

Comment Set B0002, cont.  
Boulevard Planning Group

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1380 WIND TURBINE PROJECT.

The wind turbine system (medium sized) use type refers to the production of electric power two wind turbines, or systems in which the total blade swept area is greater than 220 square feet but no more than 850 square feet. The blade swept area shall be measured in the vertical plane perpendicular to the wind direction. This use type is permitted in all zones (except those having the S81 Ecological Resource Area Use Regulations) upon issuance of an administrative permit. This use type does not include uses classified as Major Impact Services and Utilities. Typical uses include wind turbine installation of medium size for residential or small scale commercial use.

(Added by Ord. No. 6857 adopted on 10-10-84. Opr. 1-1-85)  
(Amended by Ord. No. 7117 (N.S.) adopted 4-23-86)

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- z. Wind Turbine Systems, Small. A small wind turbine system, shall be permitted on a parcel of at least one acre and in compliance with the following conditions:
1. **Setback.** The system shall be set back from property lines and roads at least two times the height of the wind system (to the top of the blade in vertical position) and shall meet the applicable setback requirements of the zone. No part of the system, including guy wire anchors, shall extend closer than 30 feet to the property boundary. The system must also meet fire setback requirements. See Subsection 7 for the exception to this setback requirement.
  2. **Fencing.** Public access to the wind turbines shall be restricted through the use of a fence with locked gates, non-climbable towers or other suitable methods.
  3. **Signs.** Suitable warning signs containing a telephone number for emergency calls shall face all approaches to the system. Individual signs shall be between 5 and 16 square feet.
  4. **Noise.** The wind turbine shall be operated in such manner that it does not exceed the sound level limits of Title 3, Division 6, Chapter 4 of the San Diego County Code (Noise Abatement and Control). See Subsection 7 for the exception to this noise standard.
  5. **Height.** For the purposes of calculating height, the height of the wind turbines shall mean the distance from ground to the top of the blade in vertical position. Height of a small wind turbine system shall not exceed 60 feet. See Subsection 7 for the exception to this height standard.
  6. Any non-operational wind turbines shall be removed within 12 months after becoming non-operational.

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7. For any Wind Turbine System that meets the definition of "Small Wind Energy System" as defined by Government Code Section 65892.13 (c)(1), the requirements for setbacks, noise and height are reduced as follows:
- (a) The system shall be set back from property lines at least the height of the wind system. The system must also comply with any applicable fire setback requirements pursuant to Section 4290 of the Public Resources Code.
  - (b) Decibel levels for the system shall not exceed the lesser of 60 decibels or the sound limits of the Noise Element of the San Diego County General Plan, as measured at the closest neighboring inhabited dwelling, except during short-term events such as utility outages and severe wind storms.
  - (c) Height. Height of a small wind turbine system shall not exceed either of the following:
    - (1) Up to 65 feet on parcels less than 5 acres in size, and up to 80 feet on parcels 5 acres or more.
    - (2) Height cannot exceed manufacturer's recommendations.

Any waiver or modification of the above requirements shall be allowed only in accordance with the Variance Procedure commencing at Section 7100.

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6158

- b. Wind Turbine System, Small. A wind turbine system, small shall be permitted as an accessory use in all zones where the Civic, Commercial, Industrial or Extractive use types are permitted provided the system complies with the conditions specified in Section 6156z.

6950 WIND TURBINE SYSTEM, MEDIUM.

A medium wind turbine system, shall be permitted on a parcel of at least one acre and require an Administrative Permit approved in accordance with the Administrative Permit Procedure commencing at Section 7050 and the following requirements:

- a. Notification. Notification shall be in accordance with paragraph c of Section 7060.
- b. Setback. The wind turbines shall be set back from property lines and roads at least three times the height of the wind turbine (to the top of blade in vertical position) and shall meet the applicable setback requirements of the zone. The system must also meet fire setback requirements. See paragraph i below for the exception to this setback requirement.
- c. Fencing. Public access shall be restricted through the use of a fence with locked gates, non-climbable towers or other suitable methods.
- d. Signs. Suitable warning signs containing a telephone number and an address for emergency calls and informational inquiries shall face all approaches to the project. Individual signs shall be between 5 and 16 square feet.

Comment Set B0002, cont.  
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- e. **Review.** Review shall include an assessment of the impact on adjacent property with regard to:
  - 1. Location of installation in its relation to topographic features which would constitute an unusual safety hazard.
  - 2. Sensitivity of adjacent uses to noise and electrical interference and visual impact.
- f. **Noise.** The system shall meet the sound level limits of Title 3, Division 6, Chapter 4 of the San Diego County Code (Noise Abatement and Control). See paragraph i below for the exception to this noise standard.
- g. **Height.** For the purpose of calculating height, the height of the wind turbines shall mean the distance from ground to the top of the blade in vertical position. The system shall not exceed 60 feet. See paragraph i below for the exception to this height standard.
- h. It shall be a condition of the permit that non-operational wind turbines shall be removed within 12 months after becoming non-operational.
- i. For any Wind Turbine System that meets the definition of "Small Wind Energy System" as defined by Government Code Section 65892.13(c)(1), the requirements for setbacks, noise and height are reduced as follows:
  - 1. The system shall be set back from property lines at least the height of the wind system. The system must also comply with any applicable fire setback requirements pursuant to Section 4290 of the Public Resources Code.

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B0002-113 cont.

2. Decibel levels for the system shall not exceed the lesser of 60 decibels or the sound limits of the Noise Element of the San Diego County General Plan, as measured at the closest neighboring inhabited dwelling, except during short-term events such as utility outages and severe windstorms.
3. Height of a small wind turbine system shall not exceed either of the following:
  - (a) Up to 65 feet on parcels less than 5 acres in size, and up to 80 feet on parcels 5 acres or more.
  - (b) Height cannot exceed manufacturer's recommendations.

Any waiver of modification of the above requirements shall be allowed only in accordance with the Variance Procedure commencing at Section 7100.

(Added by Ord. No. 6857 (N.S.) adopted 10-10-84. Opr. 1-1-85)  
(Amended by Ord. No. 7117 (N.S.) adopted 4-23-86)  
(Amended by Ord. No. 9596 (N.S.) adopted 9-17-03)

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6951 WIND TURBINE SYSTEM, LARGE.

Large wind turbine systems, shall be permitted on a parcel of at least five acres and considered a Major Impact Services and Utilities use type requiring a major use permit approved in accordance with the Use Permit Procedure commencing at Section 7350 and the following requirements:

- a. Setbacks. The wind turbines shall observe the following setbacks measured from the closest point on the base or support structure. For purposes of calculating setbacks, height of the wind turbines shall mean the distance from ground to the top of blade in vertical position:
  1. From property lines or public road setback 4 times the height.
  2. From all existing residences or buildings occupied by civic use types setback 8 times the height.
  3. From the furthestmost property line of adjacent parcels which are vacant setback 9 times the total height.
  4. Setbacks for experimental wind turbines (those which are not produced by an established wind turbine manufacturer on a production basis) may be greater than those specified above based on the discretion of the permit granting authority.
  5. Setbacks may be reduced up to a maximum of 50% with the written consent to the granting of a setback reduction signed by the owner or owners of each lot or parcel affected by the proposed setback reduction.

See paragraph k below for the exception to this setback requirement.

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B0002-113 cont.

- b. Fencing. Public access shall be restricted through the use of a fence with locked gates, non-climbable towers or other suitable methods.
- c. Signs. Suitable warning signs containing a telephone number and an address for emergency calls and informational inquiries shall face all approaches to the project. Individual signs shall be between 5 and 16 square feet.
- d. Noise. The project shall meet the sound level limits of Title 3, Division 6, Chapter 4 of the San Diego County Code (Noise Abatement and Control). See paragraph k below for the exception to this height requirement.
- e. Height. For the purposes of calculating height, the height of the wind turbines shall mean the distance from ground to the top of the blade in vertical position. The system shall not exceed 80 feet. See paragraph k below for the exception to this height requirement.
- f. Visual. The following measures should be followed whenever possible in order to minimize the visual impact of the project:
  - 1. Removal of existing vegetation should be minimized.
  - 2. Internal roads should be graded for minimal size and disruption.
  - 3. Any accessory buildings should be painted or otherwise visually treated to blend with the surroundings.
  - 4. The turbines and towers should be painted with non-reflective paint to blend with the surroundings.
- g. Turbine Description. The following information shall be specified as part of the permit:
  - 1. The wind turbine manufacturer, model, power rating and blade dimensions.
  - 2. The tower manufacturer and model.
- h. Non-Operational Wind Turbines. It shall be a condition of the permit that non-operational wind turbines shall be removed:
  - 1. The project owner shall insure that a copy of all prospectuses shall be placed in the County's permit file.
  - 2. County staff may, at any time in the future, compare the amount of power stated (in kilowatt hours) in the appropriate prospectus with the actual power sold to the utility (as reported in the California Energy Commissions' "Wind Project Performance Reporting System") and determine if any wind turbine systems meet the definition for "wind turbine non-operational."
  - 3. County staff may collect other data as necessary to determine if any wind turbine systems meet the definition for "wind turbine non-operational."

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B0002-113 cont.

4. Applicant may propose alternate methods to monitor the "non-operational" status of wind turbines.
  - i. Removal Surety. The project owner shall post a bond, lien contract agreement, cash deposit, or other form of surety acceptable to the Director of Planning and Land Use, sufficient to allow for the removal of non-operational wind turbines. If a bond surety is provided, such bond shall comply with Section 7612, and shall be for a minimum of 10 years (unless the permit is for a shorter period of time). Posting of bond(s) and/or other surety may be phased with the installation of wind turbines.
  - j. Existing Administrative Permits for Wind Turbine Projects - Modification or Revocation. Administrative permits for wind turbine projects granted pursuant to Section 7060 prior to January 1, 1986, shall be treated for all purposes as if they are major use permits shall be subject to all the provisions of the Zoning Ordinance which apply to Major Use Permits for purpose of modification or revocation.
  - k. For any Wind Turbine System that meets the definition of "Small Wind Energy System" as defined by Government Code Section 65892.13(c)(1), the requirements for setbacks, noise and height are reduced as follows:
    1. The system shall be set back from property lines at least the height of the wind system. The system must also comply with any applicable fire setback requirements pursuant to Section 4290 of the Public Resources Code.
    2. Decibel levels for the system shall not exceed the lesser of 60 decibels or the sound limits of the Noise Element of the San Diego County General Plan, as measured at the closest neighboring inhabited dwelling, except during short-term events such as utility outages and severe windstorms.
    3. Height of a small wind turbine system shall not exceed either of the following:
      - (a) Up to 65 feet on parcels less than 5 acres in size, and up to 80 feet on parcels 5 acres or more.
      - (b) Height cannot exceed manufacturer's recommendations.

(Added by Ord. No. 7117 (N.S.) adopted 4-23-86)  
(Amended by Ord. No. 9596 (N.S.) adopted 9-17-03)  
(Amended by Ord. No. 9676 (N.S.) adopted 9-22-04)

Comment Set B0002, cont.  
Boulevard Planning Group

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[Introduction] [Scope] [Hydrology] [Hydrogeology] [Hydroecology]  
[Stream morphology] [Groundwater hydraulics] [Synthesis] [Conclusions] [Summary]  
[Endnotes] [References] [Reviewers] •

B0002-114



Fig. 1 Closeup of fracture in rock outcrop in the Tierra del Sol watershed.

**IMPACT OF THE PROPOSED CAMPO LANDFILL  
ON THE HYDROLOGY OF THE TIERRA DEL SOL WATERSHED  
A REFERENCE STUDY**

**Victor M. Ponce**

**May 2006**

**EXECUTIVE SUMMARY**

The impact that the proposed Campo landfill will have on the hydrology of the Tierra del Sol watershed is examined using an interdisciplinary perspective. Analysis of precipitation and well data suggests the presence of an effective hydraulic connection between surface water and groundwater in the region. Existing fracture maps and other geologic evidence reveal the extent to which the underlying aquifer is fractured. The presence of numerous springs and photogeologic lineaments indicates that water flows readily from the fractured-rock aquifer to the creeks, streams, and wells of the Tierra del Sol watershed.

Selected vegetative species with an established moisture affinity are documented in the Tierra del Sol watershed. Specimens of blue elderberry (*Sambucus mexicana*) appear to be aligned along fractures, where moisture can be sustained for long periods. Thick stands of red shank (*Adenostoma sparsifolium*) constitute the predominant species in several of the lineaments identified in aerial images. Unlike the chamise (*Adenostoma fasciculatum*), its closely related and more widely distributed chaparral species, the red shank is a tall arborescent shrub which thrives on moist sites. The spatial distribution of blue elderberry and red shank points to the existence of local moisture gradients which could be tied to the rock fractures.

## Comment Set B0002, cont. Boulevard Planning Group

Impact of the proposed Campo landfill on the hydrology of the Tierra del Sol watershed Page 2 of 35

In fractured-rock aquifers, a leachate plume will move preferentially along the fractures. Advection is likely to be the predominant physical mechanism, with travel times from capture zone to nearby wells measured in days, rather than in years as would be the case in more traditional diffusion-dominated settings. Given the complexity of the fractured-rock system, the probability that leachate plumes will be missed by the system of monitoring wells is high. Thus, placing a major landfill on top of a fractured-rock aquifer such as Tierra del Sol's significantly compromises the health and welfare of the local population on both sides of the U.S.-Mexico border. Moreover, Tierra del Sol is part of the federally designated Campo-Cottonwood Sole Source Aquifer, i.e. it has been determined that, should this aquifer become contaminated, there are no reasonably available alternative sources of drinking water.

B0002-114 cont.

### • INTRODUCTION •

[Scope] [Hydrology] [Hydrogeology] [Hydroacology] [Stream morphology]  
[Groundwater hydraulics] [Synthesis] [Conclusions] [Summary] [Endnotes] [References]  
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The impact that the proposed Campo landfill will have on the hydrology of the Tierra del Sol watershed is examined herein. The Campo landfill site is located within the Campo Indian reservation in East San Diego County, California, in the headwaters of Lower Campo Creek. The Tierra del Sol watershed is located in the community of Boulevard, adjacent to the landfill site and immediately east of it. The landfill project has been under planning and engineering since the early 1990s. Construction, however, has not occurred due to legal, regulatory, market, and other issues. Currently, a revised landfill project on the same site is being developed by the Campo Indian reservation in partnership with commercial landfill operators.

At issue is the impact that leakage through the landfill liner and the resulting groundwater contamination will have on the hydrology of the Tierra del Sol watershed. The latter is located "right in the landfill's backyard," to use a phrase which is common among environmental professionals.

Questions about the effect that a leakage plume will have on the surface water and groundwater of the vicinity remain without a clear answer. It is noted that the landfill site sits on top of a fractured-rock aquifer. Moreover, this aquifer is part of the federally designated Campo-Cottonwood Sole Source Aquifer.<sup>1</sup> This means that the U.S. Environmental Protection Agency (EPA) has established that this aquifer is the main source of drinking water in the area, and that should it become contaminated, there are no reasonably available alternative sources.

**At issue is the impact that leakage through the landfill liner and the resulting groundwater contamination will have on the hydrology of the del Sol watershed.**

Geologic and other physical evidence indicates that a complex system of fractures underlies the landfill site. This fact alone would tend to invalidate flow downgradient assumptions based solely on surface topography. Under the geologic conditions prevalent at the Campo landfill site, the groundwater flow direction may not coincide with the surface-water flow direction. Thus, contaminated leachate plumes may flow from one catchment to another based on fracture location, extent and connectivity, rather than on the local surface topography.

The site engineering of the Campo landfill has ensured that at least on the surface, the drainage will flow in the northwestern direction and will eventually drain into Lower Campo Creek, and away from Tierra del Sol. However, the documented existence of the fractures, including their location, extent, and patterns of connectivity, raises a serious "red flag" regarding the technical viability of the project.



## Comment Set B0002, cont. Boulevard Planning Group

Impact of the proposed Campo landfill on the hydrology of the Tierra del Sol watershed Page 3 of 35

Normally, a landfill can be placed on a thick sedimentary geologic formation, where a contaminated plume would be slowly diffused on the adjoining porous media. It is more risky to place it on an extensively fractured rock formation, where the plume would be advected, through the fractures to downgradient locations, while undergoing very little diffusion.

B0002-114 cont.

### • SCOPE •

[\[Hydrology\]](#) [\[Hydrogeology\]](#) [\[Hydroecology\]](#) [\[Stream morphology\]](#) [\[Groundwater hydraulics\]](#)  
[\[Synthesis\]](#) [\[Conclusions\]](#) [\[Summary\]](#) [\[Endnotes\]](#) [\[References\]](#) [\[Reviewers\]](#) • [\[Top\]](#) [\[Introduction\]](#)

This study examines the impact that a leakage in the Campo landfill liner will have on the surface and groundwater hydrology of the Tierra del Sol watershed. The study, which is interdisciplinary in nature, examines the hydrology, hydrogeology, hydroecology, stream morphology, and groundwater hydraulics of the proposed landfill site and the watershed immediately east of it.

The focus is the general direction and velocity of transport of water and contaminants through the fractured rock. The specific emphasis is on the difference between the matrix velocity and the fracture velocity. The latter may be several orders of magnitude greater than the matrix velocity (Davis and DeWiest, 1966).

**The focus is the general direction and velocity of transport of water and contaminants through the fractured rock.**

At issue is the speed at which contaminants can travel through the individual fractures. Through a breach in the liner system and/or leachate collection and removal system, the contaminant plume would leave the landfill site and flow readily to offsite locations. High flow speeds will lead to short travel times and challenge the argument that failure can be effectively controlled.

The impact of the landfill extends beyond the Tierra del Sol watershed, to other neighboring areas including the Lower Campo Creek watershed. This study focuses on the Tierra del Sol watershed for the following reasons: (1) many private wells are located in Tierra del Sol, in relatively close proximity to the landfill site, and (2) there is long-term rainfall and well data in Tierra del Sol to support the analysis.

### • HYDROLOGY •

[\[Hydrogeology\]](#) [\[Hydroecology\]](#) [\[Stream morphology\]](#) [\[Groundwater hydraulics\]](#)  
[\[Synthesis\]](#) [\[Conclusions\]](#) [\[Summary\]](#) [\[Endnotes\]](#) [\[References\]](#) [\[Reviewers\]](#) • [\[Top\]](#)  
[\[Introduction\]](#) [\[Scope\]](#)

The focus of this study is the Tierra del Sol watershed, located immediately east of the proposed Campo landfill site, with a surface area of 1760 acres, or 2.75 square miles (Fig. 2). The watershed drains gentle slopes and foothills of California's Peninsular Range, at an average elevation of 3,600 feet, in a predominantly southern direction. The watershed features numerous rock outcrops and springs.

The main watercourse, hereafter named Tierra del Sol Creek, crosses the U.S.-Mexico border at N 32° 35' 57" and W 116° 20' 49". Once in Mexico, Tierra del Sol Creek flows past Roca Magisterial,

[http://ponce.sdsu.edu/tierra del sol study.html](http://ponce.sdsu.edu/tierra_del_sol_study.html)

4/15/2008

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about one kilometer west of the community of Jardines del Rincón. The creek is in the watershed of Arroyo Las Palmas, which joins Arroyo Alamar in East Tijuana to form the Tijuana River. In turn, the Tijuana River flows past Imperial Beach, in South San Diego County, to enter the Pacific Ocean.

The Tierra del Sol watershed land use is a mixture of the native chaparral ecosystem, albeit with a substantial presence of phreatophytes along well defined moisture paths, a few mesophytes, and anthropogenic land uses such as ranch clearings and rural housing.

B0002-114 cont.

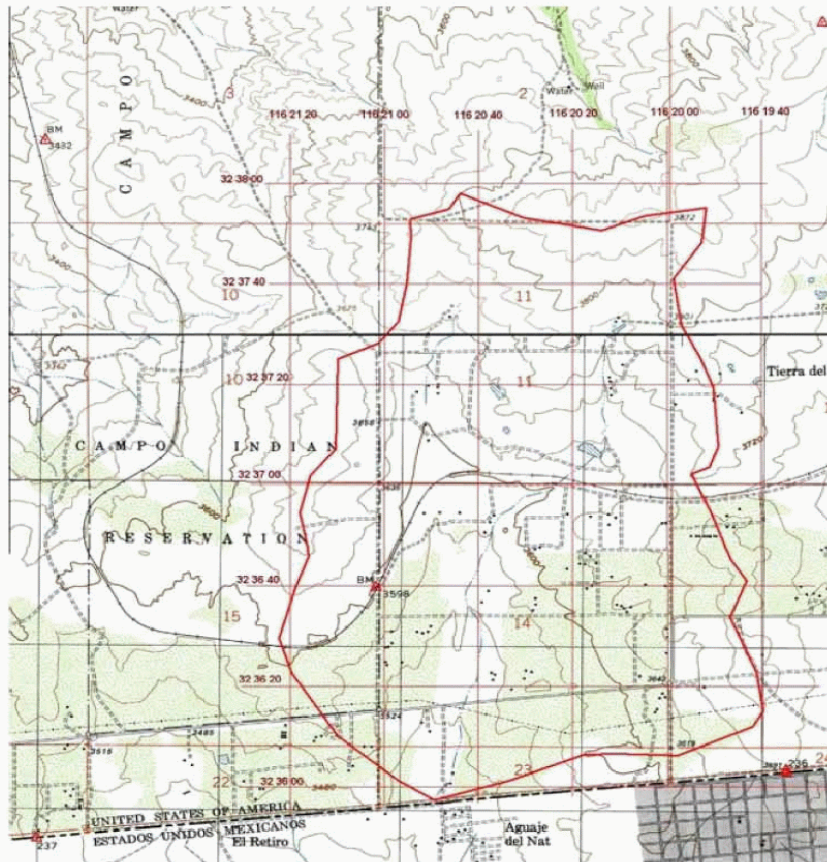
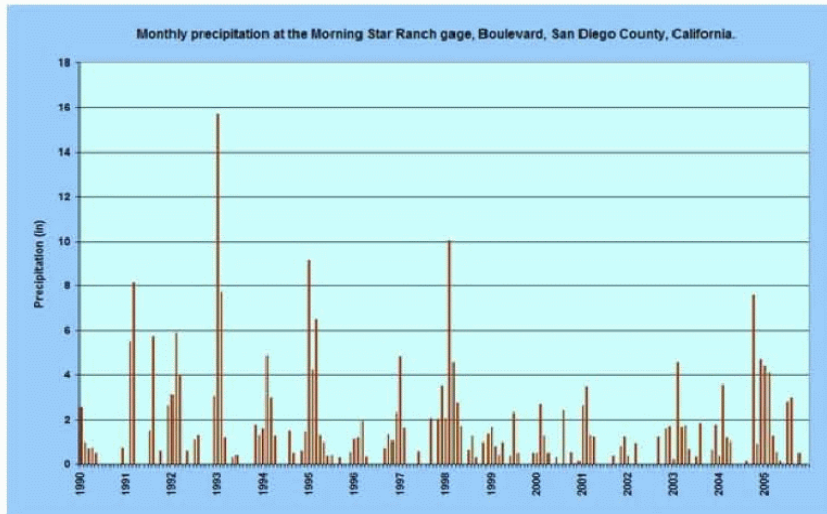


Fig. 2 The Tierra del Sol watershed.

**Precipitation data.** Precipitation in the Tierra del Sol watershed has been measured at the Morning Star Ranch from 1990 to the present. The raingage is located at N 32° 37' 27" and W 116° 21' 04". The record of monthly precipitation is shown in Fig. 3. The rainy season is from November to April (winter rains), although there are some documented instances of summer rain. February is the wettest month of record, with 4.09 inches of average precipitation.

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B0002-114 cont.

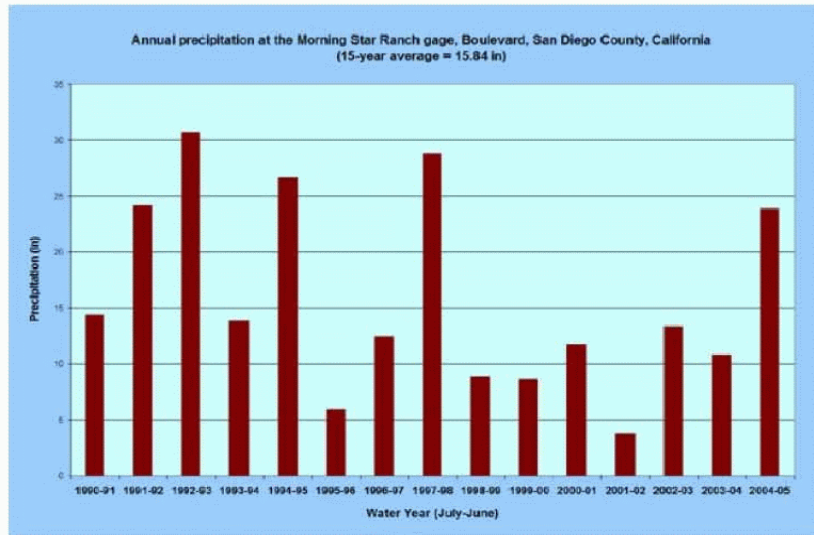
Fig. 3 Monthly precipitation record at the Morning Star Ranch (1990-2005).

The record of annual precipitation, with the water year defined from July to June, is shown in Fig. 4. The average precipitation for the 15-year period is 15.84 inches. The record shows two very wet years, 1992-93 and 1997-98; and three other significantly wet years, 1991-92, 1994-95, and 2004-05. The years 1991-92, 1992-93, 1994-95, and 1997-98 were El Niño years. In the year 2004-05, monthly and annual precipitation were near record highs.

The years 1995-96 and 1998-99 were La Niña years, showing substantially below average precipitation. A La Niña event is the opposite of an El Niño, leading to cooling, instead of warming, of the sea-surface temperatures (SST) in the Pacific Ocean along the equator.

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Impact of the proposed Campo landfill on the hydrology of the Tierra del Sol watershed Page 6 of 35



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Fig. 4 Annual precipitation at the Morning Star Ranch, 1990-91 to 2004-05.

In summary, the precipitation record shows two very wet years (1992-93 and 1997-98), and one significantly wet year (2004-05), the latter following at the end of a persistent six-year drought (1998-99 to 2003-04).

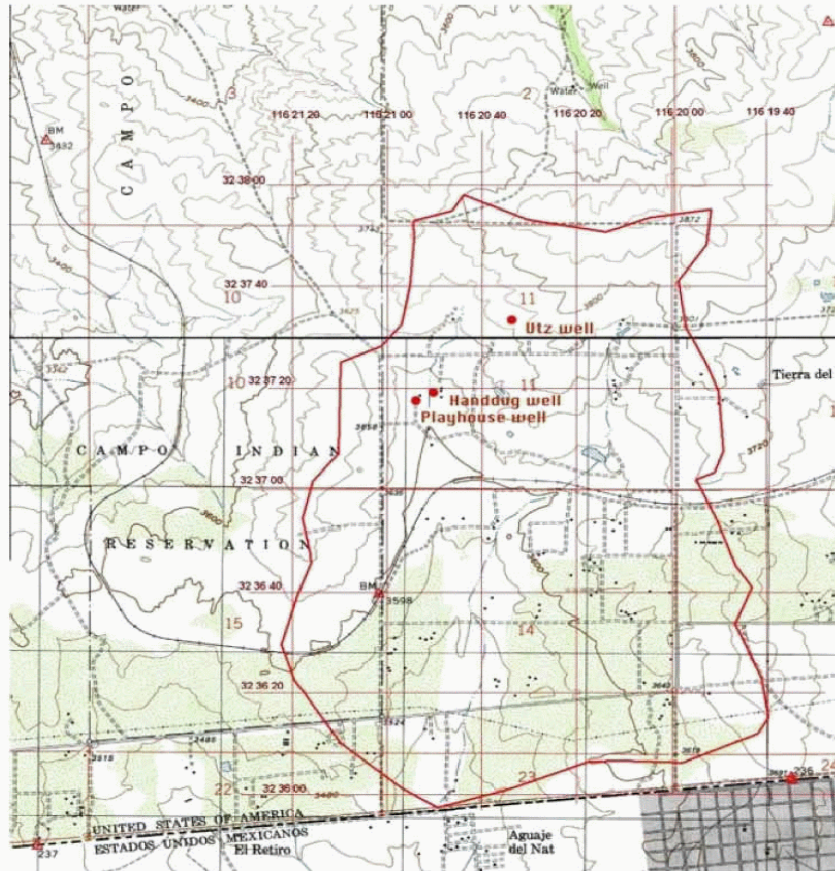
• HYDROGEOLOGY •

[Hydroecology] [Stream morphology] [Groundwater hydraulics] [Synthesis] [Conclusions]  
[Summary] [Endnotes] [References] [Reviewers] • [Top] [Introduction] [Scope] [Hydrology]

Water level data from three wells located in the Tierra del Sol watershed were compiled and analyzed for this study. These wells are named: (1) Handdug, (2) Playhouse, and (3) Utz. The well locations are shown in Fig. 5.

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Fig. 5 Location of wells at the Morning Star Ranch, Tierra del Sol.

**Well data.** Well data spanning the 12-year period from 1993 to 2005 is shown in Figs. 6 to 8. Fig. 6 shows the Handdug well, Fig. 7 shows the Playhouse well, and Fig. 8 shows the Utz well. The measurements were performed by San Diego County personnel as part of the county's groundwater monitoring program. The elevations shown are the water surface in the well, above mean sea level.

The records shows a clear recovery of the groundwater levels in the years 1995, 1998, and 2005, indicating the effect that these three wet years had on aquifer replenishment. Significantly, all three wells show water table drawdown during the six-year drought period ranging from 1999 to 2004. Furthermore, the two dry years of 1995-96 and 1996-97 also show some degree of water table drawdown.

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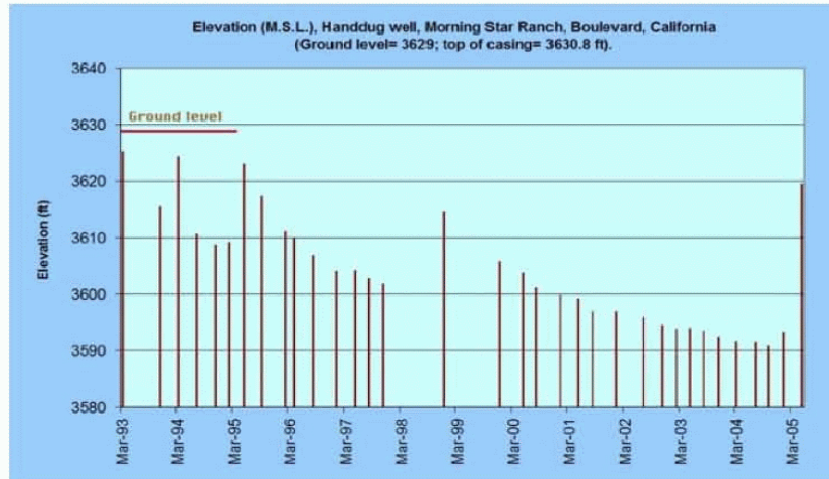


Fig. 6 Water-surface elevation at Handdug well.

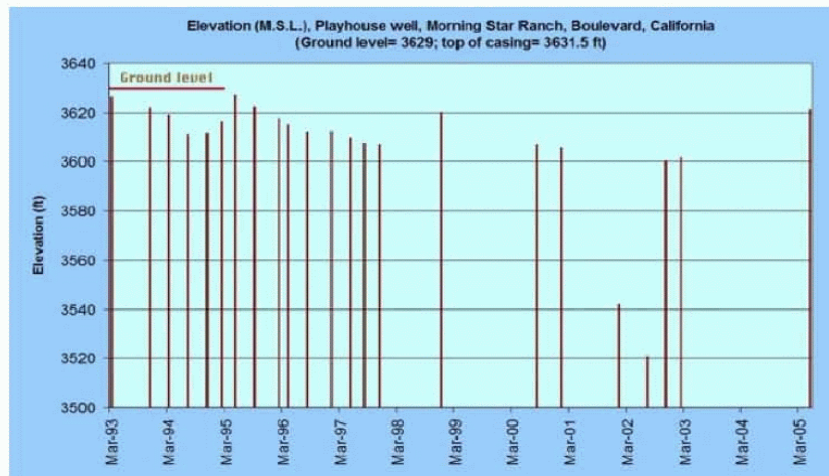


Fig. 7 Water-surface elevation at Playhouse well.

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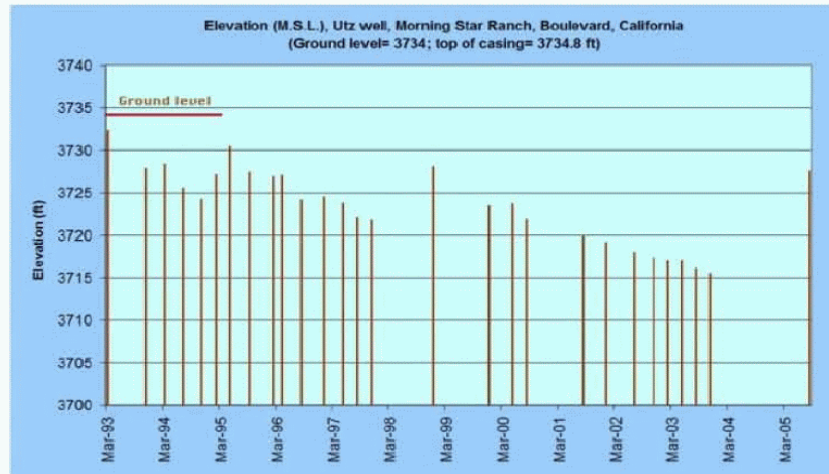


Fig. 8 Water-surface elevation at Utz well.

**Relation between precipitation and well data.** Analysis of the precipitation and well data reveals an effective hydraulic connection between surface water and groundwater in the Tierra del Sol watershed. A fraction of the precipitation percolates into the ground; in turn, a fraction of this percolated water joins the groundwater, increasing the water-surface elevation in the wells. The remaining portion (of the percolated water) eventually returns to the atmosphere as evaporation and/or evapotranspiration. The timing of the groundwater level response is relatively fast, not exceeding a half season (six months). The paucity of well data precludes a more precise assessment of the response time; however, the existence of an effective connection between surface and groundwater is clearly borne out by the data.

**Analysis of the precipitation and well data points to an effective hydraulic connection between surface water and groundwater in the Tierra del Sol watershed.**

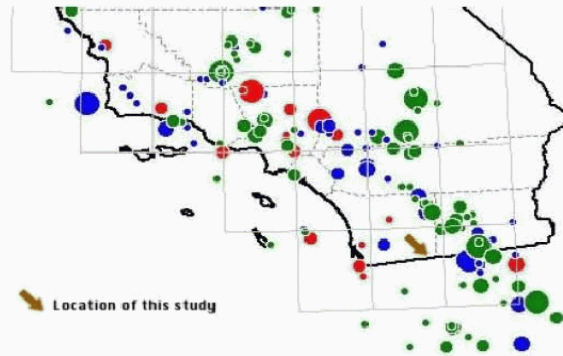
**Geologic characteristics.** The Tierra del Sol region is underlain by the Peninsular Range batholith, which straddles the mountains of central Southern California. The region lies within the La Posta pluton, a deep-seated igneous intrusion (Walawender *et al.*, 1990). This pluton varies inward from rim to core, from a sphene-hornblende-biotite tonalite rim to a muscovite-biotite granodiorite core.<sup>2</sup> In the early 1990s, the landfill's engineering consultants classified the rocks of the Campo landfill as tonalites. However, many of the rocks in Tierra del Sol and vicinity may actually be granodiorites.<sup>3</sup>

The rocks are extensively fractured, due either to batholith cooling or tectonic uplift. There is substantial tectonic activity east of Tierra del Sol, near El Centro (Fig. 9). In addition, the site is within the area of influence of the Elsinore fault system (at a distance of less than 22.5 miles) in San Diego County and other faults in Imperial County and neighboring northern Baja California. Thus, the region has a potential for earthquake-generated strong ground shaking. Anecdotal evidence suggests that ground tremors of varying intensities are not uncommon in the immediate vicinity of Tierra del Sol.<sup>4,5,6</sup> Also, well cave-ins have been reported as a direct result of earthquake shaking.<sup>7</sup>

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Source: California Geological Survey.

Fig. 9 Magnitude of earthquakes in Southern California (Magnitudes: small 5.5-5.9; medium 6.0-6.4; large 6.5-6.9; very large 7+). (Data sets: red 1769-1868; blue 1869-1931; green 1932-2000).

A striking geological feature of Tierra del Sol, and one possibly related to the fractures, is the significant number of white, mostly pegmatitic, seemingly vertical dikes that cut across the study area. These dikes are formed by quartz and feldspar-rich magmas left over in the final stages of crystallization of the granitic rocks. Since the age of the fractures is not known with certainty, the relation between the dikes and the fractures is not readily discernible. One possibility is that the dikes were injected into the fractures which formed in the initial stages of crystallization and cooling of the granitic rocks. This would place the age of [at least] some of the fractures at about 90-140 million years old (Deméré, 2006). Another possibility is that the fractures formed as a result of stresses produced during the [later] uplift of the Peninsular Ranges. In this case they would be only a few million years old.

It is not immediately apparent which one of the above two scenarios is more plausible. If the fractures preceded the dikes, an east-west preference in dike orientation would suggest that less energy was required to shoulder aside the rock in an orthogonal (i.e., north-south) direction. In turn, this would imply denser fracture spacing and/or greater fracture lengths and widths in the east-west direction. One significantly major dike located on the Turner Ranch in Tierra del Sol, is about 5-ft wide and 1,465-ft long (Fig. 10). Notably, this dike trends east-west almost exactly (Fig. 20). A geologic fault crosses this dike near its eastern edge, in an approximate NE-SW direction. Significantly, the Turner Ranch's well is located at or near this fault.

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Fig. 10 Major dike in Turner Ranch, Tierra del Sol.<sup>8</sup>

**Photogeologic lineaments.** Existing studies have revealed the considerable extent of the fractures in the vicinity of the proposed landfill site. Figure 11 shows an excerpt of a geologic map prepared in the early 1990s by the landfill project's engineering consultants. The proposed landfill site is shown with a light-brown background, immediately west of the Tierra del Sol watershed, the latter with its boundary highlighted in red. The photogeologic lineaments, which are highlighted in green, depict alignments of resistant rock outcrops and variations in the density of vegetation and subtle tonal texture or color variations. Many of these lineaments are known to be the expression of fractures and other discontinuities in the weathered and unweathered rocks.

B0002-114 cont.