Delineation of Potential Groundwater Discharge Boundaries and Evapotranspiration Units in Nevada

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Potential areas of groundwater discharge (i.e., potential areas of groundwater evapotranspiration) in Nevada were identified and mapped using previously published groundwater studies in the State, as well as a number of ancillary data sets. Reconnaissance Series and Water Resource Bulletin investigations conducted between 1940 and 1980 resulted in numerous reports containing original delineations of potential areas of groundwater discharge for many of the hydrographic areas (HAs) in Nevada (e.g., Maxey and Eakin, 1949; Eakin, 1962; Cohen, 1964; Eakin et al., 1965; Rush and Everett, 1966; Everett and Rush, 1966; Harrill and Moore, 1970; Glancy and Katzer, 1975). The rest of these published reports are available to the public on the Nevada Division of Water Resources' (NDWR) website (http://water.nv.gov/index.aspx). More recent studies conducted by the U.S. Geological Survey (USGS) have provided supplemental delineations of potential areas of groundwater discharge and evapotranspiration units (ET units) for select HAs (Smith et al., 2007, Garcia et al., 2015; Berger et al., 2016), as well as new boundaries for previously unreported HAs (Berger, 2000; Plume and Smith, 2013). Boundaries from these more recent studies were incorporated into the statewide data set to increase the areal coverage and to compare them with the previous delineations when available. A total of 187 HAs are covered by this data set; a map showing which HAs contain discharge boundaries and another that shows the areal extent of the data set are shown in figures 1 and 2, respectively.

Scanned images of the maps from the Reconnaissance Series Reports and Water Resource Bulletins (1:250,000 scale) were brought into a geographic information system (GIS) and georectified so that the potential groundwater discharge boundaries could be digitized and used for spatial analyses. Potential groundwater discharge boundaries for Nevada were then classified into various land cover categories, or ET units, similar to those defined in other USGS reports (Smith et al., 2007; Plume and Smith, 2013). Numerous ancillary data sets and field reconnaissance were used to modify the original potential groundwater discharge boundaries and also to define the various ET units. The six categories include bare soil, phreatophytes (i.e., phreatophyte shrublands), riparian, open water, irrigated croplands, and meadows.

A xerophytic vegetation class was not included in this data set because the vegetation of this category rely on soil moisture derived from precipitation and do not contribute to groundwater evapotranspiration. Mid-summer land surface temperature (LST) products (30-meter resolution) were computed from Landsat imagery (Allen et al., 2007b) and used to modify original discharge boundaries to ensure that only the discharging vegetation was included (e.g., July 3, 2014, Landsat 8 Thermal Infrared Senor [TIRS] data). LST products were useful to identify and remove xerophytic vegetation adjacent to, or within the potential groundwater discharge boundaries. In the mid-summer when soil moisture derived from precipitation has been transpired by vegetation, there is a stark contrast in surface temperature between groundwater

dependent (i.e., phreatophytes) and non-groundwater dependent (i.e., xerophytes) vegetation. Phreatophytes relying on the groundwater during the mid-summer have a cooler temperature signature at the surface because of evaporative cooling.

Ancillary data sets like well logs from NDWR and the USGS's National Water Information System (NWIS) well databases helped determine the extent of the phreatophyte shrubland ET unit. The sparse to moderately-dense communities of the phreatophyte shrubland ET unit typically inhabit the majority of the lowland areas in most HAs of Nevada. The phreatophyte shrublands occupy areas where the depth to groundwater ranges from ten feet to fifty feet (Plume and Smith, 2013), thus, allowing them to access relatively shallow groundwater to supplement their water resources throughout the growing season. Beyond the latter depth, phreatophyte shrubs like greasewood (Sarcobatus vermiculatus) cannot reach the water table or capillary fringe with their taproots (Robinson, 1958). Using a 10-meter digital elevation model (DEM) in coordination with the well data and true-color National Agriculture Imagery Program (NAIP) data (2010 and 2013 imagery), the phreatophyte ET unit was restricted to the areas where shallow groundwater is available for consumption by greasewood, rabbitbrush, saltbush, saltgrass, and other phreatophyte species. Field reconnaissance was conducted in select HAs during the summers of 2016-2018 (July-August) to confirm the presence of the phreatophyte indicator species mentioned above and to ensure that potential groundwater discharge areas were delineated accurately. Field reconnaissance was primarily conducted in and around the HAs of the Humboldt River Basin and further south in central Nevada.

The meadow ET unit contains denser communities of phreatophyte shrubs, saltcedar, and a lush understory of perennial grasses. The vegetation that makes up this ET unit typically occupies the areas between the riparian, irrigated croplands, and phreatophyte shrubland ET units. The primary way of distinguishing between the phreatophyte shrubland and meadow ET units was the use of mean, median, or max normalized-difference vegetation index (NDVI) images computed from Landsat imagery (e.g., July-Oct 2011, Landsat 5 Thematic Mapper [TM] data), as well as true-color NAIP imagery. NDVI values for the meadow ET unit typically exceed 0.3, whereas the NDVI values of the phreatophyte shrubland ET unit are usually within the range 0.05 to 0.25.

The riparian ET unit is composed of complex communities of rushes, forbes, reeds, willows, cottonwood trees, and other shrubs. Typical depths to groundwater in this ET unit are a few feet to twenty feet. Riparian vegetation occupies the areas along rivers and interconnected streams. This ET unit was delineated using true-color NAIP imagery and NDVI images. NDVI values for the riparian ET unit are typically above 0.25.

The use of LST products and NAIP data assisted in the manual detection and delineation of the irrigated cropland and open water ET units in Nevada. Irrigated areas are significantly cooler than the predominant phreatophyte shrubland ET unit surrounding these areas. The presence of the irrigated croplands were further confirmed by the true-color NAIP imagery.

Within the attribute table for this data set, there are nine fields containing information about each feature. Definitions for each field are as follows:

FID – Internal feature number

Shape – Feature geometry

Type – Evapotranspiration (ET) Unit name. This can be one of six categories: phreatophytes, bare soil, open water, riparian, meadow, or irrigated cropland.

Source – The original report/document that the feature originated from, or the creator of the feature.

Comments – General description of the modifications made to the original features.

Area – The area in acres of the feature.

HYD_AREA – The number of the hydrographic area that the feature lies within.

HYD_AREA_N – The name of the hydrographic area that the feature lies within.

Inside_Dis – Whether or not the feature lies within the potential area of groundwater discharge (1 = inside discharge area, 0 = outside discharge area).

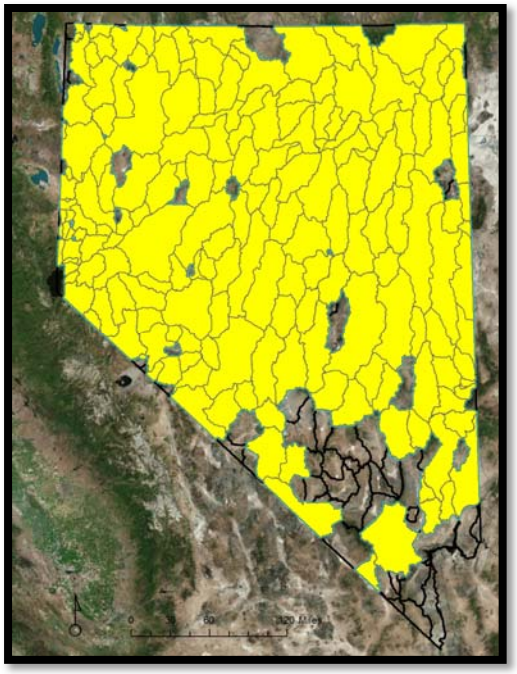

Figure 1. Hydrographic areas (yellow) containing potential groundwater discharge boundaries and evapotranspiration units.

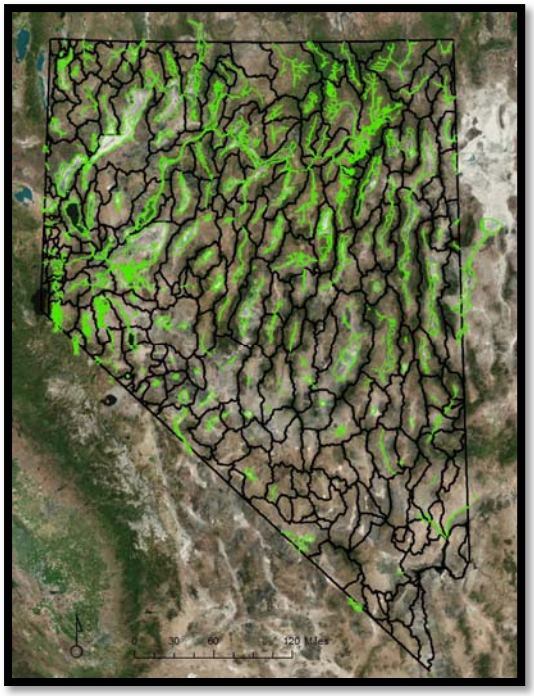

Figure 2. Areal extent of potential groundwater discharge boundaries and ET units (green) that were originally delineated during previous U.S. Geological Survey studies and modified by the Desert Research Institute.

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