# Four Study Methods Described

Providing the public with updates on our progress is an important part of NASA's Groundwater Cleanup Project at the Jet Propulsion Laboratory. This information sheet describes tools NASA used in recent studies. The findings are explained in a separate information sheet entitled, "Results of Additional Studies".

NASA is making significant progress on the Groundwater Cleanup Project at the Jet Propulsion Laboratory (JPL). Our efforts include investigating the site according to the framework required by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The investigation phase of CERCLA involves in-depth sampling and other analyses to identify the types of chemicals that might be present at a site and how such chemicals might be moving in groundwater deep beneath the surface. A thorough understanding of these conditions enables us to determine the needs for cleanup.

Key to this investigation is the data we collect using conventional and multi-port groundwater monitoring wells. Conventional wells (single screen) and multi-port wells (2 - 5 screens at different depths) give us information from various specific locations at a cleanup site. Installation of a series of wells in and around the cleanup site provides a wealth of data for characterizing the extent of chemicals traveling in a specific area underground. NASA has been collecting groundwater samples on a quarterly basis from monitoring wells, both on- and off-site, for more than a decade. These data help NASA characterize the extent of perchlorate and other chemicals associated with historic operations at the JPL facility in the 1940s and 1950s.

Since completing an initial investigation in 1999, NASA has recommended and implemented several cleanup activities onsite and beyond the JPL fenceline. Even with all the detailed information collected from that investigation, several questions emerged in the late 1990s regarding the widespread occurrence of perchlorate (since analysis for it began in 1997) in the Raymond Basin. These questions prompted NASA to supplement the initial investigation results and conduct further study in the area.

## objectives

**The primary objectives of this supplemental study are twofold:**

**Understand the downgradient (southern) extent of chemicals that originate from JPL, and**

**Determine if the occurrence of perchlorate in the Sunset Reservoir area was associated with migration from the JPL facility.**

Four Study Methods

**The methods NASA has used in this investigation include: 1 Groundwater Modeling, 2 Groundwater Geochemistry, 3 Groundwater Chemical Data, and 4 Perchlorate Isotope Analysis. Each of these tools provides valuable information. Rather than relying on any one method in and of itself, we have used the four tools in an integrated manner to investigate the complexities of underground conditions in the Raymond Basin.**

## 1 Groundwater Modeling

Computer modeling has a variety of applications in the field of environmental science and is commonly used to investigate groundwater movement such as the direction and rate at which groundwater travels. Computer modeling also allows us to ask, "What would happen if…?" Ranging from relatively simple mathematical equations to complex multi-layer computer programs, groundwater models can create a virtual environment where "what ifs" can be explored. As one tool in a comprehensive investigation, groundwater models can help us estimate possible outcomes on groundwater levels and flow paths from human activities such as development, irrigation and water production wells. Models are particularly helpful in studying the direction and velocity of groundwater flow, predicting how chemicals move in groundwater, and evaluating the potential effectiveness of remediation alternatives. Because models simulate and cannot exactly duplicate all the conditions in a real environment, modeling results are more robust when supported by other data. Properly characterizing a site's geology and hydrology is a key element in building a better groundwater model. The more data describing the site-specific conditions we have to input into the model, the closer it will approximate the real physical setting (called model calibration) and provide an accurate prediction of groundwater flow and direction.

For the initial investigation, NASA developed a computer model using information gathered from historical records and actual site measurements to estimate groundwater flow paths (direction) from JPL. We have used this model to perform particle tracking. The computer-generated particles simulate how chemicals found at the site might move over time. Part of this analysis included asking what effects do the existing water production wells have - while operating and during periods when they are not - on groundwater flow. When a water production well is operating, the pumping action will draw groundwater flow toward the well. This area is called the "capture zone" of that well. We have looked at whether production wells in the Monk Hill Subarea – one of three subareas that together make up the Raymond Basin aquifer – disrupt the natural flow path of groundwater from JPL and whether perchlorate migrating in that groundwater is being contained within the capture zones of those wells.

A groundwater model was developed independently by the Raymond Basin Management Board (RBMB). The RBMB used the model to evaluate potential changes in groundwater levels and movement throughout the Raymond Basin, including the Monk Hill Subarea. NASA has examined the results of that groundwater model as part of our study to verify our model results and increase our knowledge of groundwater conditions. ■

## 2 Groundwater Geochemistry

Every drop of groundwater tells a story. Groundwater geochemistry is the science that looks at how that story unfolds. It is one tool NASA has used to identify the distinct chemical makeup of groundwater that in turn can tell us where the water came from, when it entered the aquifer, and whether factors have been at work on it underground, potentially changing its makeup. Some of these factors include the breakdown (dissolution) of naturally occurring minerals and other interactions with soils, mixing of different water sources, and human activities.

Groundwater samples are collected from monitoring wells and from municipal drinking water production wells in the Monk Hill Subarea. Analysis of these samples in the initial investigation found three general types of groundwater to be present. These data have been used to understand the origin of each of the three types of groundwater and whether there are any connections with sources of perchlorate in the Raymond Basin.

Different water sources have different groundwater geochemical fingerprints that can be identified by looking at the chemicals in the water. Calcium, magnesium, sodium, potassium, bicarbonate, chloride, sulfate, and nitrate are chemicals commonly found in water in significant quantities. These chemicals are naturally occurring, and some are from human activities. The groundwater in the Raymond Basin has been used as a source of drinking water for more than 100 years, and chemical data are available from production wells dating back to the early 1900s. (Federal and state regulations oversee and require water purveyors to provide safe drinking water to consumers.)

In addition to using specific chemicals to analyze and identify groundwater samples, other trace chemicals are used to track the origin of the groundwater. The radioactive isotope tritium, for example, proves to be an excellent tracer for identifying relatively young water. Tritium input to surface waters has occurred in a series of spikes following periods of atmospheric testing of nuclear devices that began in 1952 and reached a peak in 1963-64. Radioactive decay of tritium has a half-life of 12.43 years, and the decay product is helium. Measuring the concentrations of tritium and helium in groundwater can provide accurate information on the time since the groundwater was exposed to the atmosphere or when it was introduced into the aquifer. Having this information helps us to track the water to its origin. ■

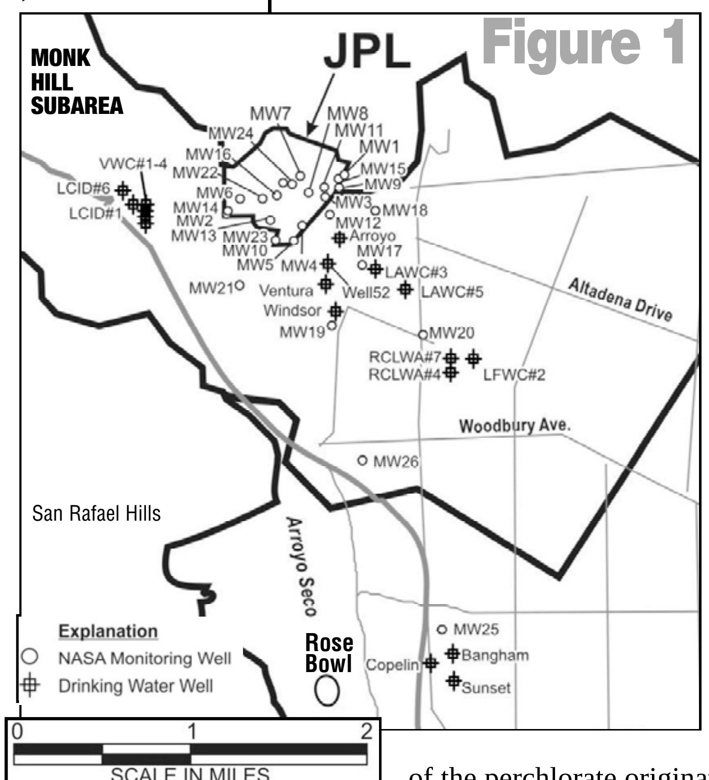

Figure 1

## 3 Groundwater Chemical Data

Multi-port groundwater monitoring wells, which have screens at different and specific depths, allow us to draw groundwater and take samples from many levels below the surface. Installing a series of wells in strategic locations at a cleanup site and collecting and analyzing samples on a regular basis is a standard practice for tracking chemicals underground. Since completion of the initial investigation, perchlorate has been detected in wells near the City of Pasadena's Sunset Reservoir area. To gather additional information, NASA installed two new multi-port groundwater monitoring wells in 2004. The new wells, MW-25 and MW-26, are located between what was formerly the southernmost NASA monitoring well (MW-20), and the Sunset wells area. [See Figure 1]

As part of our CERCLA groundwater monitoring program, we routinely collect samples from all 25 monitoring wells on a quarterly basis and analyze these samples for volatile organic compounds (VOCs), perchlorate and other chemicals historically used at the facility. The presence or absence of perchlorate at a particular well location and at specific depths, as well as any changes in perchlorate levels found there during a period of time, are recorded. These data can help determine the extent to which a particular chemical has or has not moved over time. Groundwater monitoring data have shown that the presence of a particular VOC, carbon tetrachloride, in the Monk Hill Subarea groundwater is associated with the JPL facility. Carbon tetrachloride is, therefore, considered a tracer for chemicals originating from JPL. We have evaluated the connection between the occurrence of carbon tetrachloride and perchlorate to help us better understand the extent of the perchlorate originating from JPL. ■

CONTINUED ON NEXT PAGE

## 4 Perchlorate Isotope Analysis

An isotope is an alternate form of an element such as hydrogen or oxygen that has the usual number of protons but a nonstandard number of neutrons. This gives each isotope a different atomic weight, which can be measured in the laboratory using a technology called mass spectrometry. Natural isotopic variations can arise from a number of chemical and physical processes and can alter the isotopic composition, or fingerprint, of a chemical. This can happen, for example, when fluids are heated or cooled, and when they evaporate or condense; during mixing of two or more sources of fluid, and in the natural biological processes of organisms (metabolic activity). The isotopic fingerprint of certain chemicals can be distinguished based on (1) where it came from (geographical location) in the case of naturally occurring chemicals, and (2) what it was made from (source materials) in the case of man-made chemicals. For example, naturally occurring perchlorate found in the Atacama Desert in Chile has a unique isotopic fingerprint.

Isotopic analysis is a growing field of study that helps scientists understand the origin of certain chemicals by their distinct fingerprints. Stable isotopes of chlorine and oxygen can be used to identify natural versus man-made perchlorate and to distinguish one perchlorate source from another.

In our study, an independent laboratory at the University of Illinois at Chicago has performed isotopic analysis – looking at the stable isotopes of perchlorate (e.g., chlorine and oxygen) on groundwater samples collected from NASA's monitoring wells and water production wells in the Sunset Reservoir area.

Isotopic analysis is one tool NASA has used to understand the perchlorate fingerprint originating from the man-made sources historically used at JPL.

NASA is committed to communicating with the public about the results of these studies. ■



## For More Information

More information about the
NASA Groundwater Cleanup Project
at JPL is available on our **Web site** http://jplwater.nasa.gov
and at the **NASA Information Repositories**
located in the Pasadena Central Library, La Cañada Flintridge Public Library or the Altadena Public Library.

### Please contact

Merrilee Fellows
NASA Manager for Community Involvement
**Email** mfellows@nasa.gov **Phone** (818) 393-0754
**Mail** NASA Management Office
180-801 Jet Propulsion Laboratory
4800 Oak Grove Drive, Pasadena, CA 91109