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In Search of Subflow: Arizona's Futile Effort to Separate Groundwater From Surface Water

by

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Articles

IN SEARCH OF SUBFLOW: ARIZONA'S FUTILE EFFORT TO SEPARATE GROUNDWATER FROM SURFACE WATER*

Robert Jerome Glennon** and Thomas Maddock, III***

I. Introduction and Background.....	567
II. General Adjudications.....	568
III. Arizona Supreme Court Decision on <i>Issue No. 2</i>	570
IV. General Principles of Hydrogeology.....	574
V. Capture in the Upper San Pedro River.....	585
VI. Problems with the <i>Issue No. 2</i> Decision.....	590
VII. The Role of Federal Law.....	599
VIII. Conclusion.....	609

I. INTRODUCTION AND BACKGROUND

Cottonwood-willow forests and mesquite bosques, characteristic desert riparian habitats, once lined many rivers in Arizona, including the Salt and Gila Rivers in the Phoenix valley, and the Santa Cruz and Rillito Rivers in the Tucson area. The trees and accompanying associated shrubs and herbaceous vegetation gradually died of thirst as groundwater pumping and surface water diversions for domestic and irrigation purposes disrupted surface flows and lowered the groundwater table below the root zone of these plants. Sadly, surface water diversions and groundwater pumping have contributed to the degradation of 90% of Arizona's once perennial low desert streams and rivers and about an equal amount of its riparian habitat.¹

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1. See SUSANNA EDEN & MARY G. WALLACE, ARIZONA WATER: INFORMATION AND ISSUES (1992); Arizona State Parks, ARIZONA STATEWIDE COMPREHENSIVE OUTDOOR RECREATION PLAN 63-69 (1989); Arizona Dep't of Water Resources, PRELIMINARY

Prior appropriation doctrine has two critical elements, the first of which is the principle that first-in-time is first-in-right.⁶ The earliest diverters have superior or senior rights relative to later appropriators. If shortages occur, the most junior appropriators may have their supply cut off. Second, appropriative rights may be lost through abandonment or forfeiture through non-use.⁷ These common law and statutory doctrines reflect a use-it-or-lose-it principle. Under the prior appropriation doctrine, a watershed may have literally thousands of users whose rights are contingent upon the date of the original diversion and upon continued use of the water. Although senior diverters have the most valuable rights, their claims often depend on establishing historical practices that are impossible to document accurately. As a result, the prior appropriation doctrine has lost much of its desired certainty and predictability. As a partial remedy, states have devised general adjudication procedures designed to bring all water users in a given watershed together in a single litigation that will adjudicate the priority and scope of their rights.⁸

In Arizona, the Gila River General Adjudication began in 1974, when the Salt River Valley Water Users' Association filed a petition to determine the water rights in a section of the Salt River.⁹ Subsequent petitions enlarged the Adjudication to include all tributaries of the Gila River system and source.¹⁰ The Gila River General Adjudication is an astonishingly complicated proceeding that involves more than 65,000 statements of water rights claims filed by nearly 24,000 parties.¹¹ The complexity of the proceeding has meant that events have moved at a snail's pace, frustrating essentially all parties to the litigation. Although the jurisdiction rests in the Superior Court, the Supreme Court has appointed a special master to coordinate the hearing of contested claims.

The complexity of the adjudication is perhaps best symbolized by a monthly newsletter published by the Office of the Special Master. The *Arizona General Stream Adjudication Bulletin* is intended to keep concerned parties abreast of developments. The Adjudication's complexity also is reflected in a memorandum circulated by the chair of the Gila River Adjudication Steering Committee that searches for ways to expedite the adjudication.¹² To date, the adjudication has cost an enormous amount of money: six large parties and one state agency have spent approximately \$52 million on the litigation since 1974.¹³ Large utilities, mines, irrigation districts, and other water companies

6. *Id.* at 75.

7. *Id.* at 76-77; see ARIZ. REV. STAT. ANN. § 45-189 (amended by S.B. 1380, Apr. 12, 1994).

8. The Arizona General Adjudication of Water Rights statutes are set forth in ARIZ. REV. STAT. ANN. §§ 45-251 to 260.

9. For background and history, see Mikel L. Moore & John B. Weldon, Jr., *General Water-Rights Adjudication in Arizona: Yesterday, Today and Tomorrow*, 27 ARIZ. L. REV. 709 (1985).

10. A separate general adjudication concerns the Little Colorado River system and source.

11. *In re* Rights to the Use of the Gila River, 171 Ariz. 230, 241, 830 P.2d 442, 453 (1992).

12. See Memorandum from Michael J. Brophy, Chairman of the Steering Committee of the Gila River Adjudication, to the Steering Committee members (Oct. 22, 1993) (on file with the authors).

13. *Id.* at 3-4.

presumably have spent substantial sums.¹⁴ In February 1994, the frustration over the expense and lack of progress led the Arizona Legislature to establish a Joint Select Committee on Arizona General Stream Adjudications charged with exploring ways to expedite the two General Adjudications.¹⁵

In the 20 years since the adjudication began, the first legal issue focused on whether the state court had jurisdiction to hear the case. Two decisions in 1983 and 1985 finally resolved that question in the affirmative.¹⁶ In 1990, the Arizona Supreme Court accepted for interlocutory review six legal issues of overarching importance to the entire Adjudication.¹⁷ The first issue concerned the constitutionality of the proposed service of process, which the Court upheld in 1992.¹⁸ Service of process then occurred on 960,000 potential claimants.

III. ARIZONA SUPREME COURT DECISION ON *ISSUE NO. 2*

On July 27, 1993, the Arizona Supreme Court decided *Issue No. 2*. Ultimately, the case addressed whether water that was pumped from wells would be treated as appropriable surface water under the prior appropriation doctrine¹⁹ or, instead, as percolating groundwater not subject to the priority doctrine.²⁰ The legislative mandate to a general adjudication court is to determine all rights to the waters of a "river system and source" which includes "all water appropriable under §45-141 and all water subject to claims based upon federal law."²¹ Specifically, the issue was whether the Court would use the trial judge's test to determine when groundwater was "appropriable" under A.R.S. Section 45-141.

Trial Judge Goodfarb had previously ruled that certain groundwater wells were within the scope of the Adjudication.²² The owners of these wells

14. *Id.*

15. See Letter from Arizona House of Representatives Speaker Mark W. Killian and Arizona State Senate President Pro Tempore Pat Wright to Arizona State Senator Gus Arzburger (Feb. 25, 1994).

16. See *Arizona v. San Carlos Apache Tribe of Arizona*, 463 U.S. 545 (1983); *United States v. Superior Court*, 144 Ariz. 265, 697 P.2d 658 (1985).

17. *In re* General Adjudication of All Rights to Use Water in the Gila River System and Source, Nos. WC-90-001-IR & WC-79-0001 (Ariz. Sup. Ct. Dec. 11, 1990). The issues granted review were whether: (1) the procedures for the filing and service of pleadings adopted by the trial court violated the due process clauses of either the Arizona or United States Constitutions; (2) the trial court's adoption of the 50% / 90 day test for appropriability under ARIZ. REV. STAT. ANN. § 45-141 was in error; (3) defining the appropriate standard for determining the amount of water reserved for federal lands; (4) non-appropriable groundwater is subject to federal reserved rights; (5) do holders of federal reserved rights enjoy greater protection from groundwater pumping than state law rights holders; and (6) claims of interference with water rights or conflicting water use might be resolved as part of the general adjudication.

18. See *In re* Rights to the Use of the Gila River, 171 Ariz. 230, 830 P.2d 442 (1992).

19. Proposed under ARIZ. REV. STAT. ANN. § 45-141.

20. Many American states, including Arizona, govern groundwater pumping by the so-called "reasonable use" doctrine. This rule allows owners of land to pump any "reasonable" quantity of water for use on the overlying parcel. Unlike the prior appropriation system, the right involves neither a fixed quantity nor a priority date. See GETCHES, *supra* note 5 at 253-54.

21. ARIZ. REV. STAT. ANN. § 45-251 (4).

22. *In Re* the General Adjudication of All Rights to the Water in the Gila River System and Source, Nos. W-1 through W-4, 15 Indian L. Rep. (Am. Indian Law. Training Program) 5099, 5100 (Maricopa Super. Ct. October 1988).

would be subject to his jurisdiction unless, at an evidentiary hearing, the owner could demonstrate that she was not pumping "appropriable" groundwater, often termed "subflow." Judge Goodfarb instructed the Arizona Department of Water Resources (DWR) to include wells as pumping "appropriable" groundwater if, after investigation, the Department determined that:

As to wells located in or close to that younger alluvium, the volume of stream depletion would reach 50 percent or more of the total volume pumped during one growing season for agricultural wells or during a typical cycle of pumpage for industrial, municipal, mining, or other uses, assuming in all instances and for all types of use that the period of withdrawal is equivalent to 90 days of continuous pumping for purposes of technical calculation.²³

This ruling served as the basis for the appeal in *Issue No. 2*.

The Arizona Supreme Court has had a checkered history in deciding whether the prior appropriation doctrine governs groundwater pumping. At various points in time, the Court has given different answers to whether groundwater was "appropriable."²⁴ The *Issue No. 2* decision turned on the Court's understanding of the meaning of *Maricopa County Municipal Water Conservation District No. One v. Southwest Cotton*.²⁵ In *Southwest Cotton*, the Southwest Cotton Company claimed that a proposed dam on the Agua Fria River would interfere with water reaching its downstream wells, which were located in and around the riverbed. Southwest Cotton Company asserted that it was pumping appropriable water and that the doctrine of priority prevented the upstream dam from interfering with its prior appropriation rights.²⁶

Although *Southwest Cotton* is subject to varying interpretations,²⁷ the *Issue No. 2* Court read *Southwest Cotton* as holding that: (1) percolating underground water was not appropriable; (2) there was insufficient evidence that Southwest Cotton's wells drew from underground channels with known and definite banks (i.e. "subflow"), which would have made the water appropriable under Arizona law; and, (3) Southwest Cotton was not pumping appropriable "subflow" because there was no evidence that the pumping would directly or appreciably diminish the flow of the river.²⁸

Because much turns on the definition of "appropriable" groundwater or "subflow," it is worth examining the *Southwest Cotton* definition of subflow. To the *Southwest Cotton* Court, "subflow" is "waters that slowly find their way through the sand and gravel [of] the bed of the stream, or [through] lands under or immediately adjacent to the stream..."²⁹ As a consequence, these waters are deemed part of the stream and therefore appropriable. *Southwest Cotton*

23. *Id.* at 5102. The younger alluvium is the floodplain aquifer. See *infra* notes 58-60 and accompanying text.

24. See *Maricopa County Municipal Water Conservation District No. One v. Southwest Cotton*, 39 Ariz. 65, 4 P.2d 369 (1931), and compare with *Bristor v. Cheatham I*, 73 Ariz. 228, 240 P.2d 185 (1952), and *II*, 75 Ariz. 227, 255 P.2d 173 (1953). See generally John D. Leshy & James Belanger, *Arizona Law Where Ground and Surface Water Meet*, 20 ARIZ. ST. L.J. 657 (1988).

25. 39 Ariz. 65, 4 P.2d 369 (1931).

26. *In re the General Adjudication of All Rights to Use Water in the Gila River System and Source*, 175 Ariz. 382, 386-87, 857 P.2d 1236, 1240-41 (1993).

27. See Leshy & Belanger, *supra* note 24 at 687-88.

28. 175 Ariz. at 390-92, 857 P.2d at 1244-46.

29. 39 Ariz. at 96, 4 P.2d at 380 (citing 2 CLESSON S. KINNEY, *THE LAW OF IRRIGATION AND WATER RIGHTS* §1161, at 2106 (2d ed. 1912)).

unfortunately contained internally inconsistent definitions of appropriable groundwater. On the one hand, the Court suggested that the test was “there cannot be any abstraction of the water of the underflow without abstracting a *corresponding amount* from the surface stream....”³⁰ On the other hand, in the next paragraph, the Court suggested that the test was whether “drawing off the subsurface water tend[s] to *diminish appreciably* and directly the flow of the surface stream?”³¹ While the first definition seemed to require a drop-for-drop reduction in the stream flow, the second definition is far more elastic.

The *Issue No. 2* Court refused to change or overrule *Southwest Cotton*’s definitions of subflow, or even to select between them. It decided that the growth of agricultural, mining, municipal and industrial interests had been partly based on expectations flowing from the *Southwest Cotton* rule.³² The *Issue No. 2* Court felt bound by *stare decisis* and therefore understood its role as merely to interpret *Southwest Cotton*, not to correct or improve it.³³ As a consequence, the Court embarked on an inquiry into what the *Southwest Cotton* Court understood as correct principles of hydrology.³⁴ Perhaps understanding that many would snicker when it appeared that a decision of this import turned on Clesson S. Kinney’s *The Law of Irrigation and Water Rights*, published in 1912, the Court tried to put a good face on *Southwest Cotton* as based “on an understanding of hydrology less precise than current theories....”³⁵ Kinney’s hydrology is “less precise” in the same way that the nineteenth century practice of medicine, with blood letting and leeches, is less precise than today’s medical knowledge.

The *Southwest Cotton* Court relied on Kinney and his concept of subflow which divided underground water courses into “known” and “unknown” channels of water.³⁶ He further subdivided the “known” underground water into “independent” or “dependent,” with the former not influenced by surface streams and the latter constituting “subflow” of surface streams.³⁷ Kinney also distinguished “subflow” from “tributary groundwater.” To him, tributary groundwater was water that has “not yet reached the channels of the water courses to which they are tributary.”³⁸ Kinney thus combined “subflow” with the idea of underground channels and banks for streams. The *Issue No. 2* Court adhered to Kinney’s distinction between “subflow” and “tributary ground water”: only subflow is subject to appropriation.³⁹

30. *Id.* (emphasis added).

31. *Id.* at 96–97, 4 P.2d at 380-81 (emphasis added).

32. 175 Ariz. at 389, 857 P.2d at 1243.

33. *Id.*

34. “Hydrology” concerns the science of surface and groundwaters while “hydrogeology” principally focuses on groundwater, though the terms are commonly used interchangeably.

35. 175 Ariz. at 389, 857 P.2d at 1243.

36. *Id.* at 389–90, 857 P.2d at 1243–44.

37. *Id.* at 390, 857 P.2d at 1244.

38. *Id.*

39. *Id.* at 391, 857 P.2d at 1245.

What then is subflow? According to the *Issue No. 2* Court, it is water that is “found within, or immediately adjacent to, the bed of the surface stream itself.”⁴⁰ The line between subflow and water in the surrounding alluvium⁴¹ is

relatively close to the stream bed, with variations depending on the volume of stream flow and other variables. Thus, if a well is drawing water from the bed of the stream, or from the area immediately adjacent to a stream, and that water is *more closely related* to the stream than to the surrounding alluvium, as determined by appropriate criteria, the well is directly depleting the stream. If the extent of depletion is measurable, it is appreciable.⁴²

The *Issue No. 2* Court anticipated that some wells might be pumping both subflow and tributary groundwater in the surrounding alluvium.⁴³ The court noted that if the well’s cone of depression⁴⁴ “has expanded to the point that it intercepts a stream bed, it almost certainly will be pumping subflow.”⁴⁵

After criticizing the time and volume elements of Judge Goodfarb’s 50%/90 day test⁴⁶, the *Issue No. 2* Court reiterated that whether a well is pumping subflow will turn on

whether the well is pumping water that is more closely associated with the stream than with the surrounding alluvium. For example, comparison of such characteristics as elevation, gradient, and perhaps chemical makeup can be made. Flow direction can be an indicator. If the water flows in the same general direction as the stream, it is more likely related to the stream. On the other hand, if it flows toward or away from the stream, it likely is related to the surrounding alluvium.⁴⁷

In the end, the *Issue No. 2* Court remanded the case to Judge Goodfarb to determine an appropriate set of criteria for defining subflow.⁴⁸

The *Issue No. 2* Court was not entirely comfortable with its ruling. First, it recognized that Arizona’s law had failed to keep pace with scientific reality.⁴⁹ Second, it acknowledged that the *Southwest Cotton* test of “direct and appreciable diminution” was of an “inexact nature.”⁵⁰ The Court appeared to suggest that too much time has passed for it now to change the direction of Arizona water policy. Finally, the Court explicitly invited legislative action to address the problem.⁵¹

40. *Id.* (quoting *Maricopa Municipal Water Conservation District No. One v. Southwest Cotton*, 39 Ariz. 65, 97, 4 P.2d 369, 381 (1931)).

41. Alluvium, or more properly, alluvial deposits, are deposits of gravel, sand, silt and clay that are not bound or hardened by mineral cement, by pressure, or by thermal alteration of the grains, and that have been laid down by physical processes in river channels or on floodplains.

42. 175 Ariz. at 391, 857 P.2d at 1245 (emphasis added).

43. *Id.*

44. A cone of depression is a funnel-shaped area around a well, where the water table has been lowered by the withdrawal of groundwater from a well. For further discussion, see *infra* notes 74-77 and accompanying text.

45. 175 Ariz. at 391, 857 P.2d at 1245.

46. See *supra* note 23 and accompanying text.

47. 175 Ariz. at 392, 857 P.2d at 1246.

48. For analysis of Judge Goodfarb’s opinion on remand, see *infra* notes 140-151 and accompanying text.

49. 175 Ariz. at 386, 857 P.2d at 1240.

50. *Id.* at 389, 857 P.2d at 1243.

51. The Court also noted that on remand, the criteria developed by DWR as to which wells are pumping appreciable subflow would likely constitute “clear and convincing

As we demonstrate in Part IV, accepted principles of hydrogeology suggest that the *Issue No. 2* Court made a regrettable mistake in relying on Kinney's obsolete and discredited notions.⁵²

IV. GENERAL PRINCIPLES OF HYDROGEOLOGY

The Basin and Range Lowlands Province⁵³ of the arid or semi-arid southwestern United States generally is characterized by mildly sloping valleys bordered by steeply rising mountain ranges. An example is the San Pedro River Basin (Figure 1). The mountains consist of bedrock which is nearly impervious to groundwater flow. Pediment areas,⁵⁴ with comparatively shallow bedrock, may extend valleyward for varying distances from the base of the mountains. In the valleys, under favorable climatic conditions, a riparian system composed of a stream and stream-dependent plant and animal life thrives throughout the valley. The stream is sometimes perennial⁵⁵ but is likely to be only intermittent⁵⁶ or even ephemeral.⁵⁷ The valleys and their associated riparian systems typically are underlain by multi-layered aquifer systems.⁵⁸ The uppermost layer is most closely associated with the river and is usually an alluvial aquifer⁵⁹ composed of younger geologic deposits. A younger alluvial aquifer is also known as a floodplain aquifer and/or a Holocene aquifer. It tends to be shallow, most often less than 100 feet deep, and less than a mile wide. The lower layers are older basin-fill deposits which form a regional aquifer

evidence," thus shifting the burden onto well owners who disagree with DWR's criteria. The Court also rejected the idea that excluding hydrologically-connected water from the adjudication would mean that the adjudication is no longer comprehensive enough to satisfy the McCarran Amendment. *Id.* at 392-94, 857 P.2d at 1246-48. For discussion of the McCarran Amendment, see *infra* notes 200-207 and accompanying text.

52. *Issue No. 2* addressed the scope of appropriable groundwater under the prior appropriation doctrine. An open question that the General Adjudication court may yet address concerns the public trust doctrine, which protects the public's access to many riverbeds in the State for the purposes of navigation, fishing, and recreation. See *Arizona Ctr. for Law in the Pub. Interest v. Hassell*, 172 Ariz. 356, 837 P.2d 158 (App. 1991). Damage to surface flows and riparian areas through pumping of groundwater that is hydrologically-connected to surface flows harms trust property and the public's recreational opportunities. The public trust doctrine may obligate the State, through the Department of Water Resources and/or the State Land Commissioner, to assert the public trust to halt damage to riparian areas. See *Nat'l Audubon Soc'y v. Superior Court*, 658 P.2d 709, *cert. denied*, 464 U.S. 977 (Cal. Sup. Ct. 1983) (state's trust responsibility extends to curbing diversions from non-navigable streams in order to protect the environment of Mono Lake).

53. For a wonderful geologic account of the Basin and Range, see JOHN MCPHEE, *BASIN AND RANGE* (1981).

54. A pediment area is a geologic feature associated with the base of mountain ranges consisting of a valleyward-sloping, eroded bedrock surface, thinly veneered with sediment.

55. A perennial stream flows all year long.

56. An intermittent stream has flows in certain reaches but not others, and flows only when: (1) there is a hydrologic connection between the groundwater and stream water and (2) the groundwater levels next to the stream are higher than the bottom of the stream channel.

57. An ephemeral stream flows only after a storm event.

58. An aquifer is a geologic unit that can store and transmit enough water to be a significant water resource. Aquifers are usually formed layer upon layer, very slowly over a geologic period of time (i.e., millions of years). The nature of the deposited materials gives each layer its own characteristics.

59. An alluvial aquifer is formed by material laid down by physical processes in a river channel or on a floodplain.

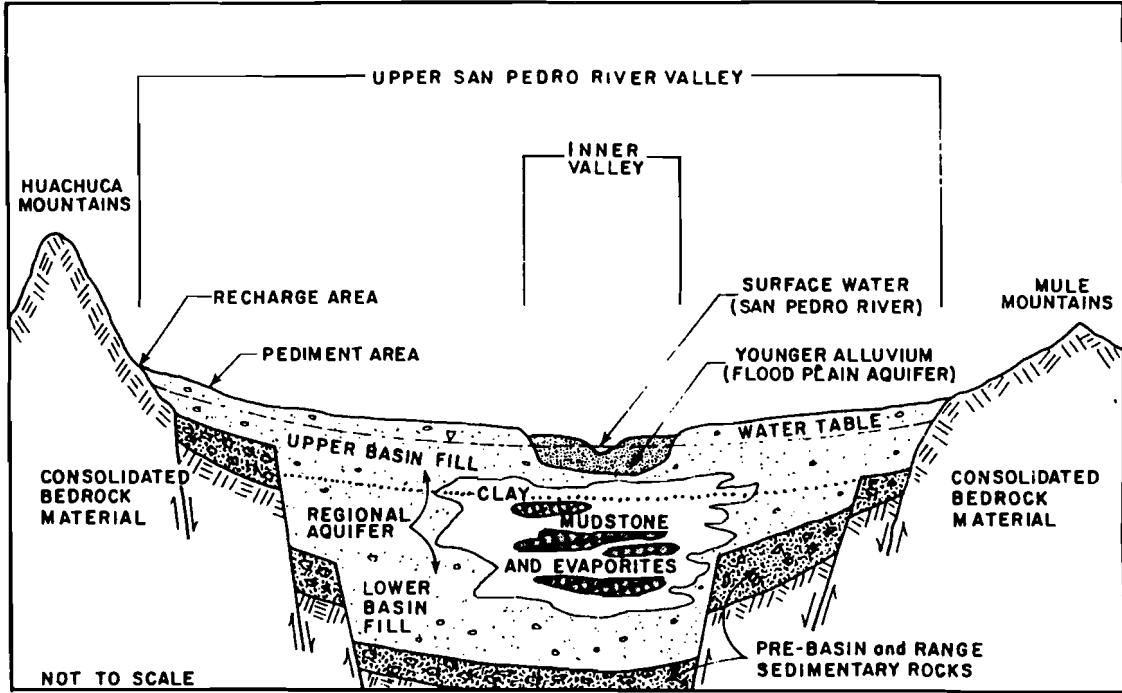


FIGURE 1

NOT TO SCALE

system.⁶⁰ This system can extend laterally for tens of miles or vertically for hundreds or even thousands of feet. Though in some cases the distinction between the upper and lower layers is not easily identified during the drilling of wells, the basin fill in the regional aquifer usually is more consolidated, deformed and finer-grained than in the alluvial aquifer.

The quantity of water that can be pumped from an aquifer depends on the aquifer's ability to store and transmit water. For an unconfined aquifer⁶¹ (Figure 2a) the ability to store water is measured by specific yield and the ability to transmit water is measured by hydraulic conductivity. A confined aquifer's⁶² (Figure 2b) ability to store water is measured by storage coefficient while its ability to transmit water is measured in terms of transmissivity. The term hydraulic conductivity relates to the transmissivity of water through the aquifer's pore spaces.⁶³ The specific yield relates to the quantity of water that may drain from the pore spaces when the water table declines.⁶⁴ The transmissivity is the product of the saturated thickness between the confining units with the vertically averaged hydraulic conductivity⁶⁵ (Figure 2b). The storage coefficient expresses the volume of water an aquifer releases from storage across its saturated thickness for a given decline in hydraulic head.⁶⁶ Storage coefficient is a function of the compressive qualities of water and matrix structures of the porous material,⁶⁷ and specific yield is a function of gravity drainage from the pores. Specific yield can be several orders of magnitude larger than the storage coefficient, thus producing more water when developed. Because most interactive processes between ground and surface water occur under water table conditions, for the purposes of this paper, hydraulic conductivity and specific yield will be used to describe the transmissive and storage properties in an aquifer.

Under natural conditions, prior to the development of wells, a groundwater system exists in a state of approximate equilibrium.⁶⁸ This equilibrium is maintained by a long-term balance between natural recharge and discharge processes⁶⁹ in the groundwater basin. Over the millennia, wet years in which recharge exceeds discharge offset dry years when discharge exceeds recharge. In the arid southwest, below elevations of about 4,000 feet, mountain

60. Regional aquifer systems form in the thick basin fill between mountain ranges.

61. In an unconfined aquifer, the water table is at the upper boundary of a saturated groundwater flow system that is at atmospheric pressure. An aquifer with a water table is also called a watertable aquifer.

62. A confined aquifer is a saturated aquifer that is bounded above and below by formations of significantly lower hydraulic conductivity.

63. S.W. Lohman et al., *Definitions of Selected Ground-Water Terms -- Revisions and Conceptual Refinements*, GEOLOGICAL SURV. WATER-SUPPLY PAPER, No. 1988, at 4 (1972).

64. *Id.* at 12.

65. *Id.* at 13.

66. *Id.* Hydraulic head is the distance that water rises in a well above a defined datum, usually mean sea level. The hydraulic head in a water table aquifer is at the water table. The hydraulic head in a confined aquifer is above the boundary interface between the aquifer and the upper confining unit.

67. Matrix structure of porous material is the geometrical arrangement of the grains of a porous media in the aquifer.

68. Charles V. Theis, *The Source of Water Derived From Wells*, CIV. ENGINEERING, May 1940, at 277.

69. Recharge processes occur when subterranean waters flow into the aquifer, and discharge processes occur when subterranean waters flow out of the aquifer.

Figure 2a: Unconfined Aquifer

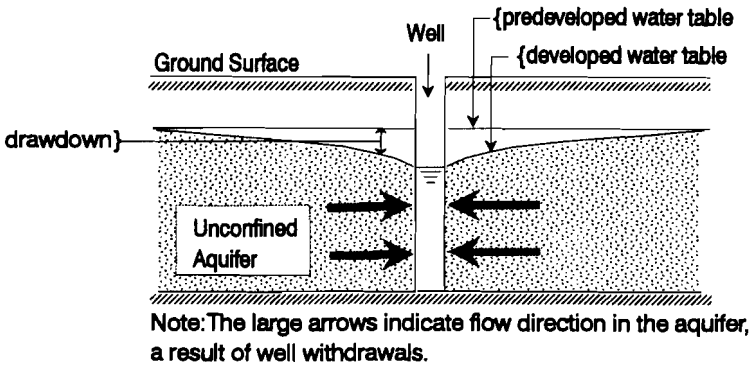


Figure 2b: Confined Aquifer

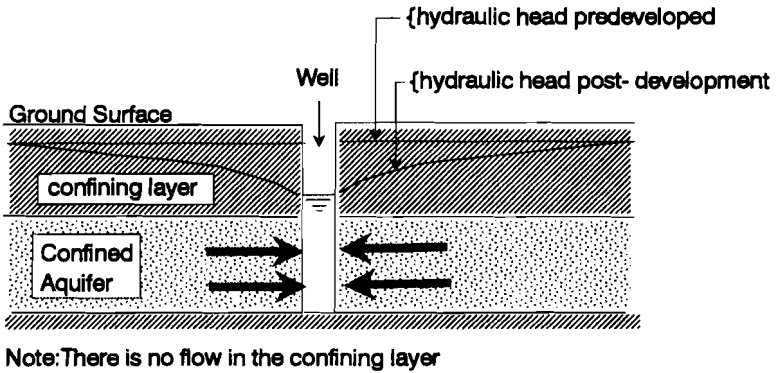


FIGURE 2

front recharge⁷⁰ and seepage from losing streams⁷¹ comprise the principal mechanisms for aquifer recharge. Discharge from the aquifer typically occurs through evapotranspiration⁷² and seepage to gaining streams.⁷³

Discharge from pumping wells is a new process imposed on the previously balanced groundwater system. The new discharge process will produce either a decrease in aquifer storage and/or some combination of an increase in recharge and a decrease in natural discharge. The sum of the induced *increase* in recharge plus the *decrease* in discharge is called capture.⁷⁴ Examples of capture that are relevant to the San Pedro River are pulling waters directly from the stream, intercepting waters that would have arrived at the stream, and reducing evaporation and transpiration processes in the riparian areas.

Before pumping from a well induces capture, all water extracted from the well is derived from aquifer storage and is considered "mined" water. The mining process creates a "cone of depression" in the water table near the well. The cone of depression is simply the manifestation of the impeding action of the aquifer material. The "cone" is inverted with its nadir centered at the well and its base at the level of the surrounding water table (Figure 3). As the water is mined from the aquifer, the cone of depression expands with the nadir deepening and the base widening. At any given time, drawdown⁷⁵ varies directly with the pumping rate and inversely with the aquifer hydraulic conductivity.⁷⁶ Thus for an aquifer, a large pumping rate or a small hydraulic conductivity produces a large drawdown while small pumping rates or large hydraulic conductivity produces a small drawdown. The rate of deepening and widening decreases as the cone becomes larger because of the increasing volume of water available from storage within the cone.⁷⁷

The cone of depression continues to grow until a source of capture is encountered. If no sources of capture exist in a region, the cone will continue to grow indefinitely until the saturated thickness of the aquifer open to the well cannot yield sufficient water to maintain pumping. If the capture source is a losing stream, the cone of depression induces an increase in inflow to the aquifer from the stream (Figure 4a). If the capture source is a gaining stream, the cone induces a decrease in outflow from the aquifer to the stream (Figure 4b). In either case, the stream loses water. The most debilitating effects occur when a stream capture source lies within a riparian area. Then, the cone of depression may lower the water table below the root zone. This reduces

70. Mountain-front recharge is subterranean water that originates from precipitation at higher elevations. Rain and snow melt percolate into the aquifer through the alluvial fans at the base of the mountains.

71. In a losing stream, water infiltrates from the stream into the aquifer. The net effect over a reach of the river is a loss of stream flow.

72. Evapotranspiration is water lost to evaporation from soils and transpiration from plants.

73. In a gaining stream, water infiltrates from the aquifer into the stream. The net effect over a reach of the river is an increase in streamflow.

74. Lohman et al., *supra* note 63, at 3.

75. Drawdown is a change in hydraulic head at a well caused by some recharge or discharge stress on the aquifer.

76. R. ALLAN FREEZE & JOHN A. CHERRY, *GROUNDWATER* 318 (1979).

77. The volume of a cone varies with the square of the radius, which is why a rate of decline in a well pumping from storage alone decreases with time.

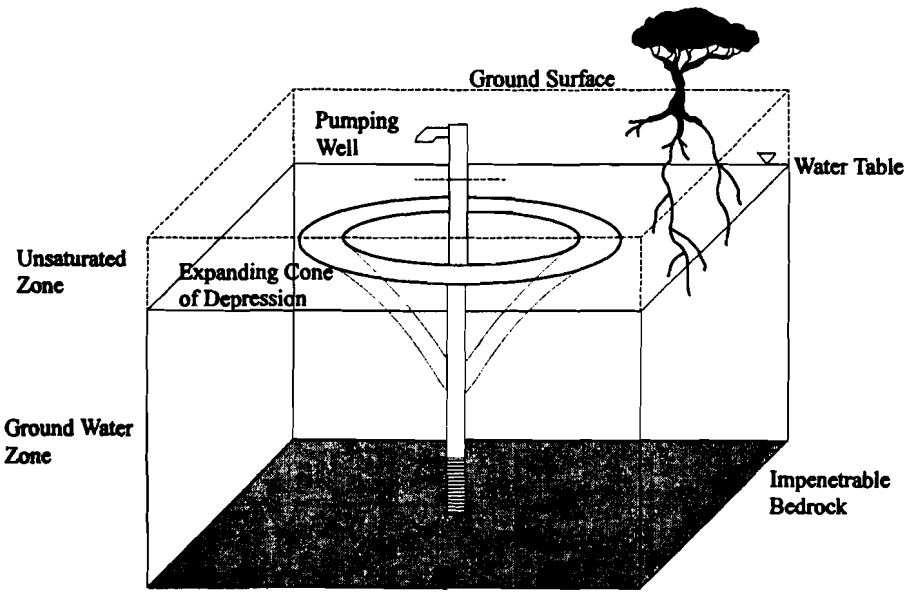


DIAGRAM OF CONE OF DEPRESSION

FIGURE 3

Main sources of capture

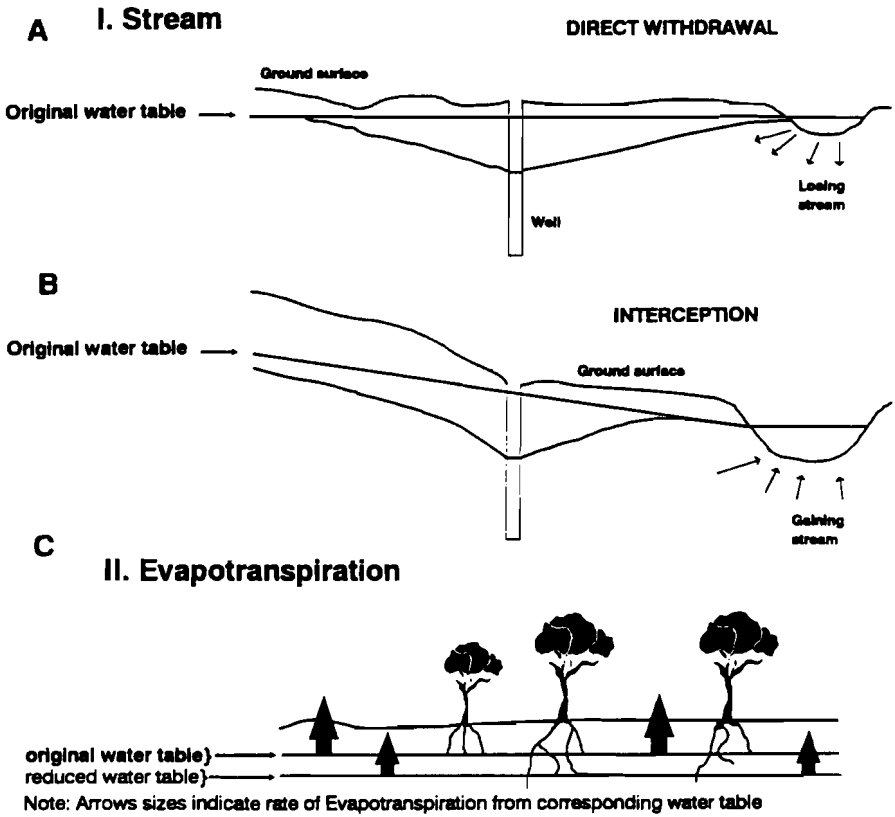


FIGURE 4

evapotranspiration and may damage plant and animal habitat (Figure 4c). Once capture begins, the growth of the cone of depression slows. If the volume of water captured equals that pumped from the well, the cone will cease to grow because no water is derived from storage.⁷⁸

In most basins, pumping wells are occasionally monitored to determine water levels. A monitored well is shut down for a period of time to allow water level to recover (usually several days), and a water level measurement is taken. Over time, numerous measurements at a well will be accumulated, and a graph of the water levels versus time plotted. These plots are called hydrographs. Hydrographs for wells that have captured water flatten as the amount of capture approaches the pumping rate (Figure 5a), while wells that have taken water only from storage continue to decline over time (Figure 5b). Pumping wells near a river (close to the source of capture) exhibit essentially flat hydrographs, indicating full recovery of the water table during non-pumping periods. Farther from the river, well hydrographs generally show a decline in water levels over time, indicating only partial recovery of the water table after pumping ceases. The rate of this decline in water levels reflects the relative volume of water coming from storage versus that captured from other sources.

In general, wells in the vicinity of a stream that have water levels below the stream stage are capturing water directly from the stream. Exceptions to this statement may include wells open only to zones known to be hydrologically isolated⁷⁹ from the stream. Unfortunately, the converse of the statement may not be true. Even if the water level in a well is higher than the stream stage, pumping from the well still may be capturing water from the stream because the well near a stream may intercept groundwater headed toward the stream.

Capture results in reduced surface flows. For example, annual flow duration curves⁸⁰ for a stream will show a decrease in the median flow⁸¹ once capture occurs (Figure 6). As long as pumped water comes only from aquifer storage and not from capture sources, stream flows and evapotranspiration processes remain unaffected by pumping. Riparian flora and fauna in the arid southwest depend heavily on stream flows, whether perennial, intermittent or ephemeral, because precipitation alone cannot sustain them. Roots of plants in riparian areas act like small wells by drawing water from the water table, creating tiny cones of depressions that ultimately capture water from the stream.⁸²

The arid southwest typically experiences four seasons: two wet—summer and winter, and two dry—spring and fall (Figure 7). Tremendous seasonal variations in both temperature and precipitation lend to seasonality in stream flows, evapotranspiration, and pumping. Stream flows in the region correspond

78. John D. Bredehoeft et al., *Groundwater: The Water-Budget Myth*, in SCIENTIFIC BASIS OF WATER-RESOURCES MANAGEMENT, 51, 53 (National Research Council, Geophysics Study Committee 1982).

79. An aquifer may be hydrologically isolated from a stream if there is a geologic unit such as a highly impermeable confining unit that prevents the movement of water between the aquifer and the stream.

80. Annual flow duration curves are graphs of stream discharge versus the percentage of time that the flow exceeds that stream discharge.

81. Half the time, the stream flow is either greater than or less than the median flow.

82. Riparian Protection Program Legislative Report, Draft, Volume A, ADWR, Feb. 1, 1994.

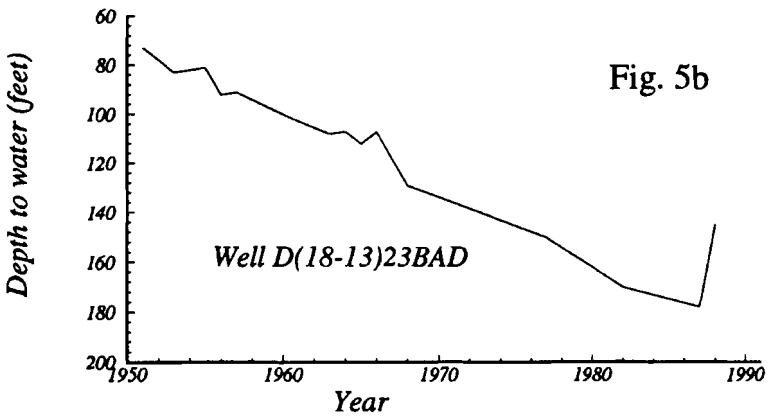
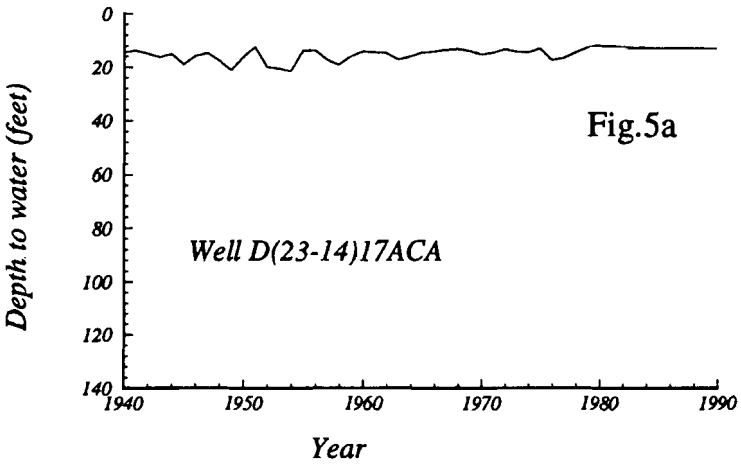


FIGURE 5

Flow Duration in San Pedro River

Charleston Gaging Station (s4710)

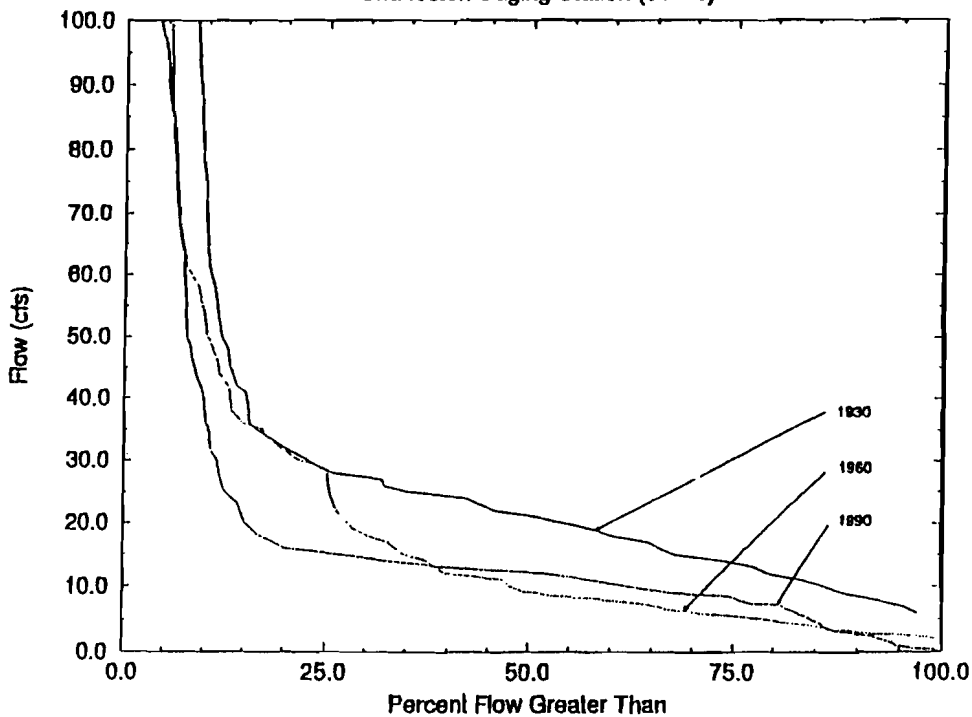


FIGURE 6

Discharge of the San Pedro River at the Tombstone Station

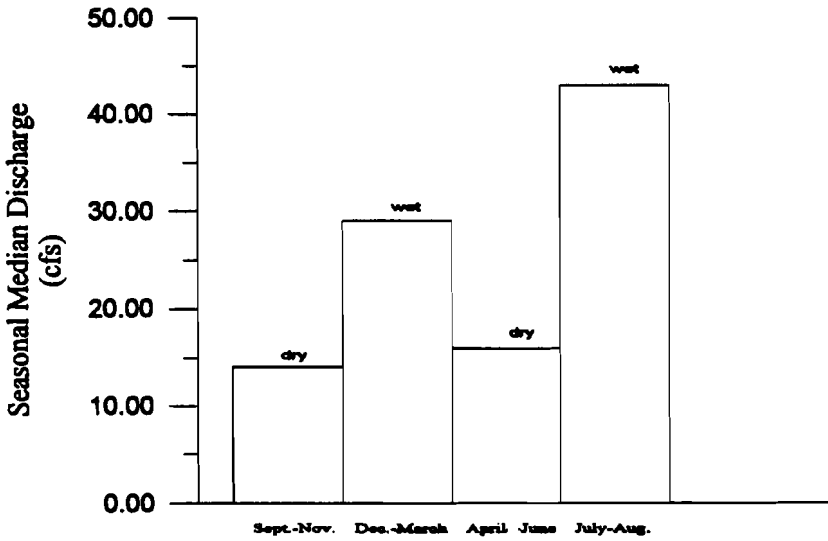


FIGURE 7

strongly, both in presence and in magnitude, to rainfall distributions. Without the buffering effect of infiltrating precipitation, capture has a more profound impact on streams during dry seasons than during wet.

Capture from a stream is a function of (1) time; (2) the hydraulic properties of the groundwater system such as hydraulic conductivity and specific yield; (3) properties of the stream such as slope,⁸³ stage,⁸⁴ sediment load,⁸⁵ channel geometry⁸⁶ and discharge; (4) pumping stress; and (5) any other recharge or discharge processes occurring in the region. Capture from streams is governed principally by Darcy's Law,⁸⁷ which states that the flow of water between the aquifer and the stream is proportional to the difference between the water level in the stream and that in the surrounding aquifer.⁸⁸

Capture from evapotranspiration processes is a function of time, the type of plant species and their mixture, extinction depths,⁸⁹ and temperature. An extreme example of capture effects from pumping can be found in the Santa Cruz River to the south of the Martinez Hill area of Tucson (Figure 8). In the 1940's, cottonwood and mesquite bosques lined the Santa Cruz River. By the late 1970's, the bosques had vanished due to the lowering of the water table in surrounding areas.⁹⁰

Estimates of capture are fundamental to quantitative groundwater and surface water analyses and planning for any long term water supply. Two crucial hydrologic questions pertain to the problem: 1) what quantity of water already is being captured as a result of existing development? and 2) what potential for capture exists with new development? If the courts desire to protect surface water rights, they should seek to control the capture processes.

V. CAPTURE IN THE UPPER SAN PEDRO RIVER

Because *Issue No. 2* ignores capture, it particularly threatens a riparian corridor along the upper San Pedro River in southeastern Arizona, an area so beautiful and rare that Congress sought to protect it in 1988 by creating the San Pedro Riparian National Conservation Area (SPRNCA).⁹¹ The danger comes from several directions. Pumping from the floodplain aquifer has had a

83. Slope is the average change in streambed elevation over a particular distance of the stream reach.

84. Stage is the elevation of stream surface above a defined datum, usually mean sea level.

85. Sediment load is particulate material carried by the stream current above or on the channel bottom.

86. Channel geometry is the shape of a cross-section of the stream channel.

87. Darcy's Law is an empirical law formulated by Henry Darcy in 1856 to describe the flow of water in a porous media.

88. More precisely, Darcy's law holds that the flow in the porous material is proportional to the cross-sectional area through which it flows and to the change in hydraulic head over the distance through which it flowed. The hydraulic heads are defined by the same datum, usually mean sea level.

89. Extinction depths are groundwater levels below which the plant can no longer draw water from the aquifer and therefore dies, and below which direct evaporation is insignificant.

90. NATIONAL RESEARCH COUNCIL, RESTORATION OF AQUATIC ECOSYSTEM 168 (1992).

91. 16 U.S.C. § 460xx (1993).



FIGURE 2A

Santa Cruz River near Martinez Hill, circa 1940



Santa Cruz River near Martinez Hill, circa 1980

1994-26-8

dramatic effect on the San Pedro River in the Sierra Vista subwatershed.⁹² There are some natural losing sections of the River located between the Mexican border and Palominas. These reaches show increasing losses from the River due to groundwater pumping.⁹³ In reaches in the Palominas-Hereford area, the River that was formerly naturally gaining is now a losing stream.⁹⁴

In general, with the loss of water from the stream comes a redistribution of gaining-losing stretches. Some reaches that were gaining water from the groundwater system have turned into losing ones. Fortunately, the gaining reaches between Lewis Springs and the Charleston bridge have experienced little change in flow rate. Two factors explain this phenomenon. First, the presence of a mass of low hydraulic conductivity rock in that area distorts the groundwater flow system and prevents the establishment of a developable floodplain aquifer. Second, the effect of the Sierra Vista-Fort Huachuca pumping is just now starting to be felt at the River.⁹⁵

With the establishment of the SPRNCA in 1988, the United States Bureau of Land Management (BLM) has acquired many of the agricultural lands within the floodplain aquifer and has retired the pumping from them. The effect on the river has been dramatic with the stream exhibiting some recovery toward its predevelopment state.⁹⁶ However, not all of the lands along the river in the Sierra Vista subbasin have been purchased by the BLM. In January 1994, a housing developer sought approval to build a 90-lot residential subdivision, to be called "Cottonwoods of the San Pedro," immediately adjacent to the SPRNCA.⁹⁷ This development would perversely contribute to killing the very trees after which it is named if wells are developed in the floodplain. Cottonwood trees, stately symbols of southwestern rivers, face competition for that water from groundwater pumping for residential subdivisions. The same developer also has proposed to build 5,000 homes next to "Cottonwoods."⁹⁸ Another developer has proposed a master-planned community of commercial parks, golf courses, resorts, and as many as 7,500 homes within six miles of the SPRNCA.⁹⁹ Several other development projects are either under construction or consideration by the county's planning and zoning commission.¹⁰⁰ The recent

92. Leticia B. Vionnet & Thomas Maddock III, *Modeling of Ground-Water Flow and Surface/Ground-Water Interaction for the San Pedro River Basin, Part I, Mexican Border to Fairbank, Arizona*, HWR no. 92-010, University of Arizona, 1992, at 4-23.

93. *Id.*

94. *Id.*

95. *Id.* at 4-27.

96. *Id.*; Testimony of Thomas Maddock III, Reporter's Transcript of Proceedings, Evidentiary Hearing, vol. 2, before the Honorable Stanley Z. Goodfarb (Feb. 1, 1994).

97. Ignacio Ibarra, *Tucson Developer Stirs San Pedro Debate*, ARIZ. DAILY STAR, Jan. 16, 1994, at B1, col. 1.

98. At the present time, the "Cottonwoods" development will have difficulty selling lots to sophisticated purchasers. Because the developer has failed to demonstrate rights to an adequate water supply, as required by Arizona law, see ARIZ. REV. STAT. ANN. § 32-2181(F), the promotional material and contracts for the sale of lots in the subdivision must explicitly advise prospective purchasers of this legal risk. See Letter from Greg Wallace, Chief Hydrologist, Arizona Department of Water Resources, to Duane Turner, Deputy Commissioner, Tucson Division (Feb. 1, 1994).

99. Ignacio Ibarra, *Benson Pinning Hopes on Annexation*, ARIZ. DAILY STAR, Jan. 30, 1994, at B1, col. 1.

100. Ignacio Ibarra, *Tucson Developer Stirs San Pedro Debate*, ARIZ. DAILY STAR, Jan. 16, 1994, at B1, col. 1.

improvement in the River would disappear if pumping for residential purposes simply replaced the now-retired agricultural pumping.

At present, municipal and industrial pumping from the City of Sierra Vista and the U.S. Defense Department's Fort Huachuca Army Base has had only a modest impact on the River. Their pumping is primarily from wells in the regional aquifer centered about 10 miles from the River. The effects from these wells have just begun to reach the river. With increased urbanization, additional well development closer to the stream is likely to occur. Such pumping, coupled with the growing Sierra Vista-Fort Huachuca effect,¹⁰¹ would further endanger the River.

In addition, in 1993, the United States Base Realignment and Closure Commission report recommended changes that would increase Fort Huachuca's water consumption by 20 percent. Because the Army decided not to construct family housing on the base, new residential development in or near the City of Sierra Vista seems inevitable.¹⁰² Moreover, the Base Commission has proposed closing the Monterey, California Defense Language Institute and a Sierra Vista developer has offered to donate 129 acres to help move the Institute to Sierra Vista.¹⁰³ The Institute would expand the Base by approximately 5,000 people and would increase water use by approximately 2,500 acre feet per year.¹⁰⁴ Without careful planning, these developments would place increased stress on the hydrologic connections between the groundwater system and the San Pedro River.¹⁰⁵

The future remains bleak for the San Pedro riparian corridor, with its estimated 400 bird species, 83 mammal species, and 47 amphibian and reptile species.¹⁰⁶ *Birder's Digest* has named the area the premier birdwatching site in the country and The Nature Conservancy has placed the San Pedro River basin, including the SPRNCA, on its list of "Last Great Places" in the western hemisphere.¹⁰⁷ American Rivers, a national environmental group, declared the San Pedro River one of the 20 most "threatened" rivers in the United States.¹⁰⁸ The threat to surface flows has been increased by the uncertainty created by *Issue*

101. An Army spokesperson, Mike Shaughnessey, recently conceded this point. See Ignacio Ibarra, *Sierra Vista Searches for Answers to Water Woes*, ARIZ. DAILY STAR, May 23, 1994, at B1.

102. In July 1994, an Arizona environmental group brought suit challenging the Army's decision to expand Fort Huachuca as a violation of the National Environmental Protection Act. See Ignacio Ibarra, *Group Sues Army over Fort Huachuca's Effect on San Pedro River*, ARIZ. DAILY STAR, July 9, 1994 at B2.

103. Alisa Wabnick, *Judy Gignac Strong in Developer Issues*, ARIZ. DAILY STAR, Jan. 17, 1994, at B2, col. 3.

104. Letter from Thomas Maddock to Defense Base Closure and Realignment Commission (May 14, 1993).

105. In July 1994, Secretary of the Interior Bruce Babbitt warned that the future of Fort Huachuca itself might depend on local water interests settling their conflicts. See Steve Meissner, *Water Fight May Imperil Huachuca*, ARIZ. DAILY STAR, July 10, 1994, at A1.

106. See Gregory McNamee, *A River Ran Through It*, TUCSON WKLY., Mar. 1, 1994, at 10.

107. *Id.*

108. See AMERICAN RIVERS, NORTH AMERICA'S MOST ENDANGERED AND THREATENED RIVERS OF 1994 37 (1994).

No. 2. The SPRNCA's survival depends on the proper implementation of *Issue No. 2*.¹⁰⁹

VI. PROBLEMS WITH THE *ISSUE NO. 2* DECISION

The *Issue No. 2* decision is legally, hydrologically, environmentally, and administratively unfortunate. First, it rejects any consideration of time as relevant to distinguishing ground and surface water. As a result, it allows groundwater pumping to intercept water moving toward the river that eventually would reach the river. This is an unfortunate event from the perspective of protecting surface flows and riparian habitats. Second, the decision is oblivious to the interconnection among groundwater wells, the aquifer, and the stream. Third, it ignores the problem of seasonality, which is critical for certain rivers in Arizona. Fourth, it ignores hydrological reality because "subflow" does not exist. Fifth, by failing to acknowledge that scientific and technological developments since 1931 might have relevance as to how the Court defines the line between ground and surface water, it undermines the security of prior appropriation rights. Sixth, it assumes wrongly that the Legislature can easily and effectively remedy the situation. Seventh, it is inconsistent with the law in other western states. Finally, it thrusts an impossible task on DWR and Judge Goodfarb, namely to develop scientific criteria to implement a legal rule that ignores principles of hydrology. The *Issue No. 2* decision embraces artificial legal categories that will have an unfortunate impact on surface water rights. Terms such as "subflow", "tributary groundwater", "percolating groundwater", and "underground streams" are legal terms that defy precise scientific definition.

In reaffirming *Southwest Cotton*, the *Issue No. 2* Court rejected time as a relevant factor in any determination of its artificial category of "subflow." Because capture is a function of time, this rejection prevents any proper determination of capture. The exclusion of time in a hydrologic process by the *Southwest Cotton* Court was understandable. In 1931, when *Southwest Cotton* was decided, the temporal process of groundwaters was not well understood. It was not until 1935 when C.V. Theis published his seminal paper that explained the temporal changes in water levels from wells.¹¹⁰ His paper provided a functional relationship between the hydraulic head and pumping and quantified the storage properties of an aquifer system.¹¹¹ Then, in 1940, Theis introduced

109. Harm to the San Pedro surface flow and riparian habitat would have an adverse affect on the local economy. A recent study concluded that nature-based tourism (primarily birdwatching) generates \$2.7 million annually for the local economy. See KRISTINE CRANDALL ET AL., NATURE-BASED TOURISM AND THE ECONOMY OF SOUTHEASTERN ARIZONA 4 (1992).

110. Charles V. Theis, *The Relation Between the Lowering of the Piezometric Surface and the Rate and Duration of Discharges of a Well using Ground-water Storage*, REP. & PAPERS, Hydrology-1935, 519 (1935).

111. *Id.*

the fundamental hydrologic principles that culminate in the definition of capture:

Under natural conditions...previous to the development by wells, aquifers are in a state of approximate dynamic equilibrium. Discharge by wells is thus a new discharge superimposed upon a previously stable system, and it must be balanced by an increase in the recharge of the aquifer, or by a decrease in the old natural discharge, or by a loss of storage in the aquifer, or by a combination of these.¹¹²

A decrease in the old natural discharge manifests itself by interception of water to the stream and by reduction of evapotranspiration processes (fewer trees), while an increase in recharge manifests itself by an increase in leakage from the stream. All of these phenomena take place over time.

A second difficulty concerns the failure to address the interconnections among wells, the aquifer, and the stream. Whenever a well field is developed near a riparian system, the historical pumping produces changes in the hydrologic properties that control the transmissive and storage properties of the aquifer and the interactions between the stream and the aquifer. Therefore, water level decline in a well is dependent on not only its own pumping, but also the historical pumping of all other wells in the system. The *Issue No. 2* ruling also ignores the problem of seasonality. Because many rivers and streams in Arizona fluctuate dramatically in response to spring snow melt and summer monsoon rains, the effect of groundwater pumping on surface flows depends on the season during the year when the pumping occurs. Pumping near the stream during low flows is extremely detrimental to the surface flows.

As the old adage goes, hard cases make bad law. So too does bad science. We have no quarrel with the Arizona Supreme Court's relying on Clesson Kinney's four volume, *The Law of Irrigation and Water Rights*, published in 1912, for the purpose of trying to discern what the Arizona Supreme Court meant in 1931 in *Southwest Cotton*. It surely was sensible to examine contemporary writers for their understanding of the connection between ground and surface water, though Clesson Kinney, a Utah lawyer and not a hydrologist, was hardly authoritative even in 1912, let alone 1931 or 1993. Our quarrel is with the Court's failure to acknowledge that scientific developments since 1931 might have some relevance as to how the Court ought to draw the line between ground and surface water. The fact that the Arizona Legislature in enacting the original version of A.R.S. Section 45-141 was ignorant about basic principles of hydrogeology does not mean that a court in 1993 must interpret the language that the legislature did use by reference to obsolete principles of hydrogeology.

Many have worshiped at the shrine of the prior appropriation doctrine as the bastion of private property and development throughout the West. In enacting Section 141, the Arizona Legislature extended statutory protection to the common law doctrine of prior appropriation. The Legislature thereby protected the most senior users' rights to water. This understanding is perfectly consistent with Clesson Kinney's treatise, as well as *Southwest Cotton*, precisely because both wrongly believed that much percolating groundwater had no impact on the surface flow of streams. The *Issue No. 2* decision jettisons this fundamental protection for the security of prior appropriation rights by

112. See Theis, *supra* note 68, at 277.

allowing subsequent pumping of hydrologically-connected groundwater to deplete the flow of rivers and streams because the *Southwest Cotton* Court, Clesson Kinney, and the Arizona Legislature that enacted Section 141, all were ignorant of principles of hydrogeology. The *Issue No. 2* Court's construction of Section 45-141 should have been informed by modern principles of the science of hydrogeology. The failure to do so has undermined the security of prior appropriation rights in favor of protecting more junior groundwater pumpers.

This result is particularly ironic because the dominant concern of the *Southwest Cotton* Court, which *Issue No. 2* purports to follow, was protection of surface water rights. At the end of its sprawling opinion, the *Southwest Cotton* Court offered a policy defense of its refusal to deem percolating waters as appropriable. It suggested that the effect of appropriating surface waters is visible and clearly understood, in sharp contrast to the uncertain and speculative character of groundwater.¹¹³ The *Southwest Cotton* Court feared that permitting groundwater to be appropriable would lead "to interminable and uncertain litigation from which no one will profit in the end but members of the legal profession" and would place a brake on economic development by discouraging surface water diversions.¹¹⁴ *Southwest Cotton* was right about one thing: the lawyers are profiting from this interminable litigation. Although the Court feared that this rule would likely lessen the use of groundwater for irrigation projects, it concluded that this result "is more than compensated by the establishment of certainty and security for the vastly more important surface projects now existing, and which will doubtless exist in the future."¹¹⁵ *Issue No. 2*'s effort to be faithful to *Southwest Cotton* has succeeded only in adhering to its letter and not its spirit. Ignorance of basic hydrogeology led *Southwest Cotton* to exclude percolating groundwater from the appropriation system in order to protect and foster surface water rights. Now *Issue No. 2* frustrates the "certainty and security" of surface water rights by choosing to ignore principles of hydrogeology.

The *Issue No. 2* Court's failure is compounded by other post-1931 developments that make it critical to have legal rules that reflect scientific reality. In 1931, groundwater pumping was not an important source of water. Before the New Deal's rural-electrification program, only 10% of American farms had powerline electric service. The Rural Electrification Administration, together with hydroelectric power generated by a series of dams built on the Colorado River, beginning with Hoover Dam in 1936, brought cheap electric power to vast areas of Arizona. Also in 1931, the technology for drilling wells and extracting groundwater was quite primitive. Ensuing years witnessed a remarkable revolution in the development of drilling mechanisms from drill bits to motors. During the 1940s, high capacity turbine pumps were developed that profoundly increased the capacity of individual wells to extract groundwater. In 1931 when the Court decided *Southwest Cotton*, it was impossible to extract water from below 50 feet below the surface of the earth. Today, it is common in Arizona, particularly in Pinal County, for wells to be drilled far below 1,000 feet. As a result, the last fifty years have witnessed an exponential increase in groundwater withdrawals. In 1976, groundwater

113. 39 Ariz. 65, 105, 4 P.2d 369, 409 (1939).

114. *Id.*

115. *Id.* at 105-106, 4 P.2d at 409-410.

withdrawals exceeded natural recharge by 2.2 million acre feet.¹¹⁶ This overdrafting of the aquifers, particularly in the heavily-populated sections of Arizona, led the Legislature, in 1980, to enact the pathbreaking Groundwater Management Act.¹¹⁷

The *Issue No. 2* ruling is one of the most important Arizona Supreme Court decisions in the last generation. It purports simply to follow precedent and to attempt to explicate some nuances of the 1931 *Southwest Cotton* ruling. However, given profound changes in our understanding of hydrogeology, and given technological developments that have revolutionized groundwater well drilling and pumping, the decision cedes to junior groundwater pumpers the right to diminish the surface flows in rivers and streams.

Another problem is the Court's assumption that the Legislature can correct the problem. Relying on *Arizona Public Service v. Long*,¹¹⁸ the *Issue No. 2* decision invites the Legislature to devise a solution. However, *Long* dealt with the subject of ownership and use of municipal effluent, an altogether new and undefined issue of water law. It was surely sensible to invite the Legislature to address the problem in a comprehensive way. After the *Issue No. 2* decision, the dilemma for legislative intervention is the serious doubt that the Legislature can retroactively undo what the *Issue No. 2* Court did. At the very least, the Court's decision may be res judicata as to the rights of existing groundwater pumpers. If the Legislature rewrites the boundary between ground and surface water, and applies the revision retroactively, it might violate vested property rights and trigger a requirement of compensation under the takings clause of the United States Constitution.

The Legislature is surely free to rewrite Section 45-141 to expand the scope of water that will be deemed appropriable. One hopes that the Legislature will do so. Because this change must operate prospectively, it becomes basically irrelevant for the Gila River Adjudication. Given that the waters in the Gila River system are largely if not completely appropriated, and given that the Gila River system covers approximately 2/3 of the entire State in which approximately 90% of the population live, a prospective rewrite of Section 45-141 will have very limited impact.

A different tack that the Legislature might take is to regulate groundwater pumping more carefully. First, the Legislature should impose a pump tax on all groundwater pumping within a certain distance of any river, stream, or wash. Second, the Legislature should impose a moratorium on drilling new wells or deepening existing wells if those wells would capture surface flows or intercept water moving toward rivers or streams. Finally, in the long term, the Legislature needs to extend some variation of active management area protection to the entire State.¹¹⁹ The Legislature could impose

116. An acre foot is approximately 325,000 gallons.

117. For analysis of the Act, see Robert J. Glennon, "Because That's Where the Water Is": Retiring Current Water Uses to Achieve the Safe-Yield Objective of the Arizona Groundwater Management Act, 33 ARIZ. L. REV. 89 (1991).

118. 160 Ariz. 429, 773 P.2d 988 (1989).

119. Some recent developments deserve mention. In 1990, Arizona voters adopted an initiative that established the Arizona Heritage Fund. The Fund annually allocates \$20 million from the Arizona state lottery for parks, trails, wildlife, habitat protection, and other environmental purposes. See Ariz. Rev. Stat. Ann. § 41-501. In 1992, the Arizona Legislature directed the Arizona Game and Fish Department, the Arizona Department of Environmental

each of these changes without running afoul of the takings clause. After the Legislature enacted the Groundwater Management Act, landowners challenged its constitutionality. The Arizona Supreme Court rejected takings, due process, and equal protection claims, holding that landowners do not have a right of ownership of groundwater prior to its withdrawal from the aquifer.¹²⁰ Another weakness is that *Issue No. 2* leaves the State of Arizona almost alone in its failure to reform its law to conform to hydrologic reality. Nearly all other western states have jettisoned a rigid separation between ground and surface water. Every state adjacent to Arizona administers groundwater that is hydrologically connected to surface flows as part of the prior appropriation system.¹²¹

A final problem with *Issue No. 2* is the horrendous task that the Court has thrust upon the general adjudication court. Despite rejecting both the time and the percentage framework, the Court has told the adjudication court that it must develop criteria for determining whether a particular well is pumping water that is "more closely associated" with the river than with the surrounding alluvium. In October 1993, Judge Goodfarb placed this impossible task on the Department of Water Resources legal division when he ordered DWR to prepare a preliminary report. On November 5, 1993, the Department filed its Preliminary Report on Proposed Criteria to Identify Stream Subflow.¹²² The Preliminary Report bluntly criticized the Arizona Supreme Court ruling. Indeed, the Preliminary Report offers an extraordinary comment by counsel for an administrative agency charged with implementing the Court ruling. Unfortunately, the criticism is entirely deserved.

Quality, and the Arizona Department of Water Resources to conduct studies relating to riparian areas. Simultaneously, the Legislature created a Riparian Area Advisory Committee, appointed by the Governor, and charged it with responsibility for developing recommendations for protecting riparian areas. See ARIZ. REV. STAT. ANN. § 45-411.02 (1994). In 1994, the Legislature took a positive step forward by creating a fifth active management area—the Santa Cruz AMA. See S. 1380 41 Cong., 2nd Sess. § 5 (1994). The act recognizes the unique hydrology and water resources of the region and establishes coordinated management of surface and groundwater rights. See ARIZ. REV. STAT. ANN. § 45-411.04(A) & (B). For the first time, it subjects *all* water pumped from wells in the Santa Cruz AMA to the conservation requirements and well-spacing provisions of the Groundwater Management Act. See ARIZ. REV. STAT. ANN. § 45-451(C). At the same time, however, the act explicitly disclaims any intent to redefine surface or groundwater rights or the legal relation between ground and surface water rights. See ARIZ. REV. STAT. ANN. §§ 45-411.04(C) & 45-451(B).

Also in 1994, the Legislature created a Water Protection Fund, to be administered by a Commission charged with maintaining, enhancing, and restoring the State's rivers, streams, and riparian habitat. The Fund has an initial appropriation of \$9 million and the Commission has authority to engage in a broad range of activities. However, the Fund's monies cannot be used to acquire water rights. See H.R. 2590, 41 Cong., 2nd Sess. Ch. 278 § 16 (1994).

120. See *Town of Chino Valley v. City of Prescott*, 131 Ariz. 78, 638 P.2d 1324 (1981).

121. See *Leshy & Belanger*, *supra* note 24, at 659-60 and 725-28; Douglas L. Grant, *The Complexities of Managing Hydrologically Connected Surface Water and Groundwater Under the Appropriation Doctrine*, 22 LAND & WATER L. REV. 63, 64 (1987); Frank J. Trelease, *Conjunctive Use of Groundwater and Surface Water*, 27 ROCKY MTN. MIN. L. INST. 1853, 1857-58 (1982); DAVID H. GETCHES, *WATER LAW* 278 (2nd ed. 1990). See also, Barbara Tellman, *My Well v. Your Surface Water Rights: How Western States Manage Interconnected Groundwater and Surface Water*, U. ARIZ. WATER RESOURCES RES. CENTER, Issue Paper No. 15 (June 1994).

122. See D.W.R., PRELIMINARY REP. ON PROPOSED CRITERIA TO IDENTIFY STREAM SUBFLOW (Nov. 5, 1993) [hereinafter PRELIMINARY REP.]. See also, D.W.R., TECH. ASSESSMENT OF THE ARIZ. SUP. CT. INTERLOCUTORY APPEAL ISSUE NO. 2 OPINION (Dec. 15, 1993).

The Report identified what it described as "technical constraints" placed on DWR by the Court ruling. It found the Court's "specific guidelines...contradictory."¹²³ On the one hand, the Court rejected the idea of determining subflow by some quantity of stream depletion over time. On the other hand, the Court had earlier indicated that depletion occurs when production is "measurable,"¹²⁴ which presumably must be over some period of time. Similarly, the Court stated that if the cone of depression has intercepted a stream bed, then the pumping is pumping subflow. Again, as DWR points out, this must involve some element of time because

the hydrologist cannot measure stream depletion, or calculate the area of a cone of depression, without knowing the relevant time parameter. In rejecting time as a relevant factor in the identification of subflow, the Court has removed most of the scientific basis for determining the true impact of pumping wells on nearby streams.¹²⁵

The *Issue No. 2* Court also rejected the idea that the "younger" alluvium¹²⁶ would delineate the geographic extent of subflow. On this point, DWR characterized the Court's opinion as having "been misled by the evidence" because the "younger" alluvium rarely stretches from ridge line to ridge line in Arizona.¹²⁷ In DWR's technical judgment "in stream reaches where subflow occurs, the younger alluvium constitutes a subterranean water course that is more commonly associated with the stream than with the surrounding tributary aquifer."¹²⁸

DWR also criticized the Court's neglecting the "long term dynamic effect of pumping wells on the direction of underground flow." The Supreme Court ruling suggested that if water was flowing *away from* the stream, it was not appropriate. "In developed streams, however, this means that water being induced to infiltrate and flow from the stream to a pumping well is not the subflow of the surface stream."¹²⁹ We agree with DWR. The Court's reasoning ignores both the impact of wells on the natural stream and the seasonal nature of intermittent streams that may gain or lose during particular seasons. It is difficult to understand why groundwater flow *away from* the stream is *not* appropriate when a well has a cone of depression that intersects the stream, extracts water from the stream, and pulls that water away from the stream. The *Issue No. 2* decision's inconsistencies are astounding.

The *Issue No. 2* opinion slights both time and geology in favor of a "brightline" based on geography. DWR concluded that it would interpret the ruling to mean "that subflow is the physical presence of water in a certain geographic location at a particular moment of time."¹³⁰ Given this understanding, DWR developed proposed criteria. As a consequence of this

123. "Some statements embody a technical principal or standard that would, in most circumstances, result in narrowing the delineation of subflow compared to the 50%/90 day 'brightline' rule set forth in the trial court's order. Other statements seem to require that the brightline be extended beyond the 50%/90 day limit, essentially negating the narrowing guidelines." PRELIMINARY REP., *supra* note 122, at 2.

124. *Id.*

125. *Id.* at 2-3.

126. This is what we refer to as the alluvial or floodplain aquifer.

127. PRELIMINARY REP., *supra* note 122, at 3.

128. That tributary aquifer is what we refer to as the regional aquifer. *Id.*

129. *Id.* at 3-4.

130. *Id.* at 4.

understanding, DWR decided to ignore the transmissivity and the storage properties of the aquifer because these scientific measures are relevant to time-based hydrologic studies. Therefore, DWR's criteria will focus on "static water levels."¹³¹ From as much known information from as many wells as possible, DWR will develop criteria. The Report will distinguish four hydrologic conditions: alluvial valley streams, alluvial valley streams with confined zones, bedrock canyon streams, and mountain front streams. DWR's criteria will attempt to identify situations in which "the saturated stream alluvium is more closely related to the stream than to the surrounding tributary aquifer."¹³²

Although DWR purports to take no position on the concepts in the *Issue No. 2* opinion, it nonetheless found that "many of the technical principles in the opinion are ambiguous and cannot be readily implemented. The opinion leaves the issue of appropriable subflow with as much technical uncertainty as it had prior to the initial taking of testimony by the trial court on this matter."¹³³ DWR will rely on "the forces of gravity" to try to determine some artificial line along the stream where water begins to flow "more with the stream than to or from the stream."¹³⁴

In January and February 1994, Judge Goodfarb held hearings on DWR's Preliminary Report and heard testimony from the various litigants' hydrologists on how best to respond to the *Issue No. 2* Court's remand.¹³⁵ From the hearings, Judge Goodfarb learned that the expert witnesses had not recently conducted any physical investigation of the San Pedro River. In March 1994, the Judge, counsel and various experts embarked on a two-day field trip to the San Pedro River, during which the Judge heard additional testimony from the experts and from long-term residents of the area. Finally, in June 1994, the Judge held a supplementary evidentiary hearing to take testimony comparing aerial photographs of the San Pedro River between 1935 and 1990. After this hearing, he took the case under advisement.

Judge Goodfarb faced a difficult task since each litigant submitted one or more criteria for defining subflow. Although each suggested definition differs, one group of litigants wants the definition as geographically narrow (as close to the stream) as possible while another group wants it as wide as possible. A humorous classification of "duck suckers" and "mountain toppers" was proposed at the hearing.¹³⁶ In general, those entities that pump principally groundwater tended to be "duck suckers" and those that principally divert surface waters tended to be "mountain toppers." Both groups recognize that the capture processes would be reduced if there was control over groundwater pumping near the stream system.

As to the issue of a well whose cone of depression intersects a stream, the "duck suckers" were far more imaginative with their arguments. One group relied on *Issue No. 2*'s insistence that the effect on the stream be direct and measurable to argue that the effect must be measurable by direct rather than

131. *Id.*

132. *Id.* at 5.

133. *Id.* at 6.

134. *Id.*

135. Tom Maddock served as the expert witness for The Nature Conservancy.

136. Reporter's Transcript of Proceedings, Evidentiary Hearing, vol. 2, before the Honorable Stanley Z. Goodfarb, at 76 (Feb. 1, 1994).

indirect means. If it cannot be so measured, it cannot be subflow.¹³⁷ Because the drawdown effect by a well on the river can be determined only through hydrologic modeling, which is an indirect measure, wells will never be pumping subflow. This approach defines away the relationship between ground and surface water.

Another extreme argument contended that the molecule of water that leaves the stream and travels tortuously through the aquifer system must actually be at the well before the system is pumping subflow.¹³⁸ We can easily envision that a group of pumpers could dry up the river system and sell off their property years before one molecule from the river actually arrived at their wells. As Attorney Steven Weatherspoon pointed out in his post-hearing memorandum, "that is akin to telling a man standing on a railroad track that the train will not have passed until the caboose goes by...."¹³⁹

In the aftermath of *Issue No. 2*, in order to protect the surface-water rights of downstream users, the imaginary line delineating "subflow" should be made as wide as possible. The further away a well is from the stream, the less water that well can capture from the stream over a period of time. Judge Goodfarb defined the line broadly in a 66-page opinion filed in July 1994. He developed a test for "subflow" and a test for the cone of depression of wells located outside the "subflow" region.¹⁴⁰ Working within *Issue No. 2*'s constraints, Judge Goodfarb broadly defined "subflow" as the outer edge of the "saturated floodplain Holocene alluvium."¹⁴¹ As described in Part IV, a floodplain or Holocene alluvium consists of younger geologic deposits usually less than a mile wide. Judge Goodfarb's decision to define "subflow" as the edge of the younger alluvium goes a long way toward bringing within the Adjudication those wells whose pumping most seriously threatens surface flows and associated riparian habitat.

To reach this conclusion, Judge Goodfarb relied on characteristics that the *Issue No. 2* Court thought relevant, namely elevation, gradient, chemical makeup, and flow direction. After analyzing the competing theories of the litigants, Judge Goodfarb concluded that the saturated¹⁴² floodplain Holocene alluvium is "the most accurate" marker of "subflow."

Judge Goodfarb also addressed the problem of wells located outside the "subflow" region where the cone of depression intercepts water from the "subflow" area or the stream itself. *Issue No. 2* only addressed the situation of those wells whose cone of depression has expanded so as to intercept a streambed. As to these wells, the Supreme Court concluded that they "almost certainly will be pumping subflow."¹⁴³ *Issue No. 2* offered Judge Goodfarb no

137. Disclosure Statement of Groundwater Users Cyprus Climax, et al. at 11, (Jan. 27, 1994).

138. See Errol L. Montgomery et al., Criteria for Determining Subflow, Report (Dec. 14, 1993).

139. Post-Hearing Memorandum of The Nature Conservancy Regarding Subflow, at 12, *In re the General Adjudication of All Rights to Use Water in the Gila River System and Source* (Maricopa County Superior Court, filed Mar. 25, 1994).

140. See *In re the General Adjudication of All Rights to Use Water in the Gila River System and Source* (Maricopa County Superior Court, July 5, 1994) [hereinafter Slip op.].

141. *Id.* at 56.

142. He used this adjective because it would demonstrate the hydraulic connection between the stream and the "subflow" deemed important in *Issue No. 2*.

143. 175 Ariz. 382, 391, 857 P.2d 1236, 1245.

guidance as to wells located outside the "subflow" region that intercept water in the "subflow" region. Relying on unanimous testimony,¹⁴⁴ Judge Goodfarb concluded that wells outside the "subflow" area will be subject to the Adjudication to the extent that the water pumped comes from either the stream itself or the "subflow" area.¹⁴⁵ This ruling makes eminent sense because a change in the water level in the "subflow" zone will produce a gradient that will extract water from the stream.

Although Judge Goodfarb's opinion arrived too late for us to analyze exhaustively, we wish to highlight several aspects of his decision. First, Judge Goodfarb's opinion departs from *Issue No. 2* in an important respect. *Issue No. 2* seemed to reject the younger alluvium as the test of "subflow" because it believed that the record demonstrated that the younger alluvium often extends all the way from the ridge line of one chain of mountains to the ridge line of another. Such an expansive definition of "subflow", *Issue No. 2* reasoned, would be inconsistent with *Southwest Cotton*.¹⁴⁶ The Court's factual predicate was incorrect for, as we noted in Part IV, the younger alluvium rarely exceeds a mile in width. Judge Goodfarb properly rejected *Issue No. 2*'s factual assumption based on unanimous testimony of the expert witnesses that the geologic formation known as the younger alluvium occurs only in the center of a broad valley.

Second, Judge Goodfarb recognized that leakage from the floodplain alluvium to the tributary aquifer beneath will effect the stream. The size of the effect will be a function of the transmissive quality of any confining unit. Given the lack of substantial confining units, a well perforated to the deepest part of the underlying tributary aquifer could be pumping subflow and thus a portion of its waters could be appropriable.

Third, Judge Goodfarb criticized the *Issue No. 2* ruling that DWR's findings would constitute "clear and convincing" evidence.¹⁴⁷ Given the impossibility of reaching unequivocal conclusions of fact concerning hydrogeologic conditions, Judge Goodfarb reasoned that well owners would find it practically impossible to overcome this burden of proof. To Judge Goodfarb, DWR findings are entitled to deference through a preponderance of the evidence standard.

Fourth, Judge Goodfarb ruled that there could be "subflow" adjacent to and beneath an ephemeral stream, if it has become ephemeral because of surface water diversions or groundwater pumping and there are other portions of the stream that are still intermittent or perennial.¹⁴⁸ This ruling may offer substantial protection for rivers, such as the Santa Cruz River, where it is well documented that groundwater pumping has transformed portions of a once perennial and intermittent stream into an ephemeral stream.¹⁴⁹

144. Slip op., *supra* note 140, at 61.

145. *Id.* at 63.

146. 175 Ariz. at 391, 857 P.2d at 1245.

147. *See supra* note 51.

148. Slip op., *supra* note 140, at 35.

149. NATIONAL RESEARCH COUNCIL, RESTORATION OF AQUATIC ECOSYSTEMS 168 (1992).

Fifth, *Issue No. 2* rejected Judge Goodfarb's original 50%/90 days test because both the time and volume elements were "essentially arbitrary."¹⁵⁰ In his opinion on remand, Judge Goodfarb carefully reviewed the strengths and weaknesses of the competing positions of the litigants. This analysis, grounded in the testimony of the expert witnesses and the evidentiary record, ultimately justified his decision to use the saturated floodplain Holocene alluvium as the definition of the "subflow" area. This meticulous effort will avoid the "essentially arbitrary" problem of his earlier ruling, except perhaps in the eyes of the most fervent advocate.

In light of Judge Goodfarb's ruling, it seems inevitable that the issue will make its way back to the Arizona Supreme Court for reconsideration because the stakes are high and the *Issue No. 2* ruling is incoherent. Indeed, in August 1994, Judge Goodfarb certified his decision for interlocutory review by the Arizona Supreme Court. That Court will have another chance to address the boundary between ground and surface water.

Even if the Arizona Supreme Court adopts Judge Goodfarb's approach, that approach will only retard capture, not control it.¹⁵¹ To truly control capture, the Arizona Supreme Court must reinstate the laws of physics and jettison the State's bifurcated system of water law. As Part VII will demonstrate, the present system of water law in this State is very likely to promote federal governmental intervention whenever uncontrolled capture processes threaten federal interests.

VII. THE ROLE OF FEDERAL LAW

In the wake of *Issue No. 2*, the two general adjudication judges and the special master filed a motion with the Arizona Supreme Court to consolidate two other issues (No. 4 and No. 5) scheduled for interlocutory review and to hear these questions next. Given that litigants, not judges, file motions in pending cases, this unusual step generated responses from several parties who questioned the propriety of the judges' and master's motion.¹⁵² Nonetheless, the Supreme Court granted the motion, noting that it dealt only with procedural matters.¹⁵³ In March 1994, the Supreme Court established a briefing schedule for the second half of 1994 and oral argument will take place in February 1995.¹⁵⁴ These issues perhaps offer the best opportunity for protecting surface flows in the San Pedro River and other remaining riparian corridors. Each addresses an aspect of the federal reserved rights doctrine. No. 4 asks: Is nonappropriable groundwater subject to federal reserved rights? No. 5 poses

150. 175 Ariz. at 392, 857 P.2d at 1246.

151. In elaborating the principles for defining "subflow," Judge Goodfarb ruled that "[t]he 'subflow' zone must be distinguished from adjacent tributary aquifers or connecting basin fill." Slip op., *supra* note 140, at 36. *Issue No. 2* left him no other choice but to make this distinction. There is a serious problem with this ruling. Tributary aquifers funnel the mountain front recharge to the stream through the floodplain aquifer. Thus, pumping from the tributary aquifers will generally intercept potential stream flow and disrupt surface-water rights.

152. *Supreme Court to Decide Federal Reserved Water Right Questions*, ARIZ. GEN. STREAM ADJUDICATION BULL. 1 (Feb. 1994).

153. *Id.*

154. *Gila River Proceedings, Issues 4 and 5*, ARIZ. GEN. STREAM ADJUDICATION BULL. 4 (May 1994).

the question: Do federal reserved water rights holders enjoy greater protection from groundwater pumping than holders of state law rights?¹⁵⁵

The federal reserved rights doctrine traces to a seminal United States Supreme Court decision in 1908, *Winters v. United States*.¹⁵⁶ When the Federal Government, through legislative or executive action, sets aside lands from the public domain for specific federal purposes, it impliedly reserves sufficient water for those lands to accomplish the purposes of the reservation. This doctrine originally recognized that, when the federal government created Indian reservations, it intended to transform those areas into viable economic enterprises. For most Indian reservations, courts have determined that the purpose was to provide sufficient water to establish an agricultural community. To that end, the U.S. Supreme Court has held that the quantity of water reserved is that quantity required to irrigate all the "practicably irrigable acreage" on the reservation.¹⁵⁷

The Supreme Court has not limited the reserved rights doctrine simply to Indian reservations; it applies as well to other federal lands set aside for specific federal purposes.¹⁵⁸ In 1952, President Truman created Devil's Hole National Monument in Nevada by executive proclamation for the purpose of preserving features of "scenic, scientific, and educational interests...."¹⁵⁹ The Proclamation noted that Devil's Hole contained a "remarkable underground pool," that was "a unique subsurface remnant of the prehistoric chain of lakes," and that its special geological features made it scientifically significant.¹⁶⁰ The Proclamation also noted that the pool contained an unusual species of fish, the desert pup fish.¹⁶¹

In 1968, the Cappaerts, who owned a 12,000-acre ranch approximately 2 1/2 miles from Devil's Hole, began pumping groundwater on their ranch. The groundwater came from the same basin that was the source of the water in Devil's Hole. The Cappaerts' pumping began to have an adverse effect on the water level of the pool in Devil's Hole. The reduction in the water level exposed most of a rock shelf, decreased the pup fish's spawning area, and thus raised the likelihood of its extinction. In 1970, the Cappaerts, pursuant to Nevada law, received a permit from the state engineer for several of their wells. In 1971, the United States sought an injunction in United States District Court to limit the Cappaerts to pumping for domestic purposes only. The United States claimed that the Cappaerts had not perfected water rights as of the 1952 date of the Proclamation. Both sides conceded that the groundwater pumped from the wells was hydrologically connected to the water in the pool in Devil's Hole.¹⁶²

155. The Interior Department has already signalled its intention to assert vigorously its federal rights that are threatened by *Issue No. 2*. See, e.g., Letter from William H. Swan, Field Director, U.S. Dept. of the Interior, to Larry Linser, Deputy Director, Ariz. Dept. of Water Resources (Nov. 17, 1993); Letter from Lester K. Rosenkrance, State Director, BLM, to Rita Pearson, Director, Ariz. Dept. of Water Resources (Nov. 22, 1993).

156. 207 U.S. 564 (1908).

157. *Arizona v. California*, 373 U.S. 546, 600 (1963).

158. *Id.* at 601; *Fed. Power Comm'n v. Oregon*, 349 U.S. 435 (1955).

159. *Cappaert v. United States*, 426 U.S. 128, 132 (1976).

160. *Id.* at 132.

161. *Id.* at 132.

162. The Court also rejected the position of the State of Arizona put forward in an *amicus* brief filed by then-Arizona Attorney General Bruce Babbitt. The brief raised the specter of terrible consequences flowing from a decision that protected federal rights from interference by

In *Cappaert v. United States*,¹⁶³ the United States Supreme Court rejected the state claim that the reserved rights doctrine required a balancing of competing interests. When the Federal Government sets aside land for a particular federal purpose, its purpose is not balanced against competing state interests. A combination of the Commerce Clause,¹⁶⁴ the Property Clause,¹⁶⁵ and the Supremacy Clause¹⁶⁶ means that when there is a dispute, the federal interests prevail. The *Cappaert* Court examined the 1952 Proclamation and determined that the government intended to reserve unappropriated water for purposes of the reservation. The Proclamation clearly focused on protecting the pool. In *Cappaert*, the Court held that, when the United States established Devil's Hole National Monument, it reserved water rights to unappropriated appurtenant water sufficient to maintain the level of the pool in order to preserve its scientific value.¹⁶⁷

At the same time, the *Cappaert* Court suggested that this implied reservation reserves only "that amount of water necessary to fulfill the purpose of the reservation, no more."¹⁶⁸ The Court approved the district court's injunction that was tailored carefully to reserving only the water necessary to preserve the water level to implement the Proclamation's objectives. On another point, the State argued that the reserved rights doctrine was limited to surface water. However, the *Cappaert* Court recognized that the pool in Devil's Hole was surface water.¹⁶⁹ These rulings offer a substantial measure of protection for the San Pedro Riparian National Conservation Area.

Potentially cutting against the federal claim in the San Pedro, the *Cappaert* Court also noted that Nevada law apparently recognized the interconnections between ground and surface water because it applied the law of prior appropriation to each.¹⁷⁰ The Cappaerts faced trouble because they did not have perfected appropriation rights, albeit to groundwater, until 1968. A second potential limit is footnote 7.¹⁷¹ The Court emphasized the facts of the case which involved wells that were within 2 1/2 miles of Devil's Hole. There was no proof that pumping from greater distances would significantly lower the water level in Devil's Hole. Nevada suggested that such pumping "will in time affect the water level in Devil's Hole."¹⁷² Testimony from a hydrologist suggested that pumping from forty miles away over a period of perhaps

groundwater pumping, including that certain cities would become "ghost towns" and that state water rights "will be worthless and Arizona as we know it today will not survive." [quoted in Leshy and Belanger, *supra* note 24, at 729.] This extraordinary language came from the current Secretary of the Interior who enjoys a reputation as an environmentalist. Secretary Babbitt was roasted for these words by his own Solicitor, John Leshy, at an American Bar Association water law conference in February 1994.

163. 426 U.S. 128 (1976).

164. U.S. CONST. art. I, § 8, cl.3.

165. U.S. CONST. art. IV, § 3, cl. 2.

166. U.S. CONST. art. VI, cl. 2.

167. 426 U.S. at 147.

168. 426 U.S. at 141.

169. "The federal water rights were being depleted because, as the evidence showed, the '[g]roundwater and surface water are physically interrelated as integral parts of the hydrologic cycle.' Here the Cappaerts are causing the water level in Devil's Hole to drop by their heavy pumping." *Id.* at 142.

170. *Id.*

171. *Id.* at 143.

172. *Id.* at 143 n.7.

decades would have a small effect.¹⁷³ Thus, it is clearly unresolved, as a matter federal reserved rights doctrine, (1) whether *Cappaert* depended, in part, on the fact that Nevada law also recognized the hydrologic connection between ground and surface water, and (2) how substantial the hydrologic connection must be between the ground and surface uses.¹⁷⁴ On the other hand, and most importantly, the Court held that "the United States can protect its [reserved] water from subsequent diversion, whether the diversion is of surface or groundwater."¹⁷⁵

Nevada also claimed that the Federal Government needed to perfect its reserved water rights according to state law. However, the Court found that "determination of reserved water rights is not governed by state law but derives from the federal purpose of the reservation...."¹⁷⁶ The Court noted that proposed congressional legislation to subject some federal reserved rights to state law appropriation doctrine failed to pass the Congress.¹⁷⁷ "Federal water rights are not dependent upon state law or state procedures..."¹⁷⁸

Several implications flow from the *Cappaert* ruling. First, the reserved rights doctrine will apply to the San Pedro Riparian National Conservation Area. Second, the reserved rights adhere as of the date of the federal reservation. Third, the purpose of the reservation determines the scope of federal water rights. Fourth, the Federal Government obtains rights to the quantity of water that is "necessary" to accomplish its purpose. Fifth, the reserved rights doctrine will protect against harm from subsequent groundwater pumping of hydrologically-connected water.

How much water is "necessary" for the purposes of the federal reservation? In a very important case, *United States v. New Mexico*,¹⁷⁹ the Court addressed what quantity of water, if any, the United States had reserved out of the Rio Mimbres River which flows through the Gila National Forest in New Mexico. The question of federal reserved rights for national forest lands is critical because (1) there are so many national forests of such large size, and (2) many forests are located in proximity to state law appropriators.

The *New Mexico* Court held that the purposes of national forests, as embodied in the Creative Act of 1891 and the Organic Administration Act of 1897, indicated two quite focused purposes: to conserve the water flows and to furnish a continuous supply of timber.¹⁸⁰ The Court rejected, as an independent purpose, that of improving and protecting the forest itself. The Court distinguished between primary and secondary purposes of a federal reservation and held that the *implied-reservation-of-water* rights doctrine only protects the primary purposes of the reservation. The Court gave this narrow construction to the purposes of federal forests, reasoning that Congress intended forests "as a means of enhancing the quantity of water that would be available to the settlers of the arid West."¹⁸¹

173. *Id.*

174. For further discussion, see *infra* notes 190-91 and accompanying text.

175. 426 U.S. at 143.

176. *Id.* at 145.

177. *Id.*

178. *Id.* at 145.

179. 438 U.S. 696 (1978).

180. *Id.* at 706.

181. *Id.* at 713.

How much water is necessary to secure favorable conditions of water flows and to furnish a continuous supply of timber? The *New Mexico* Court gave two seemingly different phrasings of the scope of reserved water rights. It began by quoting from *Cappaert* that Congress reserved "only that amount of water necessary to fulfill the purpose of the reservation, no more."¹⁸² Yet, in the next sentence, it suggested: "[e]ach time this Court has applied the 'implied-reservation-of-water doctrine,' it has carefully examined both the asserted water right and the specific purposes for which the land was reserved, and concluded that without the water *the purposes of the reservation would be entirely defeated.*"¹⁸³ The second sentence apparently anticipates that a partial defeat of the federal purposes would be permissible.¹⁸⁴

Those interests who will try to limit the scope of federal reserved rights for the San Pedro Riparian National Conservation Area might argue that the scope includes only that water without which the purposes "would be entirely defeated." How much groundwater pumping by the City of Sierra Vista would entirely defeat the purposes of the SPRNCA? We believe that one must read the "entirely defeated" language in context. The Court used this test because "the reservation is implied, rather than expressed, and because of the history of congressional intent in the field of federal-state jurisdiction with respect to allocation of water."¹⁸⁵ Given Congress's historical deference to state water rights, one can understand the reluctance of the Supreme Court to *imply* or *infer* federal water rights when Congress has been silent about the matter. However, when Congress has spoken, it would be entirely inappropriate for courts to countermand this express congressional intent.

The scope of protection given the San Pedro Riparian National Conservation Area should not be measured by the *New Mexico* standard precisely because Congress has spoken clearly and unequivocally as to the San Pedro, and has *expressly* reserved water to protect the purposes of the Conservation Area. In 1988, Congress passed the San Pedro Riparian National Conservation Area Act.¹⁸⁶ Out of public domain lands managed by the Bureau of Land Management, Congress established the Conservation Area "[i]n order to protect the riparian area and the aquatic, wildlife, archeological, paleontological, scientific, cultural, educational, and recreational resources of the public lands surrounding the San Pedro River in Cochise County, Arizona."¹⁸⁷ Congress initially reserved 56,000 acres and provided for the subsequent acquisition of additional parcels of land. The Act required the Secretary of the Interior to prepare a long range management plan with the help of an advisory committee.¹⁸⁸ Most significantly, Congress expressly reserved water rights.¹⁸⁹

182. *Id.* at 700.

183. *Id.* (emphasis added).

184. *See* *United States v. City and County of Denver*, 656 P.2d 1, 29 (Colo. 1982).

185. 438 U.S. at 701-02.

186. 16 U.S.C. §§ 460 xx to 460xx-6 (1993).

187. 16 U.S.C. § 460 xx (a).

188. 16 U.S.C. § 460 xx-2.

189. "Congress reserves for the purpose of this reservation, a quantity of water sufficient to fulfill the purposes of the [conservation area]. The priority date of such reserve rights shall be November 18, 1988. The Secretary [of the Interior] shall file a claim for the quantification of such rights in an appropriate stream adjudication." 16 U.S.C. § 460 xx-1(d).

Another issue concerns the law that courts will use in defining federal reserved water rights. *Cappaert* at least indicates that state prior appropriation groundwater rights must yield to an earlier perfected federal reserved surface water right. Would groundwater pumpers in a state like Arizona that follows the American rule of reasonable use have any greater claim?¹⁹⁰ Trying to integrate federal reserved water rights with existing state rules can be a vexing problem. To what extent might aspects of federal reserved water rights be contingent on the definition of rights under particular state laws? As noted above, there is at least an argument that the *Cappaert* ruling rests on the legal regime of the State of Nevada which integrated ground and surface water into a comprehensive system of prior appropriation rights. Perhaps *Cappaert* protected the federal reserved right from subsequent groundwater pumping because the case arose in the State of Nevada which, under state law, would have extended protection to surface water rights against harm from subsequent groundwater pumping.¹⁹¹ However, we believe that the scope of the federal reserved right must be the same even in a state like Arizona that would not extend similar protection.

Because many federal statutes operate interstitially, that is, between the lines of prevailing state law, the question frequently arises as to the role state law should play in defining federal law. When courts fill in gaps in statutes, they create federal common law, that is "federal rules of decision whose content cannot be traced by traditional methods of interpretation to federal statutory or constitutional command."¹⁹² Federal courts frequently use state law for purposes of rendering decisions about federal statutes. For example, federal reserved rights have "priority dates," a concept that derives from the state law prior appropriation doctrine. This reliance on state law may take very different forms. The state law may operate as the rule of decision because the federal law has not displaced or preempted state law.¹⁹³ It may also operate by incorporation, either because Congress has chosen to adopt state law as the appropriate federal rule,¹⁹⁴ or because the federal court chooses to use state law.¹⁹⁵

In creating federal common law, courts might adopt a particular state's law as a uniform federal rule or allow the federal rule to be contingent on the character of state law, in which case it would vary from jurisdiction to jurisdiction. In determining whether to choose a uniform national rule or to allow variation among states, a major consideration is assessing the federal interest at stake. Would the federal statute or program be adequately served by reliance on state law?¹⁹⁶ Because it is difficult to imagine that courts would be

190. See *Farmer's Investment Co. v. Bettwy*, 113 Ariz. 520, 558 P.2d 14 (1976). Under the Arizona Groundwater Management Act, more restrictive rules govern groundwater pumping in active management areas. See ARIZ. REV. STAT. ANN. § 45-451.

191. See NEV. REV. STAT. § 534.010 (1993); 1939 NEV. STAT. 178; cf. *Griffin v. Westergard*, 615 P.2d 235 (Nev. 1980).

192. PAUL M. BATOR ET AL., *HART AND WECHSLER'S THE FEDERAL COURTS AND THE FEDERAL SYSTEM* 863 (3rd ed. 1988).

193. E.g., *Erie R.R. v. Tompkins*, 304 U.S. 64 (1938).

194. E.g., Federal Tort Claims Act, 28 U.S.C. § 1346(b) (1993) ("law of the place where the act or omission occurred" is controlling).

195. See *Reconstruction Fin. Corp. v. Beaver County*, 328 U.S. 204 (1946).

196. For a general discussion of the choice of law problem, see BATOR ET AL., *supra* note 192, at 863-905.

required to borrow state law on the hydrologic connection between ground and surface water, borrowing the state rule would be as a matter of election rather than compulsion. As a consequence, there is no obligation to use Arizona's definition of the hydrologic connection if that definition fails adequately to protect federal interests. With respect to the Conservation Area, the *Issue No. 2* rule offers inadequate protection precisely because it does not protect the federal reserved right from harm caused by the subsequent pumping of hydrologically-connected groundwater.

Another principle that counsels against adopting varying state law as the federal rule is the need for a uniform federal principle. Areas like the SPRNCA should not receive substantially different and less protection than similar reservations in Nevada. Therefore, both because there is a need for a uniform federal rule and because the state rule is hostile to, or not sufficiently protective of, the federal interest, the Arizona Supreme Court should not borrow the *Issue No. 2* definition as the measure of protection accorded federal reserved rights.¹⁹⁷

Even recognizing that federal reserved rights are peculiarly federal in nature, and thus not derived from or contingent on state law, leaves many unanswered questions.¹⁹⁸ On whom is the burden of proof to demonstrate that groundwater pumping is hydrologically connected to surface flows?¹⁹⁹ Having established and quantified a reserved right, for, say, an Army base, may the federal government change the location of use, the purpose of use, or the quantity of the right? Do state law rules on these issues restrict the flexibility of federal reserved rights? May the states require the federal government to abide by state rules for determining and litigating reserved rights?

State courts clearly have jurisdiction to adjudicate federal reserved rights in the context of state court general adjudications. In the McCarran Amendment,²⁰⁰ Congress waived the United States's sovereign immunity from suit, thus opening state courts as a forum.²⁰¹ In *Colorado River Water Conservation District v. United States*,²⁰² the Supreme Court expanded the role of state courts in resolving federal reserved rights by holding that principles of

197. For discussion of the role of federal law, see Leshy and Belanger, *supra* note 24, at 728-738; Harold A. Ranquist, *The Effective Changes in Place and Nature of Use of Indian Rights to Water Reserved Under the "Winter's Doctrine"*, 5 NAT. RESOURCES LAW. 34 (1972).

198. See *United States v. District Court for Eagle County*, 401 U.S. 520, 526 (1971); *Cappaert v. United States*, 426 U.S. 128, 145 (1976).

199. See Leshy and Belanger, *supra* note 24, at 682.

200. The Amendment states:

Consent is hereby given to join the United States as a defendant in any suit (1) for the adjudication of rights to the use of water of a river system or other source, or (2) for the administration of such rights, where it appears that the United States is the owner of or is in the process of acquiring water rights by appropriation under State law, by purchase, by exchange, or otherwise, and the United States is a necessary party to such suit. The United States when a party to any such suit, shall (1) be deemed to have waived any right to plead that the State laws are inapplicable or that the United States is not amenable thereto by reason of its sovereignty, and (2) shall be subject to the judgments, orders, and decrees of the court having jurisdiction, and may obtain review thereof, in the same manner and to the same extent as a private individual under like circumstances: *Provided*, That no judgment for costs shall be entered against the United States in any such suit. 43 U.S.C. § 666 (1993).

201. *United States v. District Court for Eagle County*, 401 U.S. 520 (1971).

202. 424 U.S. 800 (1976).

efficient judicial administration required the federal district court to dismiss a federal court suit in deference to a parallel state general adjudication. Finally, in *Arizona v. San Carlos Apache Tribe of Arizona*,²⁰³ the Court held that *Colorado River* applies as well to federal suits involving Indian reserved water rights. The McCarran Amendment, *Colorado River*, and *San Carlos Apache* collectively shift federal reserved rights litigation into state courts and thus subject the federal government and affected Indian tribes to the state's procedural rules.²⁰⁴

In *United States v. Bell*,²⁰⁵ the United States filed claims with the Colorado Water Court for certain federal reserved rights in 1971. Twelve years later, the United States filed a motion for leave to file an amended application for rights to considerably more water. The Water Court denied the United States' motion in 1971 because of insufficient notice to parties with rights that would be affected by the broadened application. The Colorado Supreme Court affirmed.²⁰⁶ Thus, the United States lost its right to make a claim with the priority date of the original reservation because it had failed to timely submit its claim to the Colorado Water Court. This ruling suggests that it is permissible to impose a state law postponement doctrine as a limit on the United States' reserved rights. The decision did not deny the United States reserved rights, but rather altered the priority date of those rights. The McCarran Amendment forces the United States to quantify its rights just like any other litigant. As a consequence, state law procedural defaults may affect state court decrees. On the other hand, state procedural rules cannot place unnecessary burdens on federal rights. States may not impose procedural roadblocks that would alter the outcome of a case based solely on whether it was brought in federal or state court.²⁰⁷

In the context of general adjudications, it is also clear that state court decrees will have res judicata effect, thus foreclosing new or different claims by the United States or Indian tribes. In *Nevada v. United States*,²⁰⁸ the Court held that a general adjudication of Indian reserved rights cannot be attacked collaterally. Res judicata applies to bind parties and those in privity on all issues litigated and other matters that might have been litigated. Once the United States litigates Indian reserved rights as the trustee of the tribe, it and the tribe are bound by principles of preclusion. This decision effectively bars piecemeal reserved rights litigation and subjects those rights to final state court decrees.²⁰⁹

In *United States v. City and County of Denver*,²¹⁰ the Colorado court addressed various administrative aspects of federal reserved rights. After entry of a general adjudication decree, what law governs federal reserved rights? The federal government presumably may draw on state appropriation law to preclude junior appropriators from interfering with the senior federal rights. If

203. 463 U.S. 545 (1983).

204. See Robert H. Abrams, *Reserved Water Rights, Indian Rights and the Narrowing Scope of Federal Jurisdiction: The Colorado River Decision*, 30 STAN. L. REV. 1111 (1978).

205. 724 P.2d 631 (Colo. 1986).

206. *Id.* at 635.

207. See *Felder v. Casey*, 487 U.S. 131 (1988), and *Brown v. Western R. of Alabama*, 338 U.S. 294, 298-99 (1949).

208. 463 U.S. 110 (1983).

209. See also *United States v. Bell*, 724 P.2d 631 (Colo. 1986).

210. 656 P.2d 1 (Colo. 1982).

state law is inadequate from the federal government's perspective, the federal government may insist on federal rules.²¹¹

City and County of Denver made clear that the United States does not risk forfeiture of federal reserved rights by nonuse, though the Court did require the United States to return every four years and report on its progress in applying the reserved right to a beneficial use. In *City and County of Denver*, the federal government agreed that it must follow state law if and when it sought a change of use or a change in the point of diversion. However, the Court did not address this issue because there was no pending application for such a change.

With respect to a change of use of a federal reserved right, in *In re General Adjudication of All Rights to Use Water in the Big Horn River System (Big Horn III)*,²¹² the Wyoming Supreme Court, in a badly fragmented opinion, suggested that the tribes were not free to change the nature of the use of their reserved rights from the original agricultural purpose. The tribes must comply with Wyoming state law regarding change of use because "[f]ederal law has not preempted state oversight of reserved water rights."²¹³ The court refused to permit the tribe to change the use to that of an instream flow right for fisheries because, under Wyoming law, only the state can hold an instream flow right. One of the separate opinions would have allowed the tribe to convert the agricultural water use to an instream flow use, but only after having first put it to use for the original purpose of irrigation. Although the right is federal in nature, "state concepts...may supply guidance in determining the scope of reserved rights."²¹⁴ *Big Horn III* appears to be the broadest claim by a state court that its state law controls substantive aspects of federal reserved rights. Given the fundamental incompatibility between the *Issue No. 2* rule and Congress's express reservation of water for the Conservation Area, *Big Horn III* does not support the proposition that Arizona law limits federal reserved rights on the relationship between ground and surface water. The Supremacy Clause precludes any such result.²¹⁵

An interesting potential conflict in the San Pedro watershed may pit the Department of the Interior against the Department of Defense.²¹⁶ An additional demand for water will come from Fort Huachuca, an army base located West of the San Pedro River and North and West of the town of Sierra Vista. In 1993, the Defense Department's Base Realignment Closure Commission recommended an expansion of Fort Huachuca. The military's environmental impact statement estimated that the expansion would increase water consumption on the Post by 20 percent. The Defense Department might obtain rights to additional supplies of water either under Arizona state law or possibly under the federal reserved rights doctrine. How would this expansion dovetail with the BLM's federal reserved rights for the San Pedro Riparian National Conservation Area? As to Fort Huachuca's existing uses, it has groundwater rights under Arizona's reasonable use doctrine. It may also have federal reserved rights to groundwater, which is Issue No. 4 to be addressed by the Arizona Supreme

211. See *Felder and Brown*, *supra* note 207.

212. 835 P.2d 273 (Wyo. 1992).

213. *Id.* at 278.

214. *Id.* at 286 (Cardine J., concurring and dissenting).

215. U.S. CONST. art. VI, cl. 2.

216. See Memorandum from William H. Swan to Gary Randall (Feb. 2, 1994).

Court in early 1995. If the Court decides that federal reserved rights extend to nonappropriable groundwater, then Fort Huachuca has a federal reserved right with a priority date senior to the SPNCA. Would subsequent expansion of this existing federal use be protected by the priority date of the original set aside?

At least to the extent that an expansion in federal use involves a shift from a national forest to a national park, the answer is no. In the *City and County of Denver* case, Rocky Mountain National Park was created in 1915 and 1930 out of previously reserved national forest lands. The court held that these dates fixed the priority for national park purposes, rather than the earlier date of the national forest reservation.²¹⁷

With respect to Indian reservations, tribes clearly have a right to bring land into cultivation over time. The practicably irrigable acreage standard will apply back to the original date of the reservation. Ought this generous relation-back doctrine apply to federal military reservations? We think not. The reason for the relation-back theory with respect to Indian reservations is rooted in the cultural and economic condition of many tribes and in the federal government's treaty obligations. For some Tribes, politics and culture have produced patterns of development that are markedly different than the Anglo culture. Other tribes may strongly desire to irrigate lands but lack the capital to underwrite the distribution systems and infrastructure. In addition, the federal government has a trust obligation, reflected in the original treaties establishing Indian reservations, to establish permanent and viable homelands for Indian peoples.²¹⁸ Therefore, it would be completely inconsistent with the original reserved rights doctrine for Indian water rights to be subject to subsequent development and preemption by state water users. In contrast, there is no reason to extend this rationale to the Department of Defense which is in a completely different cultural and, especially, financial situation.

One might analogize to the prior appropriation doctrine which fixes the priority date as either when the water is put to a beneficial use or when construction began that led to the appropriation. The original intent of the diverter determines the scope of the right. For example, in *Foster v. Foster*,²¹⁹ the Oregon Supreme Court allowed a ranch gradually to be brought into irrigation. The large size of the original diversion ditch plainly indicated an intent to irrigate the entire ranch. The rancher brought the land under irrigation expeditiously and therefore was entitled to the original priority date for the total amount of water.

Fort Huachuca has been an operating military base since the 1870's.²²⁰ The contemplated expansion surely was not part of the original intent in establishing the base. Again, borrowing from prior appropriation doctrine, an appropriator may not extend the use or change the use if these new activities would harm other appropriators. In *McPhee v. Kelsey*,²²¹ the Oregon Supreme Court refused to allow a shift from timothy grass to alfalfa, because the alfalfa growing season would extend several months later in the year. In *Oliver v.*

217. 656 P.2d 1, 13 (Colo. 1982).

218. ELIZABETH CHERCHICO AND BONNIE G. COLBY, *INDIAN WATER RIGHTS: NEGOTIATING THE FUTURE*, 19 (Water Resources Research Center, 1993).

219. 213 P. 895 (Or. 1923).

220. Sara Hammond, *Fort Huachuca is Vital for Defense and Economy*, ARIZ. DAILY STAR, Mar. 27, 1994, at 17.

221. 74 P. 40 (Or. 1903), *reh'g denied* 75 P. 713 (Or. 1904).

Skinner,²²² the Court refused to allow a change in the method of irrigation sixty-seven years after the initial diversion because there was no original intent to so enlarge the scope of the water use. Courts clearly are concerned with determining a senior's original intent and with protecting the junior's reasonable expectations.

Allowing a broad relation-back theory for federal military bases could have severe consequences throughout the country, particularly in states like California with numerous military bases located in or near major population areas with a heavy water demand. California's finely tuned state water law would be dealt a severe blow if military reservations in the San Francisco, Los Angeles, or San Diego metropolitan areas operate wholly outside of state water rules by a broad relation-back theory that gives expanded uses the original priority date of the military reservation. We believe that any expansion of Fort Huachuca water rights must have a priority date junior to (1) the previously established federal reserved rights for the San Pedro Riparian National Conservation Area, and (2) state surface water rights.

Even if the Arizona Supreme Court adheres to its *Issue No. 2* ruling, the federal reserved rights doctrine will protect federal reservations in Arizona from harm caused by pumping of groundwater that is hydrologically connected to surface flows. The State law rule must yield to the supremacy of federal law.

VIII. CONCLUSION

Arizona has suffered its own form of desertification, a term that may seem inapt as applied to a State already perceived by most people as a barren desert. Yet, Arizona's natural pre-development environment included thousands of miles of rivers, streams, and creeks ranging from the Colorado River through the Grand Canyon to unnamed trickles that meandered through alpine meadows. Most low desert free-flowing water courses are now only memories. Unregulated groundwater pumping poses a serious jeopardy to those that remain.

The *Issue No. 2* Court envisioned its role as a narrow one: faithful adherence to *Southwest Cotton*. Alas, it paid homage to the letter and not the spirit of *Southwest Cotton*. The result it sanctions, allowing junior groundwater pumpers to interfere with senior surface water rights, would have horrified the *Southwest Cotton* Court. By refusing to take into account modern principles of hydrogeology and by ignoring technological developments like high capacity turbine pumps, the *Issue No. 2* Court failed to ground its opinion in reality.

Having shrugged its collective shoulders, the *Issue No. 2* Court invited a legislative response which, even if forthcoming and well intentioned, cannot cure the problems created by *Issue No. 2*. With Judge Goodfarb's decision on remand, dissatisfied litigants will appeal. That step will give the Arizona Supreme Court a chance to reconsider the relationship between surface water law and groundwater law. Meanwhile, the process of defining "subflow," in order to implement *Issue No. 2*, will not relieve the tensions between the United States and the State of Arizona. Until the Arizona Supreme Court refashions

222. 226 P.2d 507 (Or. 1951).

Issue No. 2 to take into account fundamental principles of hydrogeology, federal reserved rights doctrine will impose a completely different set of legal rules concerning the relation between ground and surface water.