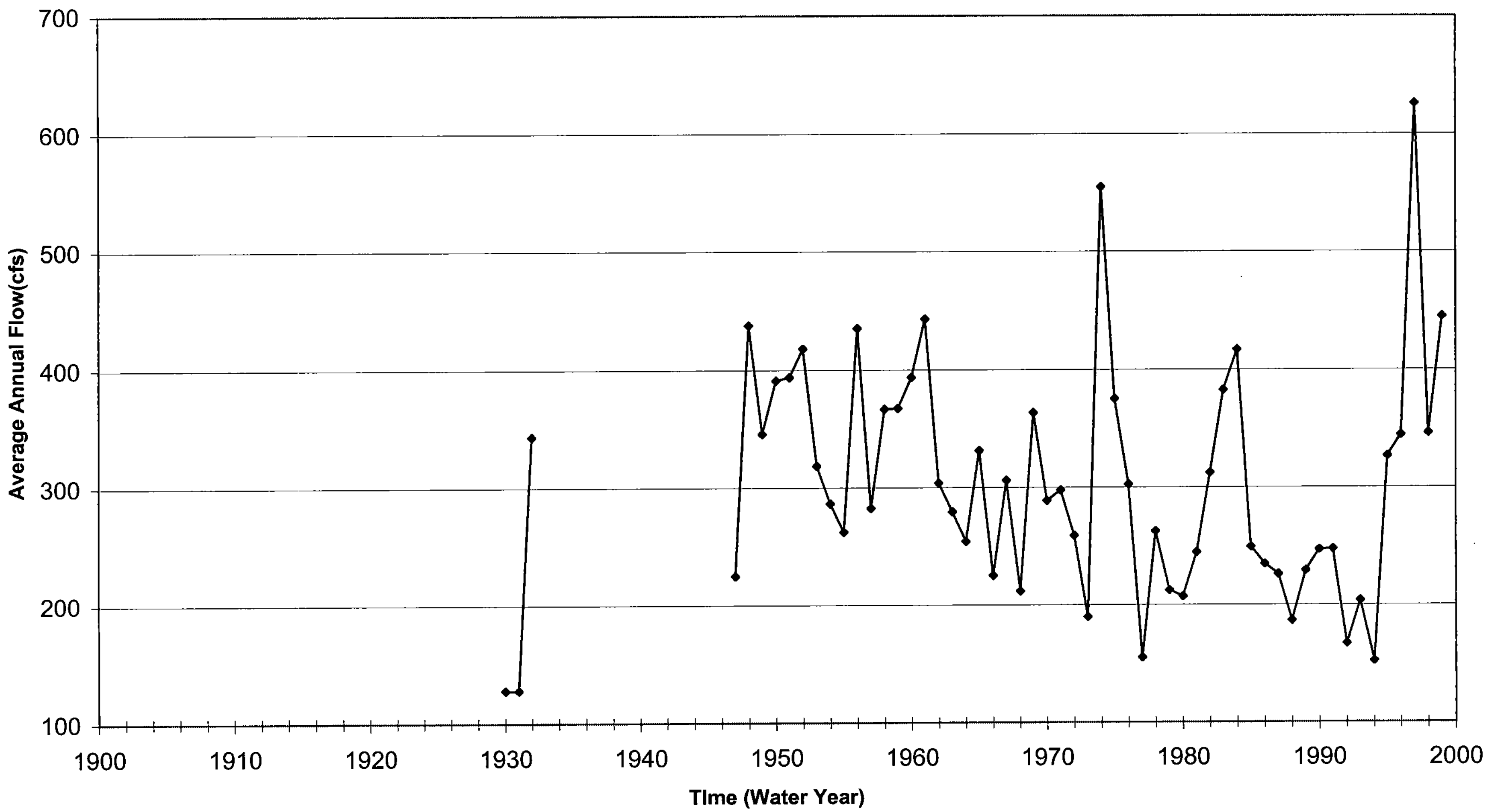
FIGURE C-3b:
Little Spokane River, Chattaroy Rd., Chattaroy, WA (SCC 8327Q)

Spokane County
Watershed Inventory Assessment

013-1392, id147.xls, 07/19/2001

Golder Associates



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Note: Data for 1933-1946 do not exist

FIGURE C-3c:
Little Spokane River at Dartford (USGS gage 12431000)

Spokane County
Watershed Inventory Assessment

013-1392, id 142.xls, 07/19/2001

Golder Associates

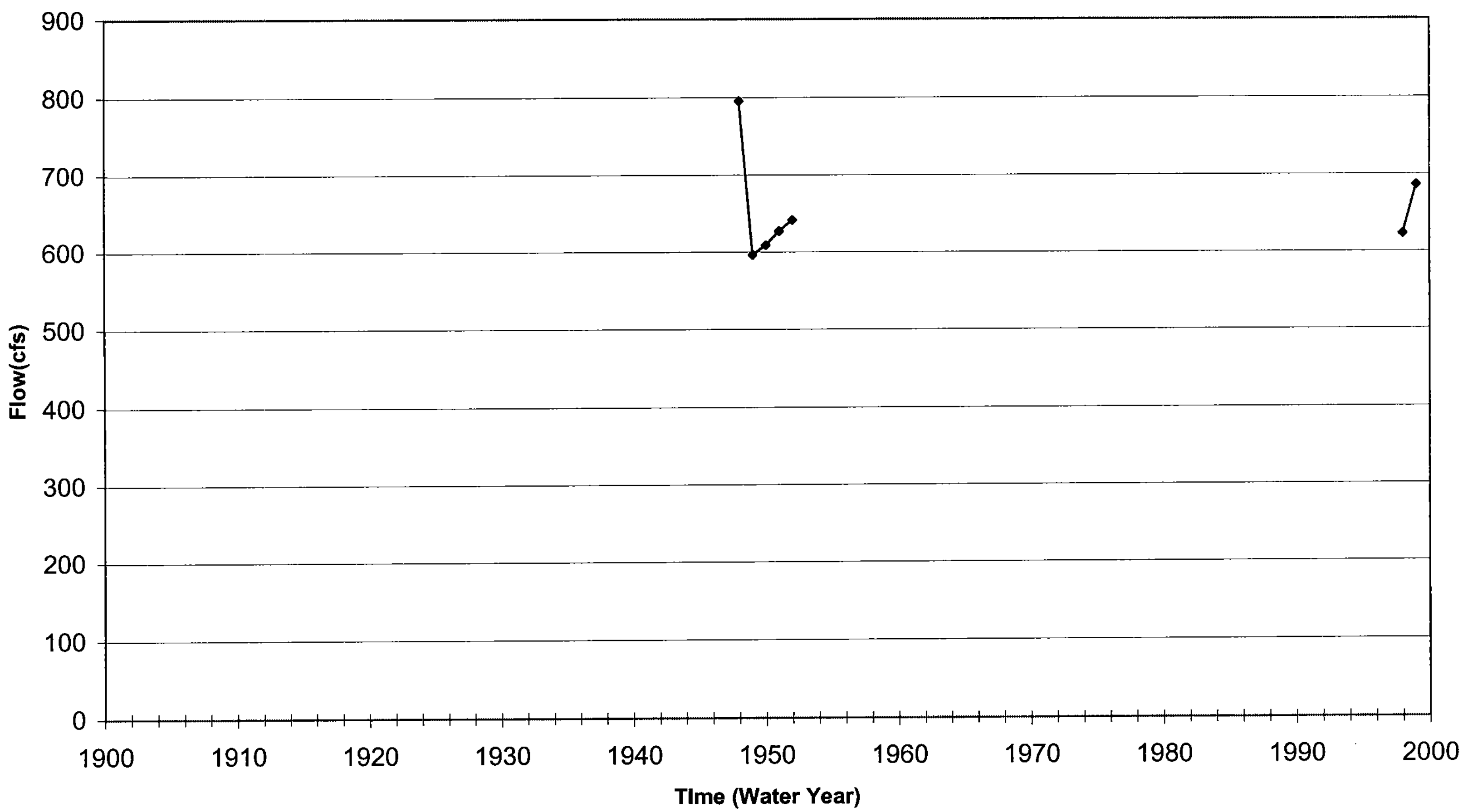

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FIGURE C-3d:
Little Spokane River Near Dartford, Wash. (USGS gage 12431500)

Spokane County
Watershed Inventory Assessment

Golder Associates

013-1392, id 146.xls, 06/19/2001

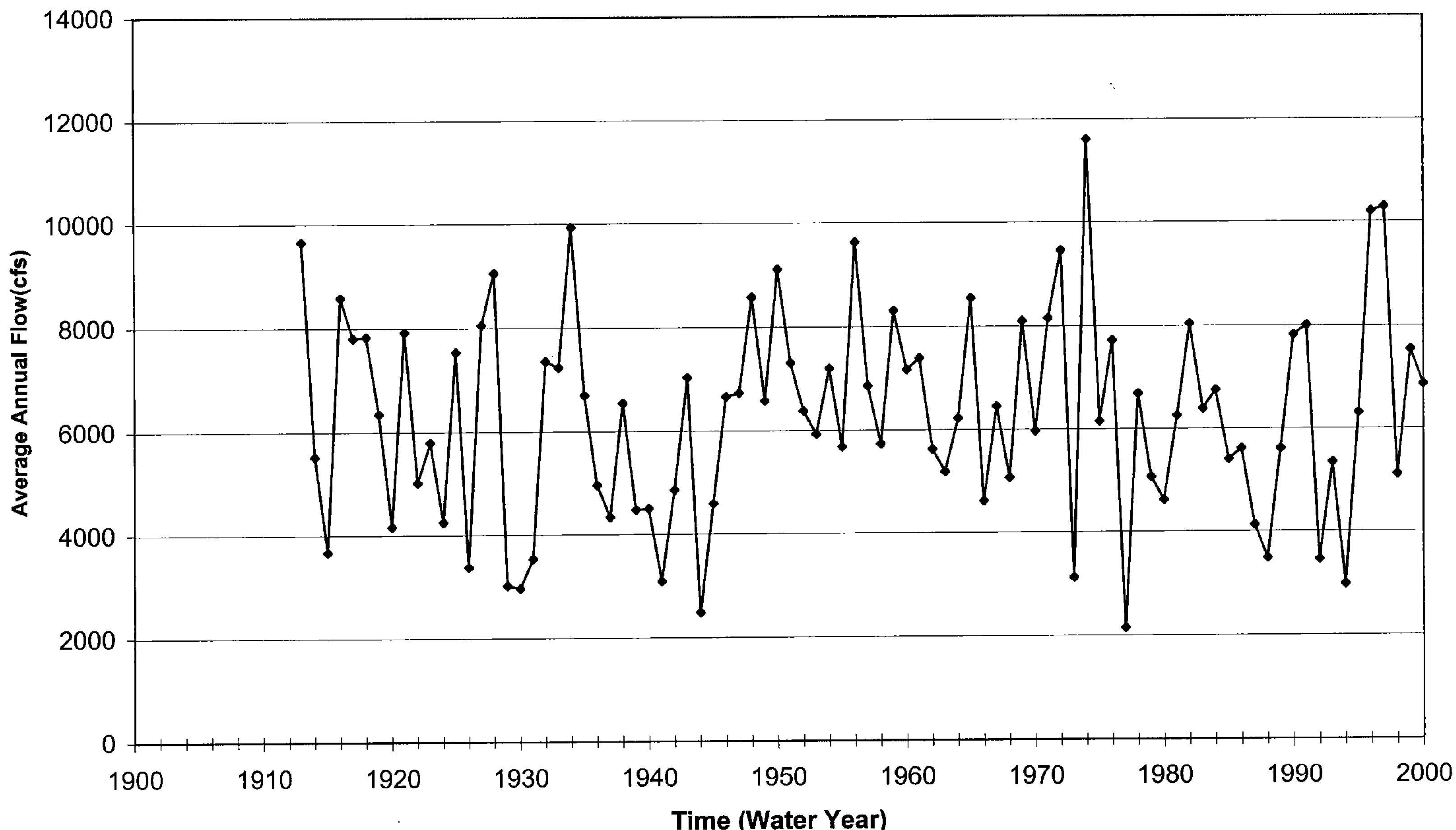

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FIGURE C-3e:
Spokane River near Post Falls, ID (USGS gage 12419000)

Spokane County Watershed Inventory Assessment

013-1392. id172 graphs.xls. 09/2001

Golder Associates

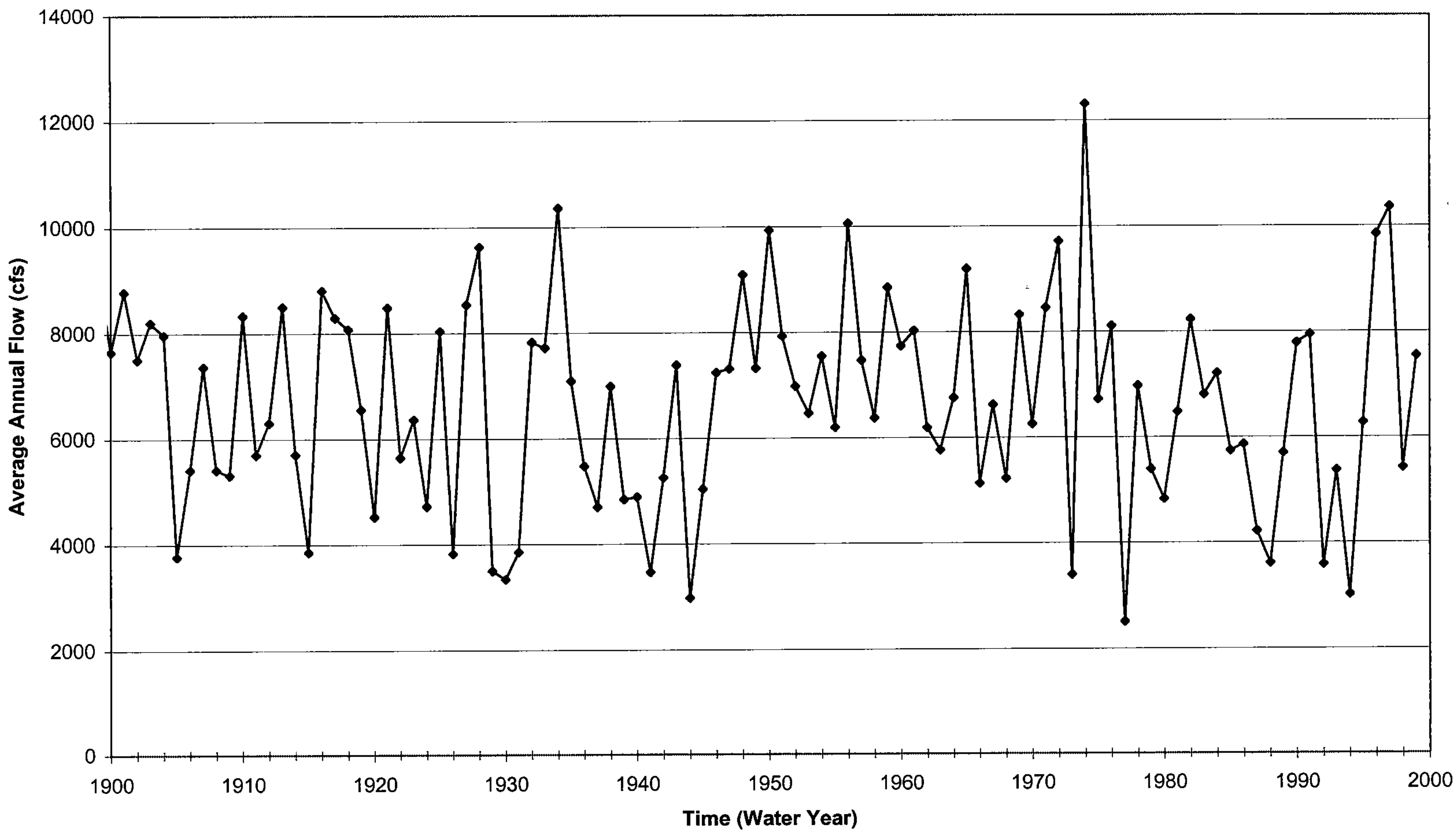

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FIGURE C-3f:
Spokane River At Spokane Wa (USGS gage 12422500)

Spokane County
Watershed Inventory Assesment

013-1372, id169.xls, 06/19/01

Golder Associates

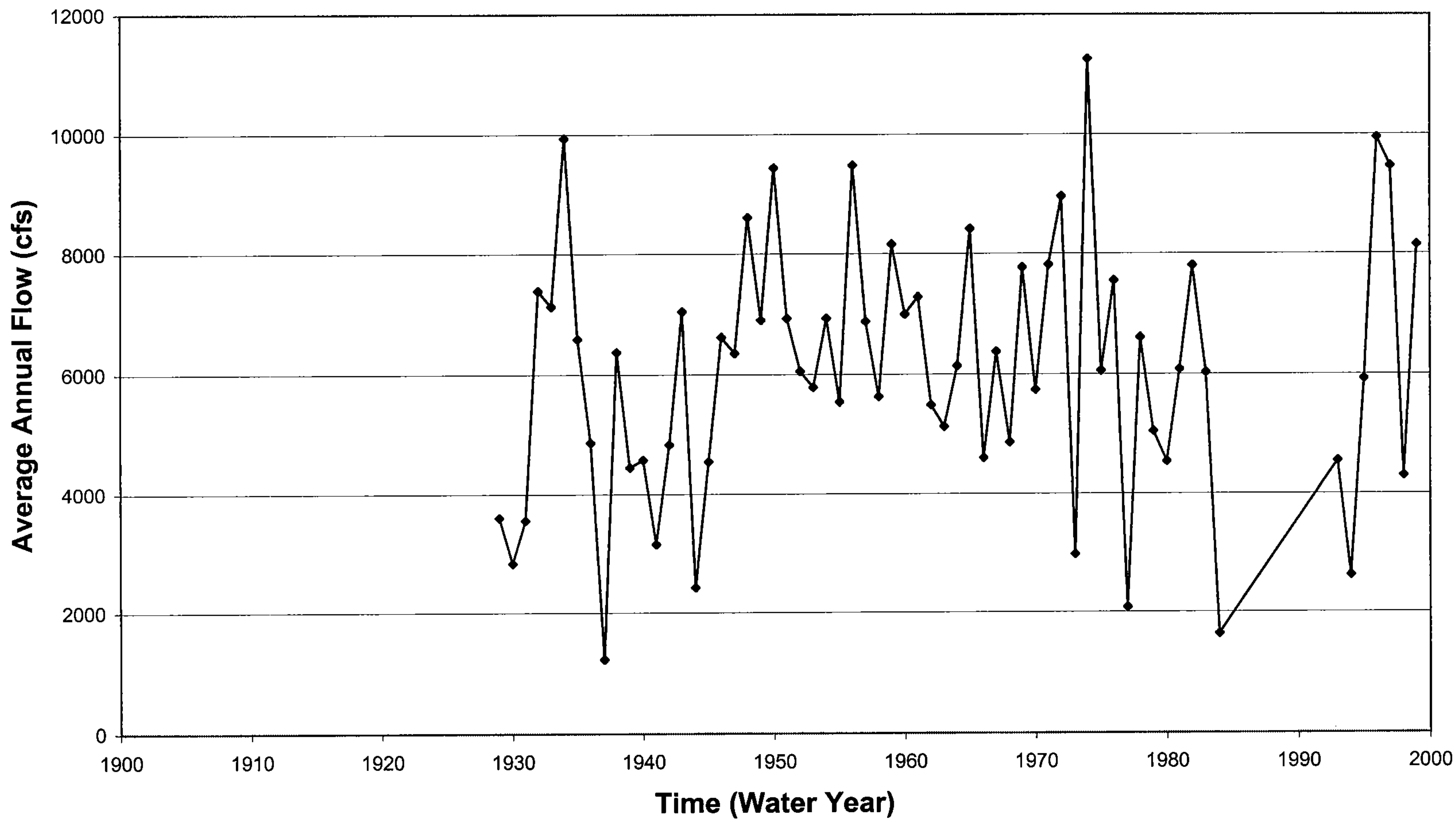

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FIGURE C-3g:
Spokane R Ab Liberty Br Nr Otis Orchard, Wash stn. 12419500

Spokane County Watershed Inventory Assessment

013-1392, id164.xls, 06/19/2001

Golder Associates

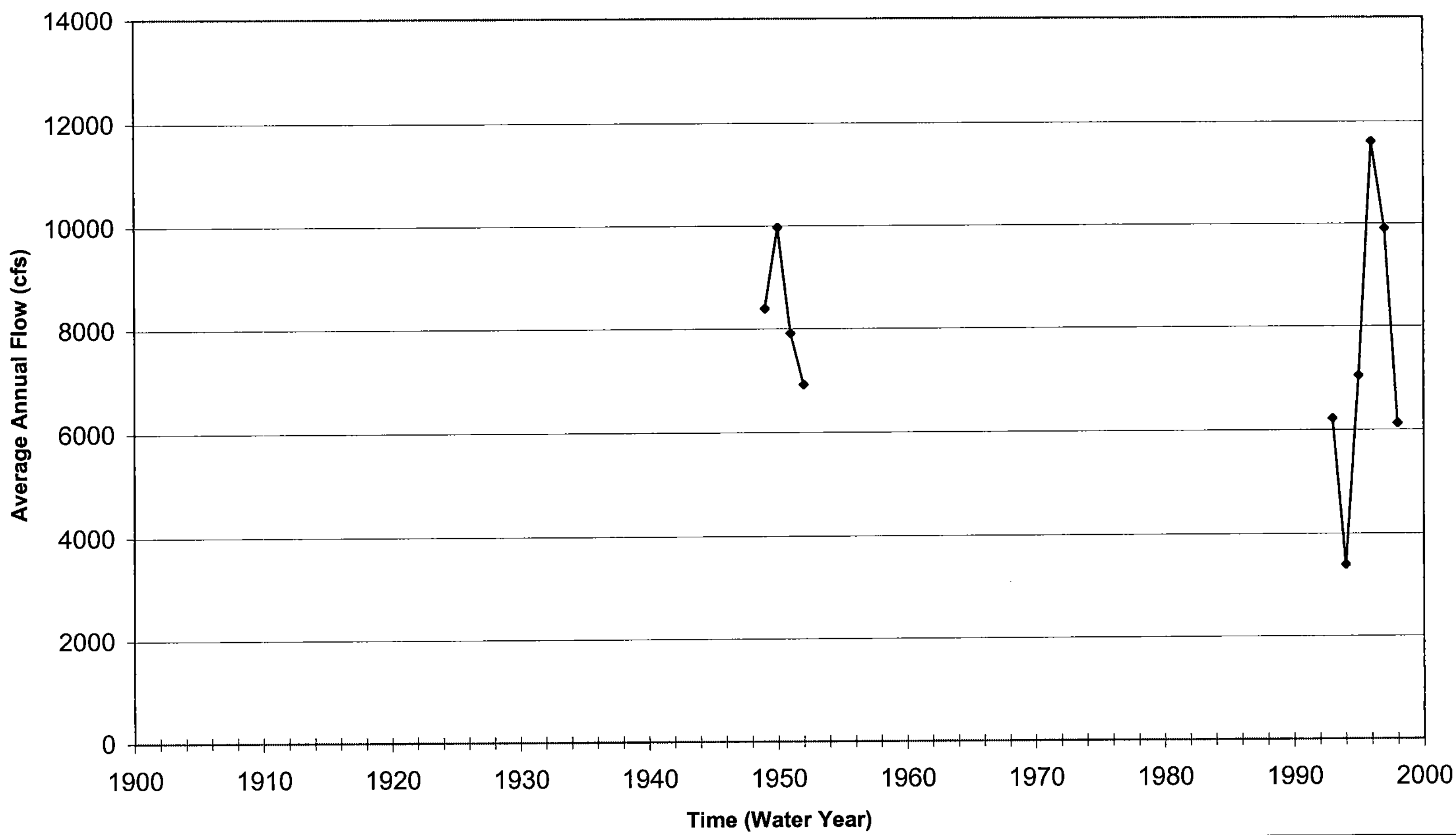

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FIGURE C-3h:
Spokane River below Greene St at Spokane WA (USGS gage 12422000)

Spokane County
Watershed Inventory Assesment

013-1372, id170.xls, 06/19/01

Golder Associates

APPENDIX C-4

CHAPTER 173-555 WAC, WATER RESOURCES PROGRAM IN THE LITTLE SPOKANE BASIN, WRIA55

CHAPTER 173–555 WAC
WATER RESOURCES PROGRAM IN THE LITTLE SPOKANE RIVER BASIN, WRIA 55

Last Update: 6/9/88

WAC 173–555–010 General provision. These rules, including any subsequent additions and amendments, apply to waters within and contributing to the Little Spokane River basin, WRIA–55 (see WAC 173–500–040). Chapter 173–500 WAC, the general rules of the department of ecology for the implementation of the comprehensive water resources program, applies to this chapter 173–555 WAC.

[Order DE 75–24, § 173–555–010, filed 1/6/76.]

WAC 173–555–020 Definition. "NONCOMMERCIAL AGRICULTURAL IRRIGATION" means beneficial use of water upon not more than three acres for the purpose of crops and livestock for domestic use.

[Order DE 75–24, § 173–555–020, filed 1/6/76.]

WAC 173–555–030 Establishment of base flows.

(1) Base flows are established for stream management units with monitoring to take place at certain control points as follows:

Stream Management Unit Information

Control Station Number, Stream Management Unit Name	Control Station Location by River Mile and Section, Township Range	Affected Stream Reach
No. 12–4270.00 Little Spokane River Elk	34.6 Sec. 8, T.29N., R.43 E.W.M.	From confluence with Dry Creek to the headwaters including tribu–taries except Dry Creek.
No. 12–4295.00 Little Spokane River Chattaroy	23.05 Sec. 34, T.28N., R.43 E.W.M.	From confluence with Deer Creek to confluence with Dry Creek including tribu–taries except Deer Creek.
No. 12–4310.00 Little Spokane River Dartford	10.8 Sec. 6, T.26N., R.43 E.W.M.	From confluence with Little Creek to confluence with Deer Creek including tribu–taries except Little Creek.
No. 12–4315.00 Little Spokane River Confluence	3.9 Sec. 3, T.26N., R.42 E.W.M.	From mouth to confluence with Little Creek including tributaries.

(2) Base flows established for the stream management units in WAC 173–555–030(1) are as follows:

Base Flows in the Little Spokane River Basin
(in Cubic Feet Per Second)

Month	Day	12–4270.00 Elk	12–4295.00 Chattaroy	12–4310.00 Dartford	12–4315.00 Confluence
Jan.	1	40	86	150	400
	15	40	86	150	400
Feb.	1	40	86	150	400
	15	43	104	170	420
Mar.	1	46	122	190	435
	15	50	143	218	460
Apr.	1	54	165	250	490
	15	52	143	218	460
May	1	49	124	192	440
	15	47	104	170	420
Jun.	1	45	83	148	395
	15	43	69	130	385
Jul.	1	41.5	57	115	375
	15	39.5	57	115	375
Aug.	1	38	57	115	375
	15	38	57	115	375
Sept.	1	38	57	115	375
	15	38	63	123	380
Oct.	1	38	70	130	385
	15	39	77	140	390
Nov.	1	40	86	150	400
	15	40	86	150	400
Dec.	1	40	86	150	400
	15	40	86	150	400

(3) Base Flow hydrographs, Figure II–1 in the document entitled "water resources management program in the Little Spokane River Basin" dated August, 1975 shall be used for definition of base flows on those days not specifically identified in WAC 173–555–030(2).

(4) All rights hereafter established shall be expressly subject to the base flows established in sections WAC 173–555–030 (1) through (3).

[Order DE 75–24, § 173–555–030, filed 1/6/76.]

WAC 173–555–040 Future allocations—Reservation of surface water for beneficial uses.

(1) The department determines that these are surface waters available for appropriation from the stream management units specified in the amount specified in cubic feet per second (cfs) during the time specified as follows:

(a) Surface water available from the east branch of the Little Spokane River, confluence with Dry Creek to headwaters, based on measurement at control station number 12–4270.00 at Elk are:

Month	May		June		July		Aug.		Sept.		Oct.	
Date	1	15	1	15	1	15	1	15	1	15	1	15
Amount	26	22	17	14	11	9	5	5	5	5	7	7

(b) Surface water available from the Little Spokane River from confluence with Little Creek at Dartford to Eloika Lake outlet, and to confluence with Dry Creek based on measurement at control station number 12–4310 at Dartford are:

Month	May		June		July		Aug.		Sept.		Oct.	
Date	1	15	1	15	1	15	1	15	1	15	1	15
Amount	340	236	152	103	62	34	11	11	11	11	20	20

(c) Available surface waters for those days not specified in (a) and (b) shall be defined from Figures II–3 and II–4 in the document entitled "water resources management program in the Little Spokane River basin" dated August, 1975.

(2) The amounts of waters referred to in WAC 173–555–040(1) above are allocated for beneficial uses in the future as follows:

(a) Three cubic feet per second from the amount available in the east branch of the Little Spokane River referred to in WAC 173–555–040 (1)(a) above and five cubic feet per second from the amount available in the Little Spokane River, besides east branch, referred to in WAC 173–555–040 (1)(b) are allocated to future domestic, stockwatering and noncommercial agricultural irrigation purposes within the stream reaches specified therein throughout the year.

(b) The remainder of the amount referred to in WAC 173–555–040 (1)(a) and (b) besides the amount specified in WAC 173–555–040 (2)(a) are allocated to consumptive and nonconsumptive uses not specified in WAC 173–555–040 (2)(a). These are further described in the figures appended hereto.

[Order DE 75–24, § 173–555–040, filed 1/6/76.]

WAC 173–555–050 Priority of future water rights during times of water shortage.

(1) As between rights established in the future pertaining to waters allocated in WAC 173–555–040 (2)(a) and (b), all rights established in (a) shall be superior to those pertaining to (b) regardless of the date of the priority of right.

(2) As between rights established in the future within a single use category allocation of WAC 173–555–040, the date of priority shall control with an earlier dated right being superior to those rights with later dates.

[Order DE 75–24, § 173–555–050, filed 1/6/76.]

WAC 173–555–060 Streams and lakes closed to further consumptive appropriations. The department, having determined there are no waters available for further appropriation through the establishment of rights to use water consumptively, closes the following streams to further consumptive appropriation except for domestic and normal stockwatering purposes excluding feedlot operation:

SURFACE WATER CLOSURES

Stream* Name	Affected Reach	Date of Closure	Period of Closure
Dry Creek	Mouth to	5–26–1952 headwaters	1 June–31 Oct.
Otter Creek	Mouth to	2–23–1971 headwaters	"
Bear Creek	Mouth to	4–13–1953 headwaters	"
Deer Creek headwaters	Mouth to	2–29–1968	"
Dragoon Creek	Mouth to	7–02–1951 headwaters	"
Deep Creek	Mouth to	6–14–1961 headwaters	"
Deadman Creek1/ headwaters	Mouth to	11–28–1961	"
Little Creek	Mouth to	4–13–1953 headwaters	"
W. Branch Little Spokane River	Outlet of Eloika Lake to headwaters	Date of adoption	"
All natural lakes in the basin		"	"

* Includes all tributaries in the contributing drainage area unless specifically excluded.
1/ An unnamed tributary flowing through Sec. 20, T26N., R.44E. is exempted from closure.

[Order DE 75–24, § 173–555–060, filed 1/6/76.]

WAC 173–555–070 Effect on prior rights. Nothing in this chapter shall be construed to lessen, enlarge or modify the existing rights acquired by appropriation or otherwise.
[Order DE 75–24, § 173–555–070, filed 1/6/76.]

WAC 173–555–080 Enforcement. In enforcement of this chapter, the department of ecology may impose such sanctions as are appropriate under authorities vested in it, including but not limited to the issuance of regulatory orders under RCW 43.27A.190 and civil penalties under RCW 90.03.600.

[Statutory Authority: Chapters 43.27A, 90.22 and 90.54 RCW. 88–13–037 (Order 88–11), § 173–555–080, filed 6/9/88.]

WAC 173–555–090 Appeals. All final written decisions of the department of ecology pertaining to permits, regulatory orders, and related decisions made pursuant to this chapter shall be subject to review by the pollution control hearings board in accordance with chapter 43.21B RCW.

[Statutory Authority: Chapters 43.27A, 90.22 and 90.54 RCW. 88–13–037 (Order 88–11), § 173–555–090, filed 6/9/88.]

WAC 173–555–100 Regulation review. The department of ecology shall initiate a review of the rules established in this chapter whenever new information, changing conditions, or statutory modifications make it necessary to consider revisions.

[Statutory Authority: Chapters 43.27A, 90.22 and 90.54 RCW. 88–13–037 (Order 88–11), § 173–555–100, filed 6/9/88.]

APPENDIX C-5

INSTREAM FLOW COMMUNICATION SPOKANE RIVER BASIN, WRIA 57

360-902-2421
fax: 360-902-2946
e-mail: beechhab@dfw.wa.gov

Date: March 24, 1999

WATER RIGHT APPLICATION REVIEW

Application Number S329607 Applicant Spokane Hutterian Brethren
Rt. 1 Box 6E
Reardan, WA 99029

WRIA 54
Water Spokane River (Little Falls Lake)
This water and/or affected reaches downstream are inhabited by resident trout & other resident fish, anadromous fish below Chief Joseph Dam

based on site-specific observations WDFW database or GIS
literature knowledge of this type of stream X

Amount 15.6 cfs gpm acre-ft
Point of diversion S16 T27N R39E
Point of use 1270 acres in S21, 29, 28, 32, 33 T27N R39E

WDFW recommended conditions:
Instream flows in WAC 173-5

X This water right should be subject to any established lake levels, if any.

X Instream flows based on IFIM study USGS toe-width X Tennant
other
WDFW requests that water right be subject to the following instream flows or natural flow, whichever is less: 4800 cfs year-round.

Instream flows to be measured at Spokane River at Long Lake U.S.G.S. gauge 12433000.

Other conditions requested by WDFW indicated by X:
X HPA
X screen

May 24, 1999

TO: David Mudd
Bruce Smith

FROM: Hal Beecher

SUBJECT: Instream flow for Spokane River

On Friday morning, May 21, I met with Rep. Cathy McMorris, Keith Phillips (Ecology), and Sen. Morton and George Schlender (Ecology, Spokane) by phone. The topic was the water right application for 10 or 15 cfs between Long Lake Dam and Little Falls Dam. The application was made by the Hutterian Brethren for irrigation. The applicants had been given some sort of verbal assurances by Ecology that the application would be approved, so the applicants spent a million dollars on intake facilities. They have since planted, based on Ecology's assurances. Phillips says courts won't support enforcement if the applicant has already put in seed, so Ecology won't try to enforce.

I have been using the Tennant method for instream flow recommendations for the Spokane River because we have no site-specific instream flow studies and the Spokane is a large, gauged river. The Tennant method uses different percentages of the mean annual flow (MAF) as the criterion for instream flow. In the past I have used 30% MAF or 30% and 20%MAF, with the lower value in low flow season. When I read the Wild Salmonid Policy, I changed the recommendation to 60% MAF year round. This precludes diversion during late summer and early fall.

Subsequently, Curt Leigh brought to my attention a study by Washington Water Power (now Avista) showing losses to rainbow trout spawning and incubation when flows in the upper Spokane River near the Idaho border drop below 6,000 cfs.

I have indicated to Kevin Robinette and George Schlender that I would defer to more site-specific studies, using IFIM or similar studies, if such studies are done. Kevin Robinette is representing WDFW on ESHB 2514 planning units that are organizing for the Spokane basin.

Keith Phillips wants to meet soon to decide how to address this application. One proposal is to issue a temporary permit for this year based on the assumption that we have a good snowpack and will have plenty of water. A longer term solution is to have the applicants make a storage arrangement with Avista.

cc: Kevin Robinette
Curt Leigh
Greg Hueckel

State of Washington
DEPARTMENT OF FISH AND WILDLIFE

Mailing Address: 600 Capitol Way N • Olympia, WA 98501-1091 • (360) 902-2200, TDD (360) 902-2207
Main Office Location: Natural Resources Building • 1111 Washington Street SE • Olympia, WA

Washington State Department of Ecology
4601 N Monroe, Suite 202
Spokane WA 99205

October 18, 1999

RE: WATER RIGHT APPLICATION REVIEW: Main Stem Spokane River(WRIA 54)

Application Number: All pending Water Right Decisions, Main Stem Spokane River WRIA 54

WRIA 54, Main Stem Spokane River, WDFW recommended conditions:

There is insufficient information concerning biological and hydraulic parameters to use a standard method for recommending instream flows. The river is highly regulated, with flows released from Idaho and reregulated in Washington. Some riverine sections of the river exist and support rainbow trout and other fish, but no IFIM nor toe-width data are available for the main stem Spokane River in WRIA 54. WDFW will recommend a flow based on the 'natural' baseflow condition that existed prior to the construction of the Post Falls Dam. This will be derived by using the baseflow condition as depicted on the 50% exceedance flow for pre-dam water years (1891 through 1906) as measured at the USGS's gaging station at Spokane. WDFW recommends that the water rights be subject to the following instream flows or natural flows, whichever is less: 2000 cubic feet per second (cfs) as measured at U.S.G.S. gage 12422500 Spokane River at Spokane.

WDFW recommends that instream flow studies be conducted to address instream flow needs in riverine portions of the Spokane River before additional water allocations are made beyond the current batch. Studies conducted by Washington Water Power (now Avista) have indicated that 6,000 to 10,000 cfs is needed in the upper reach (WRIA 57) of the Spokane River during spring (through July) for successful rainbow trout spawning and incubation.

Other conditions by WDFW:

X -HPA
X _Screen intake if accessible to fish (to be determined during application for HPA) according to WDFW standards

Hal A. Beecher

APPENDIX D

GROUNDWATER INFORMATION

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APPENDIX D1

EXPLANATION OF AQUIFER PROPERTIES

D1-1. DESCRIPTION OF AQUIFER PROPERTIES

The following text provides a brief explanation of each of the aquifer properties compiled on Table 5.6 of the Level 1, Phase II Assessment Report for WRIAs 55 and 57. The information within this Appendix supports information presented within Section 5.2.5 of the Level 1, Phase II Assessment Report for WRIAs 55 and 57.

- **Pump Rate or Well Yield** is a measure of how much water the wells completed within an aquifer produce and is expressed as a flow per unit of time (gallons per minute or gpm). Higher sustained well yields indicate an aquifer of higher productivity and vice versa.
- **Specific Capacity** is a measure of the performance of a well and is expressed as a flow rate per unit drawdown (gpm/ft). Specific capacity is a time dependant parameter until steady-state conditions are reached. It is also referred to as specific drawdown, expressed as a drawdown per unit flow rate (ft/gpm).
- **Transmissivity (T)** is a measure of the transmitting capacity of the aquifer and is expressed in units of L^2/T (ft^2/day for example). It is also often expressed as a volume capacity (gallons per day) per unit thickness of aquifer (ft). Transmissivity for an aquifer can be estimated from the specific capacity using the following empirical formula (Driscoll, 1986):

$$T = \frac{Q * x}{s}$$

Where,

T	=	transmissivity of the well (gallons per day / foot)
Q	=	yield of the well (gallons per minute)
s	=	drawdown in the well (feet)
x	=	1,500 for an unconfined aquifer and 2,000 for a confined aquifer

- **Hydraulic Conductivity (K)** is a vector quantity that describes the flow of groundwater through an aquifer. It has units of L/T (ft/day for example). As a vector, it has both a vertical and horizontal component. Hydraulic conductivity is used to determine the rate of groundwater movement. Vertical hydraulic (Kv) conductivity is not easily determined from well data. However, horizontal hydraulic conductivity (Kh) can be estimated using well test data by the following relationship:

$$Kh = \frac{T}{b}$$

Where,

T	=	transmissivity of the well (feet squared / day)
b	=	screened interval (feet)
Kh	=	horizontal hydraulic conductivity (feet / day)

Vertical anisotropy is the ratio of the horizontal hydraulic conductivity to the vertical hydraulic conductivity.

- For a confined aquifer, the storage term is referred to as the Specific Storage (Ss) and is defined as the volume of water that a unit volume of aquifer releases from storage under a unit decline in hydraulic head (Freeze and Cherry, 1979). Storativity for a confined aquifer is defined as:

$$S = S_s b$$

Where,

S	=	storativity or storage coefficient (dimensionless)
S_s	=	specific storage (1/feet)
b	=	aquifer thickness (feet)

The usual range for S_s is 0.005-0.00005.

- For an unconfined aquifer, the storage term is referred to as the **Specific Yield (S_y)** and is defined as the volume of water that an unconfined aquifer releases from storage per unit area of aquifer per unit decline in the water table (Freeze and Cherry, 1979). The storage coefficient for an unconfined aquifer is defined as:

$$S = S_s b$$

Where,

S	=	storage coefficient (dimensionless)
S_s	=	specific yield (1/feet)
b	=	saturated thickness of the aquifer

The usual range for S_y is 0.01-0.3.

Note that the higher values for specific yield versus specific storage reflect the fact that the releases from storage in unconfined aquifers represent an actual dewatering of the soil pores, whereas releases from storage in confined aquifers represent only the secondary effects of water expansion and aquifer compaction caused by changes in fluid pressure.

- **Porosity (n)** describes the ratio of the volume of voids to the total volume of the aquifer / aquitard material and is defined as:

$$n = \frac{V_v}{V}$$

Where,

n	=	porosity (decimal or % if multiplied by 100)
V_v	=	volume of voids (cubic feet)
V	=	total volume of aquifer / aquitard material (cubic feet)

The effective porosity is the porosity through which flow can occur. An understanding of porosity is required to estimate the volumes of water flowing through an aquifer or aquitard.

- **Linear Velocity (v)** describes the average horizontal velocity of groundwater flow through and aquifer or aquitard. Linear velocity has units and is defined as:

$$v = \frac{-Kh \times dh}{n \times dl}$$

Where,

Kh	=	horizontal hydraulic conductivity (feet / day)
n	=	porosity (decimal)
$\frac{dh}{dl}$	=	hydraulic gradient (dimensionless)

Where,

dh	=	change in hydraulic head (feet)
dl	=	horizontal distance (feet)

APPENDIX D2

GROUNDWATER SNAPSHOT AND HYDROGRAPH INFORMATION

APPENDIX D2 - GROUNDWATER SNAPSHOT INFORMATION

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Groundwater Snapshot Information

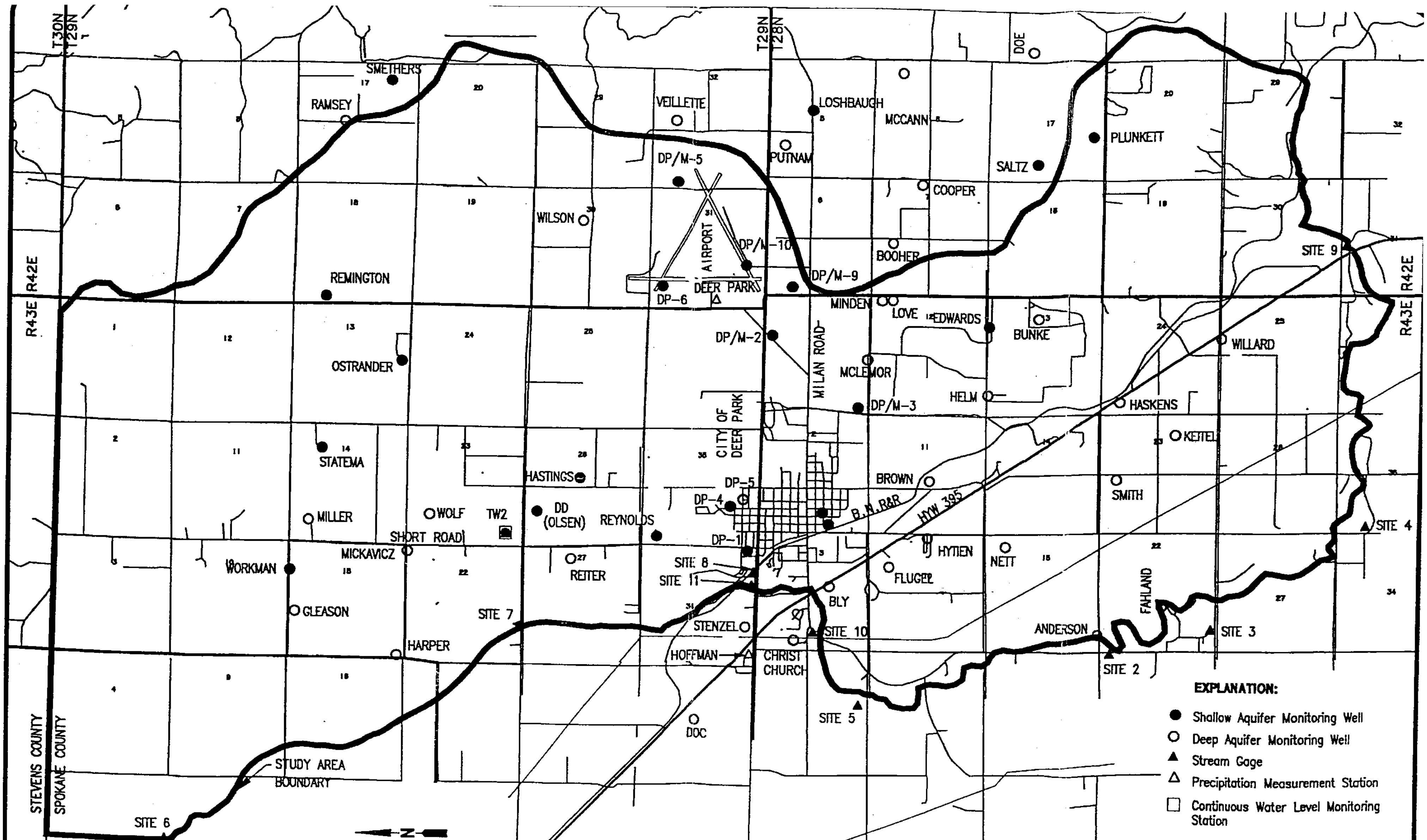
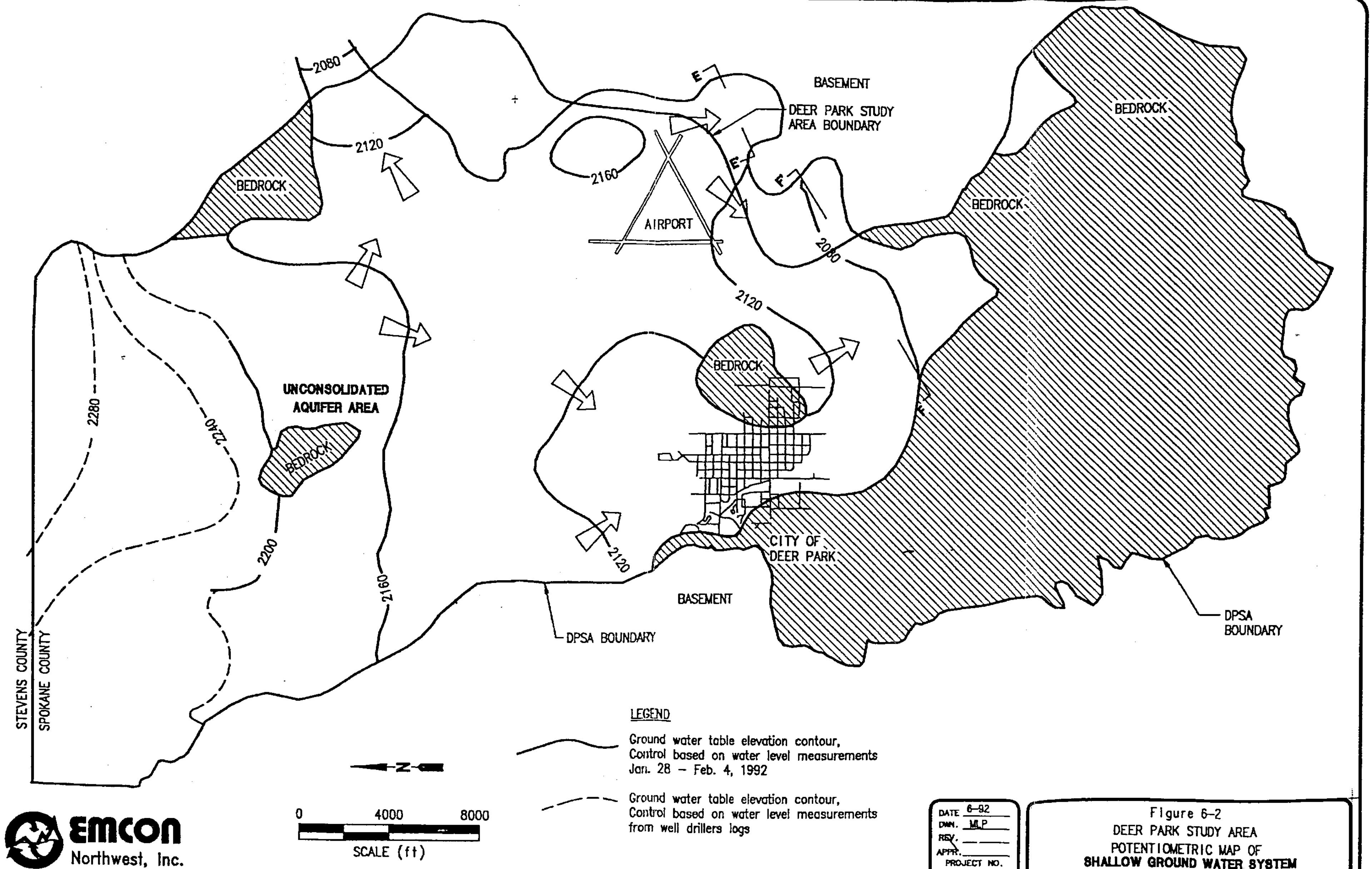


Figure 6-1
DEER PARK STUDY AREA

WATER LEVEL WELL MONITORING LOCATIONS

DEER PARK X2201C18 6-29-92



DATE 6-92
DWN. MLP
REV. ____
APPR. ____
PROJECT NO. X2201.04

Figure 6-2
DEER PARK STUDY AREA
POTENTIOMETRIC MAP OF
SHALLOW GROUND WATER SYSTEM
MEASURED JAN. 28 TO FEB. 4, 1992

DEERPARK X2201C16 6-29-92

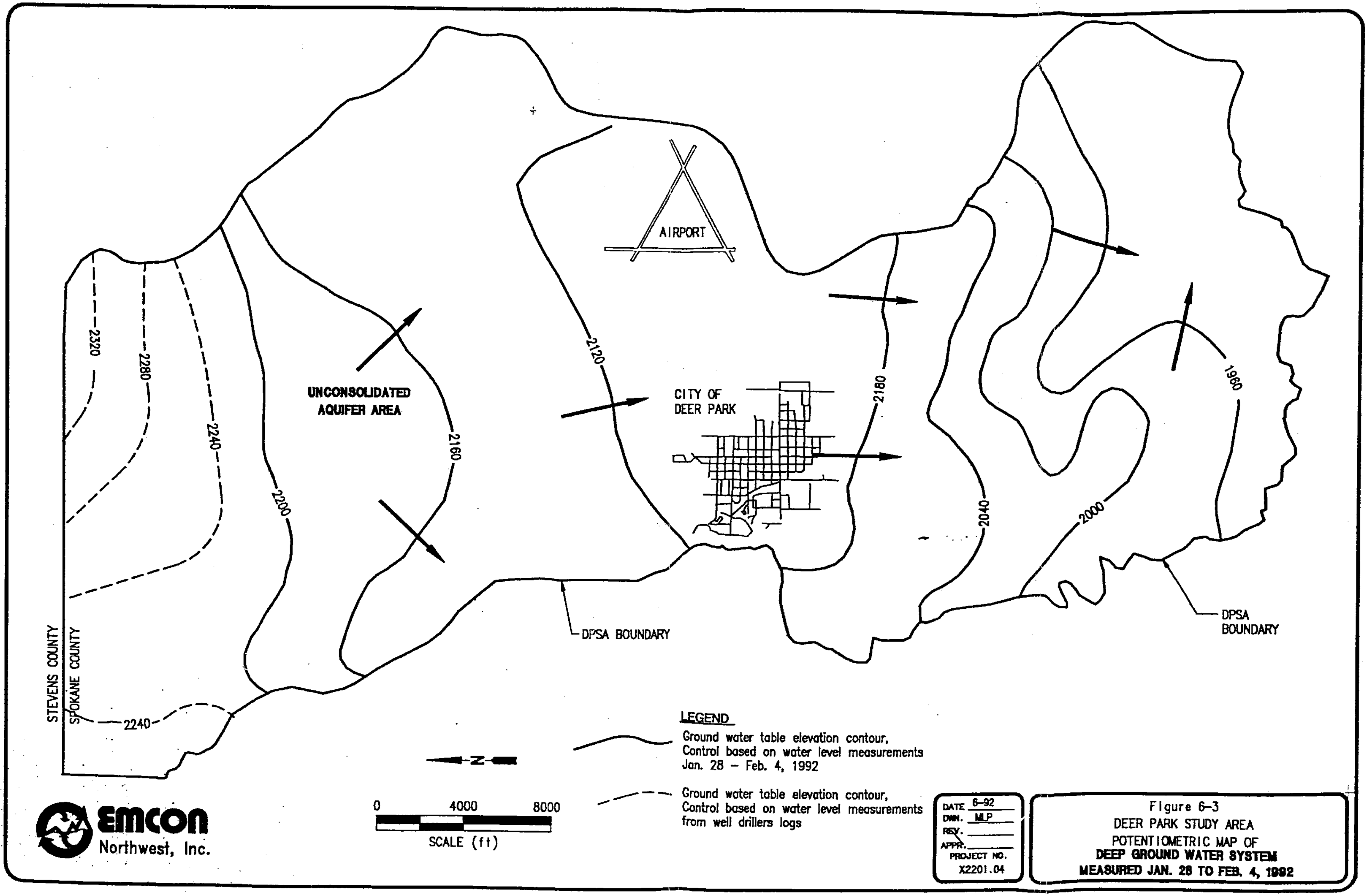


Figure 6-3
DEER PARK STUDY AREA
POTENTIOMETRIC MAP OF
DEEP GROUND WATER SYSTEM
MEASURED JAN. 28 TO FEB. 4, 1992

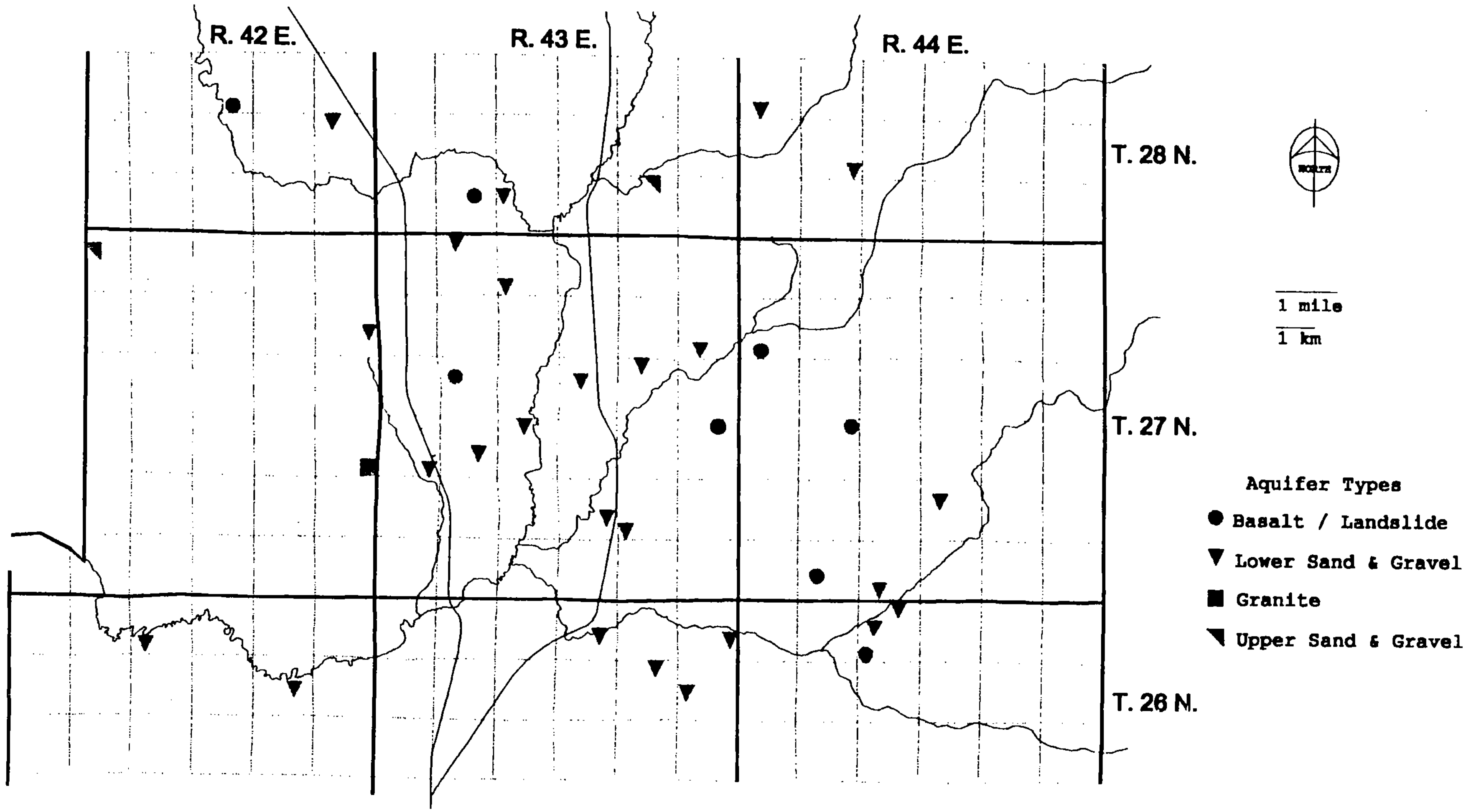


Figure 25. Location map of wells sounded for the depth to the water table in the study area, April - June, 1996.

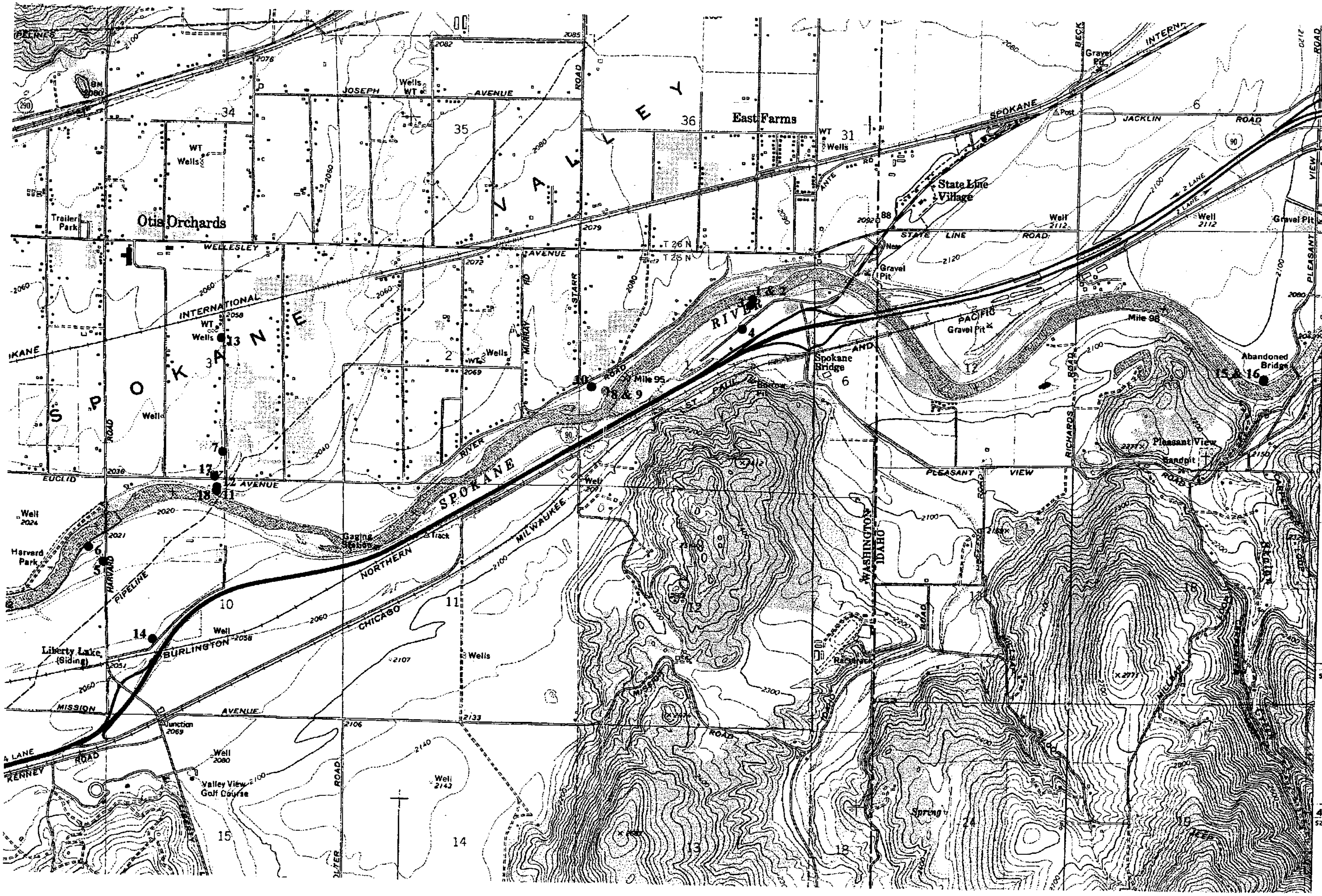

SPOKANE VALLEY
Otis Orchards
East Farms
State Line Village
SPOKANE RIVER
Spokane Bridge
Liberty Lake (Siding)
Harvard Park
Valley View Golf Course
Pleasant View Sandpit
Abandoned Bridge
WASHINGTON
IDAHO
WELLESLEY
EUCLID
AVENUE
HARVARD
JOSEPH
STARR
MURRAY
PIPELINE
BURLINGTON NORTHERN
CHICAGO MILWAUKEE ST PAUL AND PACIFIC
INTERNATIONAL
MISSION
KENNEY ROAD
STATE LINE ROAD
JACKLIN ROAD
PLEASANT VIEW
RICHARDS ROAD
Mile 95
Mile 98
Gaging Station
Gravel Pit
Junction
Well
Wells
Trailer Park
(COEUR D'ALENE 1:62 500)

FIG-2-3.DWG

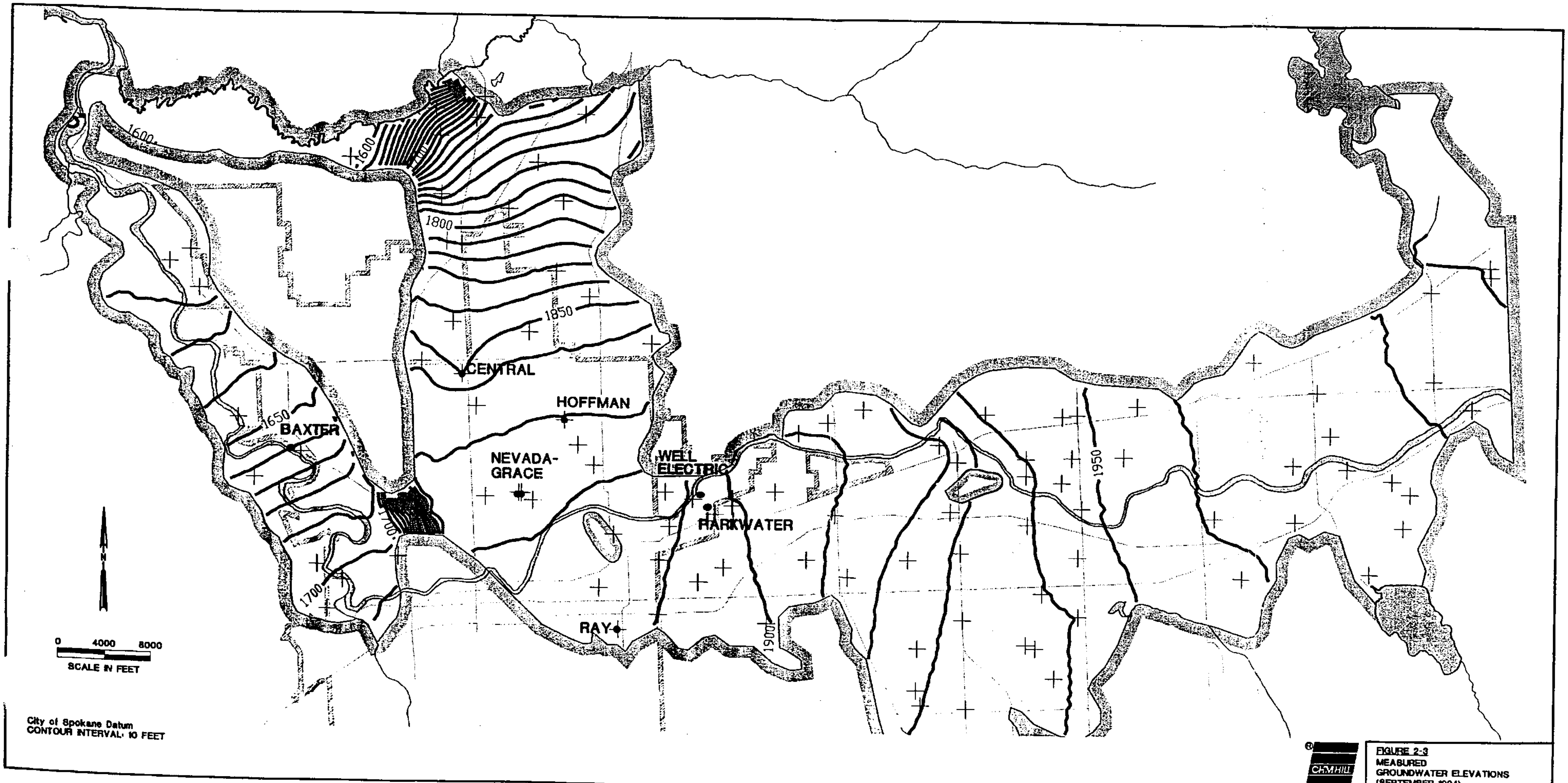
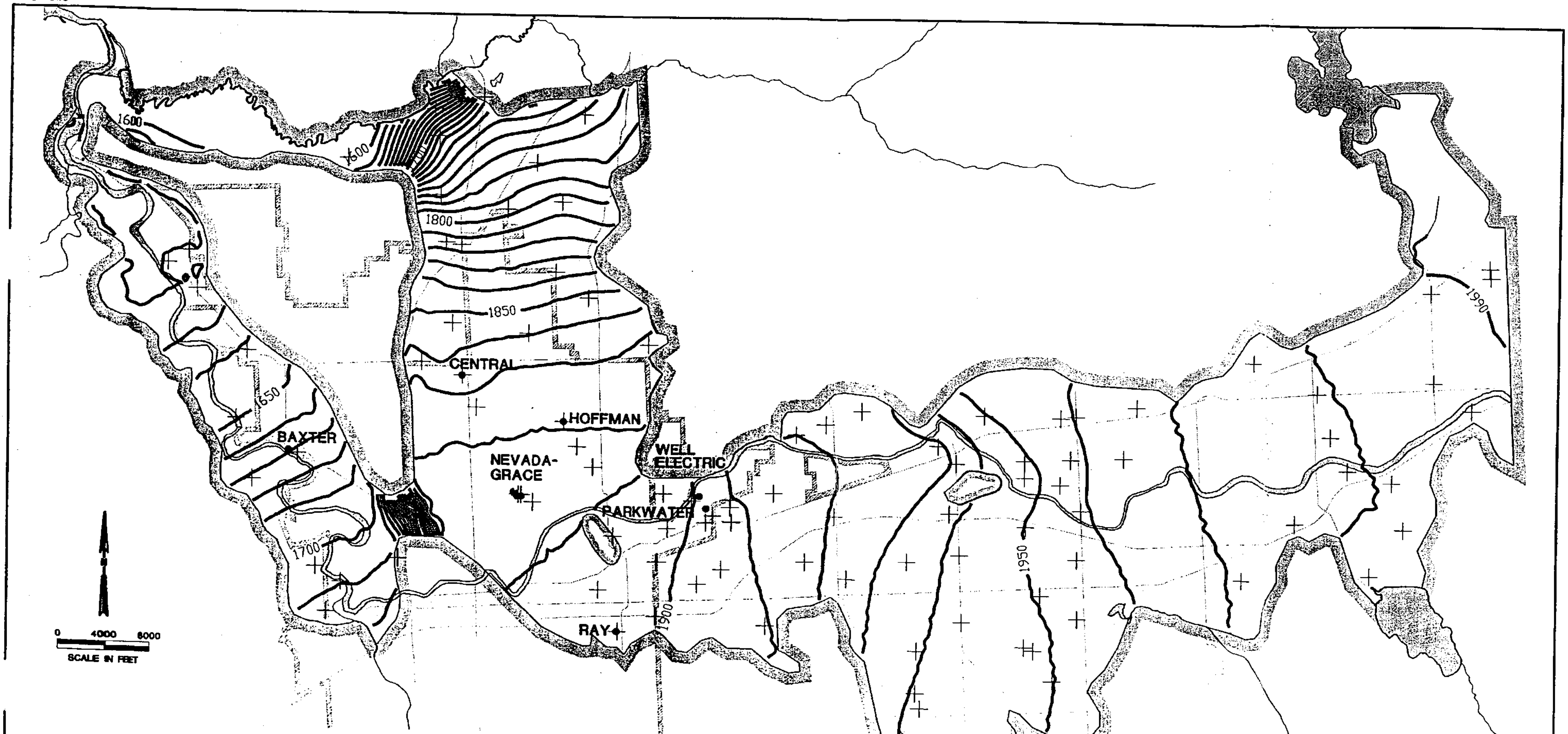


FIGURE 2-3
MEASURED
GROUNDWATER ELEVATIONS
(SEPTEMBER 1994)

FIG-2-4.DWG



City of Spokane Datum
CONTOUR INTERVAL- 10 FEET

CH2M HILL

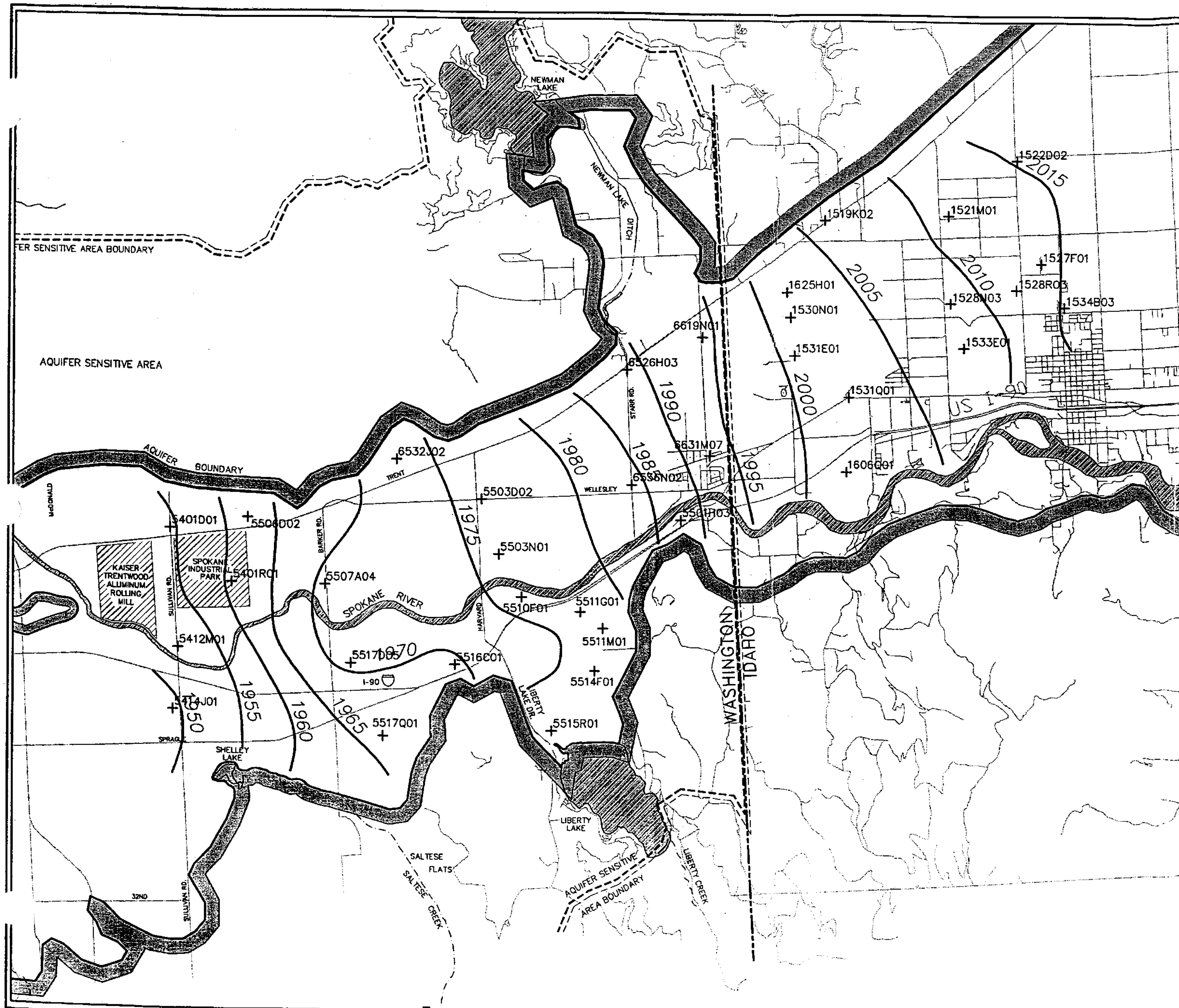
FIGURE 2-4
MEASURED
GROUNDWATER ELEVATIONS
(APRIL 1995)

Table 2-1
Groundwater Depth and Elevation Data
September 1994 and April 1995
City of Spokane Wellhead Protection Program

Well ID	Well Owner	Well Name	Location (NAD 27)		Year	Depth	Depth to Top Open	Depth to Bottom Open	Diameter	Casing	Intake	Reference Point Elevation		Fall 1994				Spring 1995			
			Easting	Northing	Drilled	(ft bgs)	Interval (ft bgs)	Interval (ft bgs)	(inches)	Type	Type	(ft USGS)	(ft City)	Date	Depth to Water	Groundwater Elevations (ft USGS)	(ft City)	Date	Depth to Water	Groundwater Elevations (ft USGS)	(ft City)
5203H01	City of Spokane	Baxter well	2826906	271955	1945	124	93	122	144			1696.11		9/15/94		1647.27	1664.20	4/13/95		1647.15	1664.08
5203H02	City of Spokane	WWTP Mon Well	2827800	271500	1994	121			2	PVC	S	1697.05	1713.98	9/13/94	51.62	1645.43	1662.36	4/13/95	42.04	1655.01	1671.94
5203Q01	Riverside State Park	Equestrian Center	2823908.9	269247.62	1979	217			6	Steel	S	1769.37	1786.30	9/13/94	123.91	1645.46	1662.39	4/11/95	114.80	1654.57	1671.5
5213B01	Inland Empire Cold Storage		2835547.51	262572.3		208			41			1886.37	1903.30	9/14/94	195.45	1690.92	1707.85	4/12/95	186.00	1700.37	1717.3
5214C02	Central PreMix-Ft. Wright	Ft. Wright	2829378.98	261797.06		140	134	140	8	Steel	S	1772.06	1788.99	9/16/94	94.35	1677.77	1694.70	4/13/95	87.78	1684.34	1701.27
5214J01	Fairmont Cemetery Assoc.	Riverside Cemetery	2831607.99	260488.26		160	119	154	18	Steel	P	1712.54	1729.47	9/16/94	26.65	1685.89	1702.82	4/13/95	19.72	1692.82	1709.75
5223B01	City of Spokane	Indian Canyon Golf Course	2830364	257944	1931	59	45		6			1732	1749	9/15/94		1687.61	1704.54	4/13/95		1697.87	1714.8
5304B01	City of Spokane	Hoffman Well #1	2850739	274479	1937	231	222	227	198			2068	2085	9/15/94		1851.87	1868.80	4/11/95		1862.82	1879.75
5304B02	City of Spokane	Hoffman Well #2	2850739	274479	1936	216			126	Brick		2068	2085	9/15/94		1853.57	1870.50	4/11/95		1862.28	1879.21
5304G01	City of Spokane	NE Comm. Center (Hoffman MW)	2851980.87	272421.11	1994	195	182	192	2	PVC	S	2039.14	2056.07	9/21/94	182.10	1857.04	1873.97	4/11/95	174.22	1864.92	1881.85
5304R01	Miles Laboratory (Bayer)		2853386.19	270692.8		185						2020.73	2037.66	9/14/94	159.65	1861.08	1878.01	4/11/95	151.52	1869.21	1886.14
5307M01	City of Spokane	Trinity MW	2838136.8	266370.64		254						1895.40	1912.33	10/7/94	147.30	1748.10	1765.03	4/11/95	127.99	1767.41	1784.34
5308A01	City of Spokane	Grace Well	2847200	268203		124	85	119	144			1963	1980	9/15/94		1858.38	1875.31	4/11/95		1866.03	1882.96
5308A02	City of Spokane	Nevada well	2846955	268207		126			216			1960	1977	9/15/94		1854.37	1871.30	4/11/95		1862.19	1879.12
5308D01	WADOT, Mayfair complex	MW-1	2844108.69	267855.49		77	62	77	2	PVC	S	1929.24	1946.17	9/13/94	72.81	1856.43	1873.36	4/13/95	66.36	1862.88	1879.81
5309E04	City of Spokane	Marietta MW	2848176.65	267584.97	1994	101	86	96	2	PVC	S	1947.17	1964.10	9/14/94	87.60	1859.57	1876.50	4/11/95	80.23	1866.94	1883.87
5310P02	Spokane County (208 Well)	Spokane Community College	2855126.28	264762.84	1977	96	41	96	6		P	1910.42	1927.35	9/15/94	41.22	1869.20	1886.13	4/13/95	33.57	1876.85	1893.78
5311E01	Arbor Crest Winery	Hand dug well at plant	2859521.96	268503.34	1924	80			36			1938.65	1955.58	9/15/94	67.88	1870.77	1887.70	4/11/95	59.88	1878.77	1895.7
5311G01	City of Spokane	Old Well Electric (#1)	2862058.75	267806.98	1907	46.7			540	Brick		1904.92	1921.85	9/14/94	32.37	1872.55	1889.48	4/13/95	23.53	1881.39	1898.32
5311G06	City of Spokane	Well Electric #5	2862730	268280										9/15/94		1872.67	1889.60	4/13/95		1881.44	1898.37
5311H01	Spokane Airports	Old USGS, Well Electric area	2862103.31	267908.35		< 100						1935.36	1952.29	9/14/94	61.71	1873.65	1890.58	4/12/95	53.20	1882.16	1899.09
5311J05	City of Spokane	Hales Ale #1 Shallow (E)	2863896.64	266619.72	1994	80	62	72	2	PVC	S	1948.22	1965.15	9/16/94	70.18	1878.04	1894.97	4/12/95	60.78	1887.44	1904.37
5311J06	City of Spokane	Hales Ale #2 Inter. (M)	2863896.64	266619.72	1994	98	80	90	2	PVC	S	1948.83	1965.76					4/12/95	61.22	1887.61	1904.54
5311J07	City of Spokane	Hales Ale #3 Deep (W)	2863896.64	266619.72	1994	120	105	115	2	PVC	S	1948.71	1965.64					4/12/95	60.85	1887.86	1904.79
5311N01	Baker Commodities		2859891.45	265504.78		70			8			1903.94	1920.87	9/13/94	32.96	1870.98	1887.91	4/12/95	25.77	1878.17	1895.1
5311R01	Burlington Northern	Well south of offices	2863294.02	266029.44		104	69					1948.60	1965.53	9/13/94	70.98	1877.62	1894.55	4/11/95	61.48	1887.12	1904.05
5312C01	City of Spokane	Felts Field MW	2865483.25	267958.9	1994	80	65	75	2	PVC	S	1950.34	1967.27	9/14/94	66.52	1883.82	1900.75	4/12/95	57.41	1892.93	1909.86
5312E01	Middco Tool		2865436.7	267343.2		103						1952.06	1968.99	9/14/94	72.37	1879.69	1896.62	4/13/95	63.48	1888.58	1905.51
5312H01	Orchard Irr. Dist.	Well #1 (at office)	2869172.94	268572.27	1917	96	55	96	120			1946.81	1963.74	9/13/94	59.46	1887.35	1904.28	4/11/95	49.80	1897.01	1913.94
5312L03	Westco Apparel Service		2865565.09	266043.11		90			6	Steel		1948.42	1965.35	9/12/94	67.15	1881.27	1898.20	4/11/95	57.55	1890.87	1907.8
5313E01	Ponderosa Drilling		2864693.18	262018.43	1984	81	81		6		OH	1938.22	1955.15	9/12/94	57.55	1880.67	1897.60	4/11/95	48.05	1890.17	1907.1
5313K01	Acme Materials	Yardley Pit	2868798.48	260983.49		125	85	125	12	Steel	P	1901.60	1918.53	9/16/94	-5.00			4/10/95	6.98	1894.62	
5314E01	Spokane County (208 Well)	Central Premix - Yardley	2859032.44	262587.11	1977	211		211	6	Steel	OH	1941.75	1958.68	9/12/94	69.70	1872.05	1888.98	4/11/95	60.47	1881.28	1898.21
5314Q01	Union Pacific Railroad		2862603.47	260743.74		< 120			6			1936.67	1953.60	9/12/94	59.87	1876.80	1893.73	4/11/95	50.58	1886.09	1903.02
5316K01	Centennial Mills	Trent plant	2851831.09	260735.57	1935	65			36			1924.60	1941.53	9/15/94	60.05	1864.55	1881.48	4/12/95	52.64	1871.96	1888.89
5316R01	Playfair Racetrack		2853915.18	260132.05	1978	100	90	100	8		S	1935.71	1952.64	9/12/94	69.58	1866.13	1883.06	4/12/95	61.50	1874.21	1891.14
5322A01	City of Spokane	4th and Havana #1 - Shallow	2858984.32	257913.35	1994	62	47	57	2	PVC	S	1927.52	1944.45	9/16/94	54.37	1873.15	1890.08	4/12/95	45.67	1881.85	1898.78
5322A02	City of Spokane	4th and Havana #2 - Inter.	2859145.1	257910.43	1994	79	66	76	2	PVC	S	1927.58	1944.51	9/16/94	54.45	1873.13	1890.06	4/12/95	45.75	1881.83	1898.76
5322A03	City of Spokane	4th and Havana #3 - Deep	2859082.7	257908.1	1994	103	90	100	2	PVC	S	1927.49	1944.42	9/16/94	54.31	1873.18	1890.11	4/12/95	45.62	1881.87	1898.8
5322F01	City of Spokane	Ray St. well	2855441	256629	1941	77	54	77	252			1932	1949	9/15/94		1863.45	1880.38	4/12/95		1875.68	1892.61
5324G01	East Spokane WD	E Spok SO #1	2868519.08	257220.96	1946	147			58			2026.61	2043.54	9/13/94	144.15	1882.46	1899.39	4/12/95	134.18	1892.43	1909.36
5401D01	Trentwood Irr. Dist.	Trentwood #5	2895418.59	275571.53	68	159	110	145	16		P	2051.54	2068.47	9/13/94	119.71	1931.83	1948.76	4/11/95	108.03	1943.51	1960.44
5401R01	Spokane Industrial Park	Well #4	2899584.36	271949.05	1974	150	120	150	22	Steel	S	2018.01	2034.94	9/12/94	81.52	1936.49	1953.42	4/11/95	69.50	1948.51	1965.44
5402B01	Trentwood Irr. Dist.	Progress #6	2894105.59	275412.64		236	112	138				2036.75	2053.68	9/13/94	106.70	1930.05	1946.98	4/11/95	95.48	1941.27	1958.2
5402N01	Kaiser-Trentwood	MW-7	2891006	271690.52		< 125						2004.90	2021.83	9/13/94	81.55	1923.35	1940.28	4/11/95	72.78	1932.12	1949.05
5402R01	Kaiser-Trentwood	MW-4	2894986.38	271833.25		< 125						2015.92	2032.85	9/13/94	86.37	1929.55	1946.48	4/11/95	75.60	1940.32	1957.25
5403B01	Trentwood Irr. Dist.	Trentwood #4 McDonald	2887472.63	275518.24	1966	120	88	118	16	Steel	P	1991.46	2008.39	9/12/94	66.37	1925.09	1942.02	4/11/95	58.60	1932.86	1949.79
5404K03	Inland Empire Paper	MW in Plantes Ferry pit	2883497	272817		< 40						1925.03	1941.96	9/13/94	24.87	1900.16	1917.09	4/11/95	14.30	1910.73	1927.66
5404Q01	Trentwood El. School	Trent near Zoo	2885084.09	271337.95		< 125						1987.21	2004.14	9/12/94	81.90	1905.31	1922.24	4/11/95	73.23	1913.98	1930.91
5406A02	Pasadena Park Irr. Dist.	#4	2873644.53	274590.7		160	121	155	16			1984.16	2001.09	9/13/94	90.58	1893.58	1910.51	4/11/95	79.50	1904.66	1921.59
5406J03	Pasadena Park Irr. Dist.	#5 (New well)	2871087.28	273671.59	1993	180	145	180	20	Steel	S	1962.22	1979.15	9/13/94	69.73	1892.49	1909.42	4/11/95	59.48	1902.74	1919.67
5407R01	Farm Credit	Old USGS MW	2874445.56	266585.6	1979	120	60	120	6	PVC	S	1976.27	1993.20	9/13/94	82.53	1893.74	1910.67	4/10/95	72.23	1904.04	1920.97
5408B01	Millwood WD	Old Park Well	2875859.11	270434.65	1953	120	70	120	80	Steel	P	1950.07	1967.00	9/13/94	50.89	1899.18	1916.11	4/11/95	40.92	1909.15	1926.08
5409E01	Irvin WD	Montgomery	2880442.98	268789.36	1973	141	104	136	16	Steel	S	1968.51	1985.44	9/14/94	77.62	1890.89	1907.82	4/11/95	67.26	1901.25	1918.18
5409Q01	WADOT, Pines complex		2884542.1	267039.26	1991	< 125						1978.66	1995.59	9/13/94	68.20	1910.46	1927.39	4/10/95	57.02	1921.64	1938.57
5411G01	Kaiser-Trentwood	MW-5	2894111.77	269674.35		< 125						2009.55	2026.48	9/13/94	81.10	1928.45	1945.38	4/11/95	70.96	1938.59	1955.52
5411J01	Kaiser-Trentwood	MW-9	2891020.6	270216.49	1991	85	65	85	2	PVC	S	1977.18	1994.11	9/13/94	56.02	1921.16	1938.09	4/11/95	49.38	1927.80	1944.73
5411N02	Consolidated Irr. Dist. (CID)	Carder, 1B	2891146.02	265984.84	1987	176	117	162	10	Steel	S	1984.58	2001.51	9/14/94	62.50	1922.08	1939.01	4/10/95	51.20	1933.38	1950.31
5412M01	Central PreMix	SPK Co (208) - Sullivan	2895922.89	267421.85		< 150						1998.07	2015.00	9/12/94	67.27	1930.80	1947.73	4/10/95	55.73	1942.34	1959.27
5414J01	Vera Irr. Dist. #15	New #2 well	2895582.04	263204.61	1994	265	210	265	20	Steel	S	2044.27	2061.20	9/15/94	115.77	1928.50	1945.43	4/11/95	105.70	1938.57	1955.5
5415E01	Modern Electric	#5	2885443.86	263482.97	1947	158			75	Steel		2053.24	2070.17	9/14/94	138.69	1914.55	1931.48	4/11/95	127.75	1925.49	1942.42
5416E01	Modern Electric	#2	2880897.97	262839.1	1947	128			74	Steel		2012.16	2029.09	9/14/94	106.10	1906.06	1922.99	4/11/95	95.00	1917.16	1934.09
5417M01	Modern Electric	#4	2875586.92	261247.71	1947	114	114	130	66	Steel	S	2000.56	2017.49	9/14/94	101.96	1898.60	1915.53	4/11/95	91.35	1909.21	1926.14
5418F01	Spokane County WD #3	Vista and Broadway	2871918.34	262698.57		110	65	105				1965.59	1982.52	9/15/94	76.33	1889.26	1906.19	4/11/95	66.49	1899.10	1916.03
5421J01	Modern Electric	#3	2885680.84	257678.67		122						2022.43	2039.36	9/14/94	107.24	1915.19	1932.12	4/11/95	96.03	1926.40	1943.33
5421N01	Model Irr. Dist.	15th & Pierce, #1	2881810.2	255188.31	1911	183	166	183	84			2082.56	2099.49	9/13/94	171.79	1910.77	1927.70	4/11/95	160.28	1922.28	1939.21
5422R01	Vera Irr. Dist. #15	#3	2891101.39	255597.68	1908	257	210	257	20	Steel	S	2082.12	2099.05	9/15/94	162.40	1919.72	1936.65	4/11/95	150.90	1931.22	1948.15
5423C01	Vera Irr. Dist. #15	#7	2892461.04	260072.53		97						2017.96	2034.89	9/15/94	95.51	1922.45	1939.38	4/11/95	84.35	1933.61	1950.54
5423J03	Vera Irr. Dist. #15	#8/9 testwell	2895656.82	258099.39		210	188	208	6	Steel	P	2043.16	2060.09	9/15/94	119.75	1923.41	1940.34	4/11/95	108.05	1935.11	1952.04
5426D01	Vera Irr. Dist. #15	#5	2891923.97	255309.14	1910	170			72	Steel		2083.65	2100.58	9/15/94	163.44	1920.21	1937.14	4/11/95	151.91	1931.74	1948.67
5426L01	Vera Irr. Dist. #15	#4	2893587.66	252728.35	1910	163	130		72	Steel		2064.32	2081.25	9/15/94	143.35	1920.97	1937.90	4/11/95	131.38	1932.94	1949.87
5428M02	Model Irr. Dist.	#5	2881721.96	251563.34	1974	160	140	160	16	Steel	S	2009.40	2026.33	9/13/94	97.46	1911.94	1928.87	4/11/95	85.45	1923.95	1940.88

Table 2-1
Groundwater Depth and Elevation Data
September 1994 and April 1995
City of Spokane Wellhead Protection Program

Well ID	Well Owner	Well Name	Location (NAD 27)		Year	Depth	Depth to	Depth to	Diameter	Casing	Intake	Reference Point Elevation		Fall 1994				Spring 1995			
			Easting	Northing	Drilled	(ft bgs)	Top Open Interval (ft bgs)	Bottom Open Interval (ft bgs)	(inches)	Type	Type	(ft USGS)	(ft City)	Date	Depth to Water	Groundwater Elevations (ft USGS)	Groundwater Elevations (ft City)	Date	Depth to Water	Groundwater Elevations (ft USGS)	Groundwater Elevations (ft City)
5428P01	Model Irr. Dist.	#3	2882127.19	250257.12	1965	167	152	167	16	Steel	S	2031.08	2048.01	9/13/94	118.33	1912.75	1929.68	4/11/95	105.63	1925.45	1942.38
5428R01	Spokane County WD #3	32 & Pines @ Circle K	2886056	250027.07		132	113					2031.09	2048.02	9/14/94	114.22	1916.87	1933.80				
5501H03	Washington State Patrol	K001 WA St Patrol	2930196.9	276370.57	1970	165	155	165	8	Steel	S	2050.99	2067.92	9/12/94	94.17	1956.82	1973.75	4/11/95	81.57	1969.42	1986.35
5503D02	Otis Orchards School		2916639.09	277701.46	1953	137	100		8		P	2058.82	2075.75	9/12/94	109.30	1949.52	1966.45	4/12/95	96.90	1961.92	1978.85
5503N01	Coen		2917834.25	273952.17	1959	138	105	135	14		P	2048.18	2065.11	9/12/94	98.88	1949.30	1966.23	4/11/95	86.40	1961.78	1978.71
5506D02	Borjessan; Lloyd	Borjessan	2900686.05	276374.12	1973	177	162	177	10	Steel	S	2064.68	2081.61	9/12/94	126.33	1938.35	1955.28	4/11/95	113.41	1951.27	1968.2
5509B02	Jacklin, Gladice		2914609.03	271330.37	1976	147	137	146	10		P	2028.99	2045.92	9/12/94	81.57	1947.42	1964.35				
5510F01	Delp Place		2919352.67	271033.49	1930	85			48			2023.54	2040.47	9/14/94	73.65	1949.89	1966.82	4/10/95	61.20	1962.34	1979.27
5511G01	Bryant Motors		2923252.04	270058.18		< 150						2057.07	2074.00	9/12/94	106.37	1950.70	1967.63	4/10/95	93.39	1963.68	1980.61
5511M01	Kennert (North Well)	Simpson Rd. N. of Sprague	2924826.27	268952.13	1965	186	158	183	16			2110.48	2127.41	9/12/94	161.10	1949.38	1966.31	4/10/95	148.60	1961.88	1978.81
5514F01	Liberty Lake Improvement Dist.	Schultz well	2924259.3	266047.2		238	216	238				2143.25	2160.18	9/12/94	192.80	1950.45	1967.38	4/10/95	179.36	1963.89	1980.82
5515R01	Liberty Lake Improvement Dist.	Sprague well	2921346.21	261987.44	1961	155	110	155	48	Steel	P	2073.32	2090.25	9/12/94	123.85	1949.47	1966.40	4/10/95	102.83	1970.49	1987.42
5516C01	Inland Empire Paper	USGS Monitoring Well	2914841.85	266414.46		129						2056.43	2073.36	9/12/94	112.38	1944.05	1960.98	4/10/95	100.01	1956.42	1973.35
5517D04	Consolidated Irr. Dist. (CID)	Greenacres, 4D	2907493.19	266652.89	1964	229	152	217	20	Steel	S	2029.35	2046.28	9/14/94	85.10	1944.25	1961.18				
5517Q01	Spokane Gun Club		2909948.13	261528.12	1950	287	221	283	8	Steel	P	2046.02	2062.95	9/12/94	104.40	1941.62	1958.55	4/10/95	92.00	1954.02	1970.95
6219A01	Riverside State Park	Offroad Vehicle Park	2809279.61	286985.8	1978	303	293	303	6	Steel	S	1881.15	1898.08	9/13/94	265.65	1615.50	1632.43	4/11/95	261.60	1619.55	1636.48
6221C05	City of Spokane	North Landfill MW-K	2818288.87	288932.43		100	81	96	6	Steel	S	1665.50	1682.43	9/12/94	65.30	1600.20	1617.13	4/11/95	61.46	1604.04	1620.97
6221D04	City of Spokane	North Landfill MW-H	2816491.24	287854.7		66	47	62	6	Steel	S	1638.81	1655.74	9/12/94	38.43	1600.38	1617.31	4/11/95	34.78	1604.03	1620.96
6221K01	City of Spokane	North Landfill MW-E	2819031.5	285582.32		121	102	117	6	Steel	S	1658.76	1675.69	9/12/94	59.04	1599.72	1616.65	4/11/95	55.02	1603.74	1620.67
6227F01	Spokane County (208 Well)	North Landfill	2823406.78	280316.71	1977	126	51	126	6		P	1689.82	1706.75	9/13/94	77.82	1612.00	1628.93	4/11/95	64.05	1625.77	1642.7
6234N03	Fairmont Cemetery	Fairmont Cemetery Well	2822478.94	274409.69	1958	71	40		12	Steel		1643.63	1660.56	9/16/94	15.88	1627.75	1644.68	4/13/95	11.60	1632.03	1648.96
6303N01	Spokane County WD #3	Cherry	2852366.75	301177.57		180	135	180				1863.07	1880.00	9/13/94	120.60	1742.47	1759.40	4/12/95	117.85	1745.22	1762.15
6306H01	Morgan; Ron		2840500	303500		136						1666.89	1683.82	9/13/94	71.10	1595.79	1612.72	4/12/95	69.52	1597.37	1614.3
6307G04	Whitworth WD #2	#3B	2839902.43	299183.89	1979	200	180	200	20	Steel	S	1816.07	1833.00	9/14/94	115.51	1700.56	1717.49	4/12/95	110.05	1706.02	1722.95
6308C02	Acme Materials	Acme Farwell (Old Corral)	2843038.45	300750.53		< 100						1745.57	1762.50	9/13/94	34.55	1711.02	1727.95				
6309N01	Kaiser-Mead	TH-5	2848313	296973		< 175						1906.09	1923.02	9/13/94	145.50	1760.59	1777.52	4/12/95	144.85	1761.24	1778.17
6310K01	Spokane County WD #3	Market & Guy	2855246.69	298134.23		116	94	106				1902.40	1919.33	9/13/94	98.82	1803.58	1820.51	4/12/95	86.82	1815.58	1832.51
6316Q01	BPA NW	MW-3	2850570.68	293610.39	1991	165	140	160	2	Steel	S	1942.33	1959.26	9/13/94	154.65	1787.68	1804.61	4/12/95	153.90	1788.43	1805.36
6317J01	NW Pipeline Co.		2845885.37	292922.6	1961	248	228	243	6		P	1953.42	1970.35	9/14/94	177.15	1776.27	1793.20	4/12/95	174.38	1779.04	1795.97
6318B01	Whitworth College	New Well	2840062.42	294100.76	1986	282	252	282	16		S	1917.33	1934.26	9/13/94	171.98	1745.35	1762.28	4/12/95	168.75	1748.58	1765.51
6319A02	Whitworth Water Dist. #2	2A	2841879.37	289794.31	1979	228	180	220	20		S	1946.48	1963.41	9/14/94	154.34	1792.14	1809.07	4/12/95	149.49	1796.99	1813.92
6320D01	Whitworth Water Dist. #2	2B	2840576.3	289991.26	1962	286	253	286	16		S	1936.04	1952.97	9/14/94	143.46	1792.58	1809.51	4/12/95	138.22	1797.82	1814.75
6321J01	Acme Materials	Crestline well	2850046.78	287517.58	1980	238	213	233	8		S	2009.99	2026.92	9/14/94	194.46	1815.53	1832.46	4/12/95	189.95	1820.04	1836.97
6322N03	JB Richardson	Fisher Well	2852856.09	285310.28	1986	275	239	254	12	Steel	S	2017.71	2034.64	9/14/94	187.08	1830.63	1847.56	4/12/95	181.82	1835.89	1852.82
6327H01	Spokane Humane Society		2858219.13	281307.35	1976	225			6	Steel		1988.85	2005.78	9/15/94	140.25	1848.60	1865.53	4/12/95	132.62	1856.23	1873.16
6328M02	Ray Turf Farm		2847727.9	282156.47	1940	250			84			2051.75	2068.68	9/14/94	215.61	1836.14	1853.07	4/12/95	209.61	1842.14	1859.07
6330H02	Holy Cross Cemetary	New well	2841168.6	282952.76		310	270	310	18	Steel	S	2041.58	2058.51	9/15/94	215.75	1825.83	1842.76	4/12/95	204.00	1837.58	1854.51
6330P03	US West	MW-3	2838489.82	279537.28		234	214	234	4	PVC	S	2063.47	2080.40	9/15/94	224.44	1839.03	1855.96	4/12/95	217.49	1845.98	1862.91
6331A02	City of Spokane	Central Well #1	2841737	278376	1959	272	220	272	96			1866	1883	9/15/94		1832.82	1849.75	4/11/95		1845.98	1862.91
6331A03	City of Spokane	Central Well #2	2841737	278376	1959	272	220	272	96			1866	1883	9/15/94				4/11/95		1846.82	1863.75
6331J01	City of Spokane	Franklin Park MW	2843278.47	275663.14	1994	222	208	218	2	PVC	S	2058.84	2075.77	9/13/94	209.24	1849.60	1866.53	4/11/95	202.12	1856.72	1873.65
6432Q02	Pleasant Prairie WD		2876833.62	275785.43	1987	139	129	139	8	Steel	S	1988.44	2005.37	9/13/94	90.95	1897.49	1914.42	4/11/95	80.45	1907.99	1924.92
6525J01	Spokane County (208 Well)	Idaho Rd #2 (Near Trent Rd.)	2931709.11	287972.16	1977	190			6	Steel	OH	2103.72	2120.65	9/12/94	139.20	1964.52	1981.45	4/11/95	127.24	1976.48	1993.41
6526H03	Pentler; Virgil	Trent & Starr Rds	2926456.72	286574.43		< 150						2066.64	2083.57	9/12/94	108.22	1958.42	1975.35	4/11/95	95.75	1970.89	1987.82
6532J02	Schmidt; Wes	Schmidt Well	2910855.42	280374.9	1954	152			8			2098.79	2115.72	9/12/94	151.74	1947.05	1963.98	4/11/95	138.95	1959.84	1976.77
6536N02	Boshears; Dell	Boshears; Dell	2926808.8	278761.39		< 150						2069.45	2086.38	9/12/94	113.60	1955.85	1972.78	4/11/95	101.30	1968.15	1985.08
6619N01	Spokane County (208 Well)	Idaho Rd #1 (Beck)	2931620.14	288776.81		263			6	Steel	OH	2080.39	2097.32	9/12/94	117.22	1963.17	1980.10	4/11/95	104.35	1976.04	1992.97



LEGEND

+ LOCATION MONITORED

1970 GROUNDWATER ELEVATION CONTOUR

NOTE:

CITY OF SPOKANE DATUM, WHICH IS 16.92 FEET HIGHER THAN NAD 1927 DATUM.

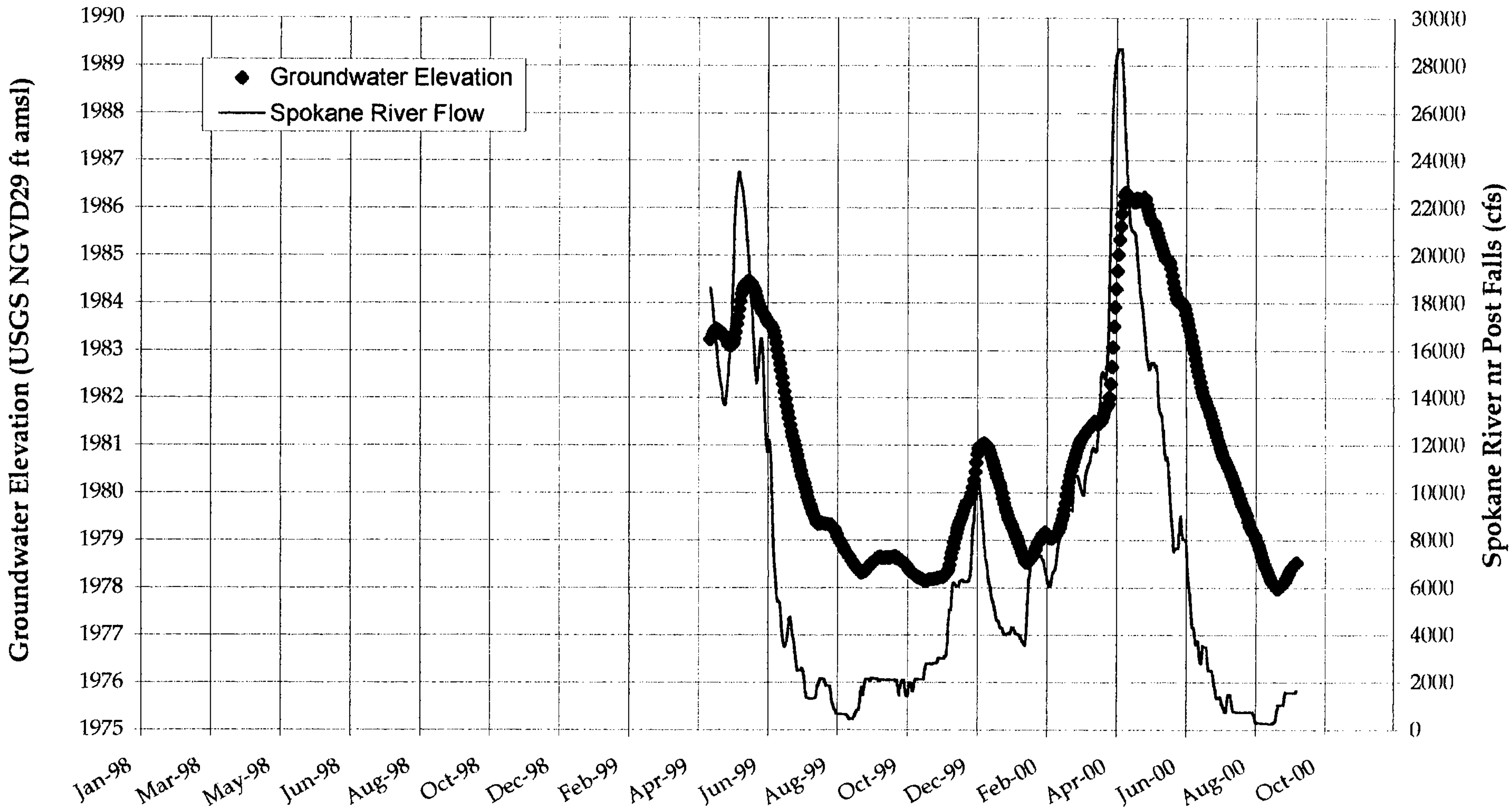
FIGURE 2-2
DATA COLLECTION POINTS AND WATER TABLE MAP FOR THE DISCRETE MONITORING EVENT
OCTOBER 30, 1996

CH2MHILL

APPENDIX D2 - GROUNDWATER HYDROGRAPHS

Table of Contents

Groundwater Hydrograph Information



Data Source: Spokane County
Date Type : Daily averages from transducer data
Station Name: Idaho Road nr Pipeline
Station ID: 6525R01

FIGURE D2-1:
Idaho Road nr Pipeline Well
5/1999-9/2000

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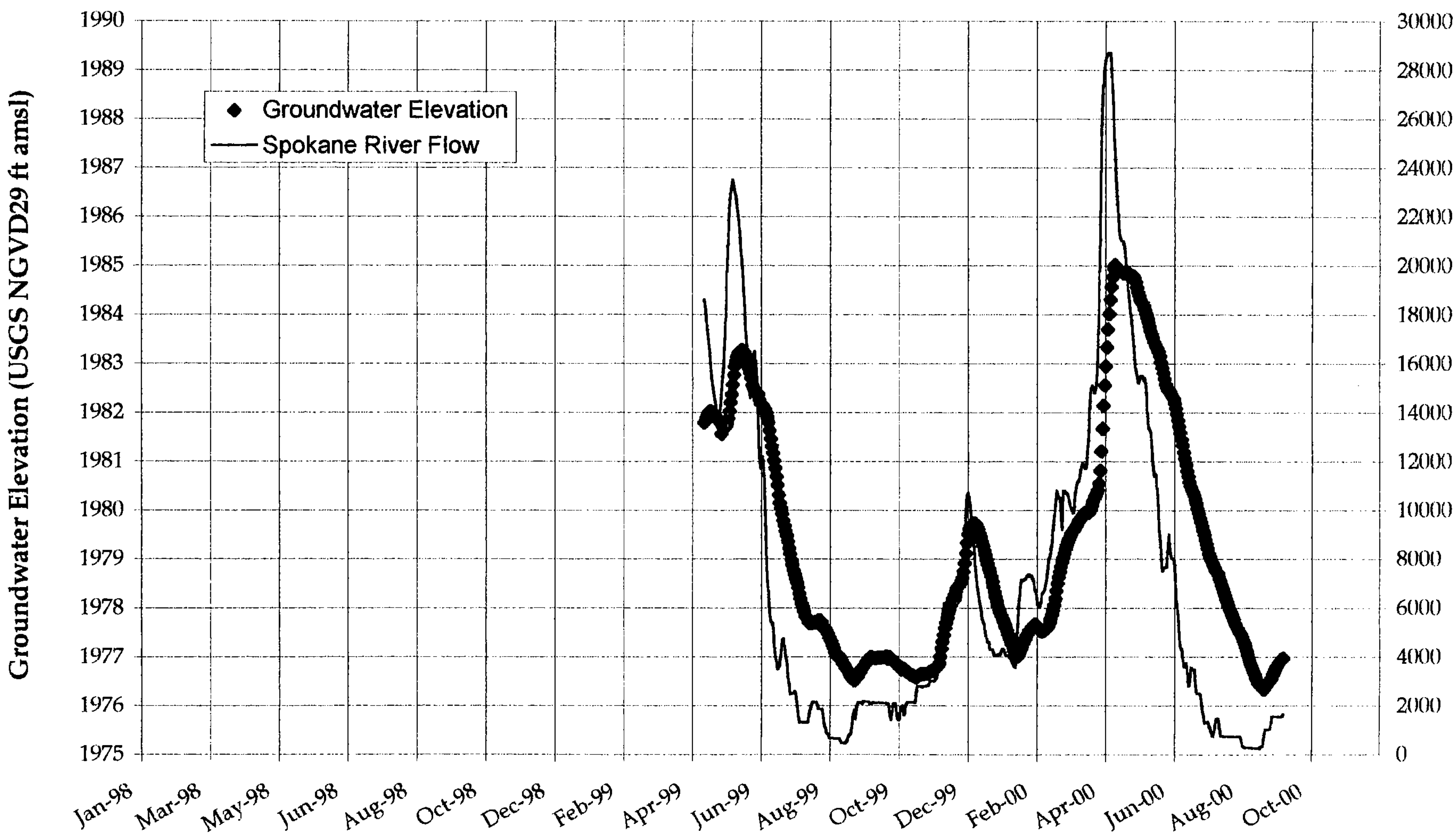

Data Source: Spokane County
Date Type : Daily Averages
Station Name: CID-11 / Idaho Road Well
Station ID: 6631M07

FIGURE D2-2:
CID 11 / Idaho Road
5/1999-9/2000

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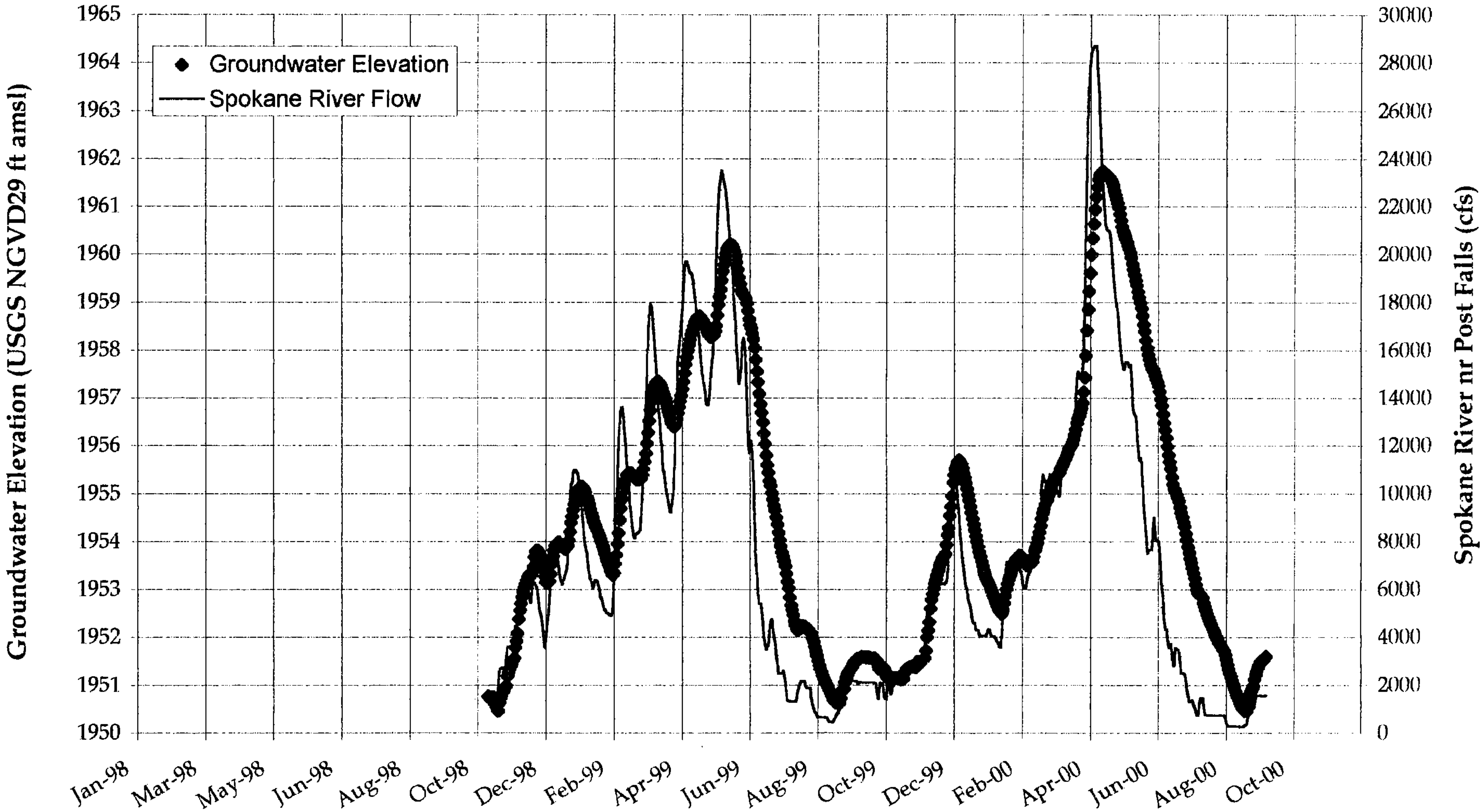
D2-2 CID-11-idaho.xls/D2-2 hydro



Data Source: Spokane County
Date Type : Daily averages from transducer data
Station Name: Barker Road North, Barker North
Station ID: 5507H01

FIGURE D2-3:
Barker Road North Well
(Barker North)
11/1998-9/2000

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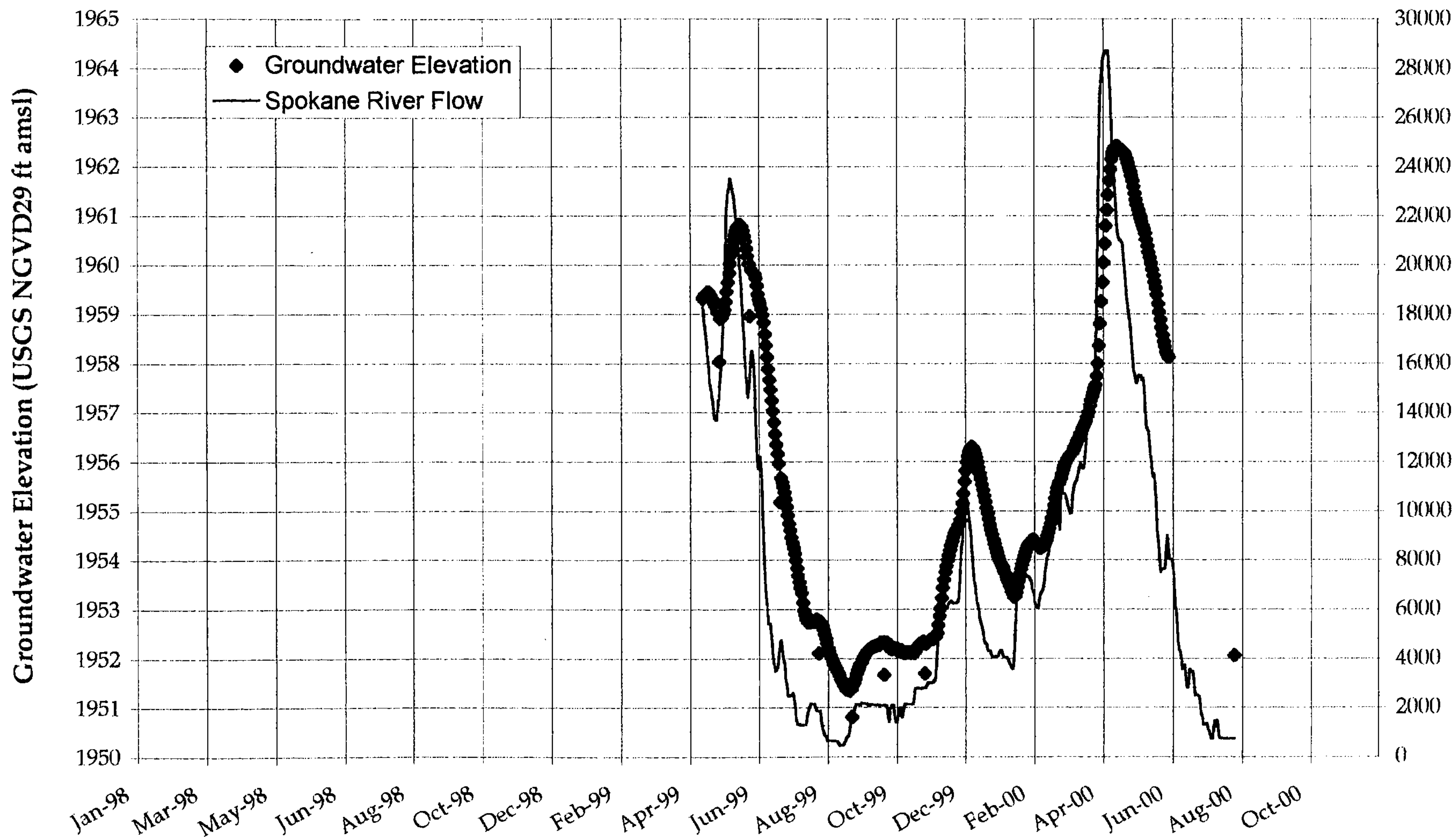
D2-3 barkerN.xls/D2- 3 hydro



Data Source: Spokane County
Date Type : Daily averages from transducer data
Station Name: Barker and Euclid, CID Barker North
Station ID: 5507A04

FIGURE D2-4:
Barker and Euclid Well
(CID Barker N)
5/1999-8/2000

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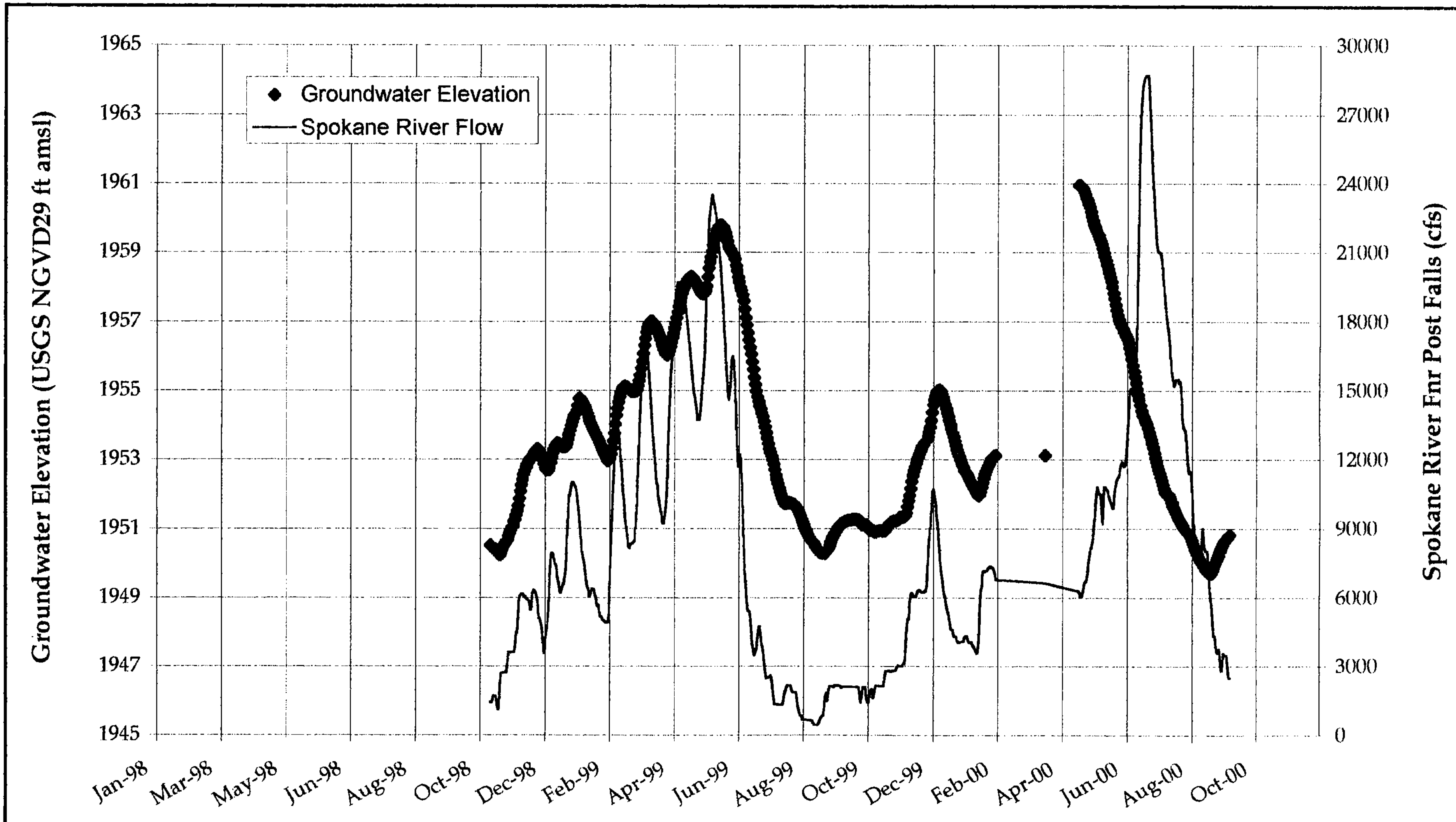
D2-4 barkereuclid.xls/D2-4 hydro



Data Source: Spokane County
Date Type : Daily averages from transducer data
Station Name: Barker and Centennial Trial S Well, Barker South 1
Station ID: 5508M02

FIGURE D2-5:
Barker and Centennial Trail S Well
(Barker South 1)
11/1998-9/2000

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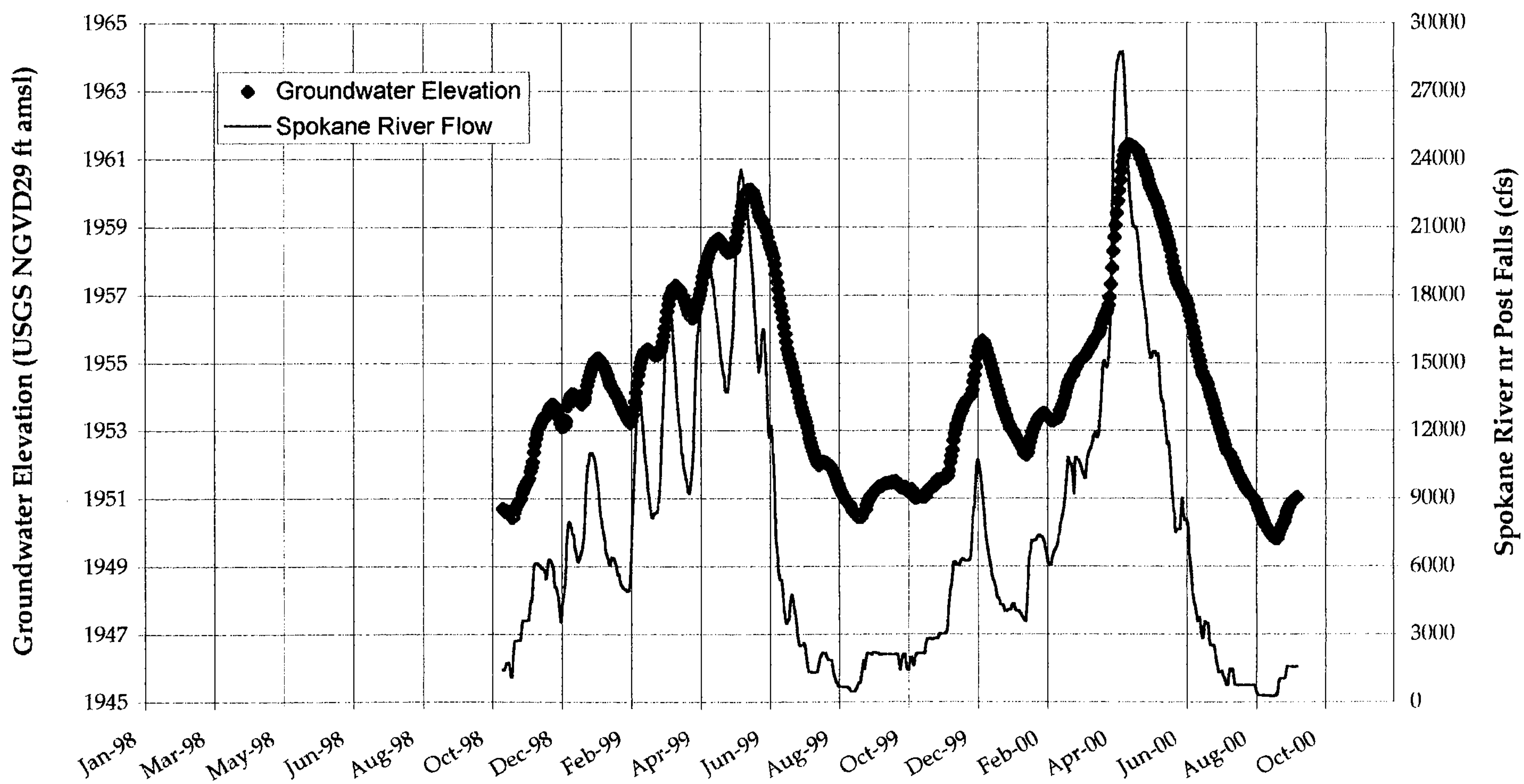

Data Source: Spokane County
Date Type : Daily Averages
Station Name: Barker and Centennial Trail N, Barker South 2
Station ID: 5508M01

FIGURE D2-6:
Barker and Centennial Trail North Well
(Barker South 2)
11/1998-9/2000

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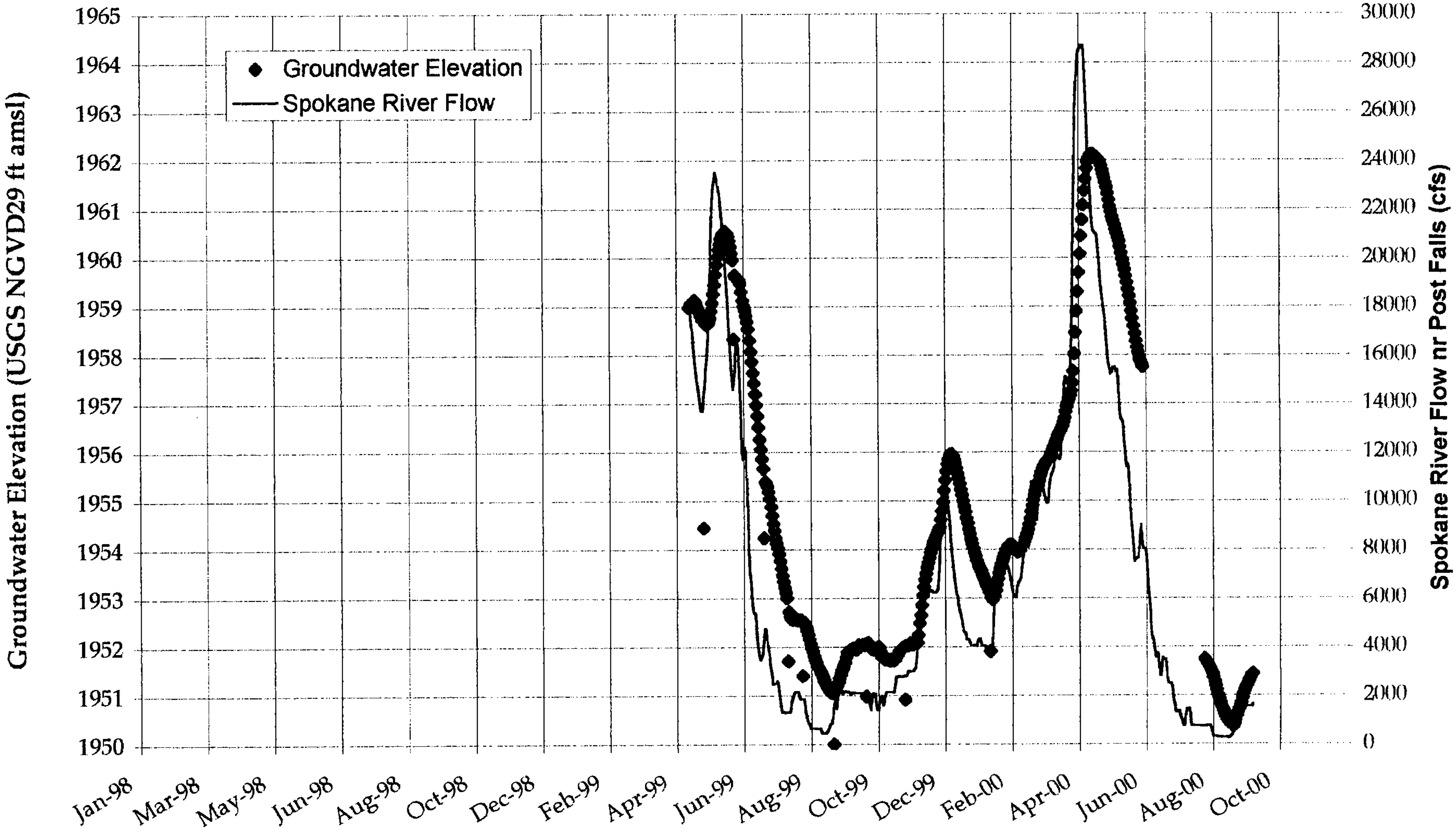

Data Source: Spokane County
Date Type : Daily averages from transducer data
Station Name: Barker and Mission Well, CID Barker S
Station ID: 5517D05

FIGURE D2-7:
Barker and Mission Well
(CID Barker S)
5/1999-9/2000

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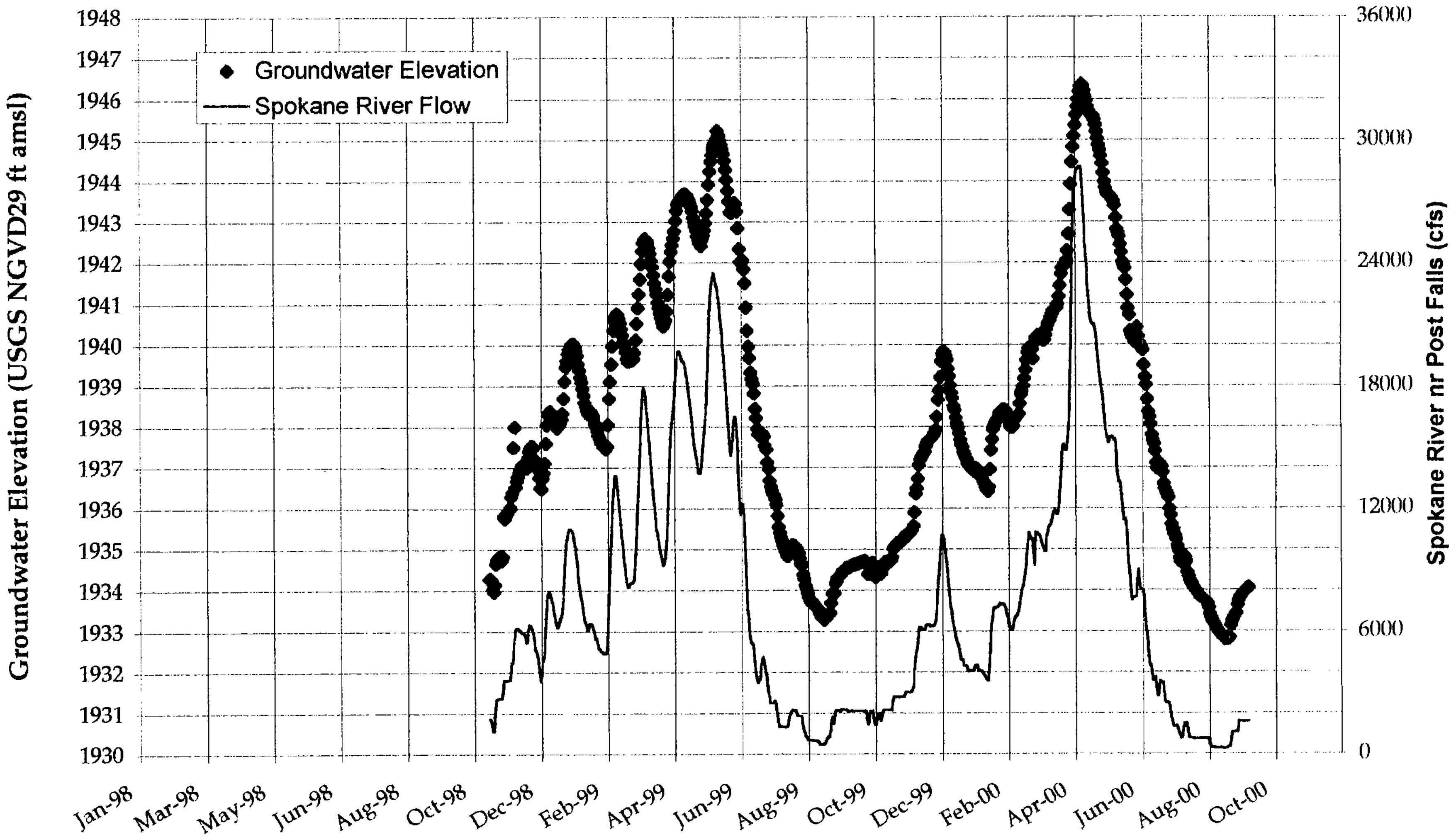
D2-7 barkermission.xls/D2-7 hydro



Data Source: Spokane County
Date Type : Daily Averages from transducer data
Station Name: Sullivan South
Station ID: 5411R04

FIGURE D2-8:
Sullivan South Well
11/1998-9/2000

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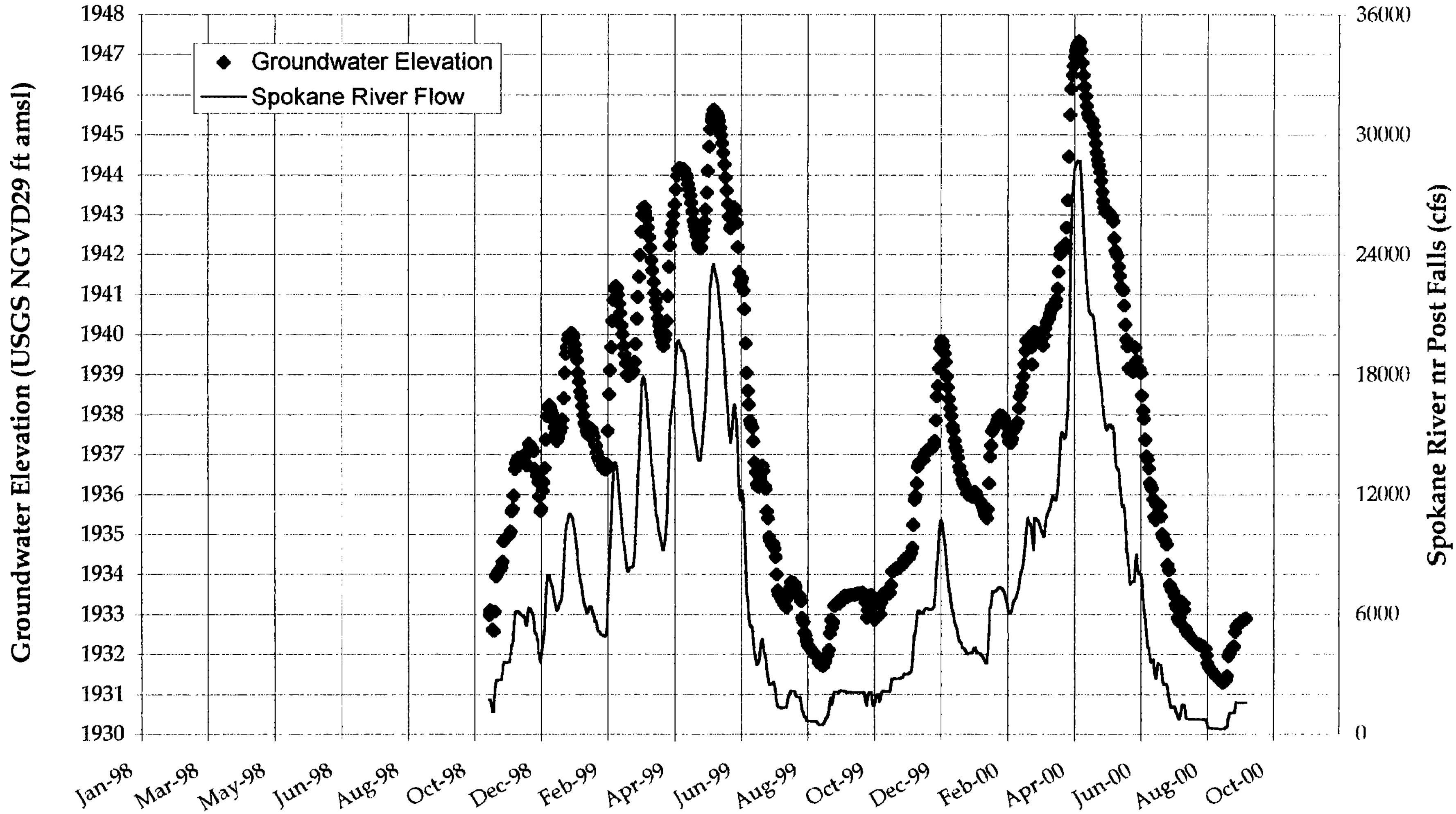
D2-8 sullivanS.xls/D2-8 hydro



Data Source: Spokane County
Date Type : Daily averages from transducer data
Station Name: Sullivan Park South, Sullivan North 2
Station ID: 5411R03

FIGURE D2-9:
Sullivan Park South Well
(Sullivan North 2)
11/1998-9/2000

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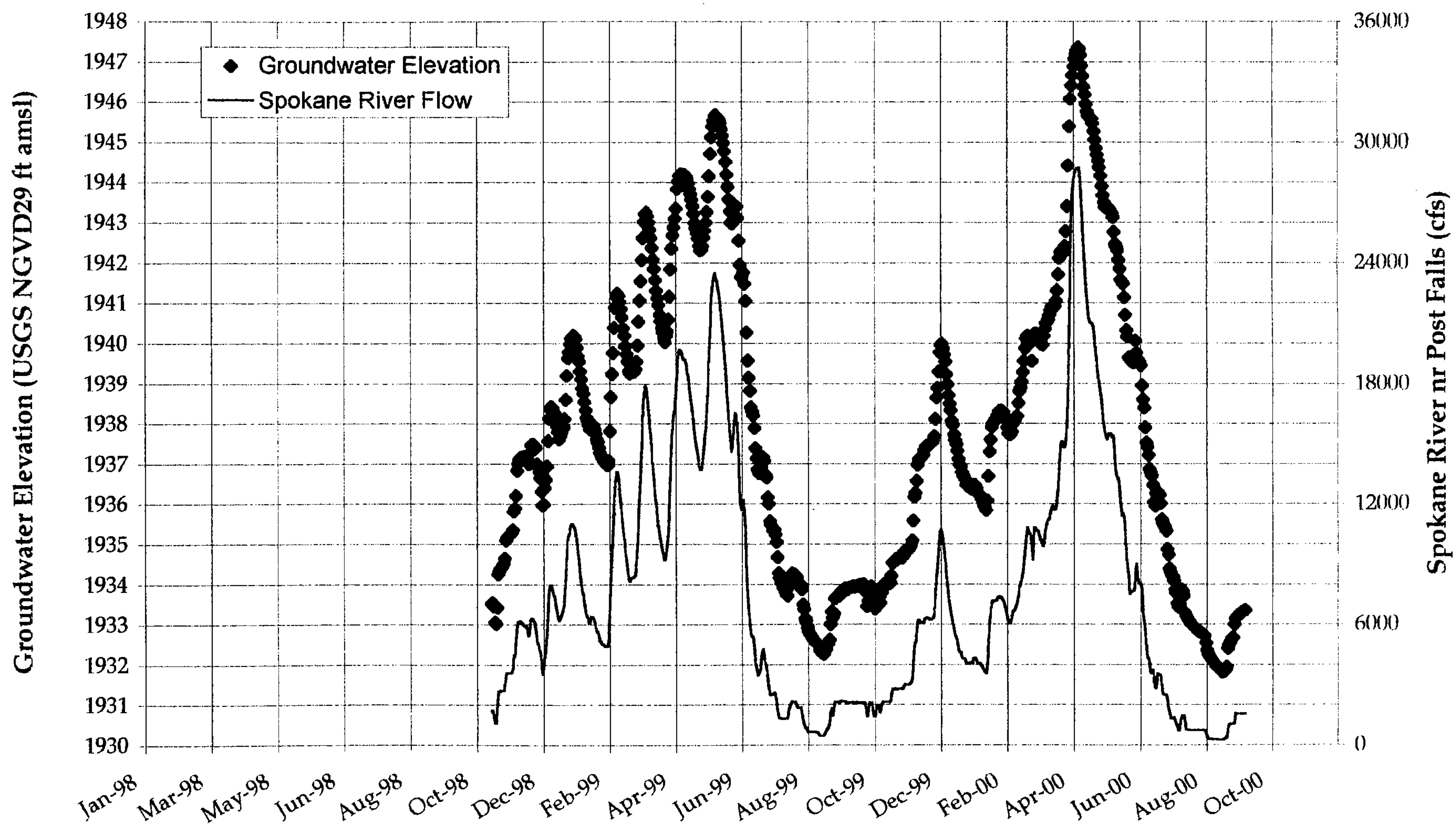

Data Source: Spokane County
Date Type : Daily averages from transducer data
Station Name: Sullivan Park North, Sullivan North 1
Station ID: 5411R02

FIGURE D2-10:
Sullivan Park North Well
(Sullivan North 1)
11/1998-9/2000

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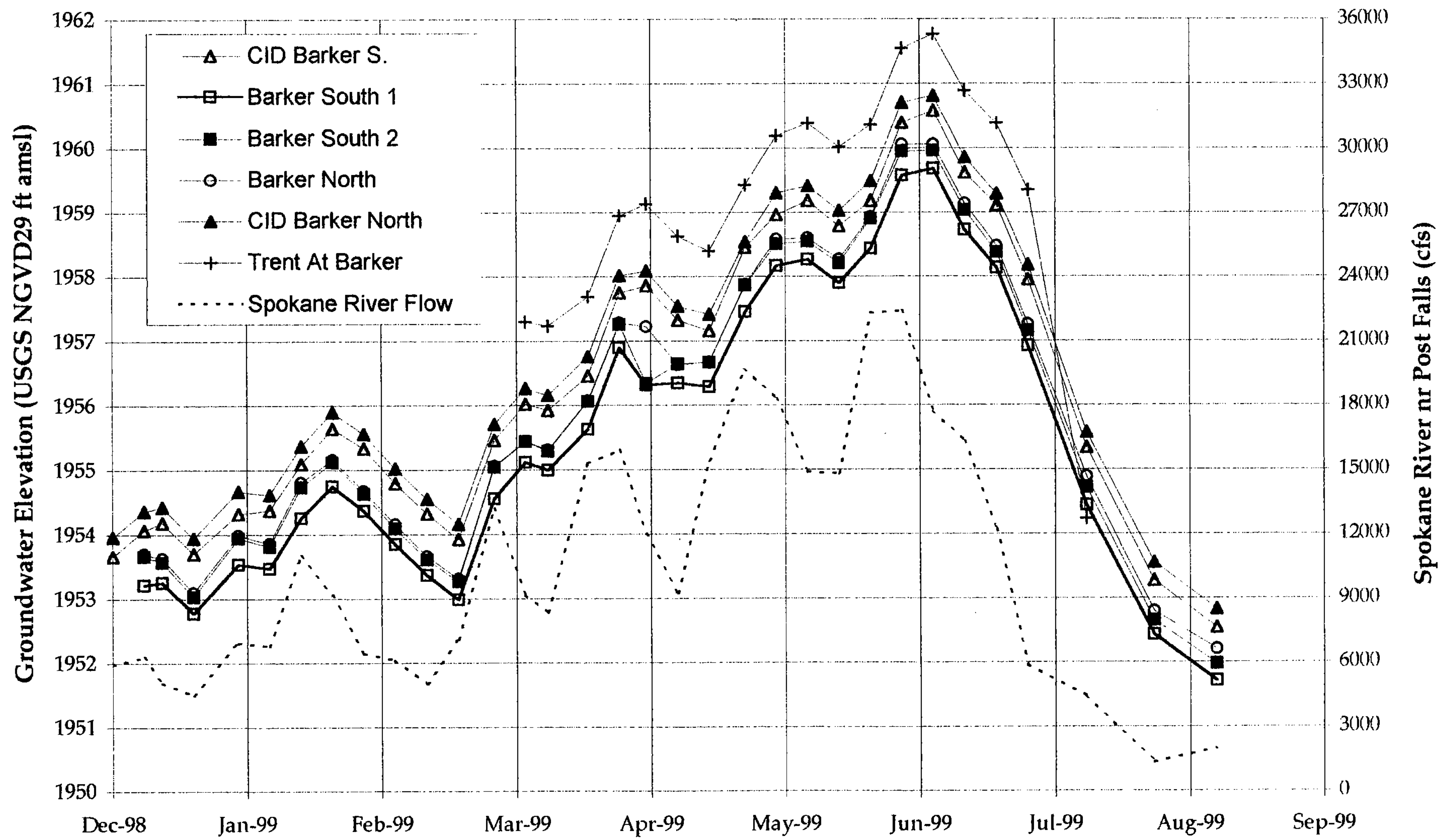

Data Source: Spokane County
Date Type : Weekly
Station Name: Spokane County Baseline Monitoring
Station ID: Barker Wells

FIGURE D2-11:
Spokane County Baseline
Barker Wells

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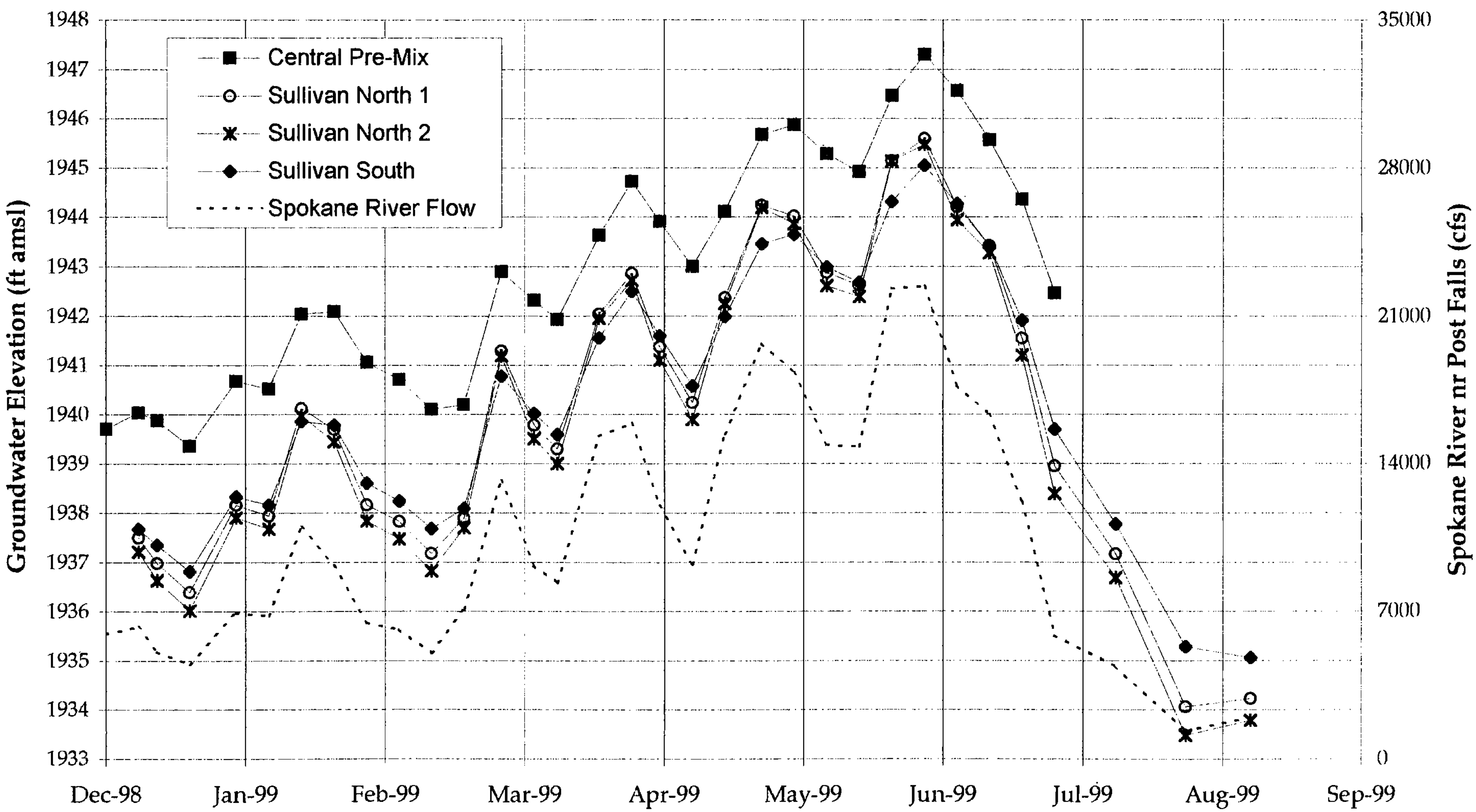
013-1372.1100 April 13, 2001 well data.xls

D2-11to13 SR-SVRP.xls/D2-11 Barker



Data Source: Spokane County
Date Type : Weekly
Station Name: Sullivan Wells
Station ID: na

FIGURE D2-12:
Spokane County Baseline
Sullivan Wells

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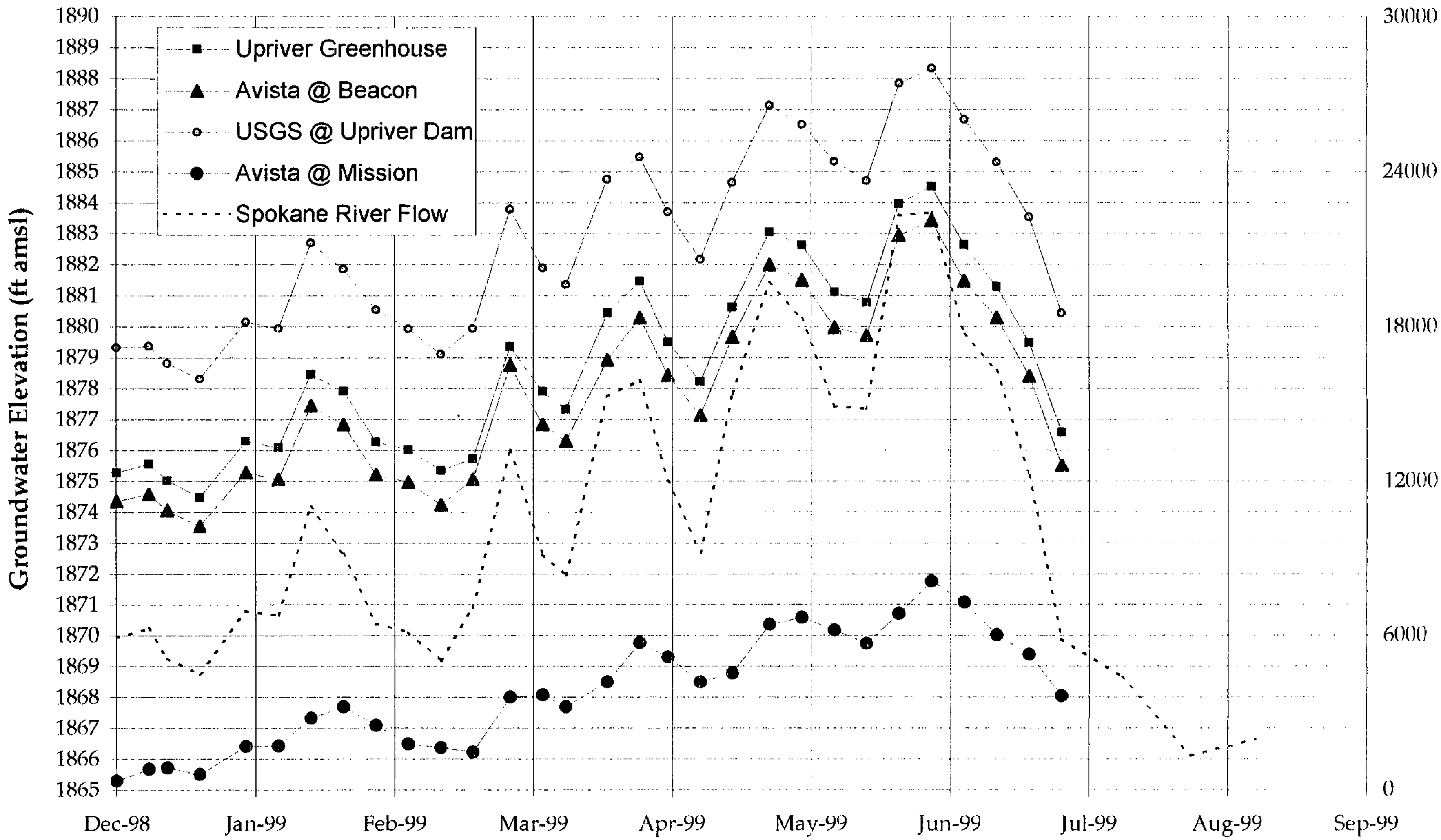
013-1372.1100 April 13, 2001 well data.xls

D2-11to13 SR-SVRP.xls/D2-12 Sullivan



Data Source: Spokane County
Date Type : Weekly
Station Name: Upriver Wells
Station ID: na

FIGURE D2-13:
Spokane County Baseline
Upriver Wells

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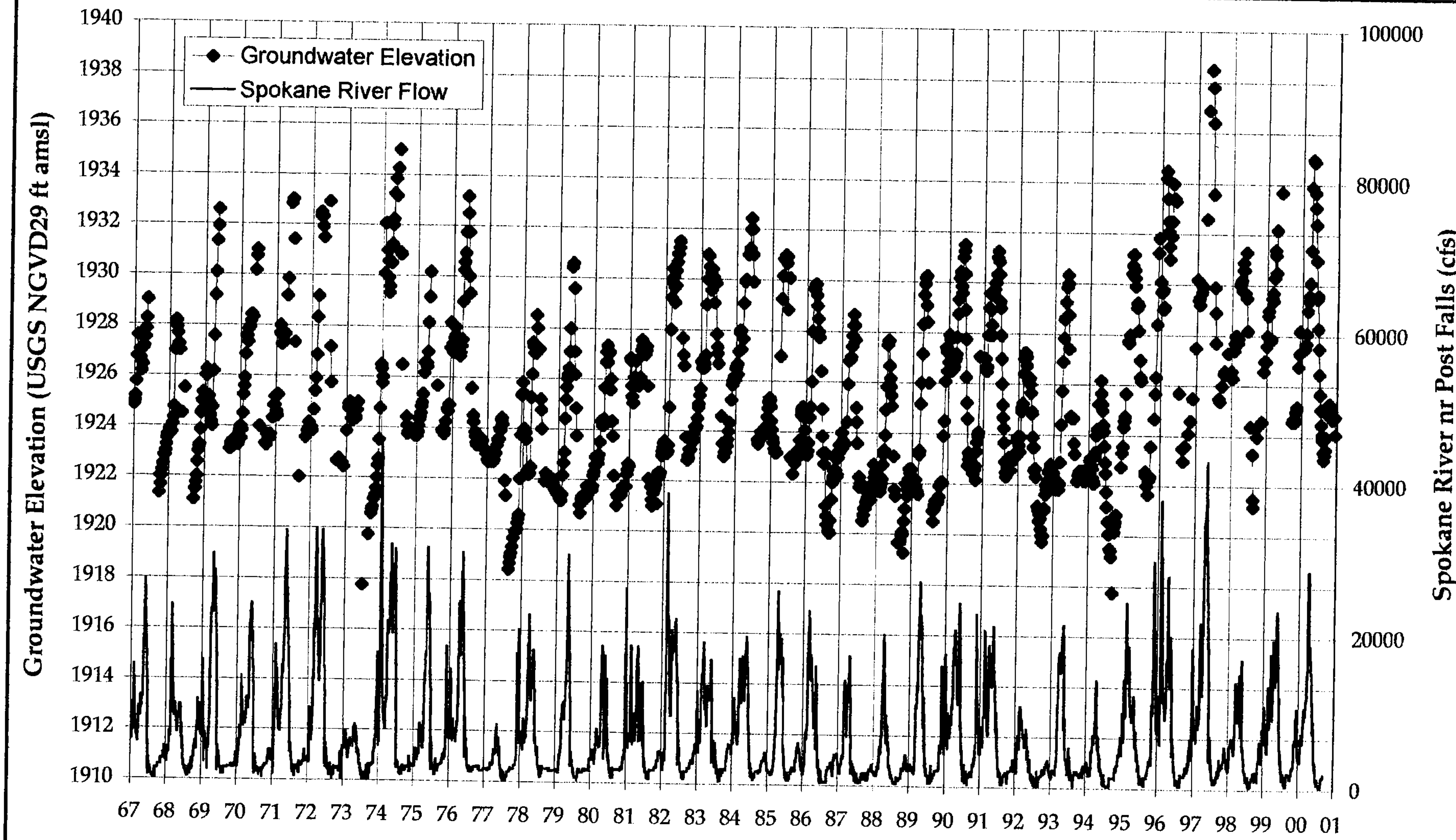
013-1372.1100 April 13, 2001 well data.xls

D2-11to13 SR-SVRP.xls/D2-13 Upriver



Data Source: Vera Water District
Date Type : Weekly
Station Name: Vera Water District Well #1
Station ID: 5415J01

FIGURE D2-14:
Vera Water District Well #1
1/1967-12/2000

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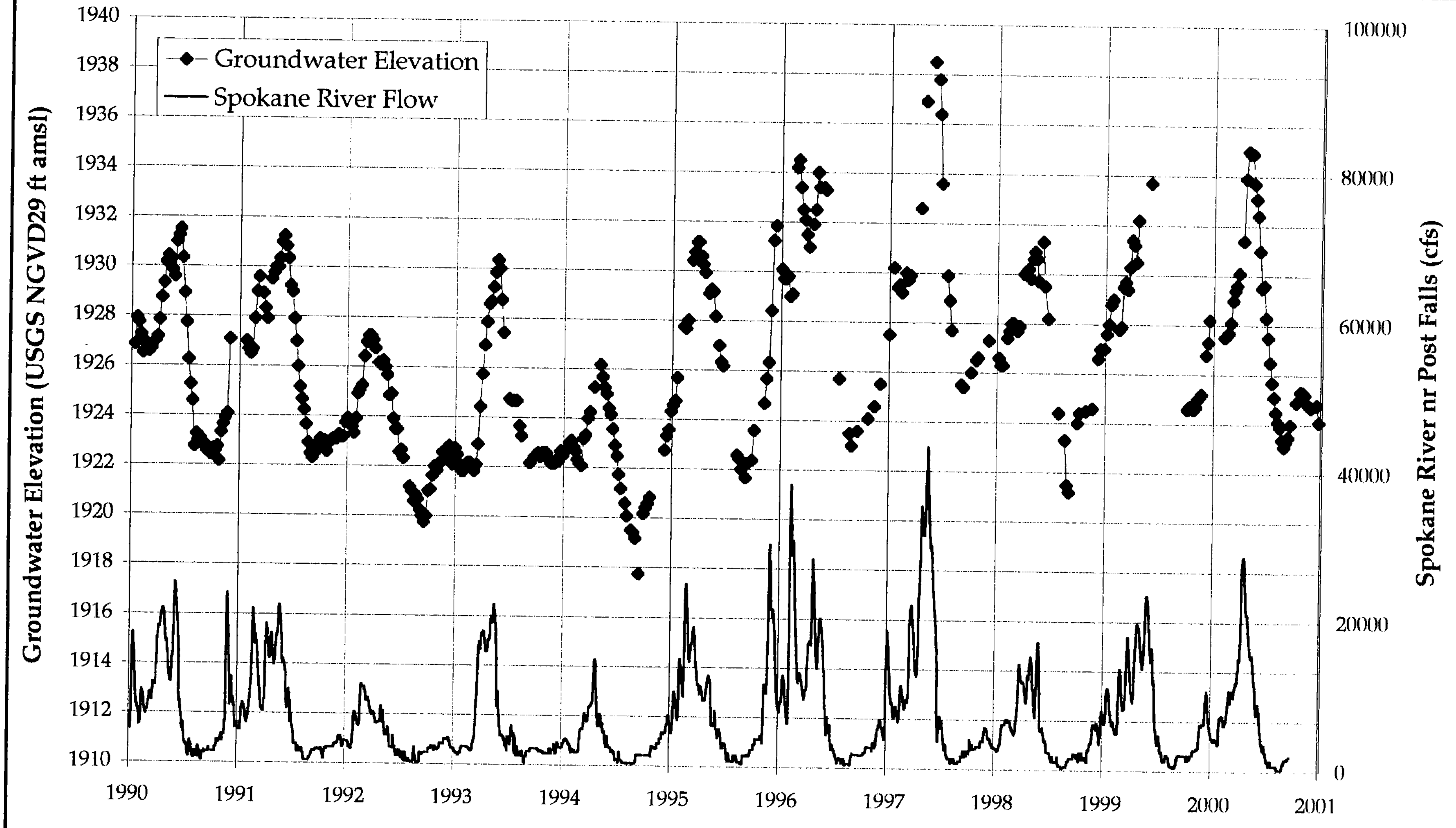
013-1372.1100 April 13, 2001

D2-14to29 Vera.xls/D2-14 Vera #1 all



Data Source: Vera Water District
Date Type : Weekly
Station Name: Vera Water District Well #1
Station ID: 5415J01

FIGURE D2-15:
Vera Water District Well #1
1990 - 2000

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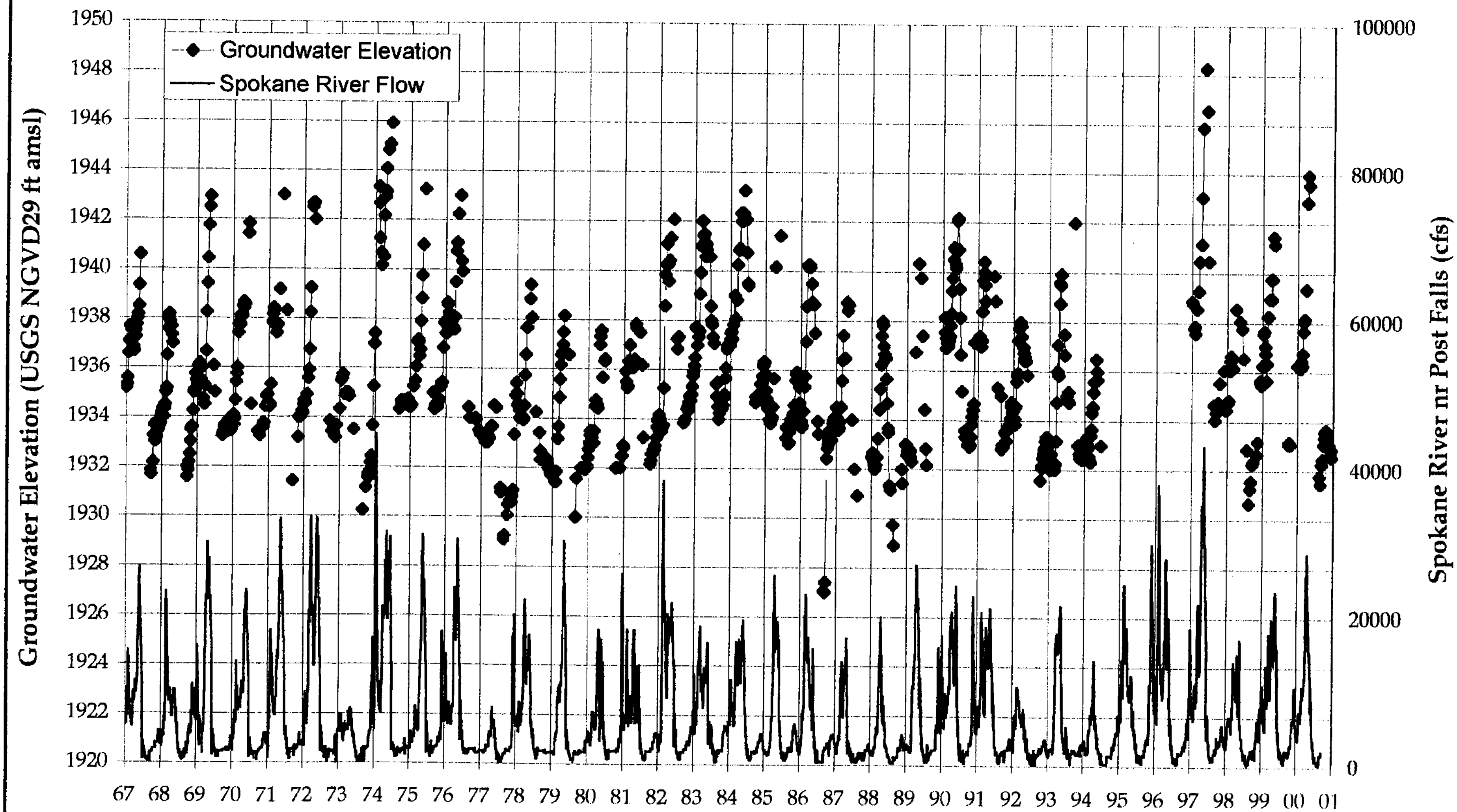
D2-14to29 Vera.xls/D2-15 Vera #1 1990-2000



Data Source: Vera Water District
Date Type : Weekly
Station Name: Vera Water District Well #2
Station ID: 5413M01(1967-1994), 5414J01 (1994 - 2001)

FIGURE D2-16:
Vera Water District Well #2
1/1967-12/2000

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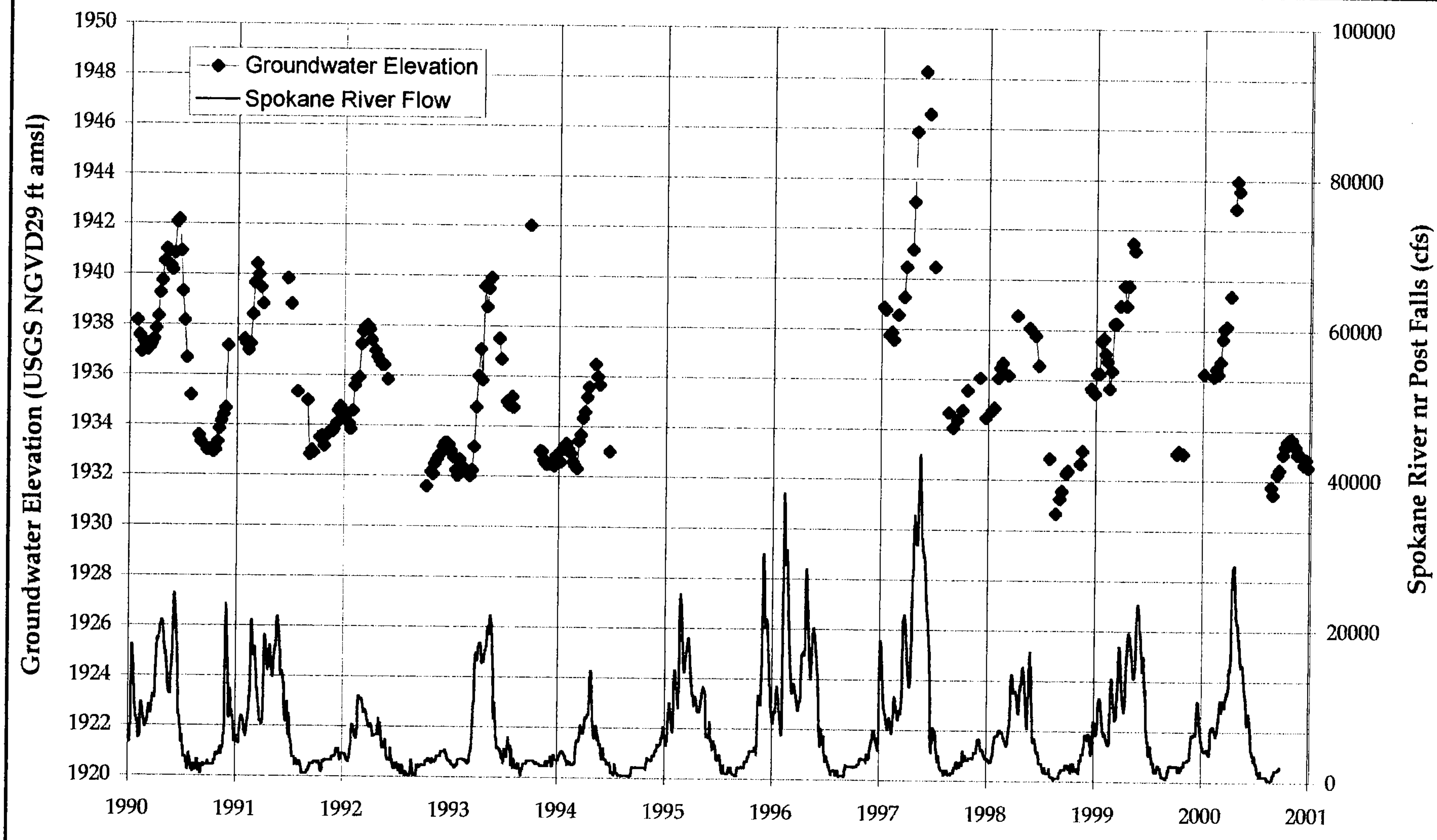
D2-14to29 Vera.xls/D2-16 Vera #2 all



Data Source: Vera Water District
Date Type : Weekly
Station Name: Vera Water District Well #2
Station ID: 5413M01(1967-1994), 5414J01 (1994 - 2001)

FIGURE D2-17:
Vera Water District Well #2
1990 - 2000

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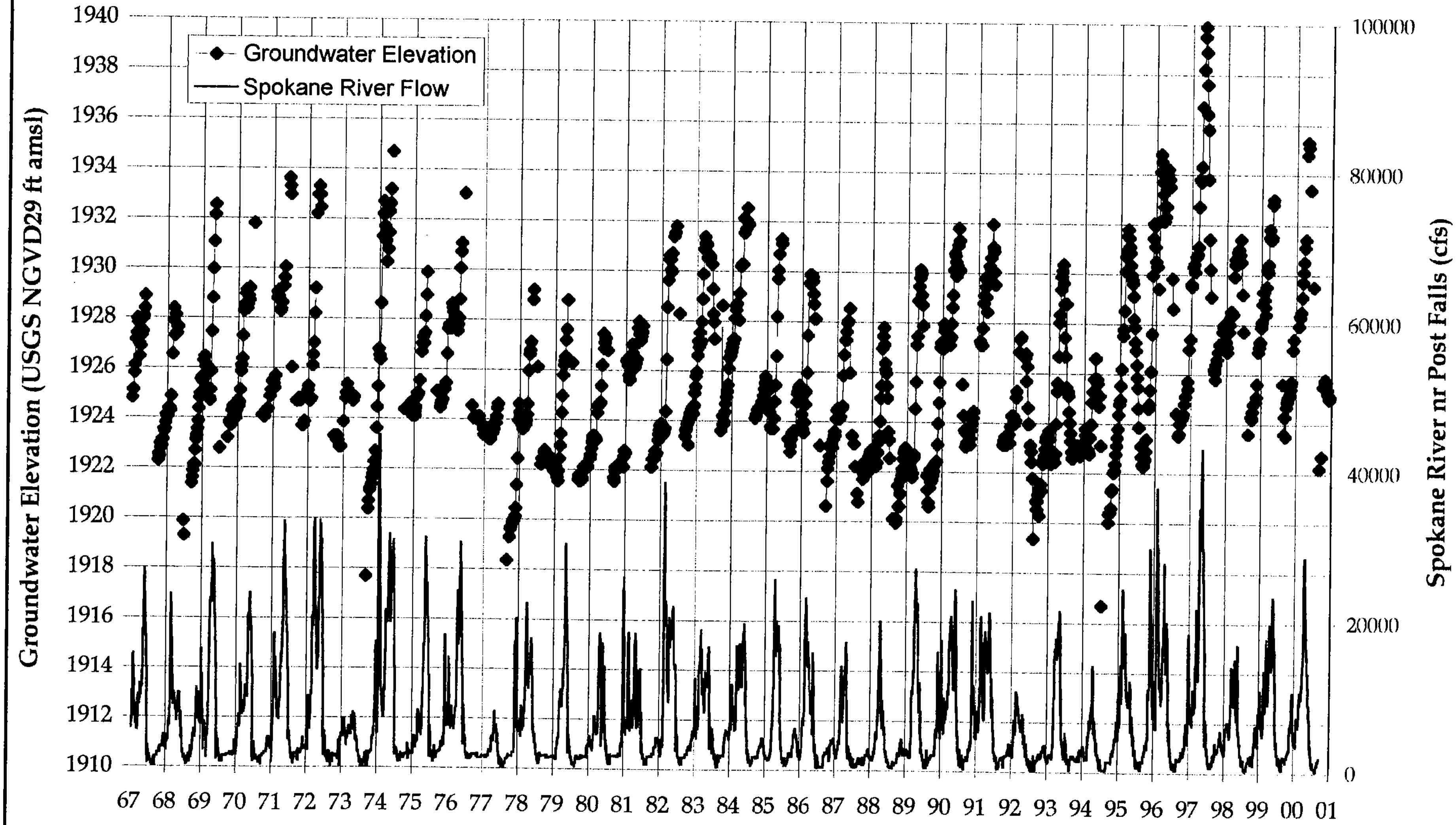
D2-14to29 Vera.xls/D2-17 Vera #2 1990-2000



Data Source: Vera Water District
Date Type : Weekly
Station Name: Vera Water District Well #3
Station ID: 5422R01

FIGURE D2-18:
Vera Water District Well #3
1/1967-12/2000

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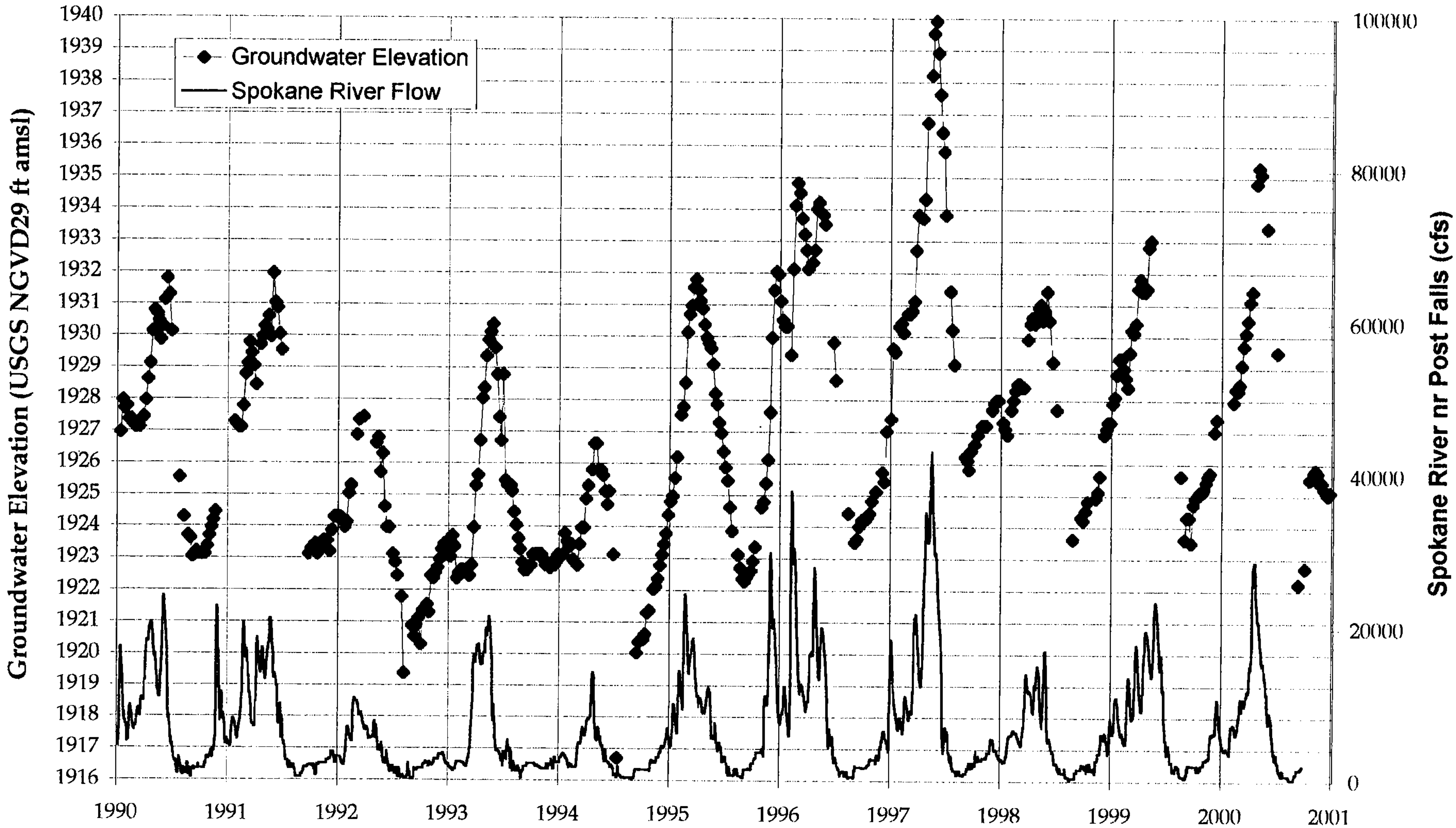
D2-14to29 Vera.xls/D2-18 Vera #3 all



Data Source: Vera Water District
Date Type : Weekly
Station Name: Vera Water District Well #3
Station ID: 5422R01

FIGURE D2-19:
Vera Water District Well #3
1990 - 2000

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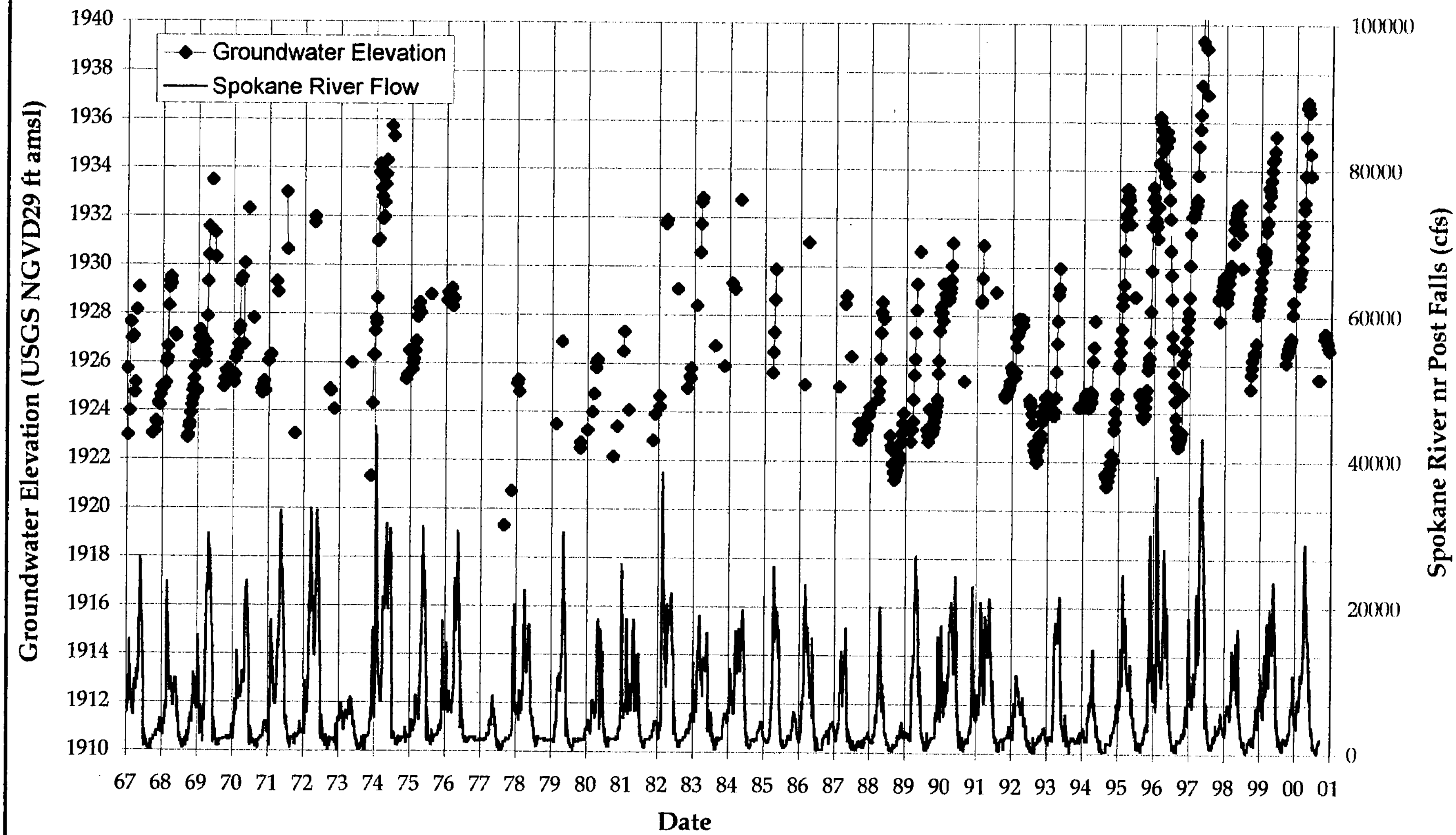
D2-14to29 Vera.xls/D2-19 Vera #3 1990-2000



Data Source: Vera Water District
Date Type : Weekly
Station Name: Vera Water District Well #4
Station ID: 5426L01

FIGURE D2-20:
Vera Water District Well #4
1/1967-12/2000

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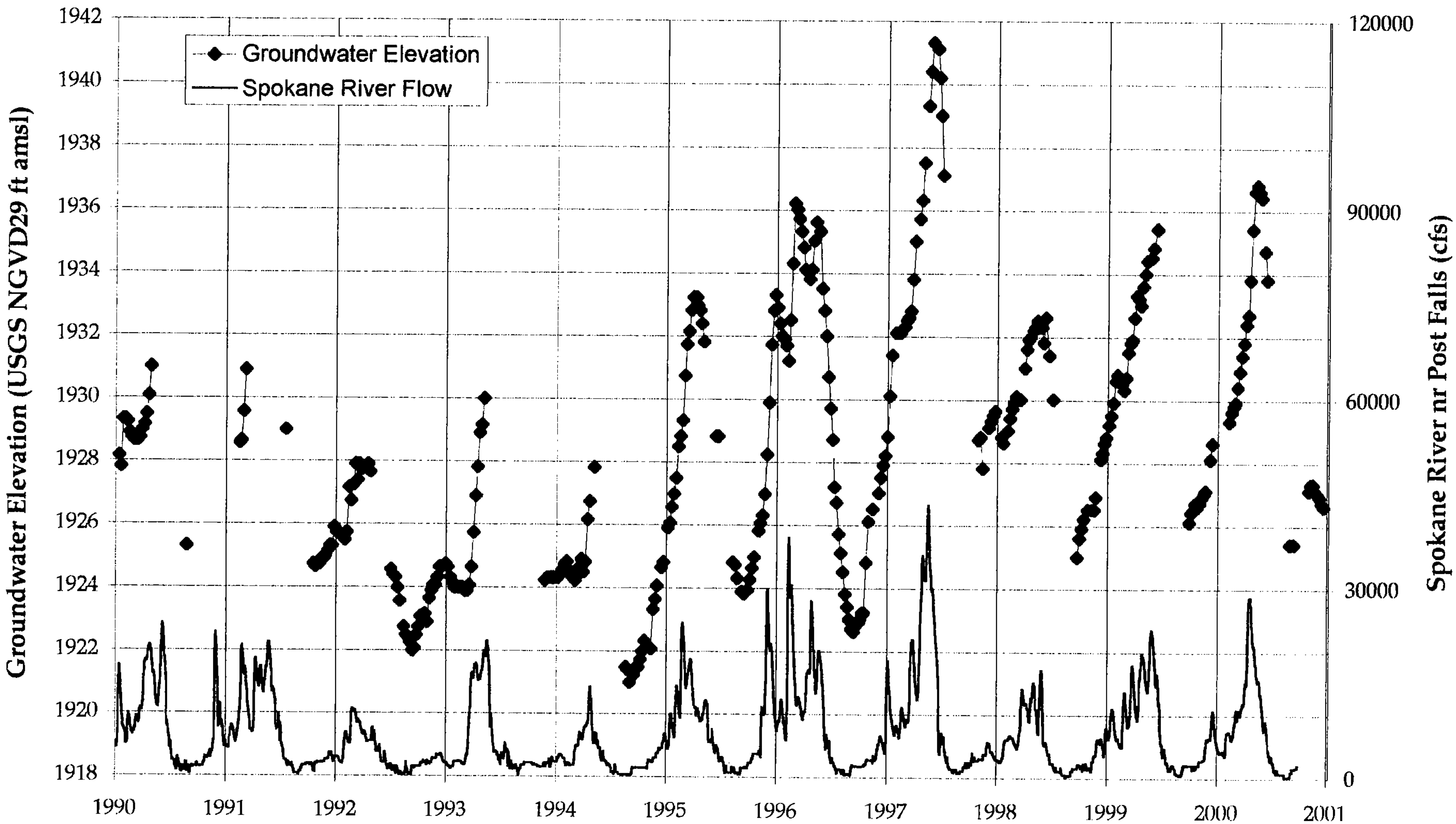
D2-14to29 Vera.xls/D2-20 Vera #4



Data Source: Vera Water District
Date Type : Weekly
Station Name: Vera Water District Well #4
Station ID: 5426L01

FIGURE D2-21:
Vera Water District Well #4
1990 - 2000

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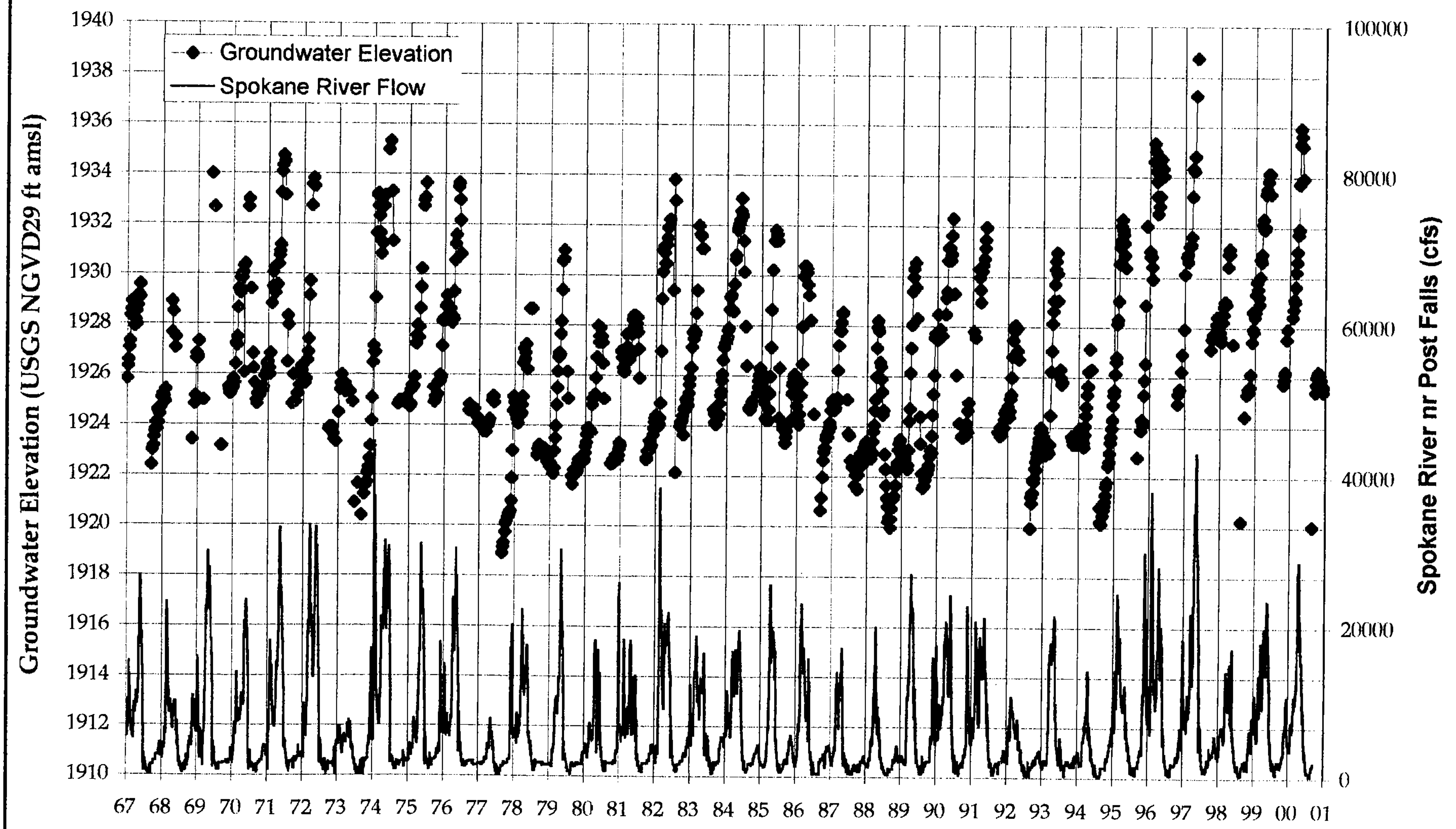
D2-14to29 Vera.xls/D2-21 Vera #4 1990-2000



Data Source: Vera Water District
Date Type : Weekly
Station Name: Vera Water District Well #5
Station ID: 5426D01

FIGURE D2-22:
Vera Water District Well #5
1/1967-12/2000

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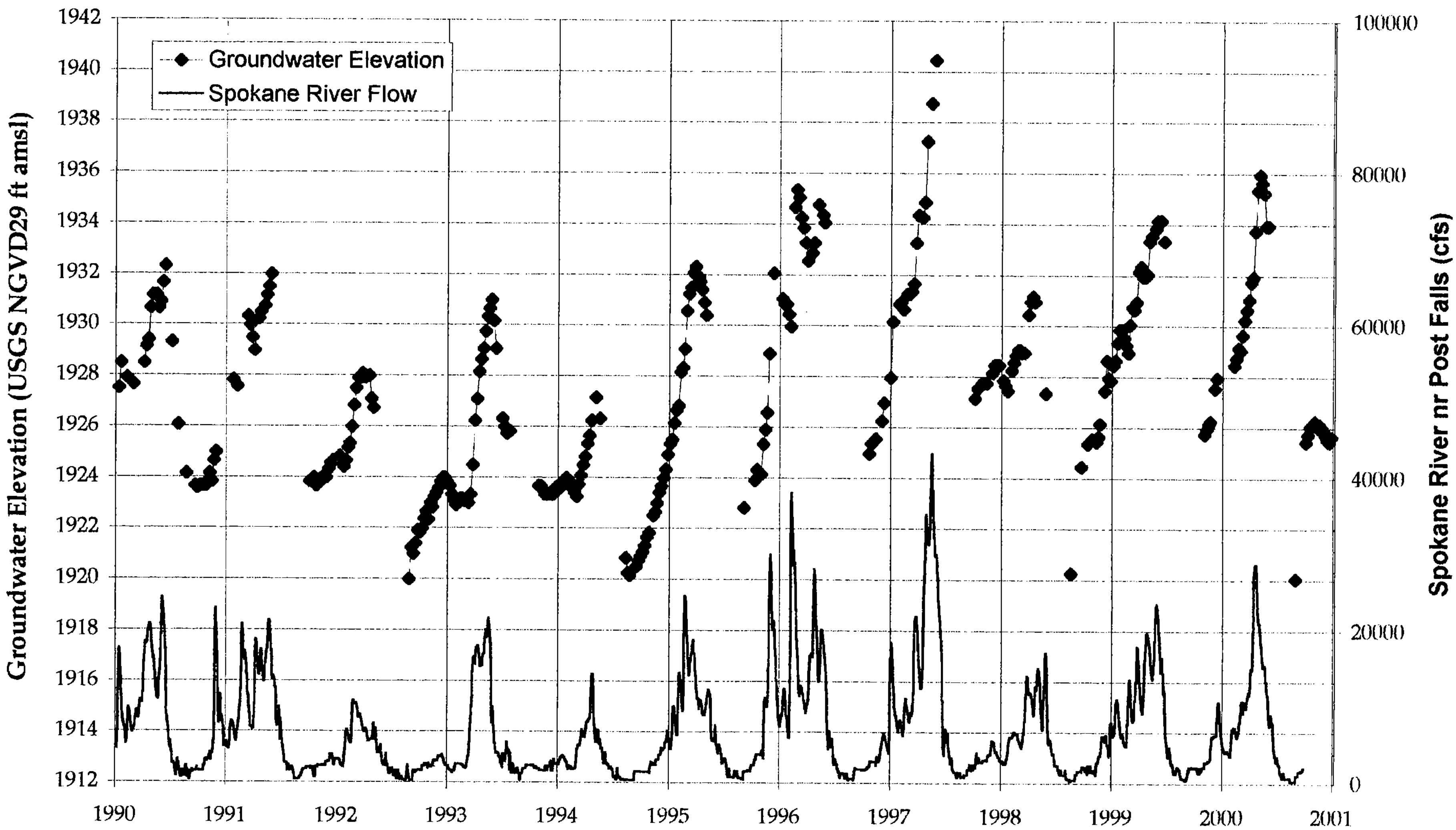
D2-14to29 Vera.xls/D2-22 Vera #5



Data Source: Vera Water District
Date Type : Weekly
Station Name: Vera Water District Well #5
Station ID: 5426D01

FIGURE D2-23:
Vera Water District Well #5
1990 - 2000

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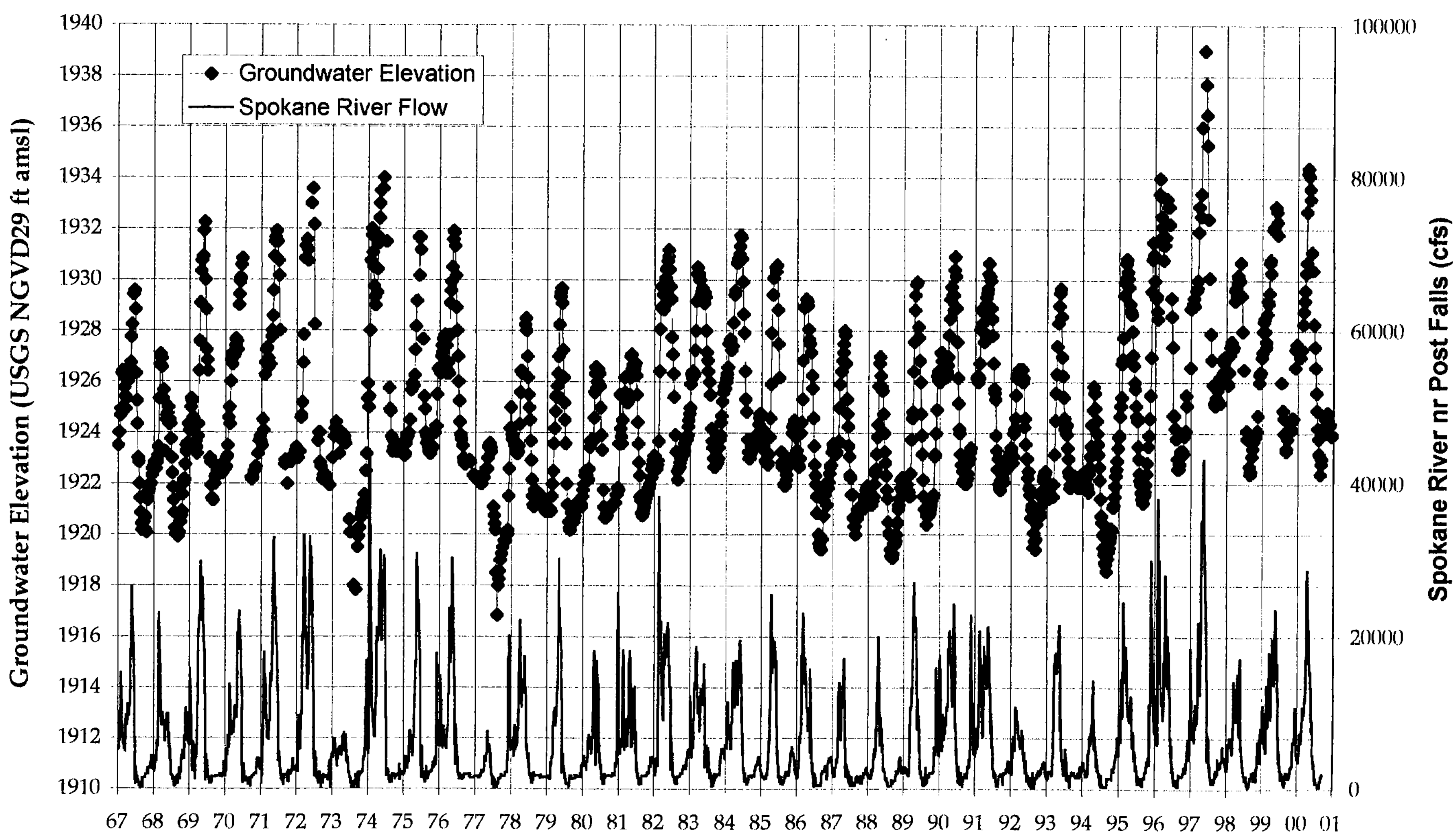
D2-14to29 Vera.xls/D2-23 Vera #5 1990-2000



Data Source: Vera Water District
Date Type : Weekly
Station Name: Vera Water District Well #6
Station ID: 5422H02

FIGURE D2-24:
Vera Water District Well #6
1/1967-12/2000

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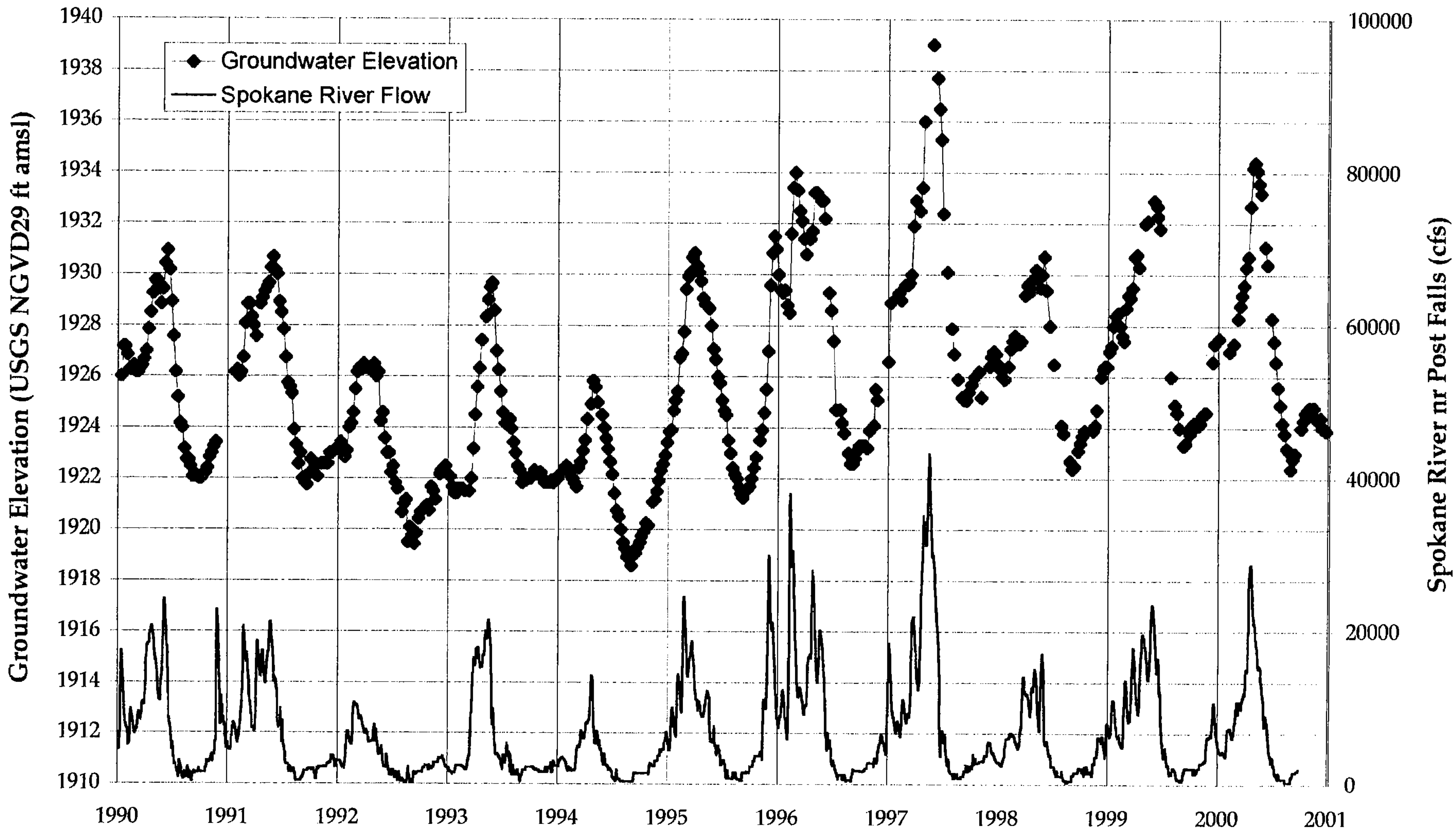
D2-14to29 Vera.xls/D2-24 Vera #6



Data Source: Vera Water District
Date Type : Weekly
Station Name: Vera Water District Well #6
Station ID: 5422H02

FIGURE D2-25:
Vera Water District Well #6
1990 - 2000

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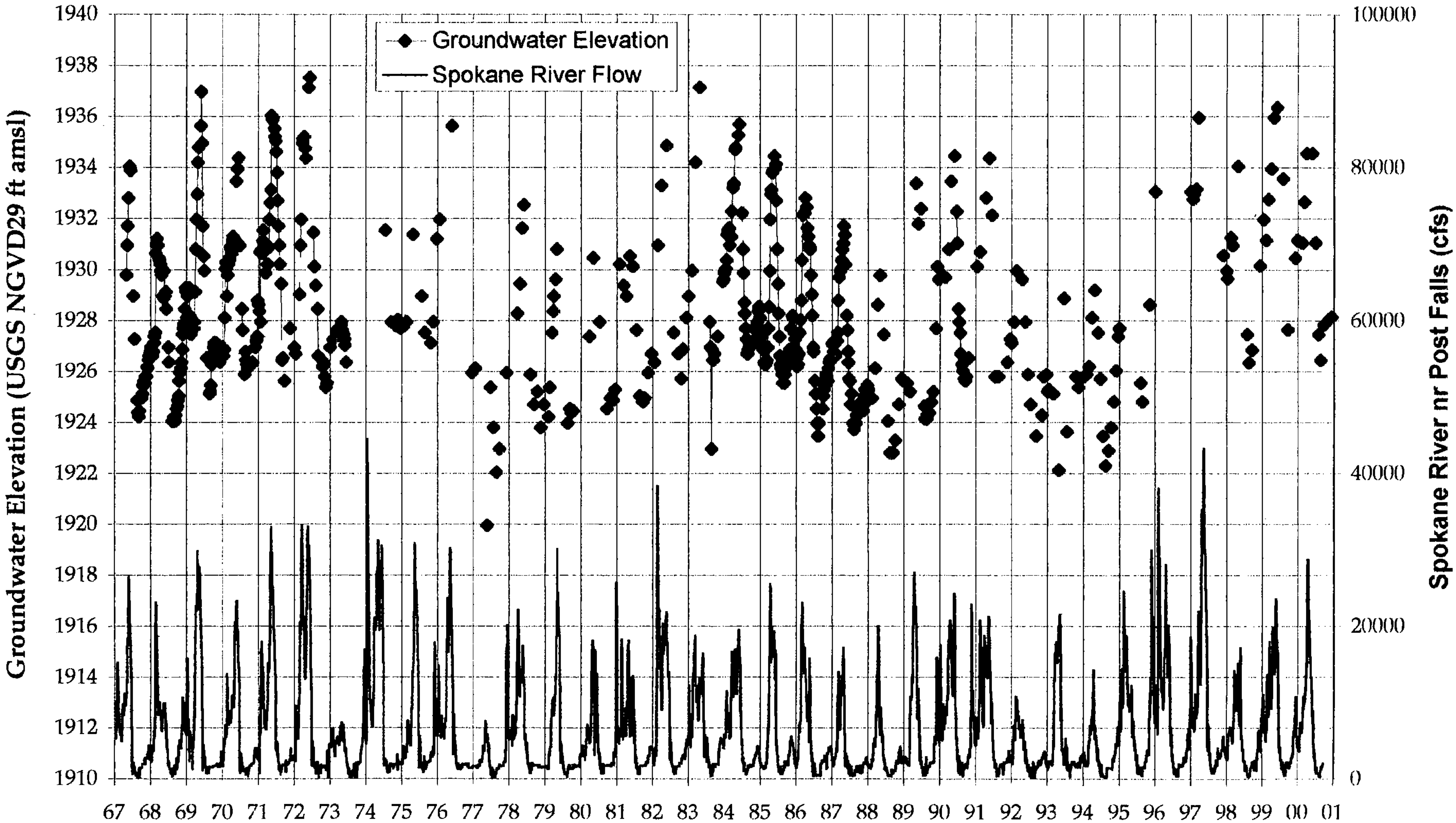

Data Source: Vera Water District
Date Type : Monthly
Station Name: Vera Water District Well #7
Station ID: 5423C01

FIGURE D2-26:
Vera Water District Well #7
1/1967-12/2000

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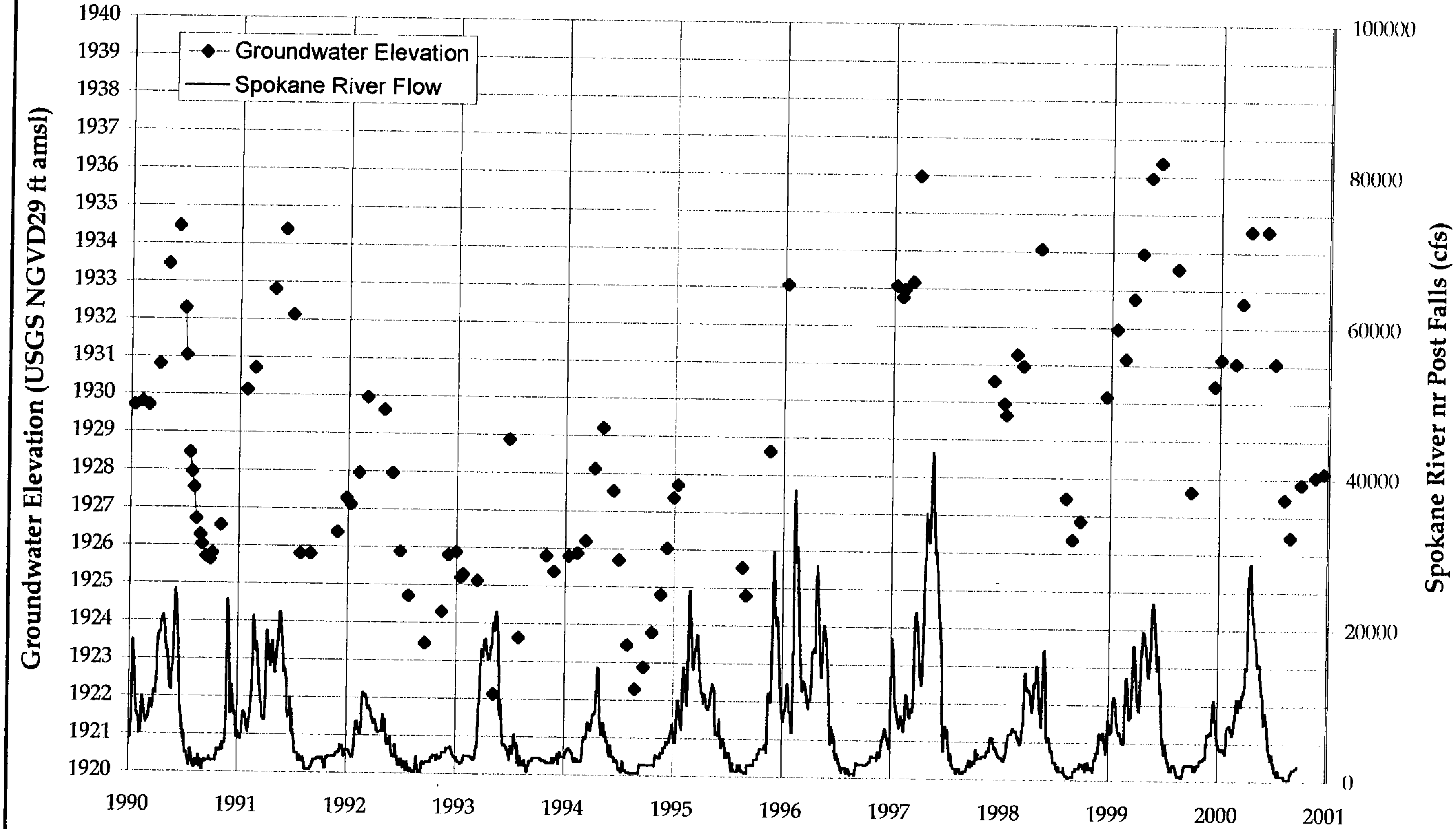
D2-14to29 Vera.xls/D2-26 Vera #7



Data Source: Vera Water District
Date Type : Monthly
Station Name: Vera Water District Well #7
Station ID: 5423C01

FIGURE D2-27:
Vera Water District Well #7
1990 - 2000

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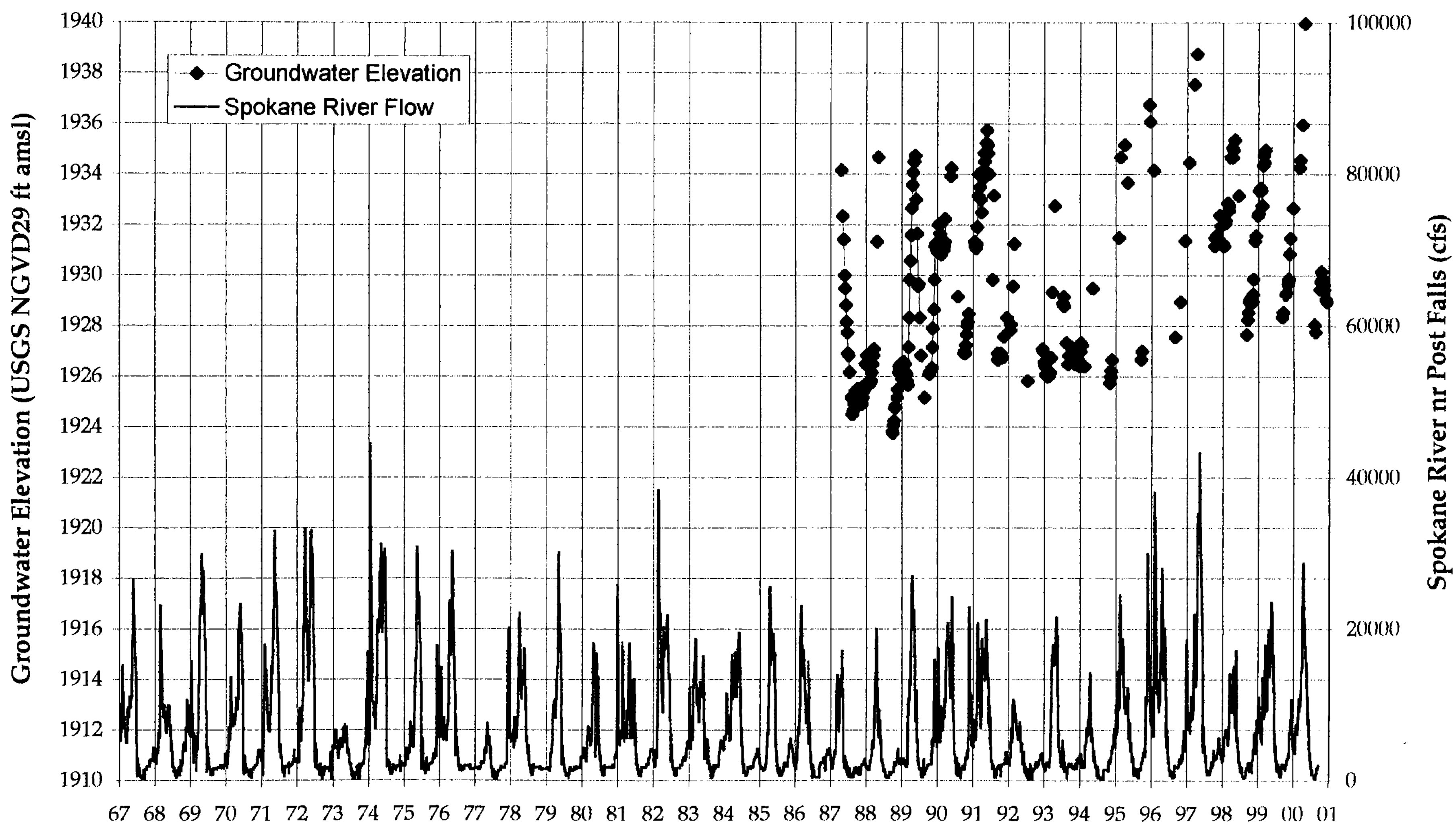
D2-14to29 Vera.xls/D2-27 Vera #7 1990-2000



Data Source: Vera Water District
Date Type : Monthly
Station Name: Vera Water District Well #8
Station ID: 5423J03

FIGURE D2-28:
Vera Water District Well #8
5/1987-12/2000

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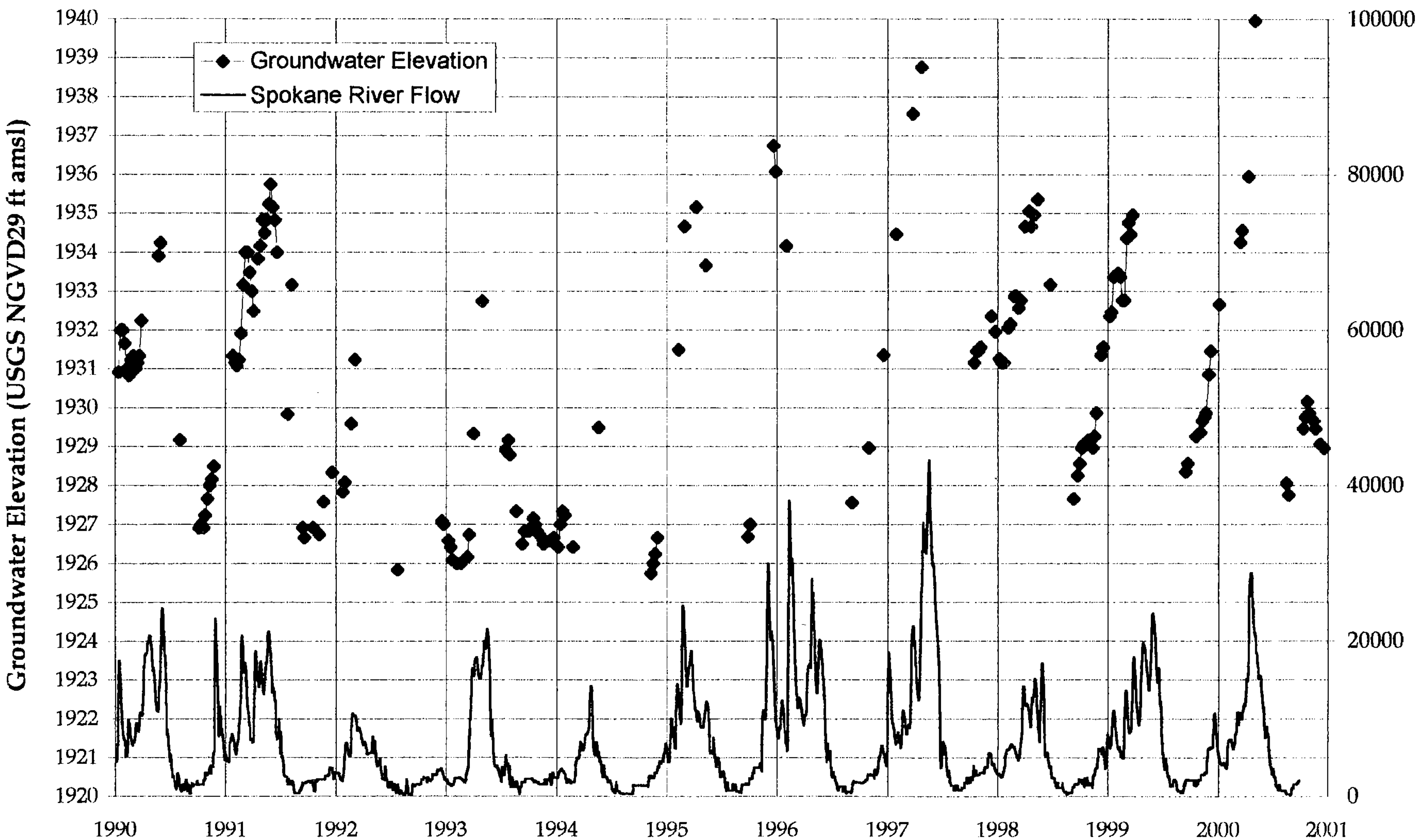
D2-14to29 Vera.xls/D2-28 Vera #8



Data Source: Vera Water District
Date Type : Monthly
Station Name: Vera Water District Well #8
Station ID: 5423J03

FIGURE D2-29:
Vera Water District Well #8
1990 - 2000

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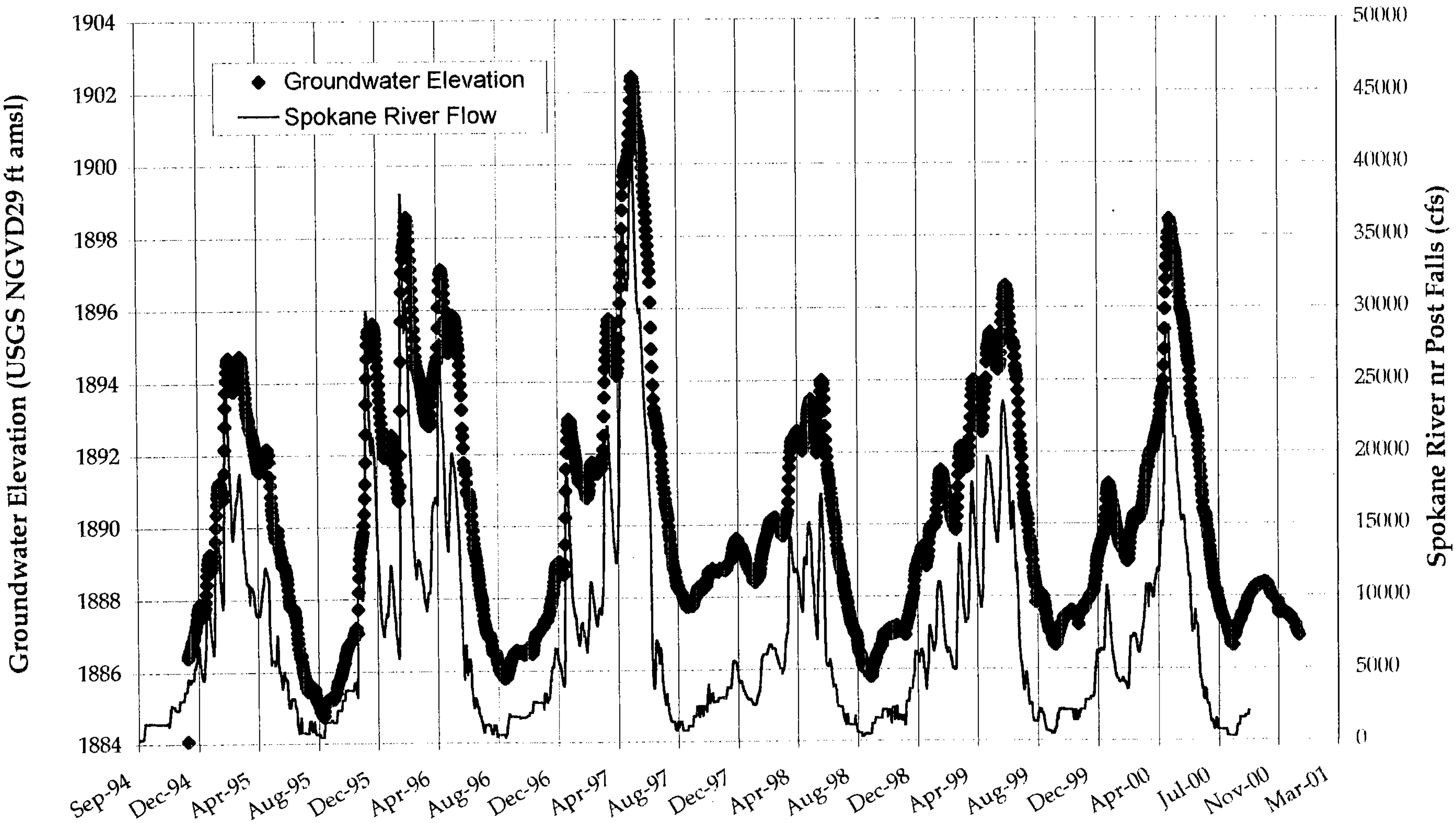

Data Source: City of Spokane
Date Type : Daily Averages from transducer data
Station Name: Felts Field Monitoring Well
Station ID: 5312C01

FIGURE D2-30:
Felts Field Monitoring Well
11/1994 - 1/2001

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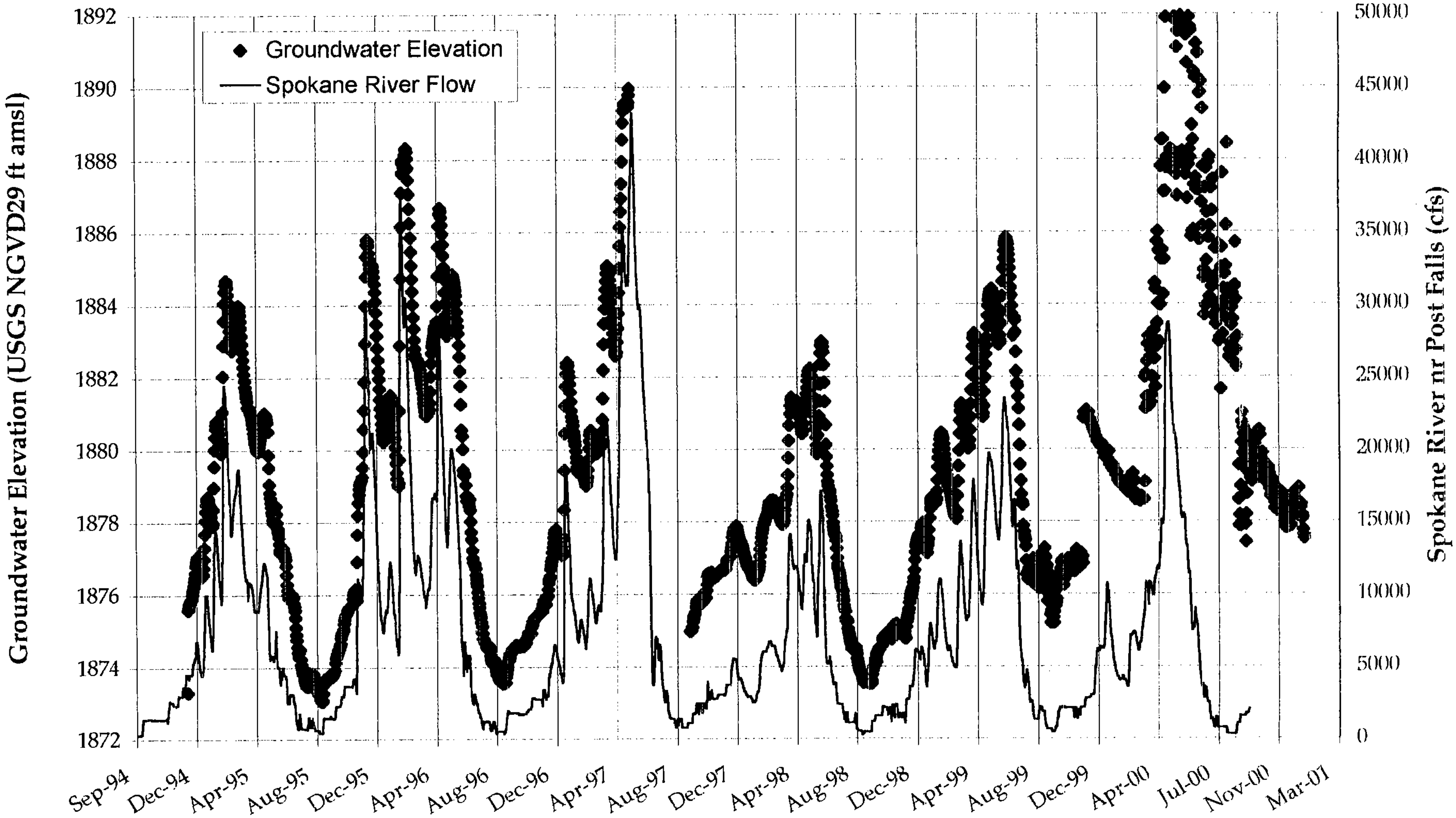

Data Source: City of Spokane
Date Type : Daily Averages from transducer data
Station Name: Central Pre-Mix at Yardley Monitoring Well
Station ID: 5314E01

FIGURE D2-31:
Central Pre-Mix at Yardley Monitoring Well
12/1994 - 1/2001

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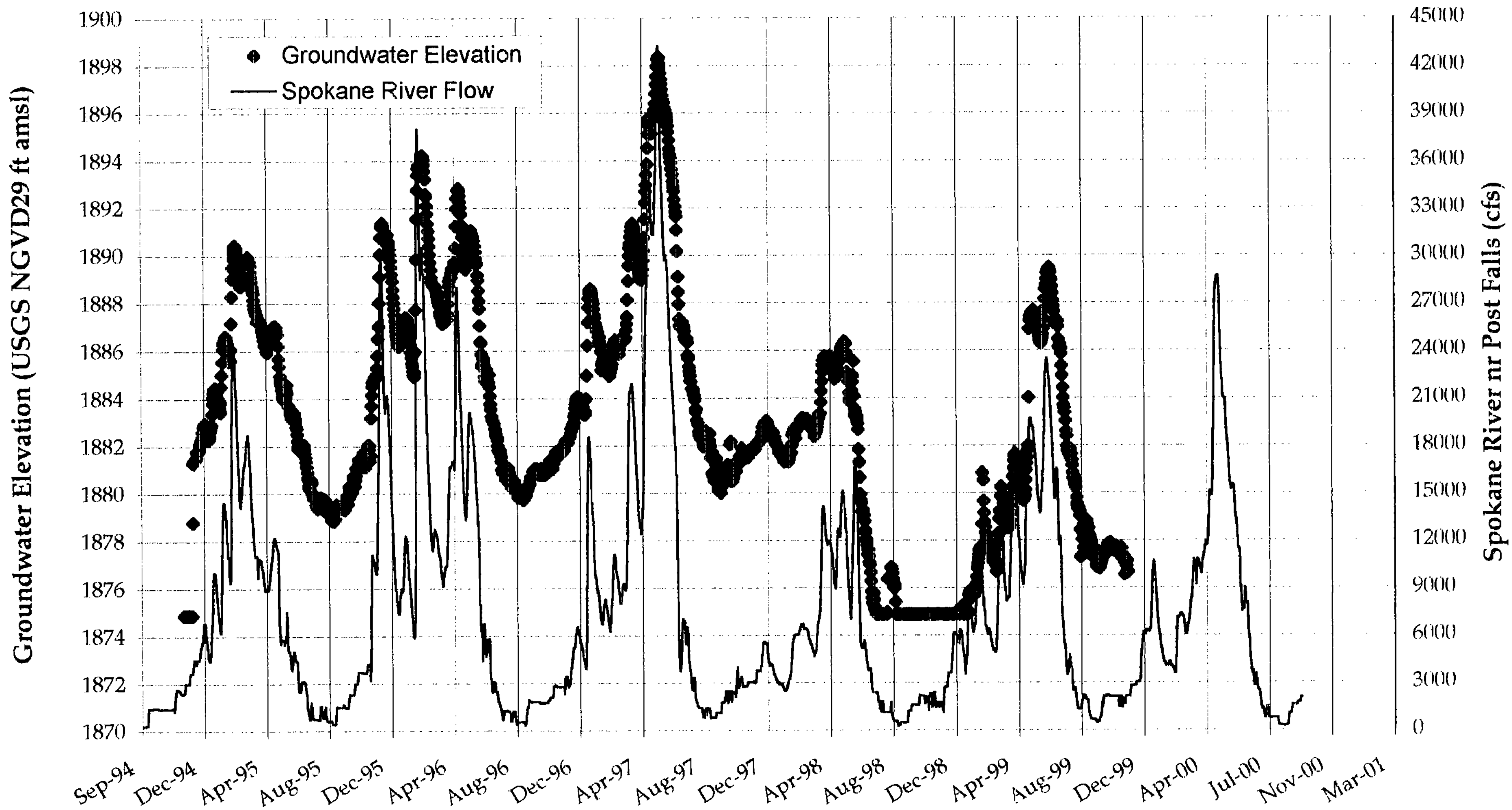

Data Source: City of Spokane
Date Type : Daily Averages from transducer data
Station Name: Hale's Nested Site - Mid Well, Monitoring Well
Station ID: 5311J07

FIGURE D2-32:
Hale's Nested Site - Mid Well
(Parkwater #2) Monitoring Well
11/1994 - 11/1999

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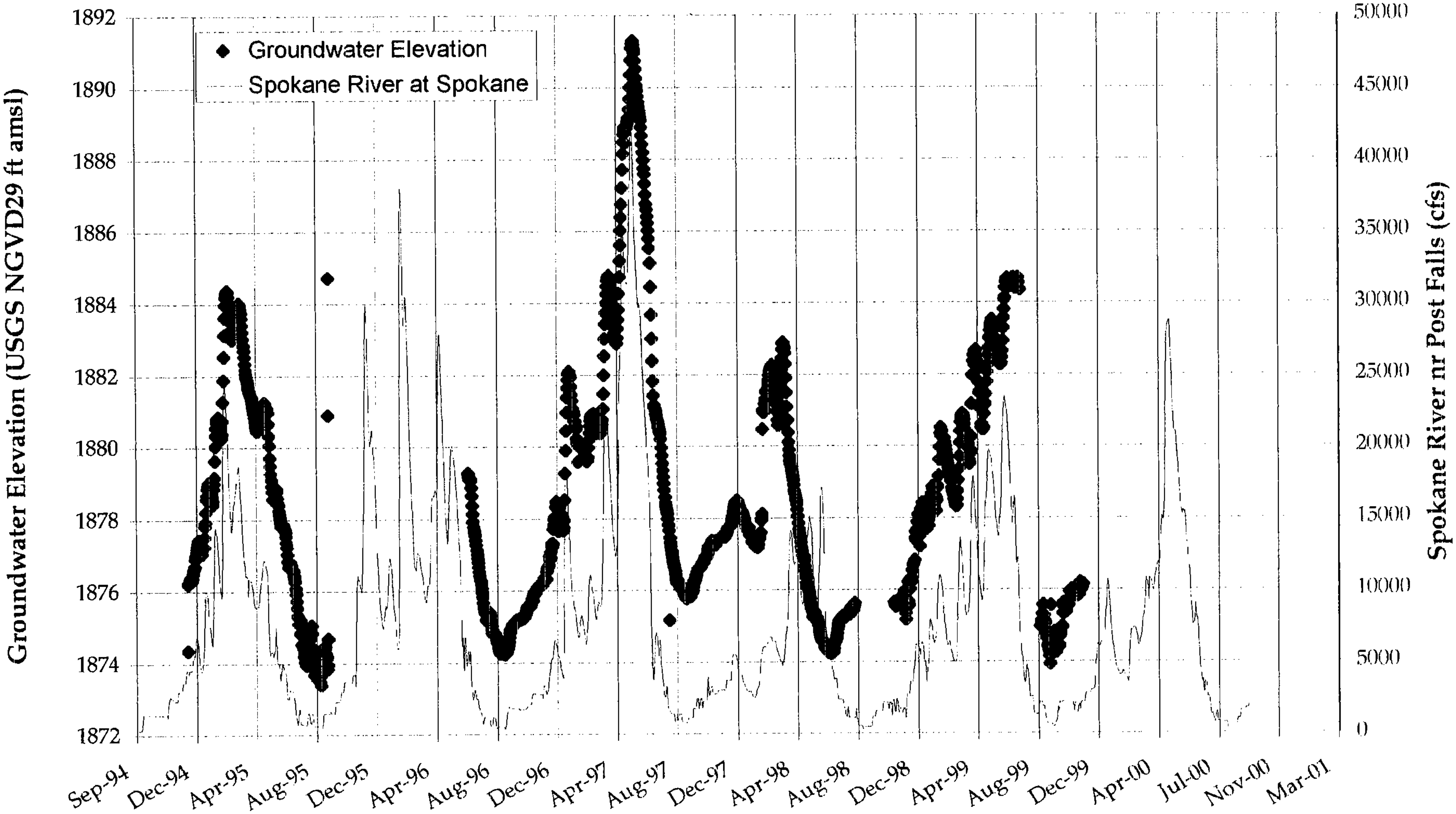

Data Source: City of Spokane
Date Type : Daily Averages from transducer data
Station Name: Third & Havanna Nested - Mid Well, Monitoring Well
Station ID: 5322A03

FIGURE D2-33:
Third & Havanna Nested - Mid Well Monitoring Well
11/1994-11/1999

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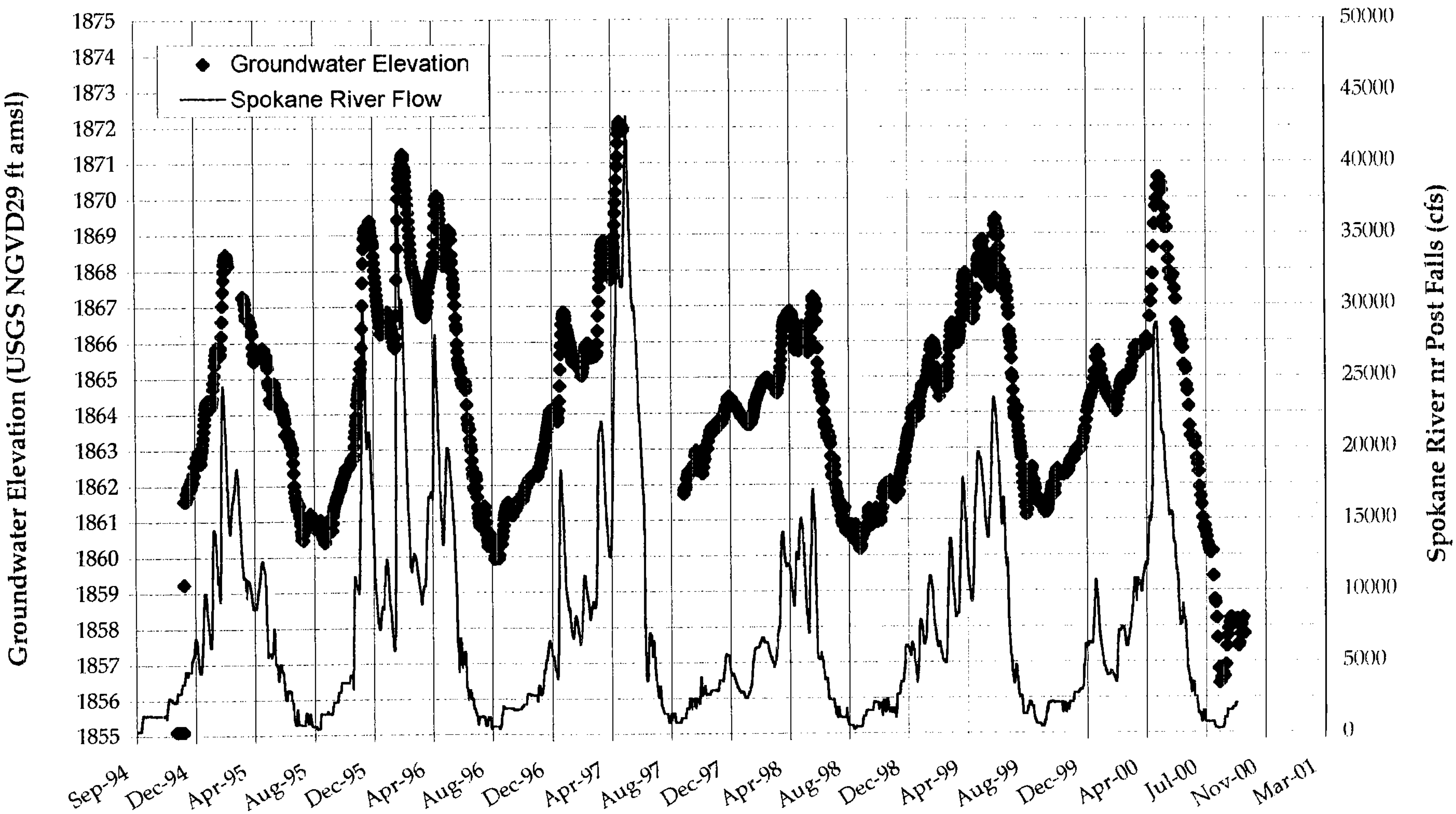
D2-30to38 CityData.xls/D2-33 Third & Havanna - Mid



Data Source: City of Spokane
Date Type : Daily Averages from transducer data
Station Name: Nevada-Grace at Denver & Marietta, Monitoring Well
Station ID: 5308H01

FIGURE D2-34:
Nevada-Grace at Denver & Marietta
Monitoring Well
11/1994 - 10/2000

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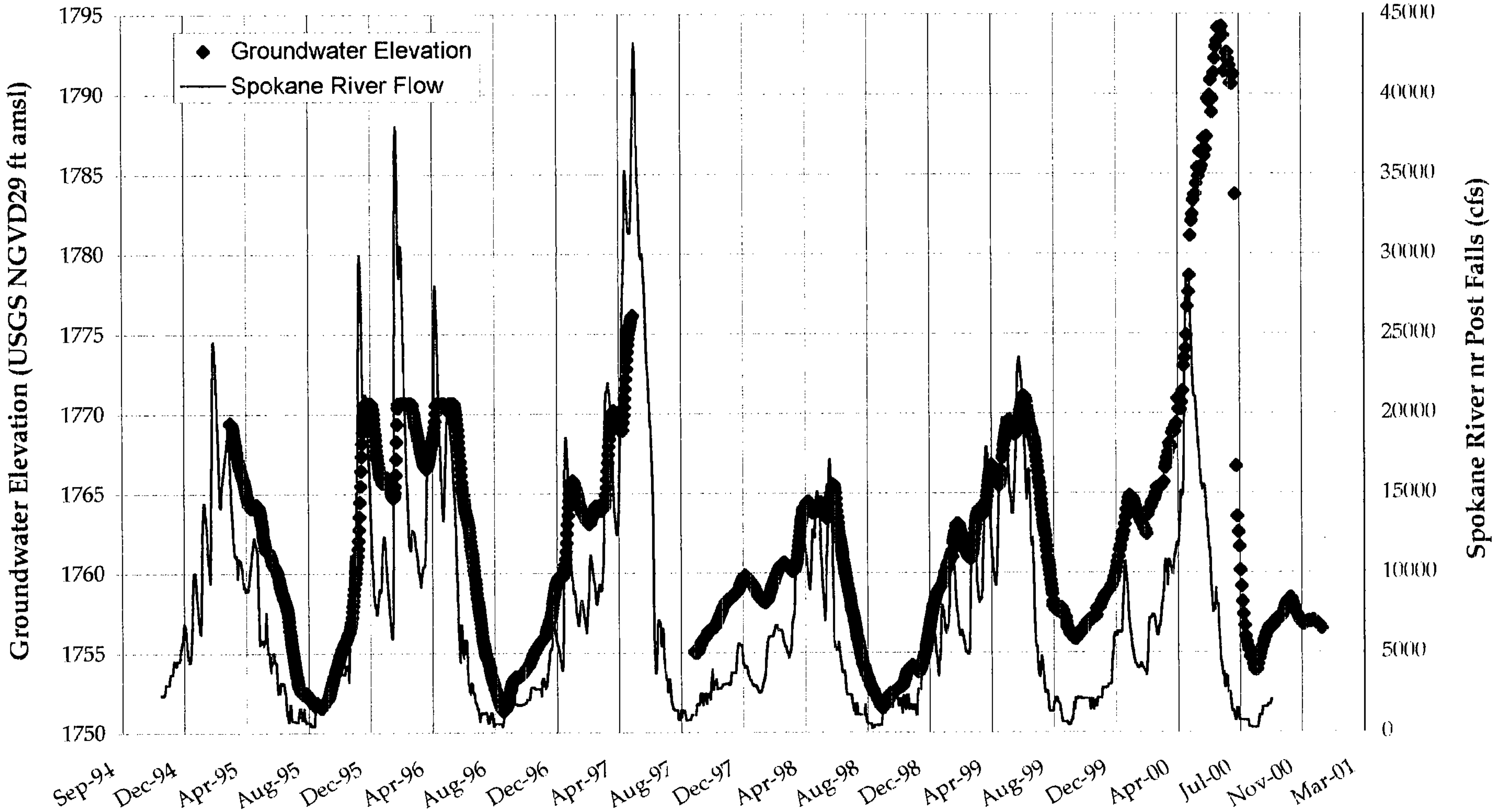
D2-30to38 CityData.xls/D2-34 Nevada Grace



Data Source: City of Spokane
Date Type : Daily Averages from transducer data
Station Name: Trinity School, Adams & Carlisle Monitoring Well
Station ID: 5307M01

FIGURE D2-35:
Trinity School, Adams & Carlisle Monitoring Well
3/1995 - 1/2001

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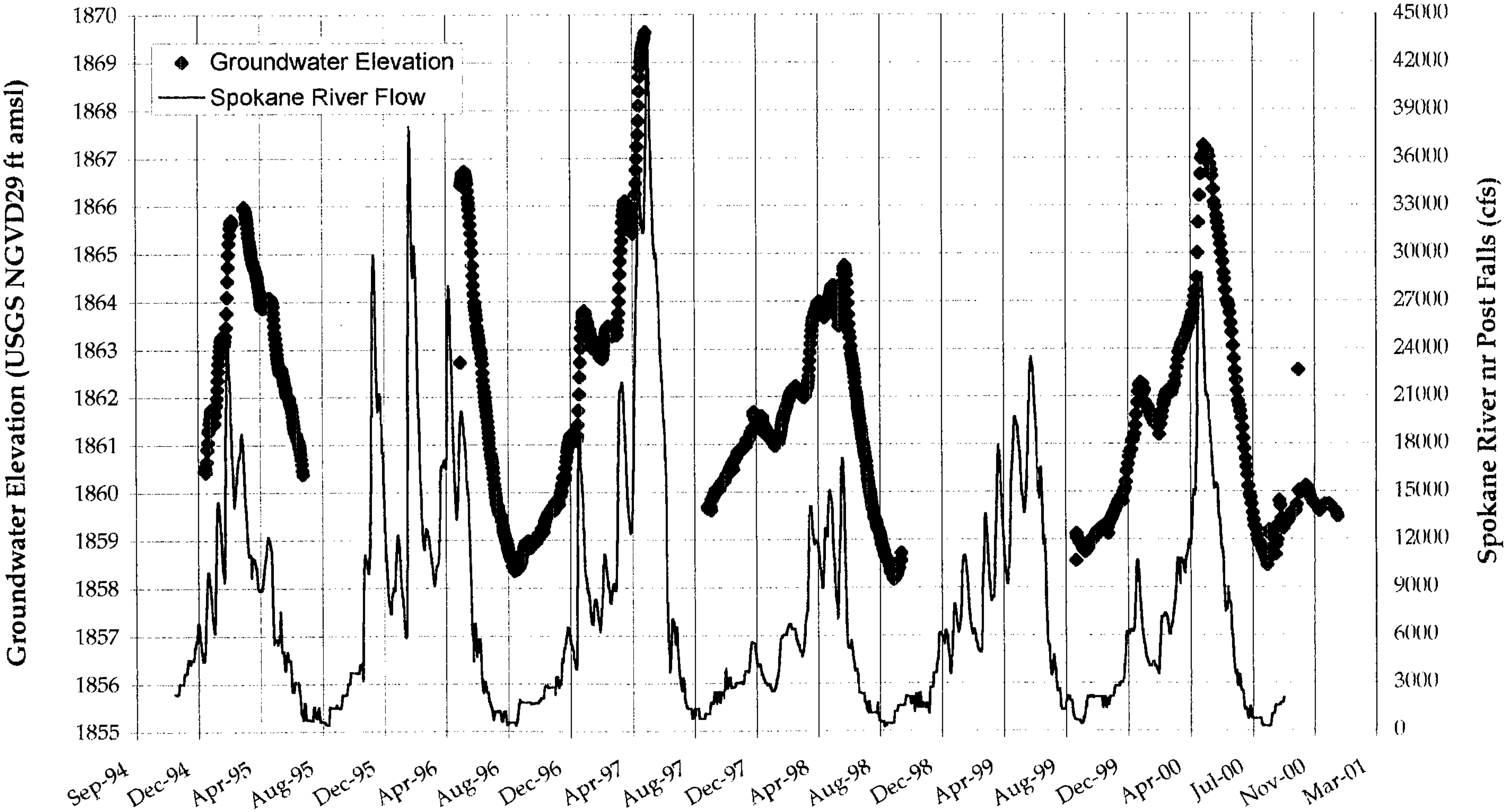
D2-30to38 CityData.xls/D2-35 Trinity School



Data Source: City of Spokane
Date Type : Daily Averages from transducer data
Station Name: NE Community Center Monitoring Well
Station ID: 5304G01

FIGURE D2-36:
NE Community Center Monitoring Well
11/1995 - 1/2001

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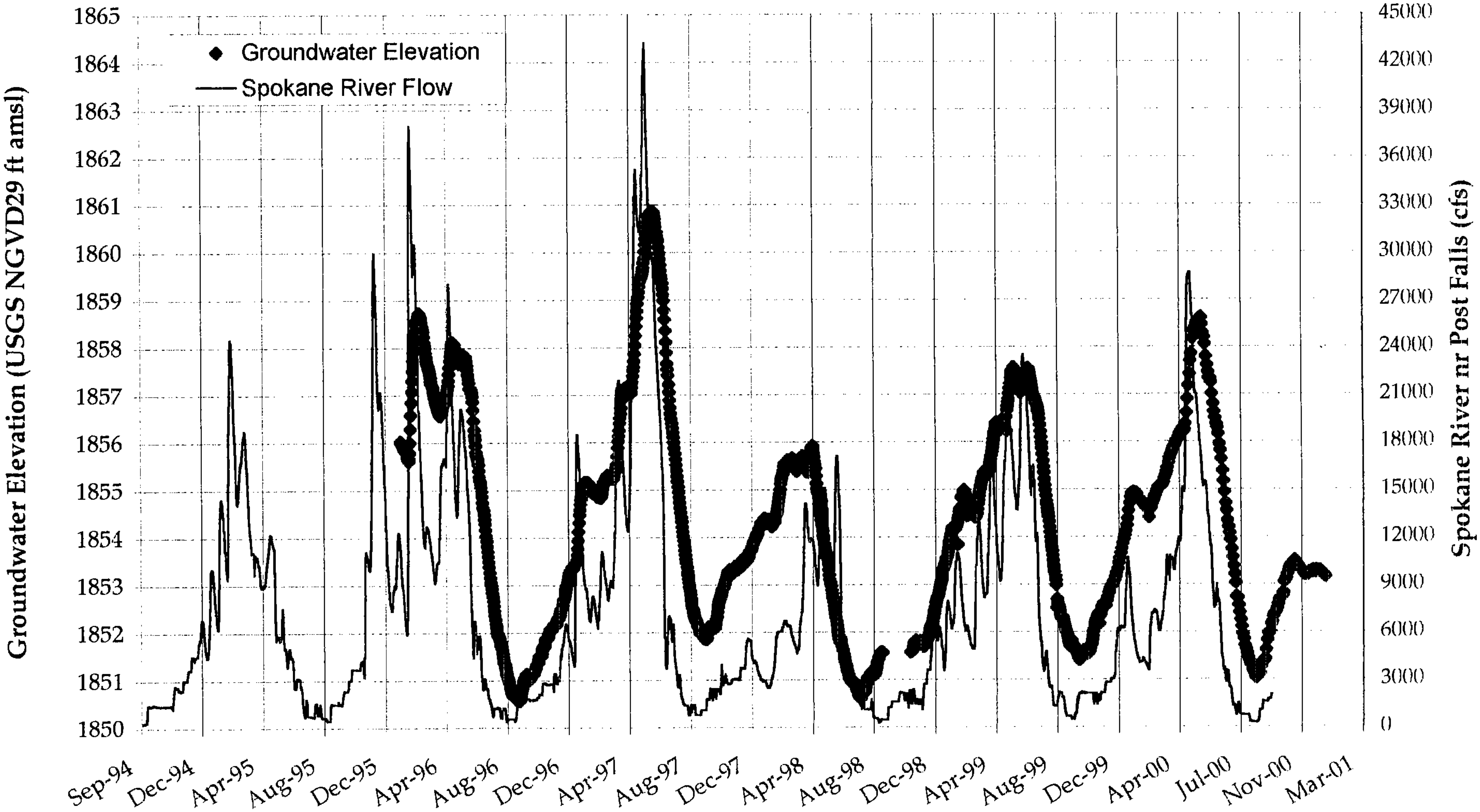

Data Source: City of Spokane
Date Type : Daily Averages from transducer data
Station Name: Franklin Park, Monitoring Well
Station ID: 5322A03

FIGURE D2-37:
Franklin Park Monitoring Well
1/1996 - 1/2001

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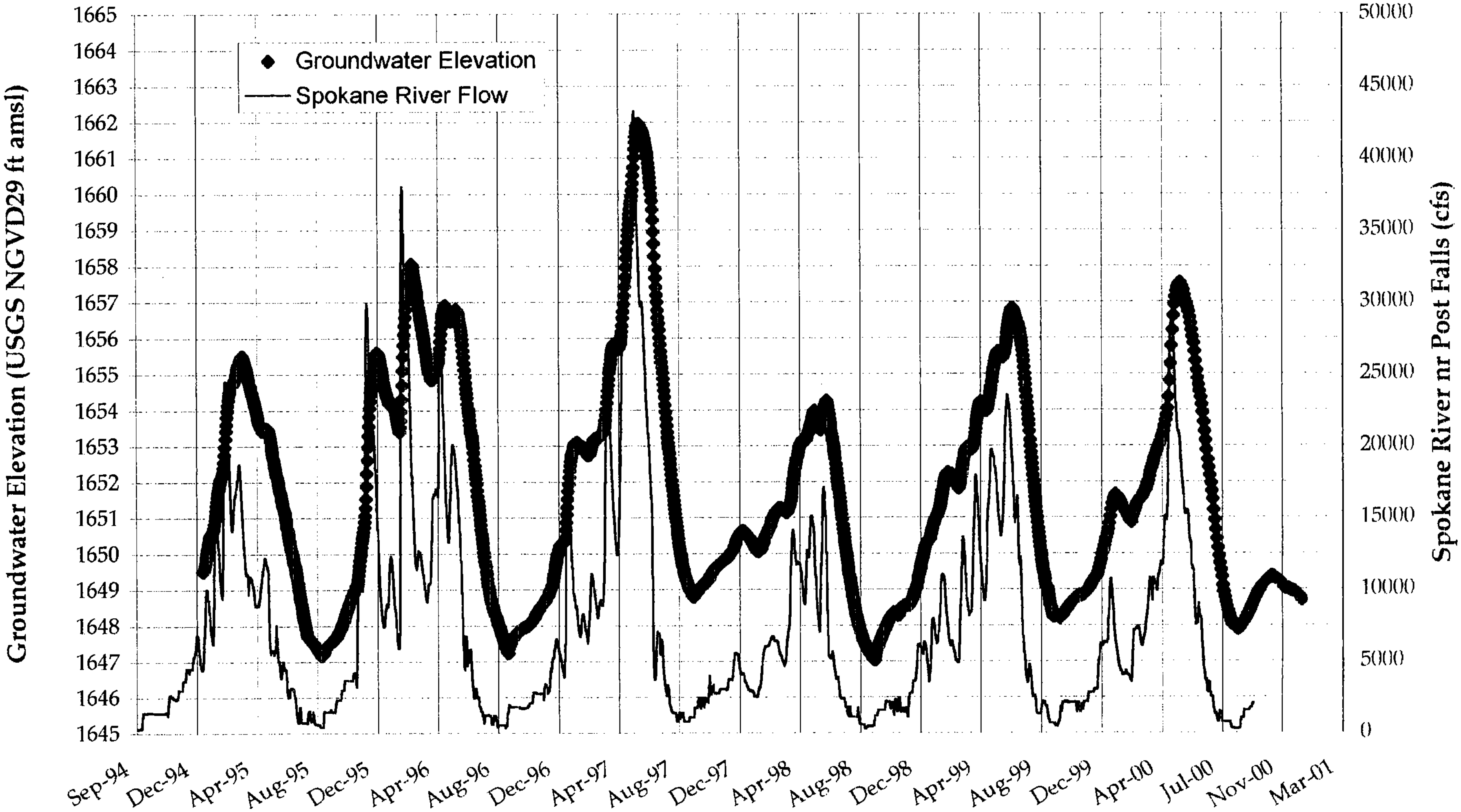

Data Source: City of Spokane
Date Type : Daily Averages from transducer data
Station Name: Wastewater Treatment Plant Monitoring Well
Station ID: 5202E01

FIGURE D2-38:
Wastewater Treatment Plant Well
1/1995 - 1/2001

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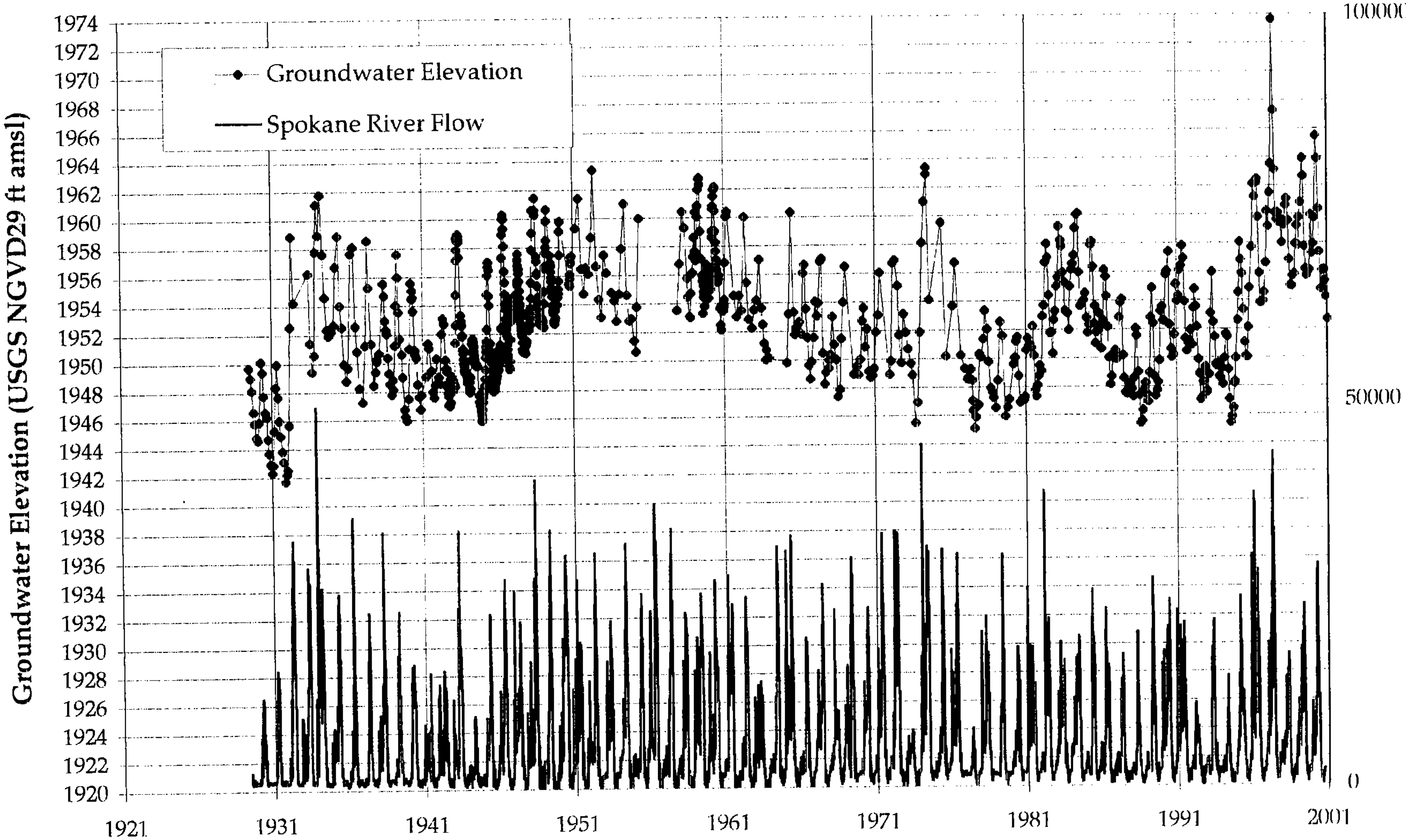
D2-30to38 CityData.xls/D2-38 WWTP



Data Source: USGS
Date Type : Monthly
Station Name: Inland Empire Paper Well
Station ID: 5516C01

FIGURE D2-39:
Inland Empire Paper Well
7/1929-01/2001

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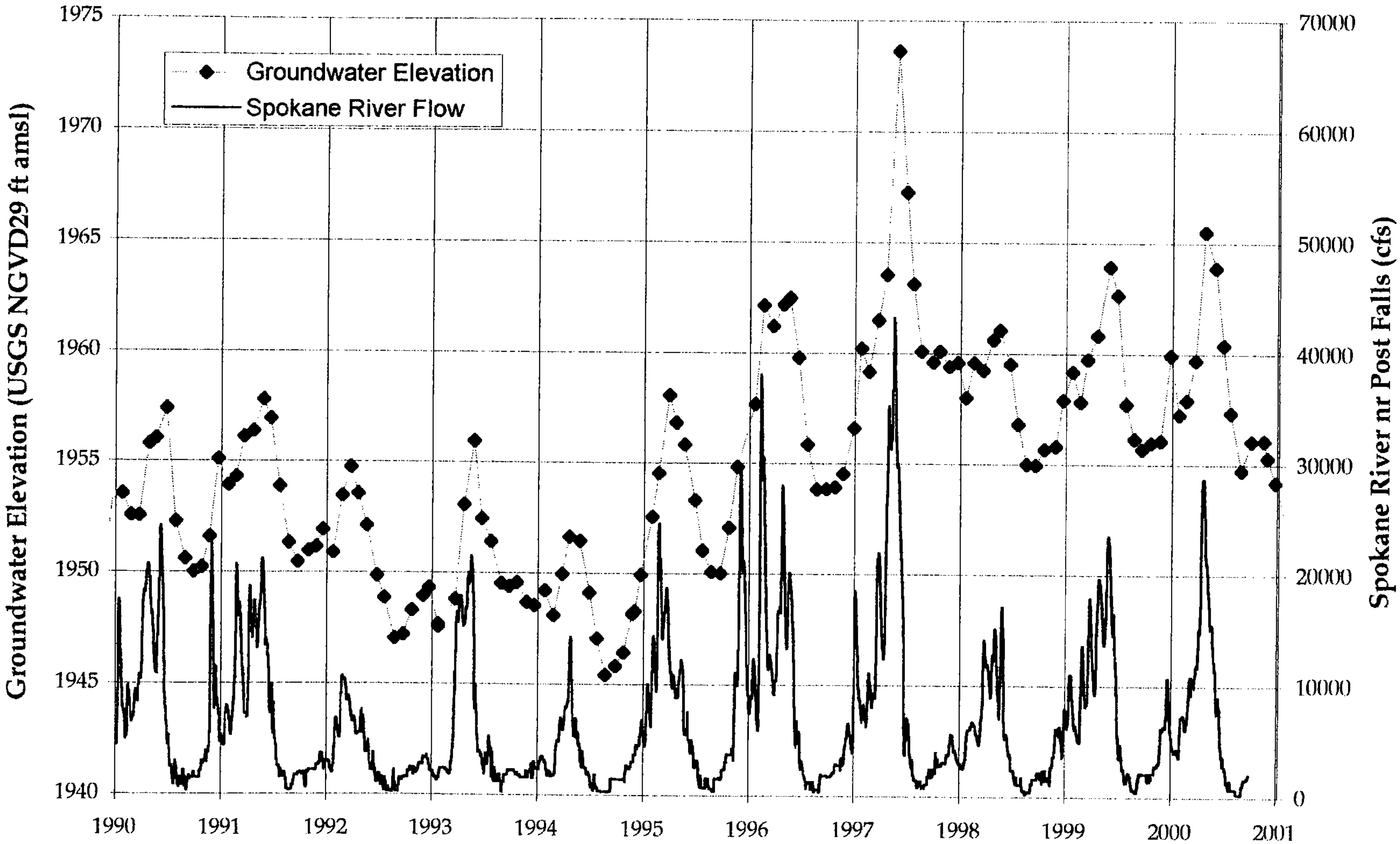

Data Source: USGS
Date Type : Monthly
Station Name: Inland Empire Paper Well
Station ID: 5516C01

FIGURE D2-40:
Inland Empire Paper Well
1/1990-12/2000

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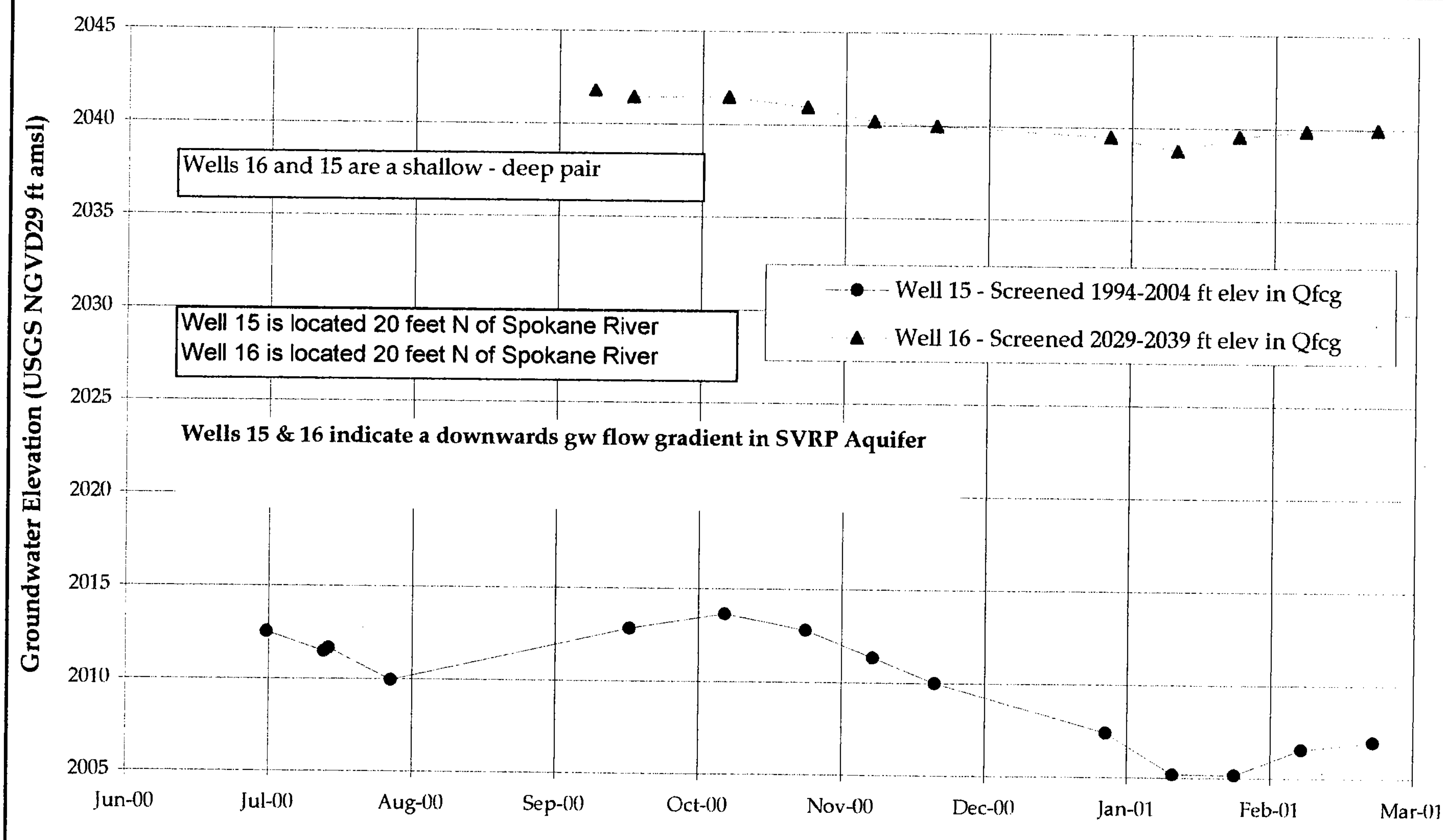
013-1372.1100 March 30, 2001

D2-39&40 inlandmonthly.xls/D2-40 hydro-1990-2000



Data Source: USGS and Spokane County
Date Type : Weekly
Station Name: River Bend Road USGS Wells
Station ID: Well Nos 15 & 16

FIGURE D2-41:
USGS Wells 2000-2001
River Bend Rd, N of Spokane River

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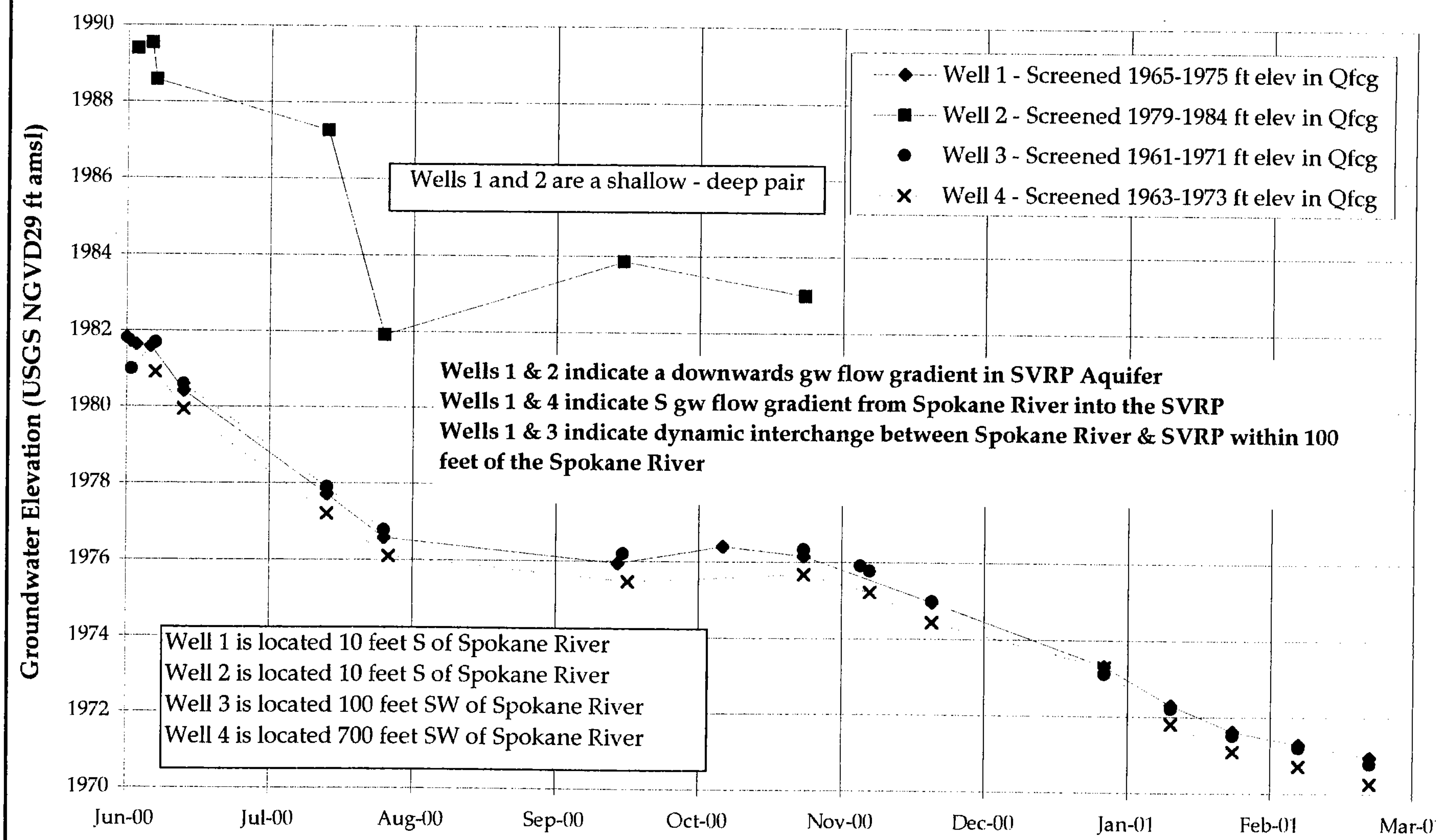
013-1372.1100 April 13, 2001

D2-41to46 USGSnewwells.xls/D2-41 River Bend Rd



Data Source: USGS and Spokane County
Date Type : Weekly
Station Name: State Line USGS Wells
Station ID: Well Nos 1, 2, 3 & 4

FIGURE D2-42:
USGS Wells 2000-2001
State Line, S of Spokane River

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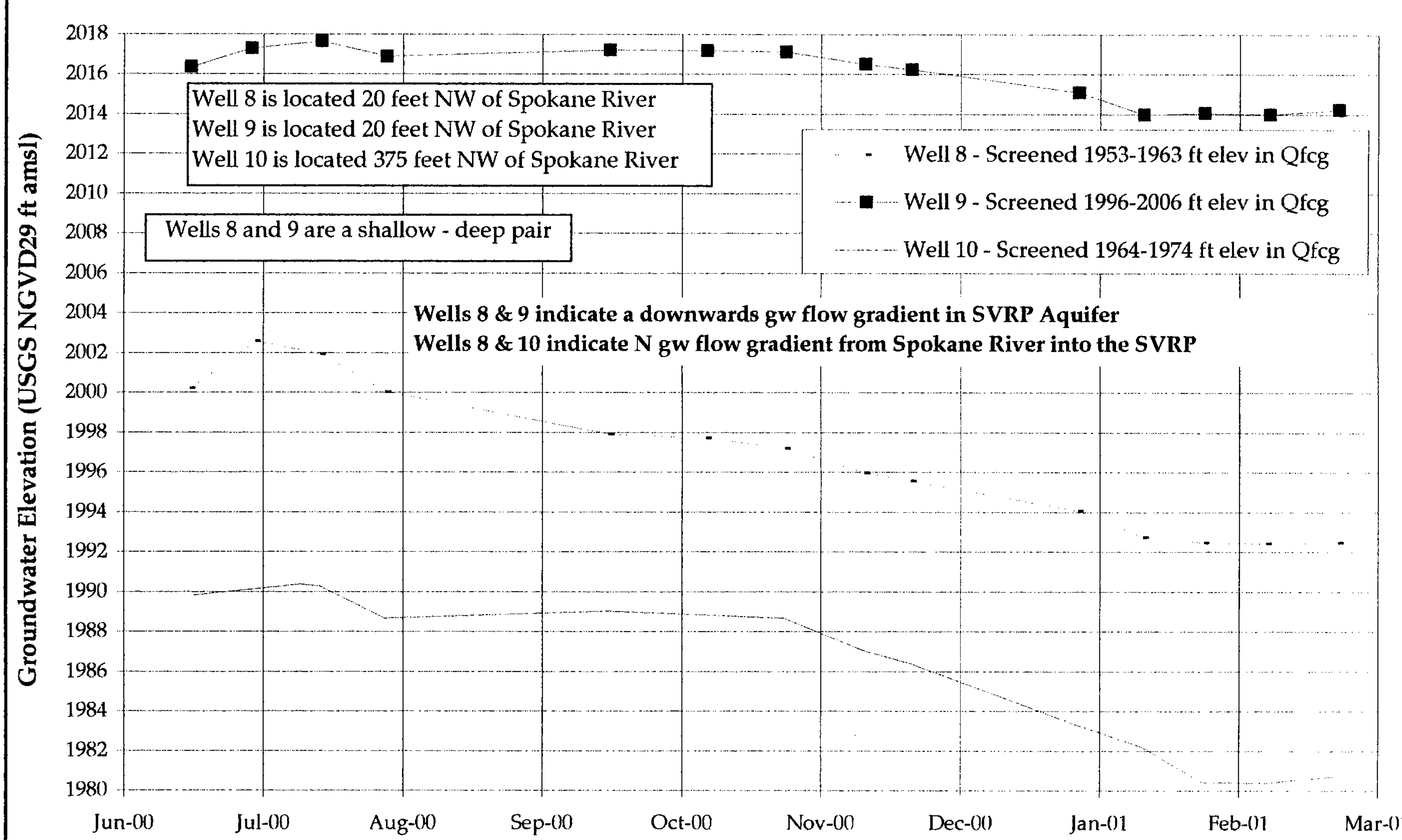
D2-41to46 USGSnewwells.xls/D2-42 State Line



Data Source: USGS and Spokane County
Date Type : Weekly
Station Name: Starr Road USGS Wells
Station ID: Well Nos 8, 9 & 10

FIGURE D2-43:
USGS Wells 2000-2001
Starr Road, N of Spokane River

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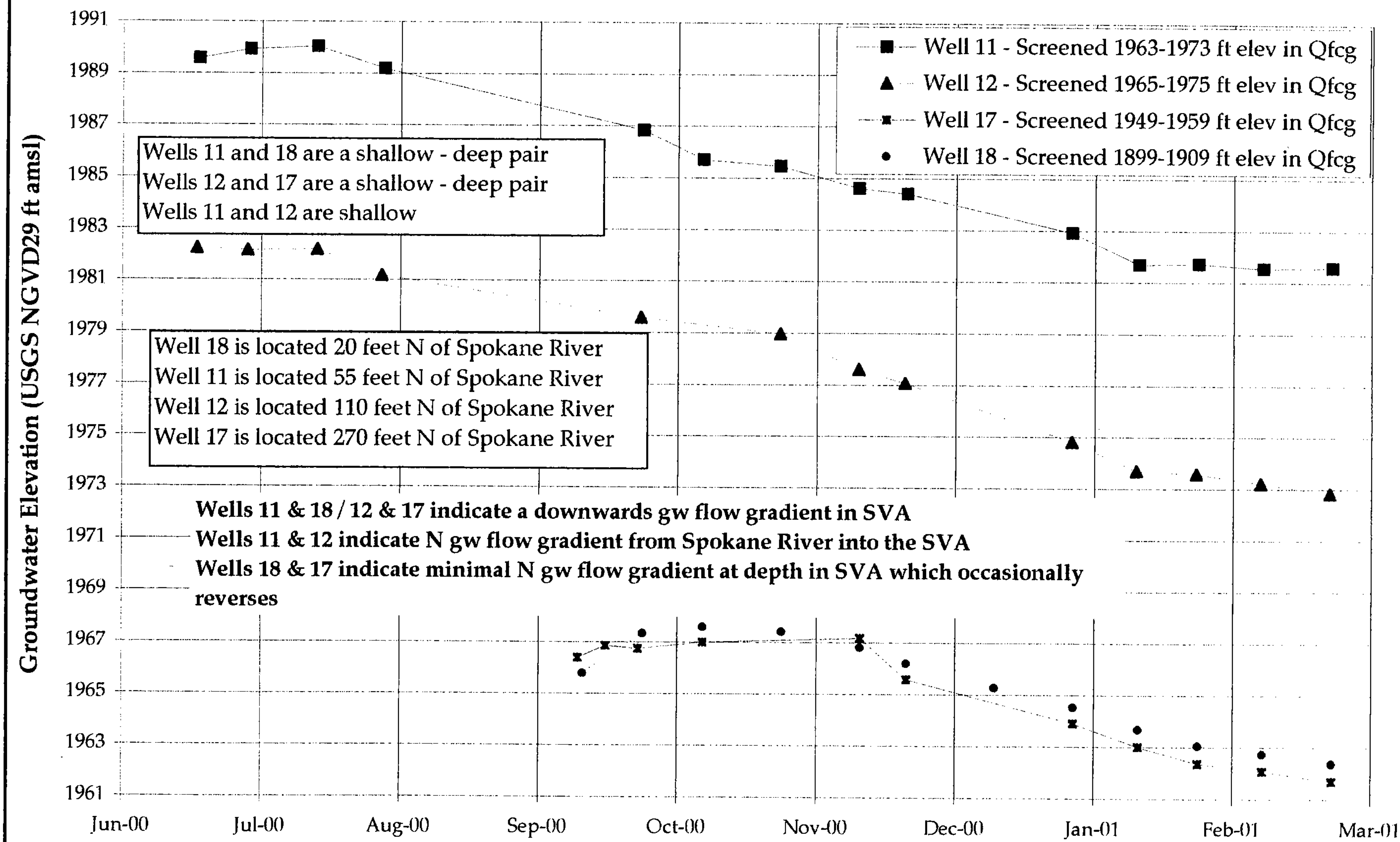

Data Source: USGS and Spokane County
Date Type : Weekly
Station Name: Euclid Ave USGS Wells
Station ID: Well Nos 11, 12, 17 and 18

FIGURE D2-44:
USGS Wells 2000-2001
Euclid Ave N of Spokane River

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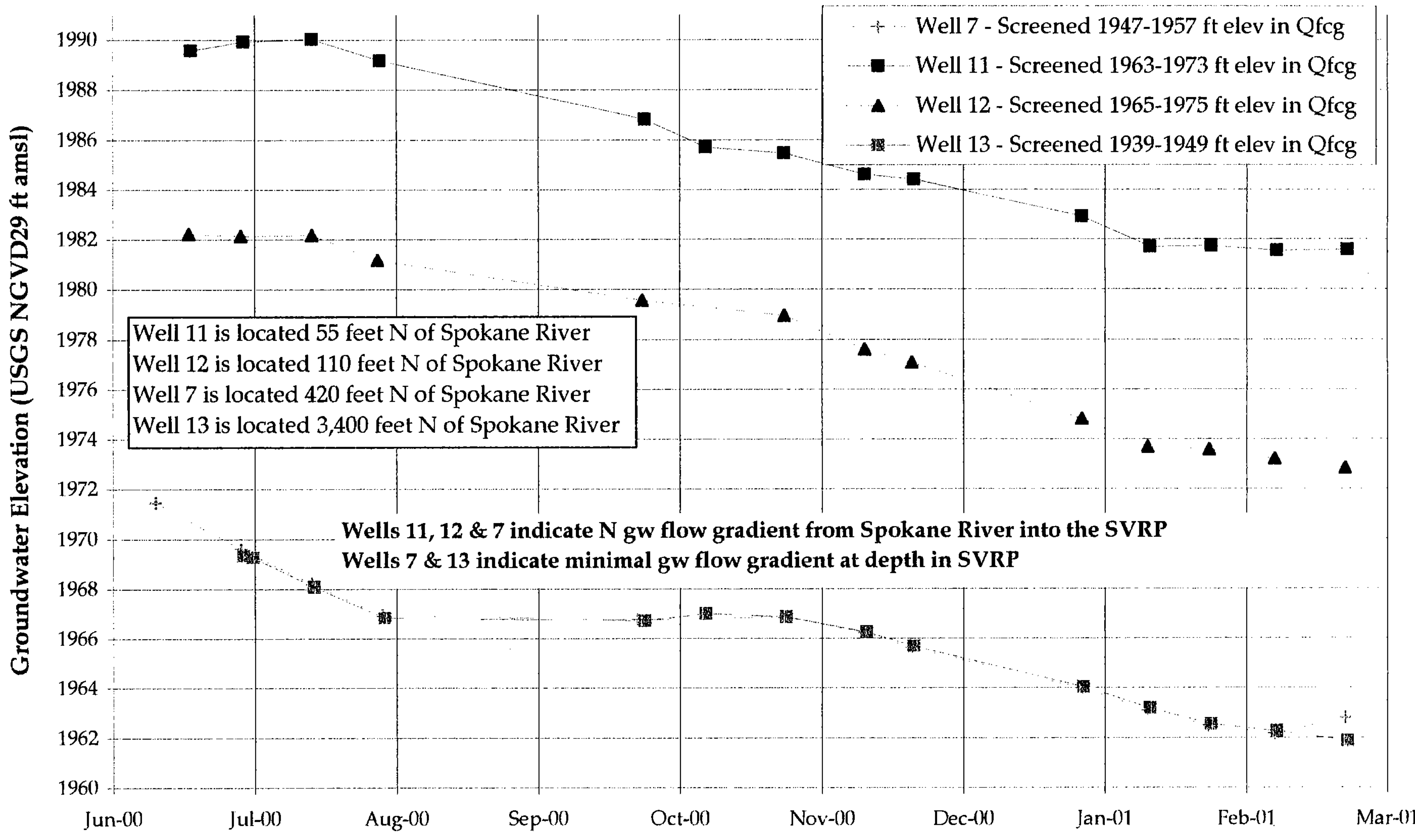
D2-41to46 USGSnewwells.xls/D2-44 Euclid Ave



Data Source: USGS and Spokane County
Date Type : Weekly
Station Name: Lynden Road USGS Wells
Station ID: Well Nos 7, 11, 12 and 13

FIGURE D2-45:
USGS Wells 2000-2001
Lynden Road, N of Spokane River

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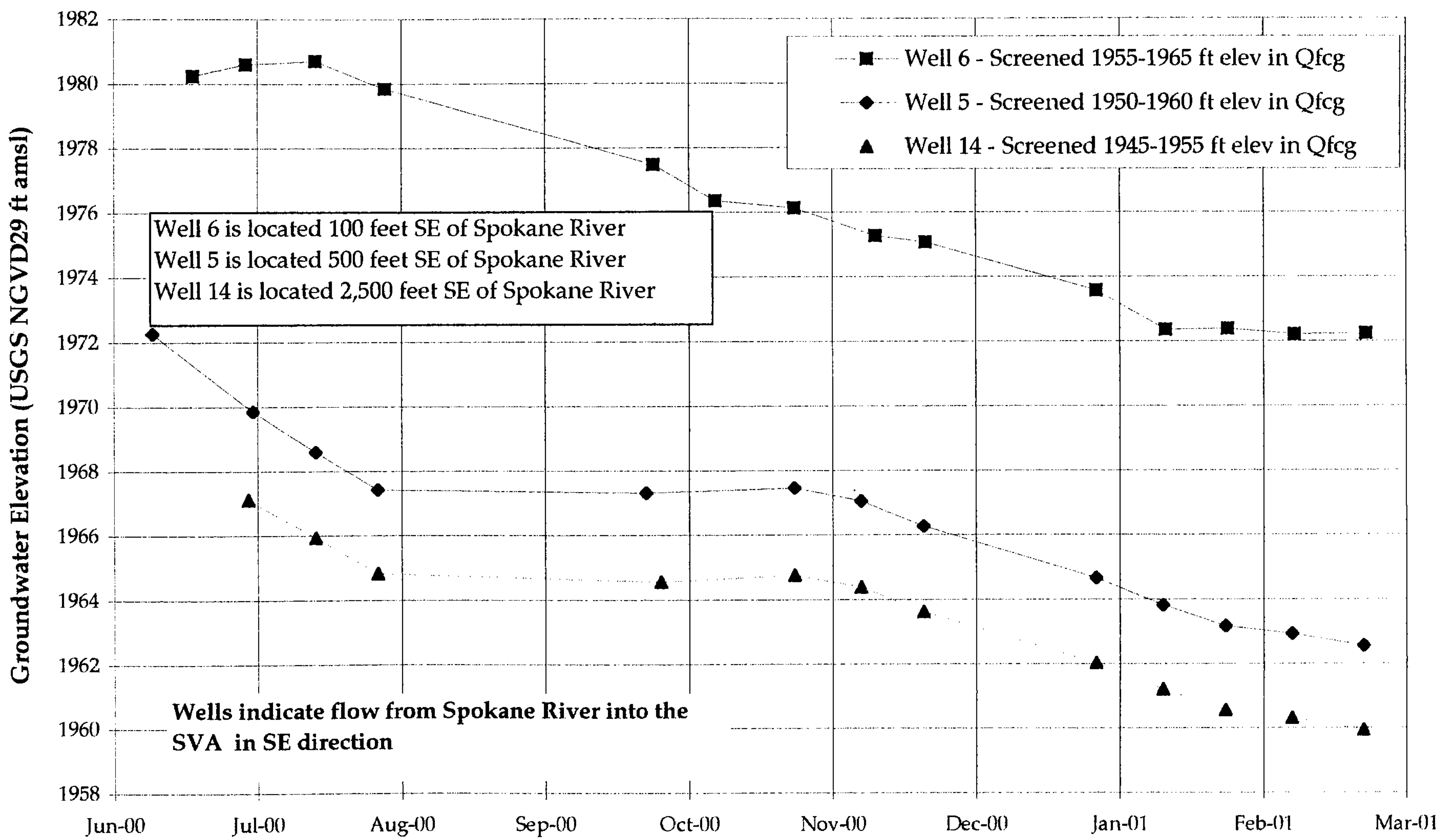
D2-41to46 USGSnewwells.xls/D2-45 Lynden Rd



Data Source: USGS and Spokane County
Date Type : Weekly
Station Name: Harvard Road USGS Wells
Station ID: Well Nos 14, 5 and 6

FIGURE D2-46:
USGS Wells 2000-2001
Harvard Road, S of Spokane River

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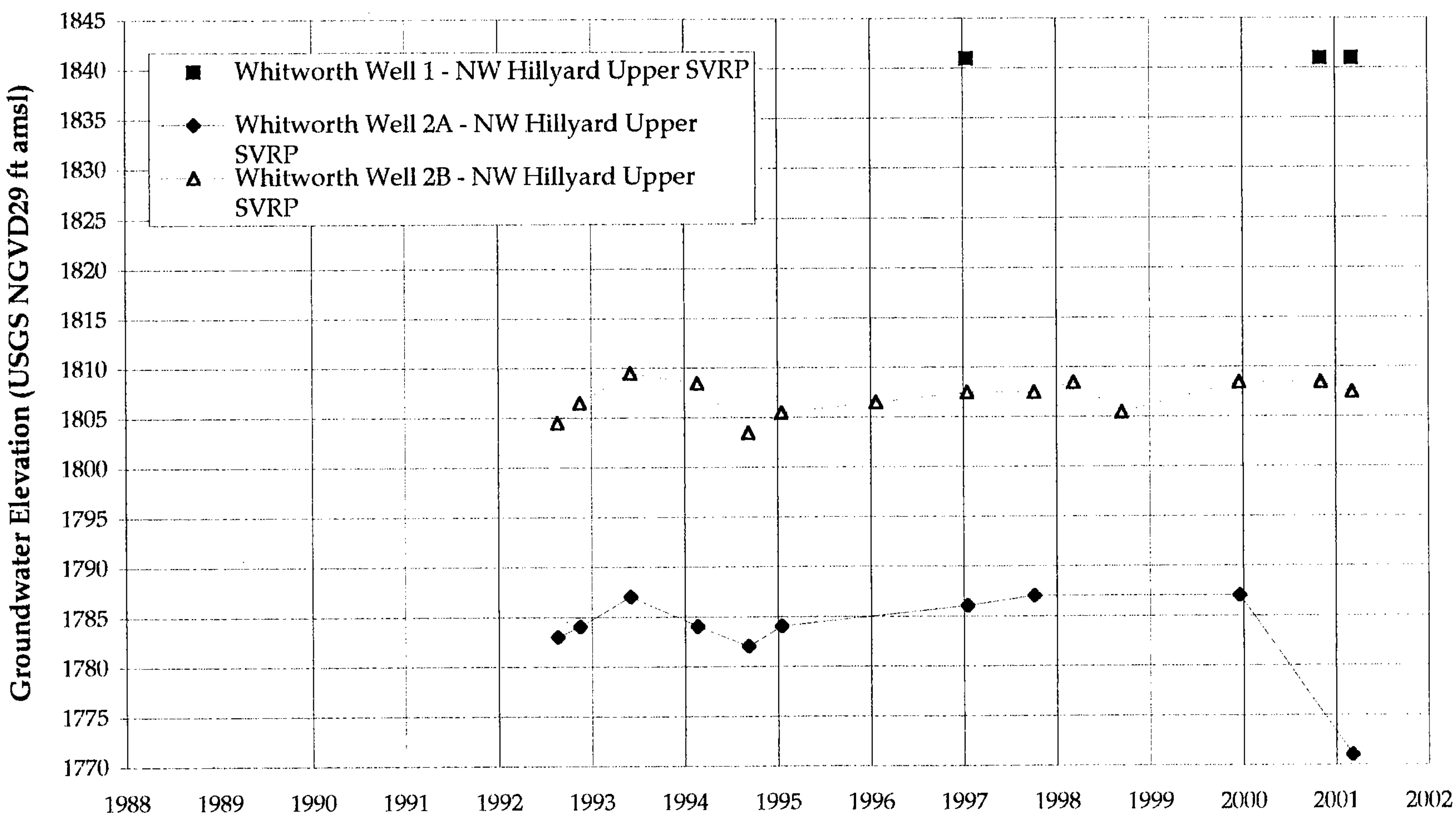

Data Source: Whitwoth Water District and Spokane County
Date Type : Randon Manual Measurements
Station Name: Whitworth Water District Well #s 1, 2A, 2B
Station ID: 6330F01, 6320D01, 6319A01
Note: Wells 1, 2A and 2B located northwest Hillyard Trough

FIGURE D2-47:
Whitworth Water District Wells
#s 1, 2A, 2B
Static Levels 1988-2001

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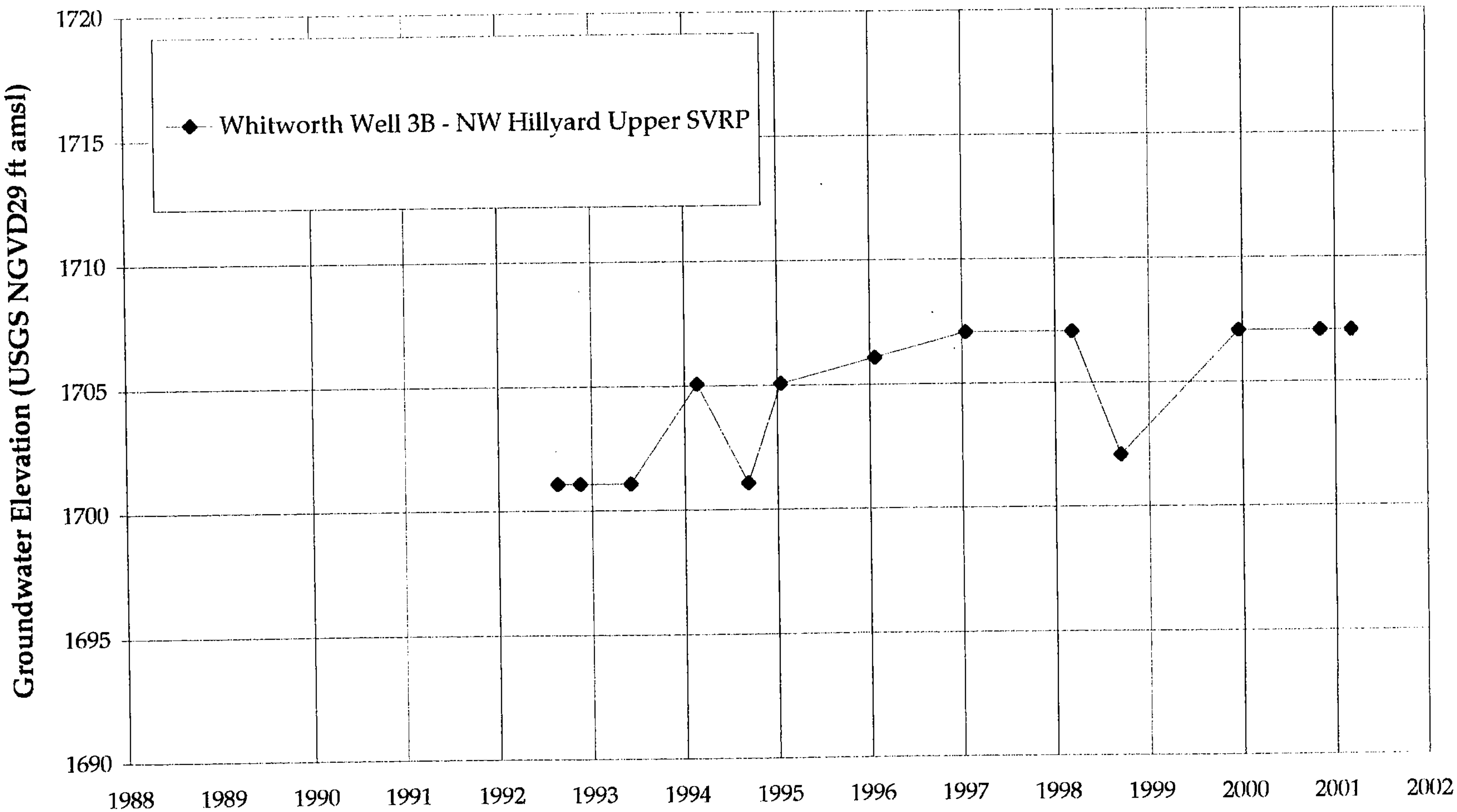
D2-47to49 Whitworth.xls/D2-47 Whitworth 1,2A,2B



Data Source: Whitwoth Water District and Spokane County
Date Type : Randon Manual Measurements
Station Name: Whitworth Water District Well #s 3B
Station ID: 6307G01

FIGURE D2-48:
Whitworth Water District Wells
 # 3B
Static Levels 1992-2001

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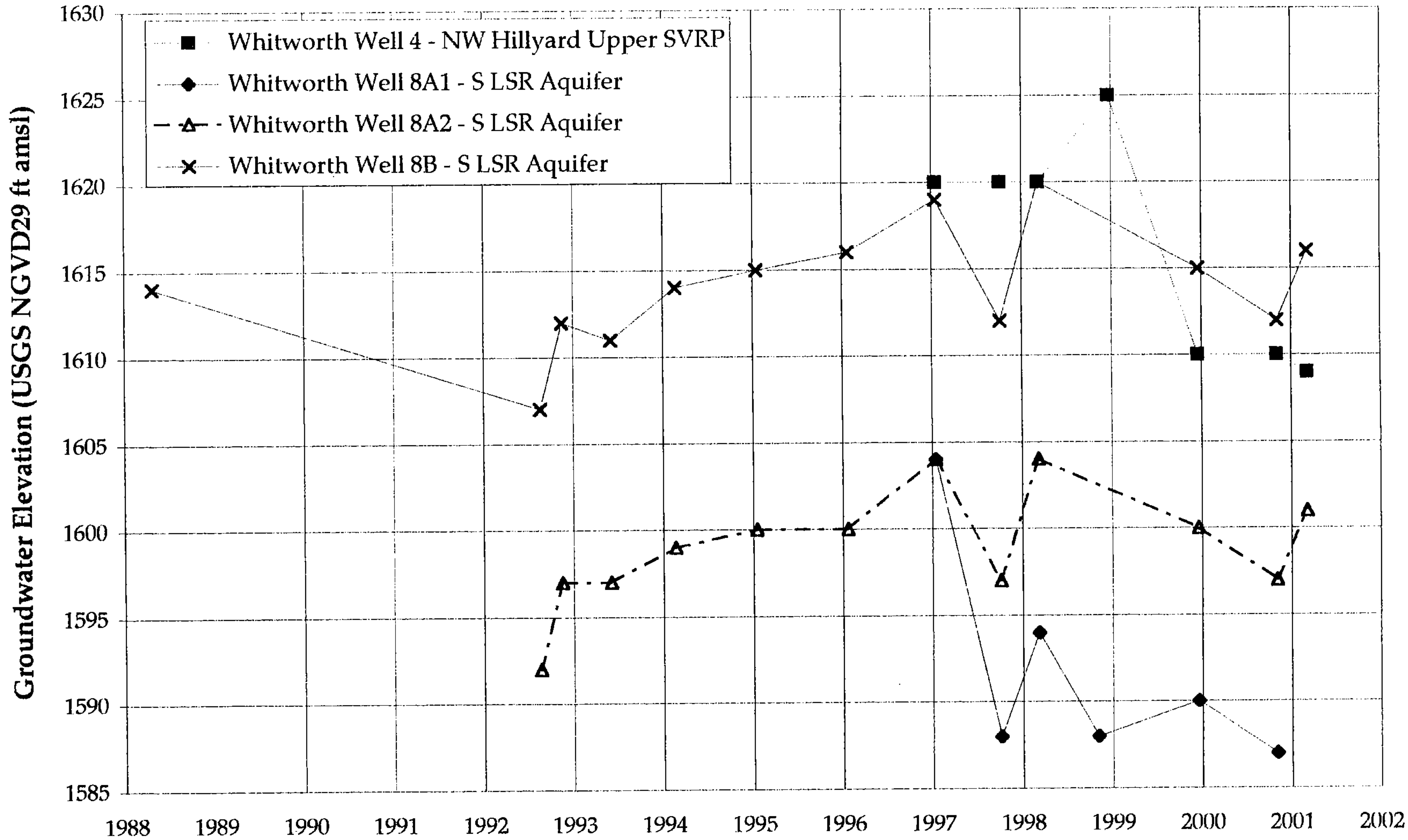

Data Source: Whitwoth Water District and Spokane County
Date Type : Randon Manual Measurements
Station Name: Whitworth Water District Well #s 4, 8A1, 8A2, 8B
Station ID: 6212L01, 7332H01, 7332H02, 7333E01
Note: Wells 8A1, 8A2 and 8B located north of Little Spokane River, just upstream of Dartford Creek.

FIGURE D2-49:
Whitworth Water District Wells
#s 4, 8A1, 8A2, 8B
Static Levels 1988-2001

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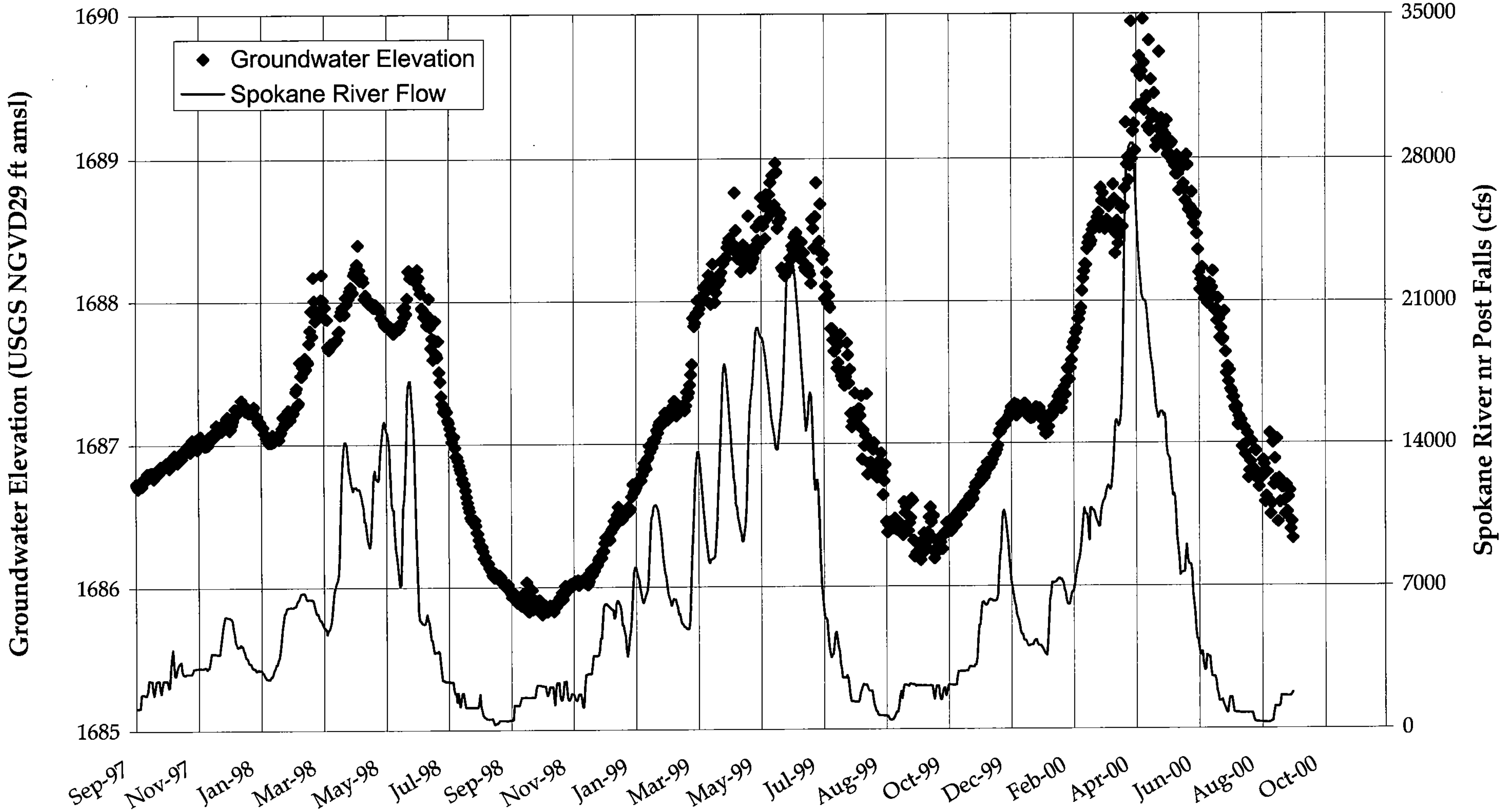
D2-47to49 Whitworth.xls/D2-49 Whitworth 4,8A1,8A2,8B



Data Source: Ecology
Date Type : Daily Averages
Station Name: Mayfair Well, Whitworth Water District Test Well
Station ID: 6308F02
Note: completed 452 - 462 ft bgs in the lower sands & gravels of N Hillyard Trough

FIGURE D2-50:
Mayfair Well
9/1997-9/2000

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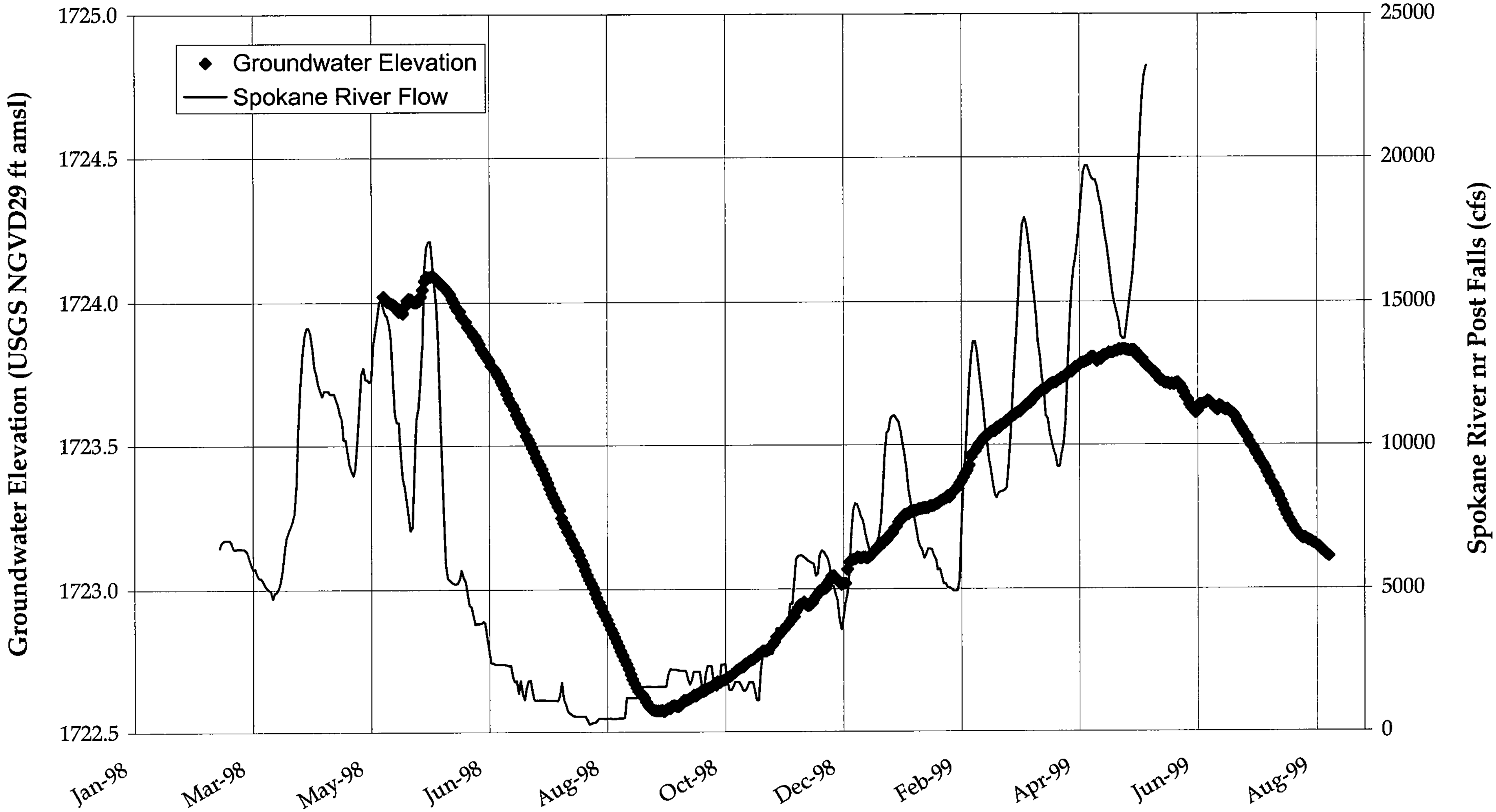
D2-50 mayfair.xls/D2-50 hydro



Data Source: Ecology
Date Type : Daily Averages
Station Name: Dakota Well, Spokane County Water District #3
Station ID: 6308B04
Note: completed 89 ft bgs in the upper sands & gravels of N Hillyard Trough

FIGURE D2-51:
Dakota Well
5/1998-8/1999

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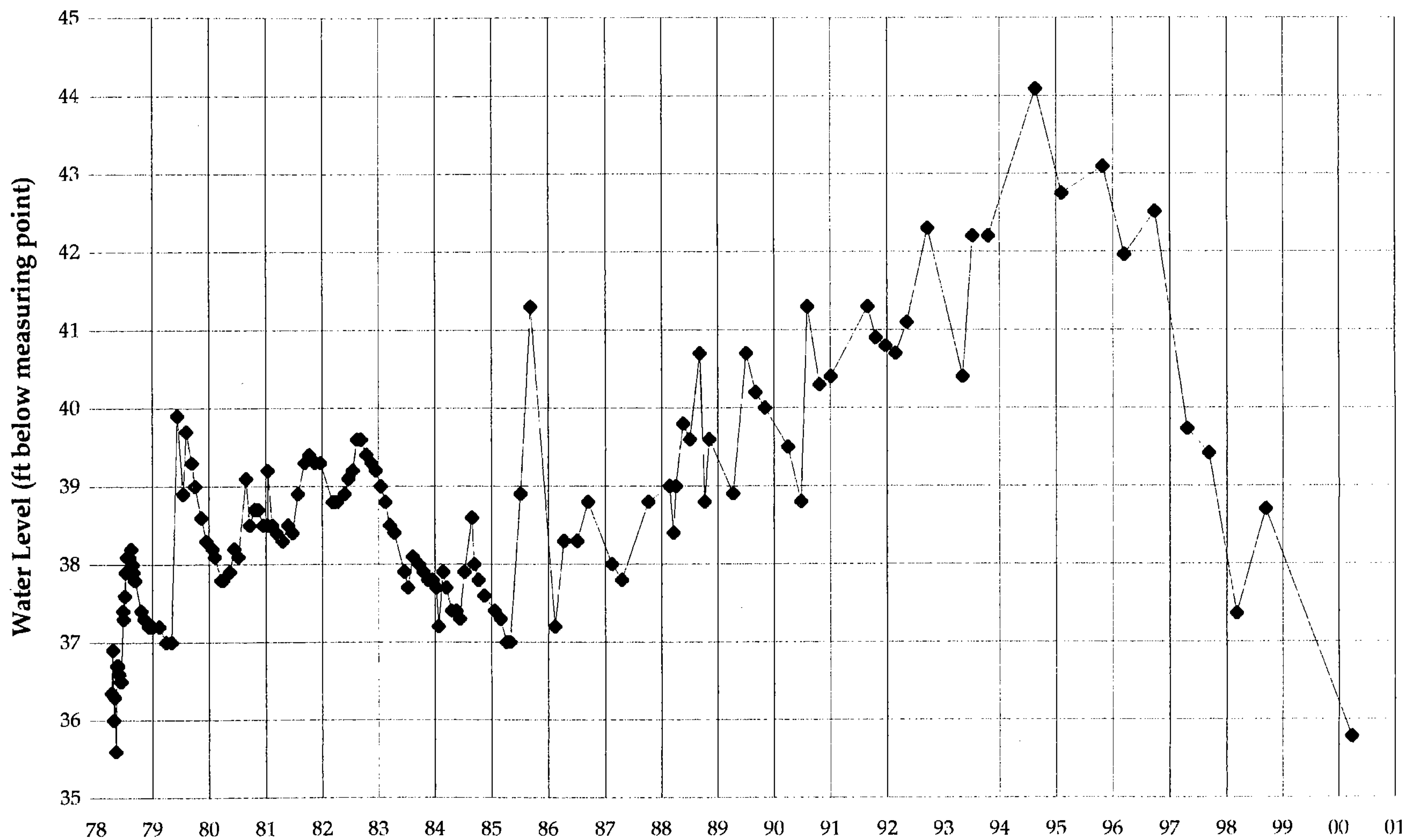
D2-51 dakota.xls/D2-51 hydro



Da□a Source: Ecology
Date Type : Quartlery manual data
Station Name: Chatteroy Observation Well
Station ID: 8316D01

FIGURE D2-52:
Chatteroy Observation Well
4/1978 - 3/2000

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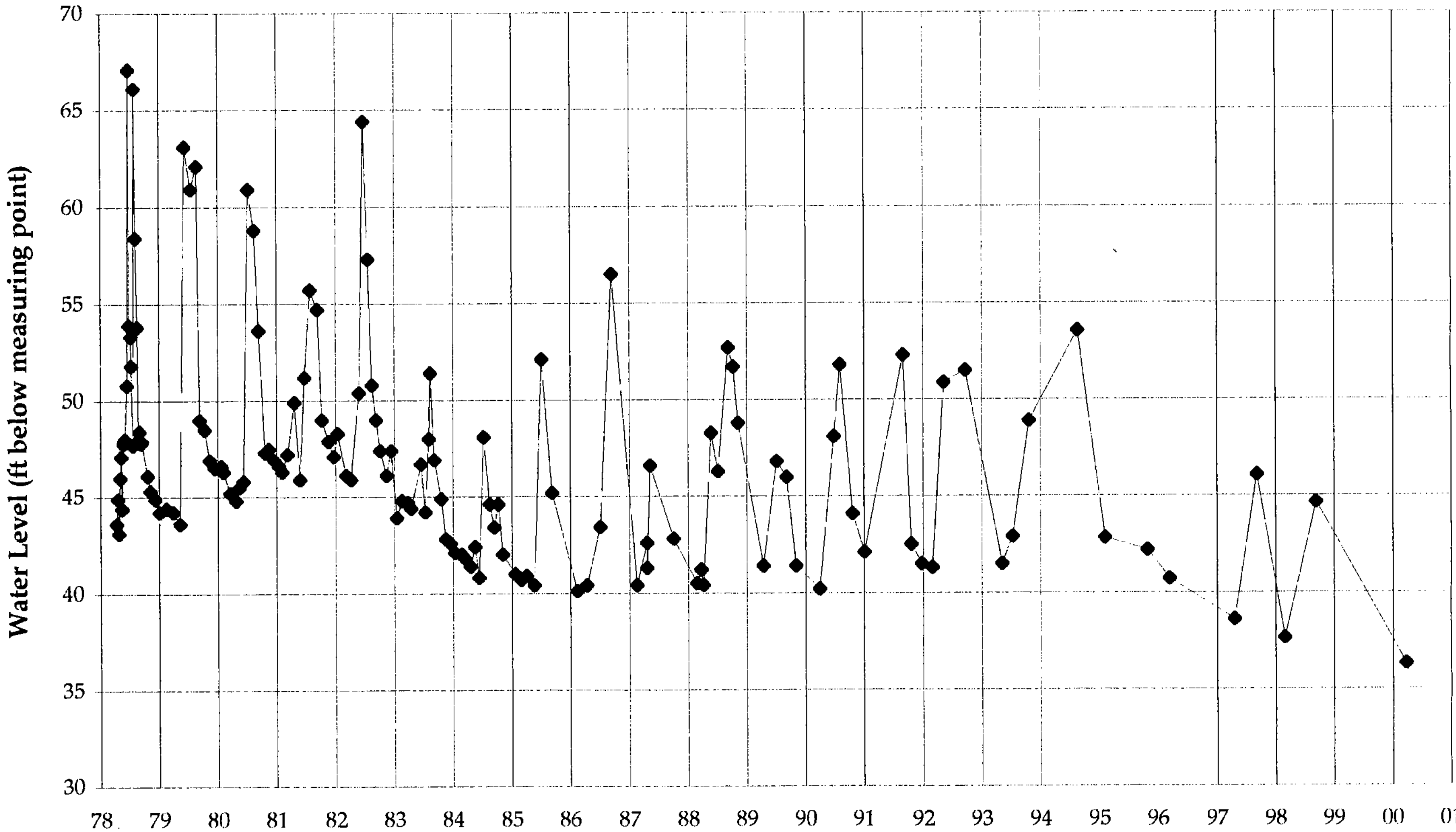
D2-52 chatteroyobwell.xls/D2-52 hydro



Da□a Source: Ecology
Date Type : Quarterly manual data
Station Name: Deer Park Observation Well
Station ID: 9233G01

FIGURE D2-53:
Deer Park Observation Well
4/1978-3/2000

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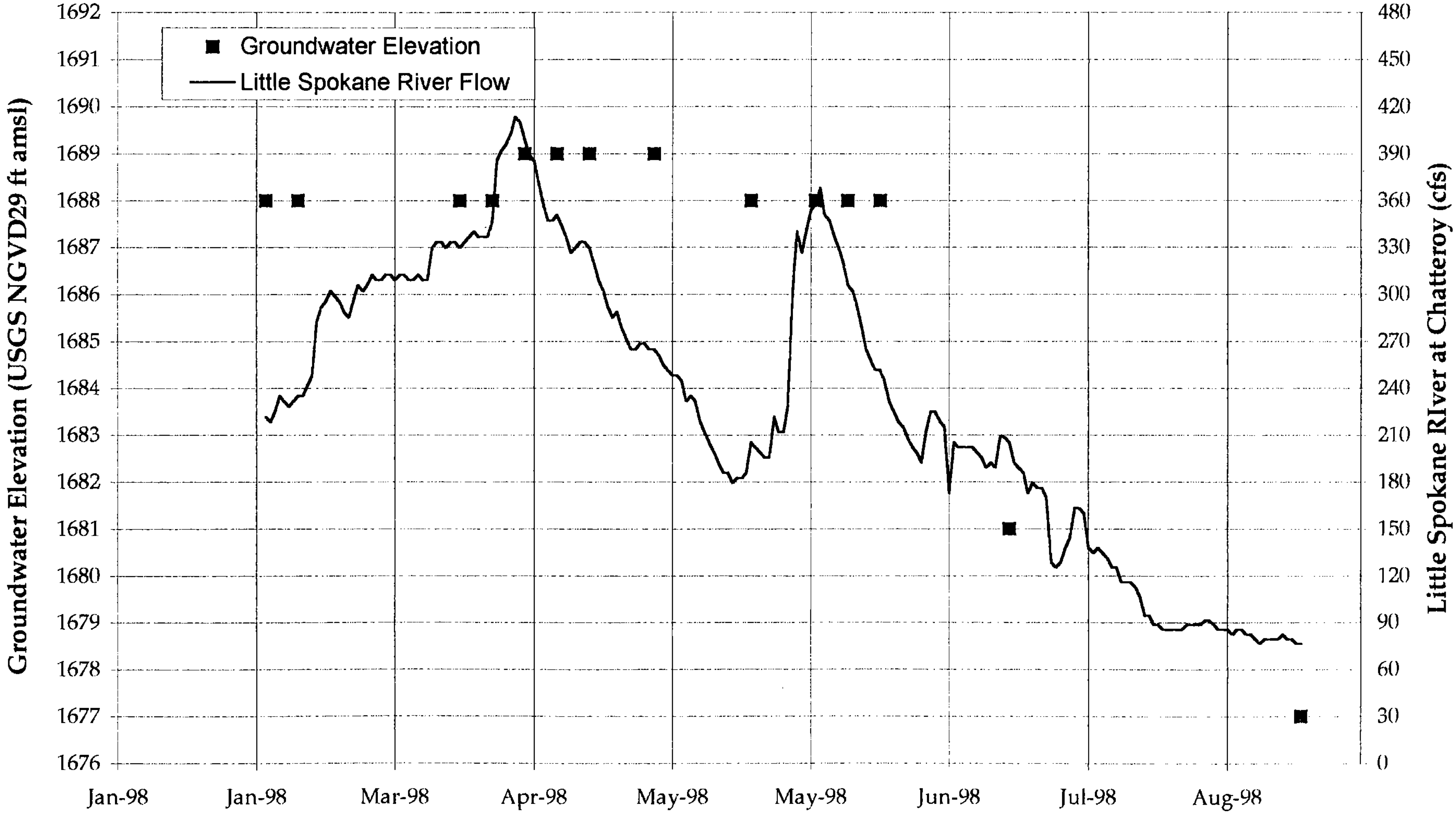

Data Source: Spokane County Water District #3
Date Type : Random
Station Name: Chatteroy Hills Well
Station ID: 8316D01

FIGURE D2-54:
Chatteroy Hills Well
2/1998 - 9/1998

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Golder Associates

013-1372.1100 March 30, 2001

D2-54 ChattaroyHills.xls/D2-54 hydro

APPENDIX D3

DESCRIPTION OF SPOKANE VALLEY RATHDRUM PRAIRIE AQUIFER GROUNDWATER FLOW MODELS

Table of Contents

D3-1. DESCRIPTION OF SPOKANE VALLEY RATHDRUM PRAIRIE AQUIFER GROUNDWATER FLOW MODELS

The following paragraphs present a review of the groundwater flow models of the SVRP Aquifer that have been developed primarily in support land of land development (i.e. groundwater supply) and to designate protection areas over aquifer zones that provide water to large water supply wells (i.e. groundwater quality protection). The information within this Appendix supports information presented within Section 5.2.7 of the Level 1, Phase II Assessment Report for WRIAs 55 and 57.

D3-1.1 Pluhowski and Thomas, 1968.

Pluhowski and Thomas (1968) completed a water balance equation for the Rathdrum Prairie with the Otis Orchard gaging station (above Liberty Bridge near Otis Orchard – station 1241950) as the outflow point. This gage is located on the Spokane River about two miles west of the Washington-Idaho state line. The water balance estimated 950 cfs of groundwater flow within the aquifer in the vicinity of the Otis Orchard gage and accounted for groundwater contributions from: 1) the Rathdrum Prairie (530 cfs); 2) Coeur d'Alene Lake and the Spokane River reach between Coeur d'Alene and Post Falls (250 cfs); 3) the Spokane River reach between Post Falls and Otis Orchards (120 cfs); and, 4) return flows from irrigated areas (50 cfs). The authors noted that groundwater contributions from the Rathdrum Prairie may be overestimated by as much as 200 cfs due to poorly understood groundwater flow conditions near Spirit Lake and Blanchard (located within the northwestern portion of the Rathdrum Prairie).

D3-1.2 Drost and Seitz, 1978.

Drost and Seitz (1978) completed the first comprehensive overview of the SVRP Aquifer to provide the EPA with technical data to support the aquifer's Sole Source status. The report compiles the existing information available for the aquifer and reviews estimates of recharge to and discharge from the aquifer. Based on the information available at this time, Drost and Seitz (1978) estimated that about 800 cfs of groundwater flow enters Washington at the Washington-Idaho state line.

D3-1.3 Bolke and Vacarro, 1981.

Bolke and Vacarro (1981) developed the first groundwater flow model of the Spokane Aquifer; a steady state (average annual) and transient (monthly discretization) two-dimensional finite element groundwater flow model for the Spokane Valley aquifer from Post falls to the confluence of the Little Spokane and Spokane Rivers. The purpose of the model was to assess the impacts of groundwater pumping on groundwater levels and stream flow. Data for model set up and calibration included: 1) water levels measured in 142 wells between march 1977 and May 1978 (Bolke and Vaccaro, 1979); 2) pumping records from 135 wells; 3) streamflow records for the Spokane and Little Spokane Rivers and Hangman Creek, and, 4) data and results from previous studies.

Lateral and vertical hydraulic conductivity were assumed to be the same for the geologic units.

The model boundary conditions are summarized below:

- Constant specified heads at the eastern boundary (based May 1977 to April 1978 field measurements);
- Constant discharge of the Spokane River, Little Spokane River and Hangman Creek;
- No-flow boundaries along the north and south limits of the aquifer except at nodes where hillside watersheds drain into the aquifer;
- Constant groundwater inflow at nodes where hillside watersheds drain into the aquifer based on data estimated by Drost and Seitz (1978);
- Constant specified heads at the western boundary (based May 1977 to April 1978 field measurements);
- Outcrops of basalt and crystalline basement within the model area were treated as areas of low transmissivity; and
- A no-flow boundary was used to define the base of the aquifer.

The main model inputs are summarized below:

- Average annual precipitation of 17.2 inches / month and 1977-1978 monthly values from the Spokane International Airport;
- Average annual evapotranspiration of 1.31 inches / month and monthly values based on a evapotranspiration equation developed by the U.S. Department of Agriculture (1967).
- Average annual 1977 pumping rate of 227 cfs applied to specific grid elements and distributed monthly based on available records;
- Constant specified heads ranging from 1,980 to 1,985 feet amsl at the eastern boundary;
- Constant specified heads ranging from 1,536 to 1,543 feet amsl at the western boundary;
- Constant discharge of the Spokane River at Post Falls of 5,383 cfs;
- Constant discharge of the Little Spokane River at Dartford of 229 cfs;
- Constant discharge of Hangman Creek to the Spokane River at 268 cfs; and.
- Total inflow at specified flow nodes of 269 cfs.

The table below summarizes the results of Bolke and Vaccaro's (1981) May 1977 to April 1978 model.

Bolke and Vaccaro (1981) Spokane Valley Groundwater Flow Model Results

	Contribution (cfs)
RECHARGE	
Precipitation minus Evapotranspiration	66
Groundwater Inflow Eastern Boundary	399
Subsurface Inflow (tributaries)	269
Leakage from the Spokane River	420
Land applied water	114
Septic systems	20
Total:	**1,288**
DISCHARGE	
Groundwater outflow at Nine Mile Dam	105
Groundwater pumpage	227
Groundwater Discharge to the Spokane River	702
Groundwater Discharge to the Little Spokane River	254
Total:	**1,288**

In a model simulation where wells were pumped at twice the estimated 1977 rates, the groundwater table within the Spokane Aquifer was lowered less than three feet during the one-year simulation period. However, the loss from the Spokane River to the Spokane Aquifer was simulated at about 150 cfs during the summer months and about 50 cfs during the remainder of the year. The contribution of the Spokane Aquifer to the Little Spokane River during the increased pumping run decreased by less than 10 cfs.

D3-1.4 Painter, 1991.

Painter (1991, unpublished) completed a mass balance approach based on previous investigations and accounting for all recharge into the Rathdrum Prairie aquifer. Painter estimated that 753 cfs of groundwater flowed into Washington across the state line. Inflow to the system from hillside lakes was simulated using an average yield of 0.59 cfs per square mile of tributary watershed per year. This average yield was estimated based on studies of recharge into the aquifer from the Spirit Lake tributary watershed (0.57 cfs / square mile of watershed), Twin Lakes watershed (0.79 cfs / square mile of watershed) and the Hauser Lake watershed (0.39 cfs / square mile of watershed). The sources of recharge to the Rathdrum Prairie aquifer are summarized below.

Painter (1991) Rathdrum Prairie Water Balance Model Results

Recharge Source (watershed name)	**Drainage** (square miles)	**Average Recharge** (cfs)	**Percent of Recharge**
Spirit Lake	39.0	22.3	3.0
Twin Lakes	31.4	25.0	3.3
Hauser Lake	21.1	8.2	1.1
Hidden Valley	12.3	7.3	1.0
Blanchard	106.4	62.2	8.3
Bayview / Kelso	25.3	14.8	2.0
Chilco Channel	69.4	40.6	5.4
Hayden Lake	64.0	37.8	5.0
Canfield	7.9	4.6	0.6
Lake Coeur d'Alene and Spokane River	3,718.0	230.0	30.6
Lake Pend Oreille	22,900.0	50.0	6.6
Rainfall	283.0	250.0	33.2
TOTAL		**753**	

D3-1.5 Buchanan and Olness, 1994.

Buchanan and Olness (1994) developed a groundwater flow model of the Spokane Valley portion of the SVRP Aquifer using the finite-difference MODFLOW code (McDonald and Harbaugh, 1988). The model was prepared for the Spokane County Water Quality Management Program and estimated a groundwater through flow at the state line of 320 cfs. This model was updated and linked to a Rathdrum Prairie model in 1999 (Buchanan, 1999).

D3-1.6 CH2M Hill, 1998.

CH2M Hill (1998) developed a three dimensional, steady state finite element groundwater flow model for the Spokane Aquifer (from the state line to the confluence of the Spokane and Little Spokane Rivers) for the City of Spokane's wellhead protection program. MicroFem (ver 3, Hemker and Nijsten 1996) was selected as the modeling software. The following data collection effort was completed to provide information with which to construct and calibrate the model:

- Installed 12 monitoring wells;
- Conducted aquifer pumping tests at two City production wells;

- Established a water level monitoring network from the Washington-Idaho state line to Nine-Mile Dam;
- Collected water level data in September 1994 and April 1995;
- Collected continuous water level data at nine monitoring wells;
- Conducted seismic reflection profiling across about 3 miles within selected areas of the City of Spokane; and,
- Reviewed well logs and entered about 300 well logs into a project database.

The model boundary conditions are summarized below:

- Specified flux at the state line;
- Specified heads (based on September 1994 field measurements) for the Little Spokane River valley and the lower reaches of Nine-Mile reservoir;
- Constant stage for the Spokane River;
- No-flow boundaries along the north and south limits of the aquifer except at nodes where hillside watersheds drain into the aquifer;
- No-flow boundaries (simulated by very low transmissivities) along the edges of Five-Mile Prairie, the Green Street Knoll and Pine Street Knoll;
- Specified flux at nodes where hillside watersheds drain into the aquifer; and,
- A no-flow boundary was used to define the base of the aquifer.

The main model input parameters are summarized below:

- Effective precipitation (precipitation minus evapotranspiration) was specified at 66 cfs across the study area using a distribution based on work completed by Olness (1991).
- Land applied water was recharged at a rate of 2.5 inches / year in areas of high population density (up to 6,000 persons / square mile), 1.0 inches / year in areas of moderate population density (about 1,000 persons / square mile), 0.25 inches / year in areas of low population density (about 100 persons / square mile) and 2 inches/ year for areas outside City limits where irrigation is known to occur.
- Septic recharge was modeled at 16 cfs.
- Pumping rate inputs are based on data provided by the purveyors and were varied seasonally.
- Hydraulic conductivity was simulated with 20 zones and varied between 7,000 ft/day in the eastern portion of the Spokane Valley Aquifer to 1,500 feet/day in the northern Hillyard Trough area. The hydraulic conductivity of sediments in the Trinity Trough was modeled at 120 feet /day.
- The horizontal hydraulic conductivity of aquifer materials was assumed to be ten times greater that the vertical hydraulic conductivity.

- The riverbed leakage rates were specified for 16 reaches of the Spokane River and allowed to vary during the model calibration process.

The model was calibrated to aquifer conditions measured in September 1994 and was verified by simulation of the aquifer conditions measured in April 1995. The table below summarizes the results of CH2M Hill's (1998) average annual steady state model for the Fall 1994 and Spring 1995 for the model area from the Washington-Idaho state line to the Little Spokane River.

CH2M Hill (1998) Spokane Valley Groundwater Flow Model Results

	Fall, 1994 (CFS)	**Spring, 1995** (CFS)
RECHARGE		
Precipitation minus Evapotranspiration	23	46
Groundwater Inflow Eastern Boundary	383	383
Subsurface Inflow (tributaries)	38	57
Leakage from the Spokane River	222	226
Land applied water	10	2
Septic systems	16	16
	692	730
DISCHARGE		
Groundwater outflow at Nine Mile Dam	-	-
Groundwater pumpage	220	125
Groundwater Discharge to the Spokane River	172	270
Groundwater Discharge to the Little Spokane River	300	335
	692	730

The following points summarize the main results of the water budget (CH2M Hill, 1998):

- The two main recharge components to the Spokane Aquifer are: 1) groundwater inflow at the state line; and, 2) leakage from the Spokane River.
- Areal recharge and recharge from tributary valleys to the Spokane Aquifer are relatively small contributions.
- The magnitude of groundwater flow through the Trinity Trough is insignificant in comparison to the overall water budget for the Spokane Aquifer.

D3-1.7 Buchanan, 1999.

This groundwater flow model was created using the finite-difference MODFLOW code (McDonald and Harbaugh, 1988) and represents the first regional groundwater flow model that extends any significant distance across the SVRP aquifer system from Idaho and into Washington. Although not suitable for highly resolved particle tracking and advective transport modeling, the model does function as a valuable tool in understanding the overall water balance of the aquifer system. The model is constructed using data gathered during years of work on the aquifer system in both Idaho and Washington (Bolke and Vaccaro, 1981; Painter unpublished, 1991; Buchanan and Olness, 1994; R&A Technical Consultants, 1997). In addition, the model considers the data generated in the delineation of wellhead capture zones for the City of Spokane and the Spokane Aquifer Joint Board (CH2M Hill, 1998; CH2M Hill, 2000).

The conceptual hydrogeologic model comprises a permeable sand and gravel aquifer within a bedrock valley. Recharge is primarily from lake and river leakage and areally distributed precipitation in Idaho. Discharge from the system takes place mostly to the Spokane River and Little Spokane River in Washington. The steady-state model is single-layer with 1,321 active cells defining the approximately 325 square mile surface area of the aquifer system. Each cell is a half-mile square.

The boundary conditions include constant head nodes corresponding to peripheral lakes and the Little Spokane River, river nodes representing the Spokane River and no-flow boundaries representing the bedrock of the valley sides.

Hydraulic conductivity is decreased from east to west, through the model domain with values of 1,500 to 50,000 feet per day used to represent the aquifer materials. Porosity is set to 20 percent (0.20) uniformly throughout the model domain. Recharge due to rainfall is applied to the top surface of each active cell in the model, and is estimated to be 25 percent of rainfall volume. Additional recharge from hillslopes and small basins adjacent to the aquifer is applied to the appropriate cells in the model with values taken from Painter (1991) and Bolke and Vaccaro (1982).

The final model yields an aquifer throughflow at the state line of about 390 cubic feet per second (cfs). This figure agrees with that of Bolke and Vaccaro's (1981) value of 453 cfs, Buchanan and Olness' (1994) 320 cfs and that of CH2M Hill (1998) of 380 cfs at the state line. Approximately 10 cfs of groundwater flow was estimated across the Trinity Trough.

D3-1.8 CH2M Hill, 2000.

The CH2M Hill (2000) groundwater model was created for the Spokane Aquifer Joint Board (SAJB), a group of 21 Class A water utilities, including the City of Spokane. The model updated the MICRO FEM groundwater flow model created for the City of Spokane in 1998. The purpose of the update was to expand the model domain, to incorporate new information and to delineate the capture zones to the SAJB wells for wellhead protection.

The new information collected for the CH2M Hill (2000) SAJB wellhead protection project included:

- An expanded water level monitoring (including at the State Line);
- Information from 15 new monitoring wells;
- An additional discrete and continuous water level monitoring event;
- New ground surveys;

- Additional aquifer testing;
- Seismic investigations in the central Spokane Valley;
- A review to confirm / refute deep confined aquifer system in the north Hillyard Trough and Little Spokane River Valley;
- A microgravity gradiometry survey of the north Hillyard Trough area;
- Transient electro-magnetics (TEM) in North Spokane
- Establishment of river stations and a well monitoring network of the Little Spokane River Basin between Dartford and Little Deep Creek; and,
- A geochemical evaluation (to determine if upper and lower portions of the SVA are distinguishable based on geochemistry).

The following adaptations were made to the City's wellhead protection model:

- The model grid was refined in the vicinity of the SAJB wells;
- The specified head nodes at the northern end of the Hillyard Trough were converted to variable head nodes so that capture zone delineations could be performed for 3 SAJB wells in this area;
- Recharge from the tributary valleys (which does occur in reality) was not simulated because of concerns that wellhead capture zones near the edges of the aquifer would be distorted;
- The following geologic boundaries were modified: : 1) the western boundary of a bedrock knoll in the vicinity of the Pines Road Walk-In-The-Wild Zoo; 2) the southern boundary of the Spokane Valley Aquifer in the vicinity of the East Spokane Water District wells #5 and #6; and, 3) the southern boundary of the SVA at Shelly Lake;
- Modifications of Spokane Valley Aquifer properties and river stage were made to the west of the Kaiser Aluminum Company Trentwood Rolling Mill (since the 1998 model did not correctly simulate groundwater flow directions in the western portion of the facility);
- The pumping rates for SAJB wells were made equal to annual water rights over 365 days per year;
- The pumping rates for the City of Spokane and private wells were set at rates equal to those in Fall 1994 simulation; and,
- All the SAJB wells and non-SAJB wells pumped simultaneously in the steady state model for a total pumping of 410 cfs or 184,000 gpm (about 1.75 times higher than City's model).

The model was recalibrated to aquifer conditions measured in September 1994. The table below summarizes the results of CH2M Hill's (1998) average annual steady state model for the Fall 1994 and Spring 1995 for the model area from the Washington-Idaho state line to the Little Spokane River.

CH2M Hill (2000) Spokane Valley Groundwater Flow Model Results

	1998 Model Fall, 1994 (CFS)	**2000 Model Fall, 1994** (CFS)
RECHARGE		
Precipitation minus Evapotranspiration	23	23
Groundwater Inflow Eastern Boundary	383	383
Subsurface Inflow (tributaries)	38	38
Leakage from the Spokane River	222	182
Land applied water	10	10
Septic systems	16	16
Total	**692**	**652**
DISCHARGE		
Groundwater outflow at Nine Mile Dam	-	-
Groundwater pumpage	220	220
Groundwater Discharge to the Spokane River	172	250
Groundwater Discharge to the Little Spokane River	300	182
Total	**692**	**652**

APPENDIX D4

SPOKANE RIVER – SVRP AQUIFER INTERACTION STUDIES

Table of Contents

D4-1. SPOKANE RIVER – SVRP AQUIFER INTERACTION STUDIES

The following paragraphs present a review of the Spokane River – SVRP Aquifer interaction studies that were reviewed as a component of the Level 1, Phase II Assessment of WRIAs 55 and 57. The information within this Appendix supports information presented within Section 5.3.1 of the Level 1, Phase II Assessment Report for WRIAs 55 and 57.

D4-1.1 McDonald and Broom, 1951.

McDonald and Broom (1951) published a preliminary analysis of Spokane River discharge records from the Post Falls Dam to Long Lake for the 1950 water year. They described the physical characteristics of some Spokane River reaches and identified them as either losing or gaining. This information was further developed by Broom (1951).

D4-1.2 Broom, 1951.

Broom (1951) computed annual stream gains and losses for the water year 1950 between gaging stations for seven reaches of the Spokane and Little Spokane Rivers. Broom divided the Spokane River into seven reaches from Post Falls, Idaho to the downstream end of Long Lake, Washington. The first six of these reaches (to Nine Mile Falls) are listed in Table 5.13. These reaches are illustrated on Figure 2 (taken from Gearhart and Buchanan, 2000) in Appendix D5. For the four Spokane River reaches located within WRIA 57, Broom's analyses characterized Reach 1 (Post Falls to Greenacres) and Reach 4 (Greene Street to Spokane) as losing and Reach 2 (Greenacres to Trent Bridge) and Reach 3 (Trent Bridge to Greene Street) as gaining.

D4-1.3 Drost and Seitz, 1978.

Drost and Seitz (1978) completed a Spokane Aquifer characterization report in which they cited the USGS's reanalysis of Broom's 1951 calculations. Between Post Falls, Idaho, and Greenacres, Washington, the USGS estimated an average annual loss of 80 cfs from the Spokane River to the Aquifer. The remainder of the Spokane River from Greenacres to Nine Mile Falls, was estimated to gain an annual average of 780 cfs from the Spokane Aquifer. The Drost and Seitz (1978) reanalysis is presented on Table 5.13 and illustrated on Figure 3 (taken from Gearhart and Buchanan, 2000) in Appendix D5.

D4-1.4 Bolke and Vacarro (1981)

Bolke and Vacarro (1981) further developed on Broom's 1951 losing / gaining analysis and divided the Spokane and Little Spokane Rivers from Post Fall to their confluence into 13 losing / gaining reaches. These reaches are illustrated on Figure 4 (taken from Gearhart and Buchanan, 2000) in Appendix D5. Bolke and Vacarro (1981) calculated a leakage coefficient for each of the reaches. The leakage coefficient is defined as the vertical hydraulic conductivity of the streambed divided by the thickness of the streambed:

$$C = \frac{Ks}{m}$$

Where,

C	=	streambed leakage coefficient
Ks	=	vertical hydraulic conductivity of the streambed (ft/sec)
m	=	thickness of the streambed

The table below summarizes the data that Bolke and Vaccaro (1981) used as input to their groundwater flow model from Post Falls to Hangman Creek. The data is also presented on Table 5.13.

Summary of Bolke and Vaccaro (1981) Spokane River Losses and Gains

River Reach	**Leakage Coefficient** (feet/second)	**Losing / Gaining** (cfs)
Post Falls to Greenacres	6.2×10^{-7}	- 50
Greenacres to Plantes Ferry (Irwin)	1.0×10^{-4}	+ 240
Plantes Ferry (Irwin) to Felts Field	6.2×10^{-7}	-40
Felts Field to Eastern Spokane	2.0×10^{-4}	+ 270
Eastern Spokane to Spokane Falls	6.2×10^{-7}	-200
Spokane Falls to USGS Spokane Gage	6.2×10^{-7}	+130

Based on the May 1977 to April 1978 data, Bolke and Vaccaro (1981) identified 6 losing and 5 gaining reaches along the Spokane River from Post Falls to the confluence with the Little Spokane River. In the model area between Post Falls and Hangman Creek, 3 losing reaches and 3 losing reaches were identified. The losing and gaining flows are summarized in the table above.

D4-1.5 Miller, 1996.

Miller (unpublished, 1996) used calcium concentrations in the Spokane River and Spokane Aquifer along with river stage to estimate the exchange between the Spokane River and the Aquifer. The study was based on the hypothesis that the main source of calcium to the river water is via groundwater discharge from the aquifer to the river. The following equation was used to estimate the volumetric exchange of water:

$$Q_o = \frac{(C_i Q_i + C_r Q_r - C_l Q_l)}{C_o}$$

Where,

Q_o = flow at the downstream end of a river reach
Q_I = flow at the upstream end of a river reach
Q_r = aquifer recharge to the river within the reach
Q_l = river loss to the aquifer within the river reach
C_o = concentration of the indicated parameter downstream
C_I = concentration of the indicated parameter upstream
C_r = concentration of the indicated parameter in groundwater adjacent to gaining reaches of the river
C_l = concentration of the indicated parameter in groundwater adjacent to losing reaches of the river

Miller estimated losses and gains for the six river reaches listed on Table 5.13. These reaches are illustrated on Figure 5 (taken from Gearhart and Buchanan, 2000) in Appendix D5. A summary of Miller's (1996) results is tabulated below.

Summary of Miller (1996) Spokane River Losses and Gains

<table>
<tr><th>River Reach</th><th>Low Flow</th><th>High Flow</th></tr>
<tr><td>Post Falls to Greenacres</td><td>- 207</td><td>- 319</td></tr>
<tr><td>Greenacres to Plantes Ferry (Irwin)</td><td>+ 206</td><td>+ 160</td></tr>
<tr><td>Plantes Ferry (Irwin) to Felts Field</td><td>Unquantified loss</td><td>Unquantified loss</td></tr>
<tr><td>Felts Field to Eastern Spokane</td><td>+ 209</td><td>+ 377</td></tr>
<tr><td>Eastern Spokane to Spokane Falls</td><td rowspan="2">+ 63</td><td rowspan="2">+ 122</td></tr>
<tr><td>Spokane Falls to USGS Spokane Gage</td></tr>
</table>

D4-1.6 CH2M Hill, 1998

The streambed leakage concept was used by CH2M Hill (1998) to simulate the river-aquifer interactions as a component of the groundwater flow model developed for the City of Spokane's wellhead protection program. CH2M Hill (1998) defined eleven losing / gaining reaches between Post Falls and Hangman Creek. The following is a summary of the CH2M Hill (1998) simulated streamflow losses and gains for the same reaches as those defined by Bolke and Vaccaro (1981) above. In comparison to both Bolke and Vaccaro's (1981) and Miller's (1996) models, the CH2M Hill (1998) model predicts an overall lower exchange of water (both losses and gains) between the Spokane River and Aquifer. The data is also presented on Table 5.13.

Summary of CH2M Hill (1998) Spokane River Losses and Gains

River Reach	Leakage Coefficient (feet/second)	Losing / Gaining Sept. 1994 (cfs)	Losing / Gaining Apr. 1995 (cfs)
Post Falls to Greenacres	5×10^{-7} to 2×10^{-6}	- 136	- 171
Greenacres to Plantes Ferry (Irwin)	1.0×10^{-6} to 5×10^{-4}	+ 15	+ 59
Plantes Ferry (Irwin) to Felts Field	5×10^{-8} to 5×10^{-6}	- 17	+ 4
Felts Field to Eastern Spokane	1.0×10^{-3}	+ 149	+ 194
Eastern Spokane to Spokane Falls Spokane Falls to USGS Spokane Gage	5×10^{-6}	- 75	- 42

D4-1.7 CH2M Hill (2000)

As indicated in the summary table below, the updated CH2M Hill (2000) model for the SAJB, resulted in a further lowering of the overall exchange of water between the Spokane River and the Aquifer. The data is also presented on Table 5.13.

Summary of CH2M Hill (2000) Spokane River Losses and Gains

River Reach	Leakage Coefficient (feet/second)	CH2M Hill (1998) Losing / Gaining Sept. 1994 (cfs)	CH2M Hill (2000) Losing / Gaining Sept. 1994 (cfs)
Post Falls to Greenacres	5×10^{-7} to 2×10^{-6}	- 136	- 120
Greenacres to Plantes Ferry (Irwin)	2.0×10^{-6} to 5×10^{-4}	+ 15	+ 64
Plantes Ferry (Irwin) to Felts Field	5×10^{-8} to 5×10^{-6}	- 17	- 5
Felts Field to Eastern Spokane	1.0×10^{-3}	+ 149	+ 174
Eastern Spokane to Spokane Falls Spokane Falls to USGS Spokane Gage	5×10^{-6}	- 75	- 42

D4-1.8 Gearhart and Buchanan (2000).

Gearhart and Buchanan (2000) established five study sites between the Idaho-Washington state line and downtown Spokane: 1) State Line; 2) Barker Road; 3) Sullivan Road; 4) Upriver Dam; an, 5) Mission Avenue. The locations of these five sites are shown on Figure 6 (taken from Gearhart and Buchanan, 2000) in Appendix D5. Between December 1998 and July 1999 groundwater elevations in monitoring wells and river stage elevations were collected weekly at each of the five sites. The following paragraphs summarize the findings of this study.

At the State Line site, the groundwater elevation in the SVRP Aquifer was measured between 44 and 49 feet below the Spokane River stage. The State Line site is defined as a river losing site with an unsaturated zone between the river and the groundwater table.

At the Barker Road site, the groundwater elevation in the Spokane Valley Aquifer was measured between 20 and 26 feet below the Spokane River stage. The Barker Road site is defined as a river losing site with an unsaturated zone between the river and the groundwater table. A comparison of Spokane River flows near Post Falls with groundwater levels within the Barker Road wells indicated a one day to a few days lag time between rises and falls in the river flows in relation to corresponding rises and falls groundwater levels.

The Sullivan Road site is defined as a river losing and gaining site connected by saturated flow conditions. In the summer months, when river flows are low, groundwater levels rise above the river stage and groundwater flows from the aquifer to the river. Springs can often be seen along the Spokane River bank in this location during the summer months. As flows in the river increase, the river stage rises above the groundwater table and water flows from the river into the aquifer. A comparison of Spokane River flows near Post Falls within groundwater levels within the Sullivan Road wells indicated a 1 to 2 day lag time between rises and falls in the river flows in relation to corresponding rises and falls groundwater levels.

The Upriver Dam site is complicated by the dam pool, which is maintained at an elevation of 1,910 feet amsl. All measured groundwater elevations adjacent to the pool were below 1,910 feet amsl indicating that water flows into the aquifer in the vicinity of the pool. However, on the downstream side of the pool, the flow is likely reversed, with groundwater flowing from the Aquifer to the Spokane River.

The Mission Avenue site is defined as a river losing site connected by saturated flow conditions. During the period between December 1998 and June 1999, the river stage was between 1.5 to 4 feet higher than the groundwater table elevation within the well on the north side of the river. Since data was not collected at this site in July and August 1999, it was not possible to assess if the river gains flow during these low flow summer months.

Based on observations made at the five study sites, the Spokane River was divided into the five reaches illustrated on Figure 30 (taken from Gearhart and Buchanan, 2000) in

Appendix D5. Darcy's equation was used for each reach using riverbed areas estimated from aerial photographs. A riverbed hydraulic conductivity of 1 x 10^{-5} feet / sec was used for riverbed areas covered at low flow. A hydraulic conductivity of 1 x 10^{-4} feet / sec was used to characterize riverbed areas located between the low and high water levels. A one order of magnitude difference was assumed to account for the occurrence of silt within the low flow riverbed and sands within the riverbed between the high and low flow levels. These values were assigned based on a compilation of riverbed hydraulic conductivity data from a number of previous studies. These values are presented on Table 5.14.

The estimated volumetric exchanges between the river and aquifer at five reaches are summarized below.

Summary of Gearhart and Buchanan (2000) Spokane River Losses and Gains

Spokane River Reach	Losing / Gaining Dec. 1998 – July 1999 (cfs)	Flow Conditions
Reach 1 – State Line to Harvard Road	– 307 to – 47	Unsaturated
Reach 2 – Harvard Road to Barker Road	- 137 to – 29	Unsaturated
Reach 3 – Barker Road to Sullivan Road	- 28 to + 126	Transitional
Reach 4 – Sullivan Road to Trent Avenue	-88 to + 50	Saturated
Reach 4 –Trent Avenue to Plantes Ferry Footbridge	-53 to + 30	Saturated

Based on the 1998 to 1999 data, the change in the Spokane River SVRP Aquifer interaction from a generally losing to a generally gaining stream occurs between Barker Road and Sullivan Road. This is supported by unpublished field and flow data collected by Spokane County. The only other study described above that has similar reaches to the Gearhart and Buchanan (2000) study is the CH2M Hill (1998) groundwater model. CH2M Hill (1998) places the transitional zone between Sullivan Road and the Kaiser Trentwood site located about one mile downstream (west) of Sullivan Road.

D4-1.9 United States Geological Survey (ongoing).

The USGS is currently working on a Spokane River – Aquifer hydraulic connection study as a component of their National Water-Quality Assessment Program (NAWQA). The purpose of the study is to further improve the understanding of the groundwater / surface water interactions along the losing reach of the Spokane River between Pleasant View Road in Idaho and Harvard Road in Washington. The study also aims to investigate the impacts of the river on the water quality of the aquifer.

To date, the USGS NAWQA study has involved:

- compilation of a well inventory database;
- installation of 18 new wells;

- monitoring at the 18 new wells and 7 pre-existing wells;
- assessment of pressure and temperature responses in the wells as a result of flow changes in the Spokane River; and,
- investigation of the water quality differences between groundwater within the aquifer and the surface water of the Spokane River.

Since the work is ongoing, further description of the study and the study results will not be included within the Level 1 Watershed Assessment. However, the study results may be used for the model development stage of the WRIA 57 Assessment.

APPENDIX E

MODEL SELECTION

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APPENDIX E-1

TECHNICAL MEMORANDUM FROM GOLDER ASSOCIATES INC., NOVEMBER 29, 2000

Technical Memorandum

To: Stan Miller, Spokane County

From: Chris Pitre, Bob Anderson, Robin Kirschbaum, Bryony Hansen, Golder Associates

Date: November 29, 2000

Re: Surface Water Routing Model Selection

One of the most important variables in watershed planning is the maintenance of adequate surface water flows. Therefore, it is recommended that the Spokane Planning Unit use a surface water routing model as a watershed planning tool to evaluate and understand the influences of various parameters on streamflows. This memorandum describes a variety of models to be considered for use by the Planning Unit.

There is a wide range of models available for consideration. Because it is envisioned that the model developed will be used in the future to support multiple water resource decisions, the choice of which model to use must be made with careful consideration. The consultant scope of work for Phase II watershed planning consists of two parts. The first part includes data compilation and preparation of a characterization report which is scheduled to be completed in February. The second part includes modeling and will start in March 2000. Model selection need only be made by March 2000. In the meantime, several presentations will be made to the Planning Unit to provide members of the Planning Unit the information to confidently select a model.

The concepts of a surface water routing model were introduced to the Planning Unit during the consultant selection process. The presentation on November 29, 2000 will introduce to the Planning Unit to a tangible list of considerations for model selection, including a specific set of models that have been identified for possible use. Golder will also attend the Planning Unit meeting on December 6, 2000 to participate in follow up discussions and to answer questions. Golder will present additional materials, as appropriate, in the January and February Planning Unit meetings.

Considerations presented in the Navoember 29, 2000 meeting include:

- The variables that the Planning Unit may wish to address;
- Ease/cost of using various models (including use by third parties); and,
- Institutional acceptance of the models.

Each of these points are expanded upon below.

VARIABLES TO BE ADDRESSED

A list of variables that may be analyzed with a surface water routing model and that are recognized to be important in the management of water resources in the Spokane Basins include, but are not limited to:

- Frequency and duration of low flows;
- Hydraulic continuity between surface water and groundwater;
- Timing and quantity of groundwater withdrawal effects on surface water flows;
- Effects of dam operation on streamflows; and,
- Effects of flows on water quality.

Model selection will be based in part upon the ability of the model to adequately address these variables. The data available (existing information) for input may restrict rigorous treatment of some of these variables. Therefore selection of a model to address all variables may not be necessary if reasonable analysis is constrained by the available data. Data constraints will be identified during the data compilation and characterization report, and the Planning Unit will be provided with this information to use in model selection. However, data may become available in the future to allow full analysis, and this should also be considered in model selection.

Frequency and duration of low flows: A minimum instream flow has been established for the Spokane River. The frequency that the minimum instream flow has been met can be statistically characterized. The principal output of a surface water routing model is streamflow data and can be used in a predictive or comparative manner (e.g., what will the actual flow value be under a given set of conditions, or will the flow be higher or lower if a specific parameter is modified, respectively). Minimum instream flows for aquatic biota are typically evaluated on the ten-year recurrence interval of a seven-day low flow (7Q10). Therefore, the model resolution is recommended to be daily, and output data can be aggregated to provide seven-day flow data.

Hydraulic continuity between surface water and groundwater: The Spokane Aquifer system is unique in the extreme degree of hydraulic continuity that exists between surface water and groundwater. Models can treat surface water-groundwater interactions through consideration of physical conditions that control the flow of water between the two (e.g., hydraulic gradients, the presence/absence of a "skin effect" on the bottom of the river, and other variables), or through empirical relations (e.g., fixed rates of exchange based of field data). Use of physical parameters creates a more flexible model, however high quality data is needed to realistically model a system. Review of available information during the data compilation will assess which approach will be more technically defensible.

Quantification of underflow through the Hillyard and Trinity Troughs between Water Resource Inventory Areas will be strongly influenced by the rate of exchange through hydraulic continuity between surface water and groundwater. Groundwater flows will be characterized through development of a water balance in the surface water routing model.

Timing and quantity of groundwater withdrawal effects on surface water flows: Installation of exempt wells is the primary source of water for new growth in the Spokane Basins. New water rights for purveyors to provide increased demand for water in a more controlled manner is also being considered. The effects of groundwater withdrawals on surface water is a major question that Planning Unit members have posed. Response functions will be required to address these parameters, either as pre-developed modules that come with an existing software package, or a custom designed module.

Effects of dam operation on streamflows: Incorporation of dam operations in surface water routing models is standard.

Effects of flows on water quality: Only non-reactive water quality components are to be addressed. Analysis of water quality relationship with flow is a relatively simple analytical methodology

EASE/COST OF USING VARIOUS MODELS

A large number of software packages were reviewed for presentation to the Planning Unit for consideration. A list of selected software packages are included in the attached table.

Presentation/User Interface: Output from various models have different degrees of user friendliness. Some interfaces are graphically-oriented and are manipulated in a more intuitive manner. Similarly, output from some models have a post-processor that presents the results in close to final format that is easily understood by an audience with a range of technical training. An example of a software package with a good graphical interface is GoldSim.

Pre-developed Modules: Many model software packages have pre-built response functions. These "canned" modules are generally well-accepted in the industry. However, most of them are hard-wired and cannot easily be modified to accommodate unusual conditions. The option may be available to compile a set of modules from various software packages to assemble a custom package.

Complexity of Simulation: Discretization of the model is to be completed as part of the data compilation and characterization report. The Planning Unit is to delineate sub-basins. Golder will review those delineations and may recommend modifications (changes, additions, deletions) for modeling purposes based on an examination of the data compilation. Model domain and points of model calibrations will be included in the model discretization.

If the model simulation is relatively complex, the selected model should have relatively well-developed modules that are well-integrated where calculations for many points (or sub-basins) can be conducted at the same time (e.g., SHE-Mike). If the number of calibration points are relatively few, a simpler model may be considered where certain calculations can be conducted outside of the model (e.g., in a spreadsheet) and provided as input to a more basic model.

Integration of GIS Capabilities: Significant GIS analysis is expected to be used in the preparation of a water balance model, particularly in the precipitation/runoff/recharge calculations. More advanced models have integrated GIS interface capabilities. For models without this interface, GIS analysis would be conducted outside of the model and provided as input to the model. An interface makes it easier for less technically-oriented personnel to operate the model (e.g., ______).

Operating System/Compatible Software: The model that will be developed may be used by a variety of agencies/individuals including the Initiating Agencies, the USGS, and state agencies. Most of the industry is PC-based. Models that are based in UNIX may not be as available for broad use (e.g., MSS). Some models that have GIS interface capabilities use ARC/INFO or ARC/View. ARC/INFO is a very expensive software package (e.g., , whereas ARC/View is widely used and available.

INSTITUTIONAL ACCEPTANCE OF THE MODELS.

Models that have been developed by government agencies and well-established commercial software packages that have received extensive use are generally provided with broader acceptance. Application of models to simulations similar to the type that will be done in the Spokane Basins will also increase the acceptance of a model. Examples of known models that have broad acceptance are MMS, developed by the United States Geological Survey, and Stella, which has been on the market for many years.

There may also be institutional familiarity among staff of Planning Unit agencies with some of software packages. Input from Planning Unit members on this is solicited.

Preliminary Ranking of Candidate Hydrologic/Water Quality Models for the Spokane Watershed Basin Study

Model	Initial Rank	Source	Software Cost	Operating System	Ease of Use (user interface)	Pre-Built Usable Functions	Expected Beta Level (e.g., new?, lots of bugs to be expected?: low = good)	Method of Analysis (modular, nodal, finite element, other)	Flexibility in dealing with surface water/groundwater hydraulic continuity	Time resolution of simulations (days to years)	Output Format (easily incorporated into GIS, Excel, other)	Input data format (gridded, polygonal data, other)	Storage (dams, groundwater)	Habitat Simulation, Water Quality
GoldSim with pre-built and custom modules	1	Golder	At present, must charge 5.0 multiplier for modeler effort	Windows	Highly visual, C or C++ program knowledge a plus	Yes (from other Golder offices)	Medium	Modular	Can create/borrow modules as appropriate	Flexible	EXCEL – very easy; GIS - possible	Pre-processed GIS data, tabular	Simple reservoirs pre-built; Can create/borrow modules	Can create/borrow modules as appropriate
PowerSim with pre-built and custom modules	2	Commercial	$3,000/license	Windows	Highly visual	Mathematical, statistical, business, …	Medium	Modular	Can create/borrow modules as appropriate	Flexible	EXCEL – very easy; GIS - possible	Pre-processed GIS data, tabular	Can create/borrow modules	Can create/borrow modules as appropriate
Stella with pre-built and custom modules	2	Commercial	Golder Seattle owns license	Windows	Highly visual	Mathematical, statistical, business, …	Medium	Modular	Can create/borrow modules as appropriate	Flexible	EXCEL – very easy; GIS - possible	Pre-processed GIS data, tabular	Can create/borrow modules	Can create/borrow modules as appropriate
MMS	3	USGS	Shareware	Unix or Linux	Visual, UNIX/LINUX operating system knowledge needed	PRMS modules pre-built	Low	Modular	Can create/borrow modules as appropriate	Flexible	Object User Interface allows for viewing inputs and outputs	GIS, tabular	Can create/borrow modules	Can create/borrow modules as appropriate
HSPF	4	USGS/EPA	Shareware	DOS		Fully pre-built. Can add modules.	Low			1 minute to 1 day, or any time-step that divides equally into 1 day	Tabular, or graphical if using post-processing software			Pre-built
XPSWMM	5	Commercial	Golder Seattle owns license	Windows	Highly visual, GIS-compatible	Fully pre-built	Low			Flexible	Yes	GIS, tabular	Pre-built	Pre-built
ModSim	6	Commercial	Shareware	Windows/Unix			Low			Monthly, weekly, daily			Pre-built	
Riverware	6	USGS/BoR	Shareware	Unix	Highly graphical	Fully pre-built Can add modules.	Low		Can create/borrow modules as appropriate	Flexible			Pre-built	Pre-built for Dissolved solids, Dissolved Oxygen, temperature

Notes:

1. Gray areas indicate that the model will likely not be considered further. As this product is preliminary at this time, the rankings and models to be considered further may change in later versions.

APPENDIX E-2

MEMORANDUM FROM GOLDER ASSOCIATES, INC., MAY 29, 2001

MEMORANDUM

TO:	Stan Miller, Spokane County	May 29, 2001
FR:	Chris Pitre, Sara Marxen	
cc:	Bryony Hansen	
RE:	WATERSHED MODEL - SELECTION CRITERIA	013-1372.1300

The Planning Unit wishes to select, at the June 20, 2001 meeting of the full Planning Unit, a software package to quantitatively model hydrologic processes in Water Resource Inventory Areas (WRIAs) 55 and 57 (Little and Middle Spokane Basins). This memorandum provides information for use by the Planning Unit to assist in selecting the software.

Previous model selection discussions occurred during meetings on November 29, 2000 and March 23, 2001. The November presentation reviewed general considerations of different types of models (e.g., surface water routing models, integrated software models, groundwater models, water balance models) and provided overviews of selected models for illustration purposes. The March presentation reviewed historical modeling efforts in the WRIAs and identified criteria for the modeling software as well as objectives for the modeling effort. Several main goals were identified by the planning group for the model and are outlined here.

- The model will be used in water resource allocation and management decisions.
- The model will be used to evaluate and predict surface water/ groundwater hydraulic continuity.
- The modeling software (and therefore the model) should be considered technically defensible.
- The model should provide presentation capabilities or presentation level output.
- The model should be useable by technically diverse group, from consultants and Spokane County employees to the general public.
- Model should be flexible for future changes (e.g. grid resolution changes due to additional withdrawals) and able to provide scenario comparison.

At the March meeting, the Planning Unit requested additional information related to model selection in general, and specifically related to the MIKE software, including:

1) Provide references of MIKE users to Spokane County.
2) Provide demo software of MIKE SHE to Spokane County.
3) What are the technical limitations of MIKE?
4) How does MIKE provide a better SW/GW link than ModFlow?
5) Identify other software packages competitive to MIKE in capabilities.

References of MIKE users and a demonstration model software package were promptly provided to Spokane County. Additional information is provided here including software license costs and comparison of technical capabilities of various software packages. Total cost estimates including level of effort associated with two or three models (as selected by Spokane County) will be provided with the characterization report (Level 1 Assessment) in the following month.

In summary, Golder considers that the MIKE software best meets the criteria listed above as established by the Planning Unit. The MIKE software is an integrated software package (simultaneously simulates GW and SW) with built–in presentation capabilities and a good degree of flexibility. It can meet these needs in a single package which places accountability for the integrity with one vendor. It is also commercially marketed and is well-established. Therefore it is a proven code that promises a high level of technical competence and support with a low likelihood of defects.

1) What are the technical limitations of MIKE?

MIKE SHE describes flow in the saturated, unsaturated, overland and channel zones through the use of several partial differential equations. Several assumptions associated with the use of these equations equate to a technical limitation, these are listed below.

a) Flow in the unsaturated zone is solved as one-dimensional and vertical system. It is expected that there are locations where this assumption will not hold.

This is a small scale process which is not relevant to the basin scale modeled in this project.

b) Hysteresis and freezing and thawing of soils are not coded in the unsaturated transport zone.

Hysteresis is also a small scale process which is not relevant to the basin scale modeled in this project. Freezing and thawing can be accounted for by seasonal variation of the run-off coefficient.

c) Properties are considered uniform in a single grid cell in the saturated zone. In reality, porous media properties likely vary by orders of magnitude within each grid cell.

This is true for all models evaluated for this project.

d) Overland flow is approximated by the kinematic wave approximation. This application to the full Saint Venant flow equations does not permit detailed simulation of backwater effects.

This will not largely affect the model due to the large grid size that it is anticipated will be used.

2) How does MIKE provide a better SW/GW link than ModFlow?

The main difference between the Mike11/SHE SW/GW link and the ModFlow SW/GW link is that MIKE is fully dynamic. ModFlow only allows for simple hydraulic routing, this does not include any backwater effects and/or hydraulic structures. In short, to model a somewhat complex or dynamic interaction between surface water and ground water requires a fully dynamic model. Although MODFLOW provides a three-dimensional, variably saturated approach for subsurface flow modeling, when coupling this rigorously with surface flows the model would likely be incapable of solving system complexities over the site due to numerical solver limitations over the spatial and temporal scales.

3) Identify other software competitive to MIKE in capabilities.
4) Update the model / software options matrix with purchase and licensing costs.

The Model/Software Options Matrix shown in Table 1 describes the models, software cost, and the functionality they provide. The categories are as follows:

Operating System – What operating system(s) does the software run on (Windows, UNIX, MAC)? It is highly desirable to have software that runs on mainstream computer operating systems.

Ability to Customize – Can a modeler model a process with a personal or alternate function rather than the supplied function. This category is important because every natural system is different and often non-standard processes need to be modeled to accurately predict a system.

Pre-Built Usable Functions – Are hydrologic functions already built into the software. Some software merely provides a structure for networked processes and the modeler has to know and develop all the hydrologic equations and their interactions. Other packages provide the equations and a modeler need only know the proper parameters (obviously the modeler should still understand the underlying processes).

Anticipated Beta Level – Describes the expected number of bugs that a user might expect to encounter, highly related to the version level of the software (e.g. low = good = low level of software problems encountered).

SW/GW Interaction – SW and GW processes can be modeled as independent processes or they can be integrated. Independent models can often be coupled, with additional programming, so that, for example, output from one model is utilized in another model process. This is not an ideal situation in for the Spokane project area due to the high degree of SW/GW interaction and the time involved in coupling multiple models.

Time resolution of simulations – The time step that can be used during simulation. Could be minutes to years.

Input data format – How can data be input to the model, does it have to be entered directly in a graphical interface, can it be imported from EXCEL, from GIS or from a text file?

Output Format – Describes how model output is stored. For example can output only be displayed and analyzed by a proprietary post processor, can it be directly or indirectly exported to EXCEL, to ACCESS, to GIS (indirect meaning exported to a text file which is easily imported to EXCEL)?

Storage – Is functionality available to model reservoirs or other impoundment and control structures?

Habitat and Water Quality Simulation – Is functionality available to model water quality (BOD, DO, contaminant transport) and habitat? Both of these parameters are vary directly with flow processes and so the ability to integrate this into the model is useful.

5) Provide an estimate of relative level of effort to produce, maintain and update an operating model (i.e. high / medium / low).

This information will be provided in the characterization report.

Table 1 – Model/Software Options Matrix

Model	Description	Software Cost	Operating System	Ability to Customize	Pre-Built Usable Functions	Anticipated Beta Level	Ability to Model SW/GW Interaction	Time Resolution	Input Format	Output Format	Storage	Habitat/ Water Quality
MIKE, Danish Hydrologic Institute	Simulation of Interrelationships among hydrologic processes in relations to watershed modifications	$15,600/license. $11,000 w/ public agency discount	Windows Unix	Limited	Yes, can add additional functions by purchasing additional packages	Low	Integrated SW/GW. 3-D GW flow, 1-D Unsaturated GW flow with time-varying water table.	Minutes-Months	GIS, text file	Text file Indirect EXCEL import. Indirect GIS export Integrated output of graphs, maps and animations	Many control structure's available for model and "floodplain" used to simulate ponds and their interactions with GW and unsat. Zone.	Water Quality available in separate module. No habitat
WMS/SMS/GMS, EMSI/BYU	GMS,SMS & WMS provide graphical user interfaces for industry-standard numerical models in groundwater, surface-water, and watershed modeling applications.	$16,000 for total software package. $225/license. Can buy modules separately ranging from $500-$1000 each	Window Unix	Limited	Yes, can add additional functions by purchasing additional packages	Low	Do not currently permit direct coupling of surface and groundwater flow modules	Minutes to months	Text file	Text file Indirect excel import. Integrated output of graphs, maps		Possibly through HSPF
HSPF, USGS/EPA	Effects of land-use change, reservoir operations on flow and water quality (joint deterministic stochastic)	Free. (Pre- and post-processors are commercially available at a price.)	Dos	Limited	Yes, can add additional functions through additional packages.	Medium, little documentation	Integrated modeling of interflow and baseflow, does not support 3-d gw flow, uses reservoir accounting model for unsaturated flow	1 minute to 1 day, or any time-step that divides equally into 1 day	Text file	Tabular, or graphical (requires special HSPF post-processor)	Pre-built	Pre-built
SIAM, USGS	Integrated set of models. Addresses significant interrelationships among selected physical, chemical and biological variables, and stream flow in a river. Utilizes elements of ModSim, HEC-5Q and PhabSim	Free	Windows	Limited	Yes, can add additional functions through additional packages	Medium, little documentation	Does not have specific gw component	Days to months		Output summarized in plots. Text file	Simple reservoirs pre-built	Yes (IFIM based)
GoldSim, Golder Assoc. Inc With pre-built and custom modules	Program for carrying out dynamic, probabilistic simulations to support management and decision-making in engineering, science and business.	Free	Windows	Yes	Some pre-built functions, can utilize functions built by other modelers (from other Golder offices)	Medium	Can create/borrow modules as appropriate	Flexible	Pre-processed GIS data, tabular	Direct export to Excel; GIS – possible	Simple reservoirs pre-built; Can create/borrow modules	Can create/ borrow modules as appropriate
PowerSim, PowerSim Corp. With pre-built and custom modules	Decision Support Software	$3,000/ single user license	Windows	Yes	Has pre-built Mathematical, statistical and business functions.	Medium	Can create/borrow modules as appropriate	Flexible	Pre-processed GIS data, tabular	Direct export to EXCEL GIS – possible	Can create/borrow modules	Can create/ borrow modules as appropriate
Stella, High Performance Systems, Inc. With pre-built and custom modules	Decision support software	$1100 for license. Golder Seattle owns license.	Windows	Yes	Has pre-built mathematical, statistical and business functions	Medium	Can create/borrow modules as appropriate	Flexible	Pre-processed GIS data, tabular	Direct export to excel GIS – possible	Can create/borrow modules	Can create/ borrow modules as appropriate
ModSim, Colorado State University	Generalized river basin network flow model and decision support system. Incorporates the physical, hydrological, and institutional aspects of river basin management.	Shareware	Windows Unix	Limited	Yes	Low	Can link to stream-aquifer models, with some effort.	Minutes to months		Text file Indirect excel import Graphical output (plots). Customized reports	Simple reservoirs pre-built	Can be linked to water quality simulation models such as SIAM.
Riverware, USGS/BOR	General river basin modeling tool that allows water resources engineers to both simulate and optimize the management of multipurpose reservoir systems for daily operations.	Shareware	Unix	Limited	Yes, can add additional functions through additional packages	Low	Can create/borrow modules as appropriate	Flexible			Pre-built	Pre-built for Dissolved solids, Dissolved Oxygen, temperature

Additional information was obtained from a report completed for the Rocky Flats Environmental Technology Site (RFETS), February 19, 2001 by Kaiser-Hill Company, L.L.C. titled "Model Code and Scenario Selection Report." The objective of the RFETS project is very similar to the objective of the Watershed Inventory Assessment being completed in Spokane: to evaluate how the site-wide hydrology is affected by anthropogenic, natural and water management changes. The RFETS project will also benefit from an integrated, distributed parameter, and deterministic model.

There were several software packages evaluated in the RFETS effort that were not evaluated in the Spokane project and vice versa but the analysis is still valuable. The RFETS report contained a matrix which provided a simple method for determining the "best" software for the their project. Specific code selection criteria and weightings (relative importance of each of those criteria) were identified based on the general considerations and the available model code types. Table 2 describes the 14 specific code selection criteria and weightings. Table 3 displays the final, tabulated results for nine software packages evaluated against the criteria in Table 2.

Table 2 – RFETS Criteria and Weighting

No.	Criterion	Weighting
1	Level of sophistication (physical & mathematical)	10
2	Spatial/temporal grid resolution capabilities	5
3	Spatial/temporal parameter/variable input/output capabilities	5
4	GIS capabilities, pre/post-processing	5
5	Boundary conditions (types, flexibility)	5
6	Documentation (current, complete, accurate, understandable)	4
7	Optional simplified process equations	3
8	Documented use	3
9	Ease of use, familiarity	3
10	Technical support (and access to code developers)	3
11	Animation/presentation capabilities, particle tracking	2
12	Internal consistency checks	2
13	Additional feature support (transport, erosion)	2
14	Hardware optimization	1
	Sum of weighting values (maximum possible)	53

Table 3 – RFETS Model Evaluation Matrix

Acronym	Authors Full name	Rank	% of max
MIKE SHE	British Institute of Hydrology, Danish Hydraulic Institute, and SOGREAH (France) MIKE SHE	49	92%
SWMM	US EPA Storm Water Management Model	36	68%
TOPOGDynamic	CSIRO, Australia TOPOG-Dynamic	35	66%
SWAT	USDA Soil and Water Assessment Tool	33	62%
PRMS USGS	Precipitation-Runoff Modeling System *(New code is MMS)*	29	55%
HSPF	US EPA Hydrologic Simulation Program	27	51%
SWRRB	USDA Simulator for Water Resources in Rural Basins	24	45%
DHSVM	DOE – Pacific Northwest Lab Distributed Hydrology-Vegetation Model	23	43%
MODBRANCH	USGS MODBRANCH	20	38%

APPENDIX E-3

MEMORANDUM FROM SPOKANE COUNTY, JUNE 6, 2001

M E M O R A N D U M

DATE: June 6, 2001

TO: Watershed Planning Unit

FROM: Stan Miller

RE: Summary of projects using the "MIKE" suite of models

CC:

The list below is a brief synopsis of several projects that have used MIKE products proposed for use in the Spokane Watershed Planning program. Most of these projects are described in a packet of information provided by the Danish Hydrologic Institute. Additional information for each of the DHI projects is available in the form of one page summaries. The DHI also provided several "papers" that provide additional information on some of the projects.

I will bring several sets of the complete information to the June 20 meeting for those who wish to review the total package. Let me know if you want one so I will have enough for all.

***Demonstration Application : Hydrodynamic and Sediment Model of the Coeru d'Alene River Corridor*, Carter Borden and Peter Goodwin, University of Idaho,**

> MIKE 11 is being used to develop a one dimensional flow model for the Coeur d'Alene River. Currently the model is at the "demonstration" level. There are many data gaps that need to be filled for the model to be useful for its primary intended purpose – provide stage and discharge relationships to use for more detailed modeling for any reach of the river. MIKE was chosen for this work because it has been used in several other projects in Idaho.

***Genetic Programming and its Application in Real-Time Runoff Forecasting*, Khu, Soon Thaim, Shie-Yui Liong, Vladan Babovic, Henrik Madsen and Nitin Muttil, Journal of the American Water Resources Association, April 2001**

> MIKE 11 was used to model storm water runoff in a basin in France. The Genetic Programming described in the paper was developed to provide input to MIKE.

***Isolated Wetlands Using MIKE SHE,* 1995-98, South Florida Water Management District.**

> MIKE SHE was used to model wetland – groundwater interaction in several small wetland systems to evaluate drawdown criteria, establish cause and effect relationships between various permitted activities and to develop recommendation for future actions based on sound hydrologic criteria.

***Integrated Surface and Groundwater Model for the Hemet – San Jacinto Valley,* 1996-97, Eastern Municipal Water District.**

> MIKE SHE was used to produce an integrated model of the surface and groundwater in the Hemet and San Jacinto Valley for the Hemet and San Jacinto Groundwater Association. The model is used to estimate the return to the ground water system from various sources including irrigation as well as the effect of withdrawals on the system.

***Small-Scale Integrated Surface Water and Ground Water Model Development,* 1997-98, South Florida Water Management District.**

MIKE SHE and MIKE 11 were coupled to produce an integrated model to assess the impacts of various management scenarios for the Kissimee River on the attempt to restore the Everglades wetland ecosystem.

***Caloosahatchee Basin Surface Water / Groundwater Model*, 1998-99, Torsten V. Jacobsen, Clyde Dabbs and Jesper T. Kjelds.**

MIKE SHE and MIKE 11 were used to produce an integrated model of the surface and groundwater in the Caloosahatchee Basin in South Florida.

***Napa River Salt Marsh Restoration Hydrodynamic / Transport Dispersion Modeling*, 2000, US Army Corps of Engineers and California State Costal Survey.**

This project used the MIKE 11 (1 dimensional) and MIKE 21 (2 dimensional) models to model the Sonoma River on the Central California Coast. The mixing of fresh and salt water in a tidal marsh was modeled to assess the possibility of restoring a marsh in an area that had been diked for hay production.

***Napa River Flood Plan and Marsh Restoration*, 1995, US Army Corps of Engineers and California State Costal Survey.**

This project used the MIKE 11 to model the Napa River for flood plain analysis. MIKE GIS was used for flood mapping. This information was also used to evaluate a program to restore the river's former flood planes and marshes.

***Mathematical Modeling of Irrigation Canals in the Salt River Project*, Salt River Project**

MIKE 11 was used to model nitrate distribution in the canal system. Input of high nitrate ground water into the canal system will be managed to protect public water supplies.

***Cape Fear River Basin Modeling,* 1998-99, NC Dept of Environment and Natural Resources**

MIKE BASIN was used to develop a general water quantity / quantity of the Cape Fear River. The model will be used to evaluate current and future water uses in the Basin. Model was used in a project open to stakeholder participation and public review.