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Walker Lake is a terminal lake in western Nevada that is fed by the Walker River. The Walker River watershed covers an area of approximately 4,270 square miles, and has its headwaters in the eastern Sierra Nevada mountain range. The upper Walker River system is comprised of two forks, these being the East and West Walker Rivers. Both forks flow through several agricultural areas where significant diversions of stream water occur, primarily for agricultural production. The two forks meet in the Mason Valley (near Yerington, NV) to form the Walker River, where additional diversions from the river occur. In addition to stream flow diversions, several agricultural areas within the basin use ground water to supplement their diversions during periods of low flow. The Walker River then flows through the Walker River Paiute Tribe reservation, before reaching its terminus at Walker Lake. During the last 100 years, the level of Walker Lake has fallen 138 feet, which is approximately a 6.2 million acre-ft reduction in the volume of water stored in the lake. Since the only outflux of water from Walker Lake is due to evaporation, this decline in lake levels has led to a significant increase in salinity, which is threatening the lakes ecological balance. The deterioration of lake water quality was accelerated during the drought period from 1987 through 1992. During this period, lake levels fell 28 feet. In addition, many agricultural water rights within the Walker River basin could not be met with surface water diversion due to low stream flows. Thus, significant amounts of ground water were used to supplement what little surface water was available. Flows returned to historical average levels in 1993 in the headwaters of the Walker River basin. However, the total flow reaching Walker Lake was still less than one-tenth that needed to maintain current lake levels, primarily due to large seepage losses in the stream in agricultural areas where significant ground water pumpage occurred during the drought period. This paper first presents a conceptual and water balance model of the surface and ground water flow systems in the Walker River basin. The model is then used to evaluate several planning options related to groundwater use within the Walker River Basin, these being: (1) the cessation of groundwater pumpage; (2) transferring a fraction of existing lower priority surface water rights to groundwater rights; and (3) setting groundwater rights as a function of the hydrologic condition within the basin. These options are evaluated for their ability to provide sustainable flows to Walker Lake and how they impact agricultural water use within the Walker River Basin.

GROUNDWATER RECHARGE AND IRRIGATION USING SEWAGE WATER, CAIRO, EGYPT

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Recent studies are considering treated sewage as a source of water at least for non-potable purposes rather than as an environmental threat. This is partially true for countries that suffer from shortage of water resources. Sewage application to land in Egypt takes place on sandy soil that suffers from an inherent lack of organic matter as well as micro and macro nutrients. In Egypt application of sewage has been practiced on the sandy oil of Gabal Al-Asfar (sewage from Heliopolis) and Abo-Rawash (sewage from Zenan) Farms since 1923 and 1944 respectively. Approximately 100,000 m³ sewage per day were applied out of more than 5 million m³/d effluent from Cairo. Analyses of the leaves from citrus trees show little increase of heavy metals in comparison with other citrus trees in the region. However, the sewage could be used also for irrigation of cereal crops and forest. The recharged groundwater in the aquifer is of good quality and could be used for the irrigation of fruit orchards.

HYDROGEOLOGIC INVESTIGATIONS TO CHARACTERIZE GROUND-WATER FLOW PATHS LOCALLY CONTAMINATED BY UNDERGROUND NUCLEAR TESTS, NEVADA TEST SITE

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The Nevada Test Site (NTS) U.S. Geological Survey (USGS)/U.S. Department of Energy (DOE) Cooperative Program is an almost $5million effort by the USGS to characterize ground-water flow at the NTS. The NTS, centrally located within the Death Valley regional ground-water flow system, is where the DOE conducted 828 underground nuclear tests. Of these tests, 221 were detonated at or beneath the water table, which ranges from 300 to 600 m below the land surface. Where ground water contacts the contaminants introduced by these tests, the potential for their migration is increased and their movement becomes dependent on the rate and direction of ground-water flow. USGS efforts to define ground-water flow paths within the Death Valley ground-water flow system directly support DOE's restoration efforts at the NTS and DOE's management of water resources. Program funding is through DOE's Environmental Restoration and Defense programs and through the USGS Yucca Mountain Project Branch. The USGS efforts involve close coordination between the Water Resources and Geologic Divisions, with overall coordination by Water Resources Division. The USGS also works closely and collaboratively with DOE contractors, the Desert Research Institute, and the Los Alamos and Lawrence Livermore National Labs. Geologic Division is undertaking digital geologic and geophysical mapping at 1:24,000-1:100,000 scales, geophysical surveys, and construction of geologic cross sections to generate the regional (1:100,000 to 1:250,000 scale) geologic framework of the Death Valley ground-water flow system and subregional (1:24,000 to 1:48,000 scale) geologic framework of subbasins within this system. Water Resources Division is involved in hydrologic monitoring of spring discharge, surface-water runoff, ground-water levels, water-quality, and water use. It also is reevaluating ground-water discharge from the major spring discharge areas, identifying ground-water flow rates and directions through geochemical investigations, analyzing water-level fluctuations to determine if they result from anthropogenic or natural causes, drilling characterization wells, and developing a regional ground-water flow model of the Death Valley ground-water flow system.

DENSITY EFFECT OF LANDFILL LEACHATES IN THE VERTICAL SPREADING OF POLLUTANTS IN CARBONATED AQUIFERS: LANDFILL OF MARBELLA (ANDALUSIA, SOUTH OF SPAIN)

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The urban solid waste landfill of Marbella (Andalusia, South of Spain) is located 2 km north of that city and above the marbles of Sierra Blanca, a carbonated aquifer. The hydrogeological situation and the fact that the landfill is unlined, putting in touch directly the wastes with the aquifer materials, produce a degradation of the natural quality of the groundwater, due to the infiltration of the leachates. The natural groundwater flow, towards the S and W in the aquifer, produces the horizontal distribution of the pollutants. In this work the density and the chemistry composition of the landfill leachate and of the groundwater have been studied.

The average density of the leachate (1.012 gr/cm³) is due to its high mineralization, with high contents in Cl (4800 mg/l in average). This density is 1.2% greater than the non-polluted groundwater (1.0005 gr/cm³) with average contents in Cl of 12.4 mb/l. In the nearest points to the landfill (350 m in distance) and located to the S, a lesser pollution (500 mg/l in Cl) have been detected, compared with points as far as 2500 m, where Cl contents of 840 mg/l have been measured. Nevertheless in middle points there are a lesser pollution, and in a piezometer closer to the landfill (550 m in distance) no groundwater contamination evidence have been found, though they are located in the same sense of the local groundwater flow.

The percentage of leachate in the groundwater, comparing the cloride as conservative ion, has been also calculated. The greater contribution of leachate to the groundwater (17.5%) were found in the farest piezometer (2500 m) between 110 m (25 m.a.s.l.) and 130 m (5 m.a.s.l.) in depth. The distribution of the pollutants is explained by the density difference (1.2%) and the mineralization, between the leachate and the groundwater, producing a vertical spreading effect of the pollutants and a vertical spreading effect of the pollutants and a vertical leachate migration through different groundwater flow lines than those of the non-polluted groundwater. In resume this work is a field example of a previous experimental model in porous media, proposed by Schincariol & Schwartz (1990), but taking into account the non-homogeneous characteristic of the karstic media.

GROUNDWATER QUALITY IN CANADA: AN OVERVIEW

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There are no recent national surveys of groundwater quality in Canada, but a compilation of various regional surveys can provide a nation-wide perspective. The findings for Canada are similar to those for the United States and other countries, thus lending credence to the results.

In terms of the proportion of affected groundwater supplies, nitrates and bacteria represent by far the most common groundwater contaminants in Canada. 20 to 40 % of all rural wells have nitrate concentrations or coliform bacteria occurrences in excess of drinking water guidelines. By contrast pesticides exceed acceptable concentrations in about 0.1 % of rural wells. Industrial chemicals such as trichloroethylene (TCE) have been identified in about 10 % of municipal groundwater supplies, but nearly always at concentrations considerably below those recommended in drinking water guidelines. In rural wells occurrences of industrial chemicals are rare. These findings suggest that contamination of shallow groundwater by nitrates is widespread in rural areas, while low-level degradation of groundwater by industrial chemicals may be common in urban areas.

These findings indicate that many people in rural areas of Canada are dependent on groundwater supplies which do not meet drinking water guidelines. The widespread occurrence of contamination in shallow groundwater, especially in agricultural areas, may also be a significant factor in the health of aquatic ecosystems such as springs, wetlands and rivers.

RECHARGE IN A SEMI-ARID BASIN AQUIFER: RYAN FLAT AND LOBO FLAT, TRANS-PECOS, TEXAS

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In arid and semi-arid settings the key hydrological question is: does significant recharge occur and, if so, where, how much, and by what mechanisms? Ryan Flat and Lobo Flat are underlain by a bolson aquifer in the basin and range province in Trans-Pecos Texas. This bolson aquifer is the sole source aquifer for sparsely populated semi-arid ranch land and small towns. The City of El Paso (population 600,000) has purchased a ranch of approximately 60 km^2 for the possible development of a well field to supplement their municipal water supply. Additionally, new hydroponic agricultural facilities have been constructed immediately to the south of the study area.

Regionally, groundwater recharge is generally accepted to be slight. Previous studies suggest that recharge by direct infiltration into the basin fill and typical ephemeral streams in the basins is at most a few mm/yr. Evapotranspiration and the soil texture restricts infiltration and recharge. Nor were alluvial fans near the study aquifer usually found to be the sites of recent recharge as evidenced by the lack of tritium in the groundwater beneath them. Infiltration into these fans appears to be impeded by low permeability layers deposited by sheet flow.

Yet recharge occurs in portions of the aquifer underlying Ryan Flat and Lobo Flat. Recent recharge is suggested by a potentiometric mound in the groundwater centered about a canyon entering the basin from mountains to the west. Groundwater from this mound has a different chemical facies than groundwater down gradient and is hypothesized to be the younger member of a chemical evolutionary trend. Geophysical methods (EM and WADI) were used to investigate infiltration in the ephemeral stream channel near the basin margin. Direct observations of rain events, stream flow, and infiltration provide supporting evidence that this is a site of preferential infiltration and recharge. Field mapping of faults in mountain canyons and analysis of aerial photographs indicate that the position of the mountain canyons and streams are controlled by faults. The mechanisms of recharge seem to be a combination of fracture infiltration and flow in the mountains, infiltration into the bottoms of ephemeral streams in mountain canyons that are located along fracture zones, and infiltration at a channelized ephemeral stream near the basin margin. The conditions that contribute favorably towards this atypical infiltration in the basin stream are channelized rather than sheet flow, soil texture, and comparatively small amounts of clays in the adjacent mountains. Differentiating between recharge mechanisms is not yet possible because of the intimate association between the major faults and canyon streams. The effective recharge areas are highly localized and dependant on site specific conditions.

SURFACE AND SUBSURFACE DNAPL EVALUATEIONS AND REMEDIATION APPROACHES AT THREE INDUSTRIAL SITES ALONG RIVERS

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A recent dense non-aqueous phase liquid (DNAPL) release at a Gulf Coast industrail site adjacent to a major river required immediate shallow soil and river sediment excavation and containment during the first nine months, followed by longer-term (5 to 30+ year) monitoring, modeling, and natural attenuation evaluations. These longer-term approaches have been effectively used over the past 5 years to manage two other industrial sites with older (>40 years) DNAPL releases. Groundwater to surface water loading and scediment transport modeling were conducted at two of these sites, and semi-annual surface water and groundwater monitoring of the DNAPL contaminants and degradation products continue to demonstrate significant reduction in DNAPL concentrations by bio degradation and natural attenuation.

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