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Technical Memorandum

Ground-Water Basin and Subbasin Boundaries

Antelope Valley Ground-Water Basin

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Table of Contents

Introduction

In the most general and traditional sense, a ground-water basin boundary may be thought of as a location where potentially water-bearing subsurface materials end (sand, soil, gravels, and other "unconsolidated" materials) and non-water bearing materials begin (consolidated materials, i.e., so-called basement or other rock, typically including fractured or weathered rock which may or may not be water bearing to some degree).

More specifically than the general definition above, "(a) *groundwater basin* may be defined as a hydrogeologic unit containing one large aquifer or several connected and interrelated aquifers. Such a basin may or may not coincide with a physiographic unit" (Todd, 1980, p. 47). A footnote in the Todd reference qualifies the definition: "(i)n practice the term *groundwater basin* is loosely defined; however, it implies an area containing a groundwater reservoir capable of furnishing a substantial water supply." In **Groundwater Rights in California, Background and Issues** (Schneider, 1977), the Appendix addresses common ground-water terms and concepts, and includes a listing of a number of vertical and lateral physical, hydraulic, and political boundaries that might be used to define a ground-water basin (citing Richter, "California Ground Water Geology" in University of California, Davis Extension, **Concepts of Ground Water Management**, 1974). The latter reference defines a ground-water basin as an area underlain by one or more permeable formations capable of furnishing a substantial water supply. That reference goes on to note that ground-water basins are separated from each other, or may be subdivided into ground-water subbasins, by one or more different types of lateral or vertical boundaries. "Lateral" boundaries refer to the edges of a basin or separations between basins abutting one another on a (more or less) vertical plain, while "vertical" boundaries refer to the extent (depth) of a basin along a (more or less) horizontal plane. The types of potential lateral and vertical boundaries of a ground-water basin or subbasin includes:

Lateral Physical Boundaries

- Bedrock contact
- Zone of low permeability
- Fault
- Syncline rim
- Buried bedrock ridge
- Constriction in permeable materials
- Deep underflow constrictions
- Aquifer contacts
- Crest of anticline
- Alluvial embayment
- Topographic ridge or divide

Lateral Hydraulic Boundaries

- Ground water divide
- Limit of pressure area
- Shoreline of ocean or lake
- Center of river or stream
- Unlined canal or reservoir

Lateral Political Boundaries

- State
- County
- City
- Irrigation District
- Federal Installation
- Park District

Vertical Boundaries

Unconfined Aquifers

water table

base of fresh water bearing materials

base of fresh ground water

Confined Aquifers

upper, intermediate, and lower confining beds

base of fresh water bearing materials

base of fresh ground water

Prior to considering the application of some of the above categories of potential Antelope Valley basin or subbasin boundaries, it is appropriate to consider whether any or all of them should be used for accurate depiction of a basin. In the Richter reference cited above, potential lateral basin boundaries are divided into three types: 1) those with no appreciable underflow, 2) those with restricted underflow, and 3) those with free underflow. A key factor in the Richter organization of types of potential basin boundaries is whether any of them affects, and to what degree, the movement of ground water; the greater the probability for flow across a potential boundary, the less likely that feature is truly a basin boundary.

All potential lateral boundaries which do not impede or obstruct the movement of ground water are noted by Richter to be inappropriate selections for a basin (or subbasin) boundary. Examples of such non-boundaries include: a ground-water divide; the limit of a confined aquifer (transition from confined to unconfined conditions); an alluvial embayment; a topographic ridge or divide; the shoreline of an ocean, bay, or lake; a river, stream, or unlined canal; and a political boundary. Many of these examples are present in the greater Antelope Valley; however, in light of their uniform characterictic that they do not impede or obstruct ground-water flow, they should not be considered viable basin boundaries. As discussed in detail below, that has been the case in the historical mapping and description of the Anteleope Valley Ground-Water Basin, with one minor exception.

The two remaining types of potential ground-water basin boundaries are those with no appreciable underflow or with restricted underflow. Those with no appreciable underflow are noted by Richter to be most desirable for delineating basin boundaries because they are generally definable over considerable distances, and they do not affect the movement of ground water. They include bedrock contacts, zones of low permeability, faults (in this case, where they form impermeable barriers), and syncline rims. With regard to potential basin boundaries with restricted underflow, Richter notes that they "should be used with caution" because they may not be definable over considerable distances and may not affect the movement of ground water. In other words, the mere presence of such potential boundaries does not necessarily define the boundaries of a ground-water basin; some "caution" (which can be interpreted as the need for detailed technical support to show that the "boundary" effectively impedes or obstructs the movement of ground water) needs to be exercised in selecting any of them as a viable ground-water basin boundary. Potential basin boundaries with restricted underflow include: buried bedrock ridges, constrictions in permeable materials, faults (in this case, where they retard rather than fully impede ground-water flow), deep underflow constrictions, aquifer contacts, and crests of anticlines. Again as discussed in detail below, the historical mapping and description of the Antelope Valley Ground-Water Basin has apparently considered these factors.

One final general comment about basin boundary criteria is that published mapping of the Antelope Valley Ground-Water Basin's lateral boundaries includes faults, a narrow ground-water divide, exposed contacts between water bearing and non-water bearing rocks or sediments, and the contact between the water table (the ground-water body) and non-water bearing bedrock. Strictly speaking, this latter boundary does not conform to any of the potential ground-water basin boundary criteria listed above. Nevertheless, it is reproduced on the accompanying map (Plate 1), which documents the literature published for the study area. Technically, the *basin* should extend beyond the edge of the water table, to some more or less fixed limit on the spatial extent of potentially water bearing materials. Unless there are detailed issues about water rights, etc., beyond the extent of actual ground-water in storage, i.e., on lands that do not (but could) have ground water in storage beneath them, the utilization of the extent of ground-water storage is not significantly flawed in terms of defining the extent of the ground-water basin. The key point to recognize in using such a boundary, as with other potentially changing "boundaries", is that the extent of the ground-water basin is then potentially variable: as the water table fluctuates, so does the extent of the basin.

The Antelope Valley

The Antelope Valley is a large internally draining topographic basin in the western part of the Mojave Desert in southern California. The valley is roughly triangular in shape with apexes pointing west, northeast, and southeast. The cities/communities of Littlerock, Palmdale, and Quartz Hill lie on the southwest side, Lancaster is centrally located, Mojave is at the northern side, and Edwards Air Force Base (Edwards AFB) is in the northeast. Two large desert playas, Rosamond Lake and Rogers Lake, are located in the eastern half of the valley. Elevations of the floor of this high desert valley are generally between 2,300 feet and 3,500 feet, while the upper reaches of surrounding elevations rise to nearly 8,000 feet on the northwest in the Tehachapi Mountains and 9,400 feet on the south in the San Gabriel Mountains.

The Antelope Valley Ground-Water Basin

In an Open-File Report published in 1967 to describe the water resources of the Antelope Valley - East Kern Water Agency (AVEK) area, the U.S. Geological Survey (Bloyd) described two major ground-water basins in the AVEK area: the Antelope Valley and the Fremont Valley ground-water basins. Bloyd's description and mapping of those ground-water basins included subdivision of them into a number of subbasins, eight in the Antelope Valley and six in the Fremont Valley. Subsequent to that original USGS description and mapping of the Antelope Valley Ground-Water Basin and subbasins, the USGS prepared a mathematical model of the Antelope Valley Ground-Water Basin (Durbin, 1978) in which it used the same subbasin names and boundaries. More recent work by the USGS on ground-water levels in the Antelope Valley (Carlson, et. al., 1998) has been presented on maps that show slightly different outer ground-water basin boundaries. However, other than a notation that the changes were based partly on geophysical evidence from a 1960 gravity survey of the western Mojave Desert and some well construction data that indicated consolidated bedrock near the ground surface in two areas (near Rogers Lake in the North Muroc and northeastern Lancaster subbasins, and southeast of Palmdale in the Lancaster subbasin), there is no description of the modified (smaller) ground-water basin boundaries.

Bloyd subdivided the Antelope Valley and Freemont Valley ground-water basin into subbasins (sometimes called subunits in that report); generally consistent with the criteria listed by Richter above, the subdivisions were based on faults, bodies of consolidated rock, ground-water divides, and, in some instances, convenient and arbitrary boundaries. In the case of the Antelope Valley Ground-Water Basin, essentially all of the outer basin boundaries are either bedrock contacts or faults. Two exceptions are the eastern boundary of the small Peerless subbasin in the far northeast corner of the basin, and the southeastern corner of the overall basin where it abuts the El Mirage dry lake drainage to the east; both those exceptions are discussed as part of the basin and subbasin boundary descriptions below. The overall Antelope Valley Ground-Water Basin and its eight subbasins are illustrated in the enclosed Plate 1.

Lateral Ground-Water Basin Boundaries

The outmost ground-water basin boundaries illustrated in Plate 1 surround the eight subbasins originally described and mapped by Bloyd (1967): the Lancaster, Buttes, Pearland, Neenach, West Antelope, Finger Buttes, North Muroc, and Peerless subbasins. In terms of outer boundaries, the western/northwestern boundary of the basin (and the Finger Buttes subbasin) is the contact between the unconsolidated alluvial aquifer materials and the consolidated rock of the Tehachapi Mountains. From the Tehachapi Mountains to the vicinity of Rosamond Lake, the basin (and the Finger Buttes, Neenach and Lancaster subbasins) are bounded on the north by the Cottonwood/Randsburg-Mojave/Willow Springs (Rosamond) Faults. East of the Rosamond Fault, the northern boundary of the basin (and the Lancaster subbasin) is the consolidated rocks of the Rosamond and Bissell Hills. In the northeast corner of the basin, the North Muroc subbasin is surrounded by discontinuous hills of consolidated rock, as is the outermost Peerless subbasin. Local exceptions to the truly bedrock nature of basin boundaries include: 1) gaps in the rock that allow some hydraulic connection with the adjoining California City subbasin of the Fremont Valley Ground-Water Basin, and 2) use of the eastern limit of substantial aquifer materials as a boundary in the Peerless subbasin, which cannot be mapped as precisely as faults or bedrock contacts elsewhere in the basin. On its eastern side, the basin is bounded by bedrock contact (on the east of the Lancaster subbasin) and by an unnamed fault which has been postulated from water level data (i.e. significant differences in ground-water levels across a very short distance, postulated to be the fault location). The extreme southeast corner of the basin has not been included on some mapping (although Bloyd described it as a ground-water divide between the Antelope Valley and the El Mirage dry lake drainage area to the east). Recently, it has been very generally mapped to show similar but not identical boundaries. The various map details (which lack descriptive text in their original presentations) are included on Plate 1; that mapping (when considered with the earlier description by Bloyd) suggests that the basin (and the Buttes subbasin) are bounded by a ground-water divide across a narrow saddle between the Antelope Valley and the El Mirage dry lake drainage to the east. Almost the entire southern boundary of the basin (the Pearland, and Lancaster subbasins) is noted to be unnamed faults, all postulated from ground-water level data, associated with the San Andreas Fault rift zone. At the western end of the southern boundary, the basin (and the Western Antelope and Finger Buttes subbasins) is bounded by basement rock.

Subbasin Boundaries

Internally, the Antelope Valley Ground-Water Basin has been subdivided, as noted above, into eight subbasins. Almost all the internal subbasin boundaries, as illustrated in Plate 1, are faults, some of which are named and several of which are unnamed and postulated from ground-water level data (significant water level difference over very short distances). Of those, only the boundary between the Finger Buttes and West Antelope subbasins has been reported to be not determined precisely from available data (Bloyd, 1967). However, subsequent subbasin descriptions and mapping have continued to show that boundary in essentially the same location. None of the internal subbasin fault boundaries has been reported to be a sufficient barrier to ground-water flow that it effectively isolates a subbasin from an adjoining subbasin.

The only non-fault subbasin boundaries within the overall basin are: 1) a ridge of consolidated rock beneath the northern part of Rogers Dry Lake, which separates the Lancaster from the North Muroc subbasin, and 2) discontinuous hills of consolidated rock between the North Muroc and Peerless subbasins. In those two cases, the respective subbasins are hydraulically connected by either a thin section of unconsolidated materials above the bedrock, or by gaps in the consolidated rock.

Vertical Ground-Water Basin Boundaries

In the Antelope Valley, the definition of the ground-water basin and subbasins has historically focused more on lateral, rather than vertical, boundaries. This is consistent with essentially all mapping and descriptions of ground-water basins throughout California where any vertical "boundaries" have rarely if ever been described, but are practically always considered to be the extent of water bearing materials from the ground surface to the base of fresh ground water or to the base of fresh water-bearing materials.

In the Antelope Valley, the vertical extent of the ground-water basin has been defined as the contact between the underlying basement complex rocks and the overlying unconsolidated continental deposits, older alluvium, and younger alluvium (Nishikawa and Martin, 2001). That contact is a boundary between those rocks or sediments that predominately have a high potential to store and readily transmit water (the aquifer units of the unconsolidated continental deposits, and the older and younger alluvium) and those rocks that predominately have a low potential to store and readily transmit water (non-water bearing basement rocks).

The Antelope Valley was formed as a down-dropped block between the San Andreas Fault Zone on the south and the Garlock Fault on the northwest (Plate 1). Basement complex rocks predominately consisting of pre-Cenozoic quartz monzonite are non-water bearing and comprise the elevated hills and mountains surrounding the basin. They also outcrop locally within the basin, and underlie it at depths of as much as 5,000 feet (Durbin, 1978, and Nishikawa and others, 2000) to possibly as deep as 10,000 feet based on gravity measurements in the Lancaster subbasin (Sneed and Galloway, 2000). Sediments deposited into this structural depression from erosion of the surrounding hillsides, which are late Tertiary and early Quaternary age continental deposits, are considered water bearing and consist of poorly sorted, well indurated conglomerate, sandstone, siltstone, shale, limestone, dolomite, volcanic tuff and breccia (Sneed and Galloway, 2000). Overlying the continental deposits are a sequence of Quaternary alluvial sediments which consist of unconsolidated to moderately indurated, poorly sorted gravel, sand, silt, and clay deposited as alluvial fans, stream channel and flood plan deposits, and interbedded lacustrine (lake) sediments. Lacustrine deposits form a thick, areally extensive lens-shaped body consisting of fine grained, low permeability sand, silt and clay of Pleistocene and Holocene age (Carlson and others, 1998) in the Lancaster subbasin. This confining layer lies close to, or at the surface at Rosamond Lake and Rogers Lake and dips towards the south, reaching a thickness of up to 400 feet as shown on Figure 1 (Durbin, 1987; Sneed and Galloway, 2000). Near the boundary between the Lancaster subbasin and the Buttes and Pearland subbasins, the top of this poorly permeable lacustrine deposit lies roughly 600 to 750 feet deep.

Three aquifers have been defined in the Lancaster subbasin, the largest of the subbasins in the valley: the upper aquifer, previously the principal aquifer of Bloyd (1967) and Durbin (1987); the middle aquifer; and the lower aquifer (Sneed and Galloway, 2000), previously called the deep aquifer by Durbin (Figure 1). As defined by Sneed and Galloway, the upper aquifer consists of younger alluvium; the middle aquifer is comprised of older alluvial sediments; and the continental deposits comprise the lower aquifer. The lacustrine deposit bisects the upper and then middle aquifer such that parts of the upper and middle aquifers are locally confined in the north and central portions of the Lancaster subbasin. The lower aquifer is nearly everywhere confined by the lacustrine deposits except along the southerly margin of the Lancaster subbasin and in the Pearland and Buttes subbasins.

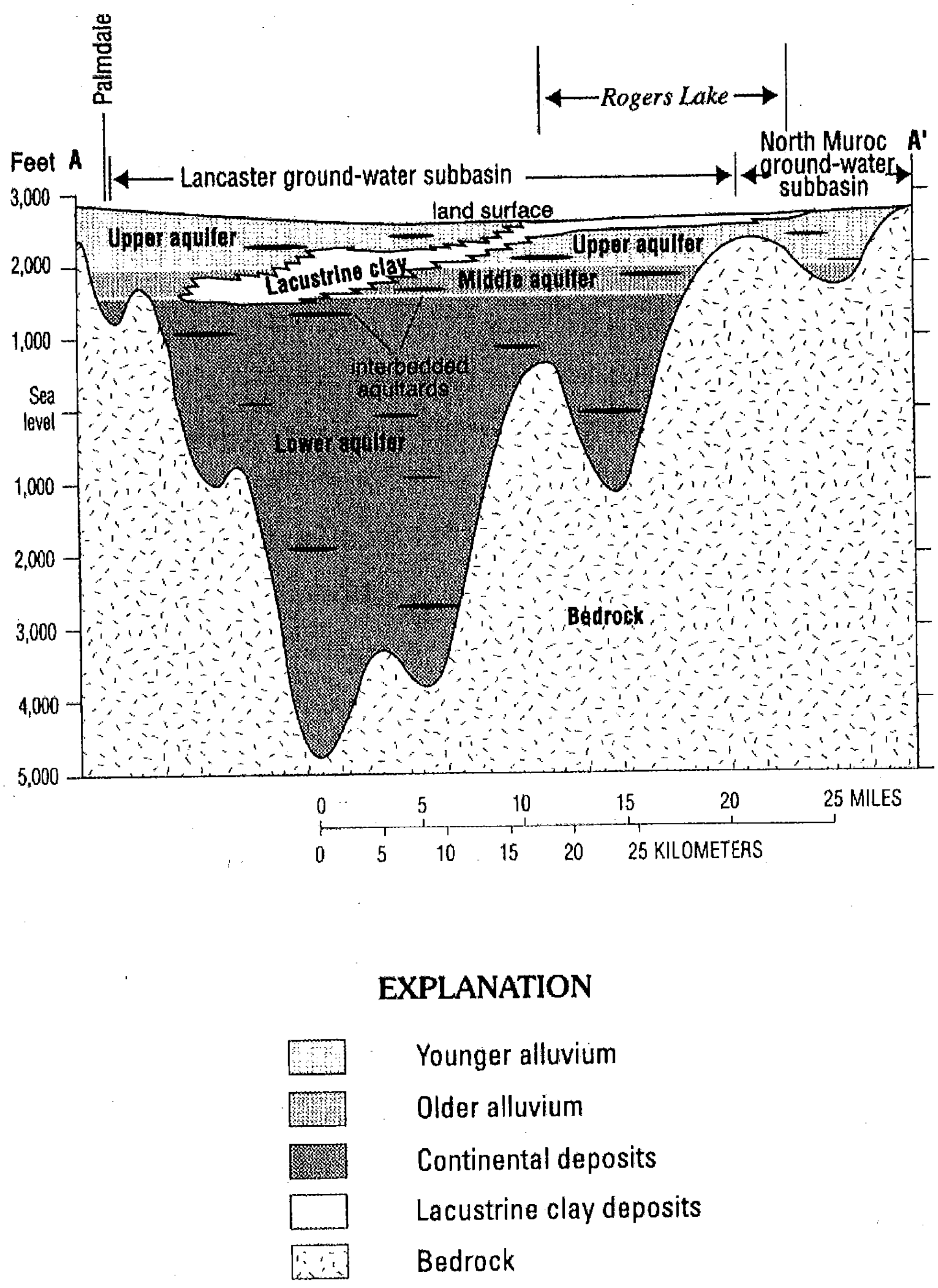

Figure 1 – Geologic Cross Section A-A'
Lancaster and North Muroc Subbasins
(from Sneed and Galloway, 2000)

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