Public Health Assessment

Initial/Public Comment Release

Evaluation of Exposure to Contamination at the BF Goodrich Superfund Site
Rialto, San Bernardino County, California

EPA FACILITY ID: CAN000905945

Prepared by
California Department of Public Health

August 22, 2011

COMMENT PERIOD ENDS: October 5, 2011

Prepared under a Cooperative Agreement with the
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

THE ATSDR PUBLIC HEALTH ASSESSMENT: A NOTE OF EXPLANATION

This Public Health Assessment-Public Comment Release was prepared by ATSDR pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) section 104 (i)(6) (42 U.S.C. 9604 (i)(6), and in accordance with our implementing regulations (42 C.F.R. Part 90). In preparing this document, ATSDR's Cooperative Agreement Partner has collected relevant health data, environmental data, and community health concerns from the Environmental Protection Agency (EPA), state and local health and environmental agencies, the community, and potentially responsible parties, where appropriate. This document represents the agency's best efforts, based on currently available information, to fulfill the statutory criteria set out in CERCLA section 104 (i)(6) within a limited time frame. To the extent possible, it presents an assessment of potential risks to human health. Actions authorized by CERCLA section 104 (i)(11), or otherwise authorized by CERCLA, may be undertaken to prevent or mitigate human exposure or risks to human health. In addition, ATSDR's Cooperative Agreement Partner will utilize this document to determine if follow-up health actions are appropriate at this time.

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1.0 Summary

The California Department of Public Health (CDPH) and the federal Agency for Toxic Substances and Disease Registry (ATSDR) are responsible for finding out if and how contamination from the BF Goodrich site could harm the health of the nearby community. It is very important to us that the Rialto area community has complete information about the site and the contamination. We are committed to providing the best scientific information available and to promoting the health of the community.

> **What is a Public Health Assessment?**
>
> A public health assessment is a report that gives information on hazardous waste sites and the effects they may have on the health of nearby communities. To write the report, we look at information about the environment near the site. We also look at the ways people may come in contact with chemicals from or at the site. This information can help tell us if people living near the site could get health problems from the chemicals.

Introduction

In September 2009, the BF Goodrich Site was added to the National Priorities List (NPL). The NPL is a list of sites (Superfund sites) around the country that contain hazardous chemicals that may be harmful to people or the environment. By law, Superfund sites must be cleaned up so that people are not harmed by the chemicals. When possible, the companies that caused the problems also pay to correct them.

As part of the Superfund requirements, CDPH, working with ATSDR, produced a public health assessment report to provide information for people living in the Rialto, California area about whether and how their health may have been harmed from chemicals found at the BF Goodrich Site. Through this process, public health officials at both the federal and state levels have an opportunity to provide public health input to those making management decisions.

Background

The BF Goodrich Site ("the site") is a one-quarter (1/4) square mile area north of the City of Rialto, California. From 1952 to the mid-1980s, different companies made fireworks and different explosive devices at the site. Two of the chemicals used at the site were trichloroethylene (TCE) and perchlorate. The companies at the site dumped chemical waste, including TCE and perchlorate, onto the ground and into pits dug on the site. Over time, the chemicals leaked out of the pits into the ground and the Rialto-Colton Basin. The Rialto-Colton Basin is a groundwater source of tap water for the Rialto area. Even though the companies at the site stopped dumping the chemicals around 1985, the pits continued to leak TCE and perchlorate into the groundwater.

Perchlorate and TCE in Tap Water

CDPH studied how the BF Goodrich contamination affected tap water in the Rialto area. Tap water for the Rialto area comes from five sources: the West Valley Water District, the City of Rialto, the City of Colton, the Terrace Water Company, and the Fontana Water Company.

In January 1989, suppliers in the Rialto area started testing for TCE in the groundwater that was used for public drinking water. The testing was initiated because state and federal water quality monitoring requirements increased as a result of chemical detections in water supplies in other parts of the country. The West Valley Water District found TCE in one of its wells (Well No. 22). This well supplied the Rialto area with tap water, but was used infrequently. After TCE was found, the CDPH drinking water regulatory program required the supplier to make sure the water in Well No. 22 was safe to drink before it was supplied to the community. TCE data prior to 1989 was not available for this document, and it is possible that there may have been TCE in water coming from Well No. 22 before the testing in January, 1989.

What is Groundwater?

Groundwater is water that lies underground. It comes from rain, snow, sleet, and hail that soak into the ground. It moves down through empty spaces or cracks in the soil, sand, or rocks. It moves down until it reaches a layer of rock or heavy clay soil, which is hard to move through. The water then fills the empty spaces and cracks above that layer. The water that fills the empty spaces and cracks is called groundwater.

In September, 1997, potable water suppliers in the Rialto area began testing for perchlorate in the groundwater. This was because high levels of the chemical had been found in tap water in other places in California. Water suppliers found perchlorate in Well No. 22 and other wells that were used to supply the Rialto area with tap water. Water suppliers stopped using water from the contaminated wells. Beginning in 2001, they added treatment systems to some wells to lower the amount of perchlorate in the water to safe levels so that the wells could be used. Perchlorate data prior to 1997 was not available for this report, and it is possible that there may have been harmful amounts of perchlorate in the water supplying the Rialto area before the testing in September 1997.

The Public Health Assessment Process

In July 2009, CDPH started the public health assessment of the BF Goodrich Site. As part of this assessment, CDPH did the following:

- Looked at past and current information about perchlorate and TCE and about the air, soil, and groundwater at the site;
- Investigated whether people living in the area from 1952 to the present could have come in contact with these chemicals;
- Investigated whether people working at the site from 1952 to the present could have come in contact with these chemicals;
- Visited the site and nearby communities;
- Held community meetings in the City of Rialto;
- Took information from community members about their health concerns; and
- Looked at scientific and medical information related to the community health concerns.

Conclusions

ATSDR and CDPH reached six important conclusions in this public health assessment about the site.

1. **People who work in businesses located on the BF Goodrich Site are not at risk from exposure to chemicals in the soil, soil vapor, or groundwater.**

The groundwater and soil at the BF Goodrich site are contaminated with perchlorate and TCE. We looked at soil information from the site and found that exposure to the amounts of perchlorate in the soil are not high enough to cause health problems. The groundwater at the site has perchlorate and TCE in it, but it is very deep below the surface and, does not present a threat from vapor intrusion[1], nor is it being used for drinking water.

2. **The drinking water supplied by the West Valley Water District, the City of Rialto, the City of Colton, and the Terrace Water Company is safe to drink and does not put people at risk for health problems.**

Since 1997, when perchlorate testing began, or since 1989, when regular monitoring for TCE began, the suppliers have regularly checked the public tap water to make sure that people are not served water with TCE or perchlorate at levels that could cause health problems.

3. **Some drinking water supplied by the West Valley Water District's Well No. 22 while it was used in the years 1981, 1982, 1985, 1987, and 1988, may have contained TCE, but it is not expected to have harmed people's health.**

Before January 1989, when TCE was discovered in Well No. 22, the well was used in 1981, 1982, 1985, 1987, and 1988. The level of TCE found in Well No. 22 in January 1989 was compared to studies of animals and humans swallowing or breathing the chemical. The level measured in Well No. 22 water was lower than levels that are expected to cause health problems.

4. **Some drinking water supplied by the West Valley Water District's Well No. 22, while it was used in the years 1981, 1982, 1985, 1987, and 1988, may have had amounts of perchlorate that could have been high enough to modestly impair iodine absorption by the thyroid gland. This could potentially have lowered the levels of thyroid hormones in fetuses, infants and children below amounts necessary for healthy development.**

During the 1980s, the West Valley Water District periodically used water from Well No. 22. In 1997, when perchlorate monitoring started, testing showed that the water in this well contained perchlorate. A study shows that perchlorate was likely in the well before 1997.

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[1] Vapor intrusion: a process by which volatile organic chemicals (VOCs) move from contaminated soil or groundwater into indoor air of buildings.

Perchlorate exposure studies show that the computer-modeled levels of perchlorate in some of the tap water when the West Valley Water District used Well No. 22 in 1981, 1982, 1985, 1987 and 1988 might have been high enough to have inhibited the uptake of iodine by the thyroid gland, which could have resulted in lower thyroid hormone levels in fetuses, infants, and children. Adults, including pregnant or lactating women, would not have been likely to have experienced any significant inhibition of iodine uptake.

5. **Some drinking water supplied by the City of Rialto's Well No. 02 from 1979 to 1997, may have had amounts of perchlorate that could have been high enough to modestly impair iodine absorption by the thyroid gland. This could potentially have lowered the levels of thyroid hormones in fetuses, infants and children below amounts necessary for healthy development.**

Until 1997, the City of Rialto used water from Rialto Well No. 02. In 1997, when perchlorate monitoring started, testing showed that the water in this well contained perchlorate. A study shows that perchlorate could have been in Rialto Well No. 02 water since 1979.

Perchlorate exposure studies show that the computer modeled levels of perchlorate in some of the tap water when the City of Rialto used Well No. 02 from 1979 to 1997 might have been high enough to have inhibited the uptake of iodine by the thyroid gland, which could have resulted in lower thyroid hormone levels in fetuses, infants, and children, but not adults.

What is the Thyroid Gland?

The thyroid gland is a small butterfly-shaped organ in the front of the neck.

The thyroid gland takes up iodine from food to make thyroid hormones.

Thyroid hormones help maintain the body's metabolism and temperature, and are especially important during pregnancy and childhood because they are necessary for normal physical growth and brain development.

A decrease in thyroid hormone during these stages can cause problems of growth and brain development.

6. **Drinking water supplied by the Fontana Water Company in some months of 1989 and 1990 was combined with water from the West Valley Water District's Well No. 22. The combined water was safe to drink and did not put people at risk for health problems.**

Based on computer modeling, the possible amount of TCE and perchlorate in some of the Fontana Water Company tap water that was combined with the West Valley Water District's Well No. 22 water in 1989 and 1990 may have resulted in exposure to TCE and perchlorate. The level of TCE was compared to studies of animals swallowing or breathing the chemical. The level measured in Fontana Water Company water was lower than levels that are expected to cause health problems. The estimated levels of perchlorate were compared to studies of people who swallowed perchlorate in water and were not at amounts high enough to have caused health problems.

7. **The drinking water supplied by the City of Colton in 1997 was safe to drink and did not put people at risk for health problems.**

The estimated levels of perchlorate in the City of Colton‘s Well No. 15 in 1997 were compared to studies of people who swallowed perchlorate in water and were not at amounts high enough to have caused health problems.

8. **It is not possible to know whether eating fruits or vegetables from a garden irrigated with perchlorate-containing water would have been harmful before 1997.**

   Fruits or vegetables could have contained perchlorate if they were grown in a garden irrigated with perchlorate-contaminated water. However, there is not enough information to determine how much perchlorate got into the fruits and vegetables.

Community Concerns

To better understand the concerns of the Rialto communities about contamination from the BF Goodrich site, CDPH held open meetings in the City of Rialto. At the meetings, community members told us about their health concerns. Most of the concerns were about the chemicals in the drinking water and include the following:

- People were concerned that contaminated water in Rialto caused thyroid diseases, migraines, attention deficit hyperactivity disorder (ADHD), allergies, skin rashes, miscarriages, stillbirths, and birth defects. They were also concerned that children exposed to contaminated water learned to talk later than other children.
- Some people were concerned that contaminated water caused kidney cancer in humans and caused tumors in fish living in home-made ponds in the area.
- Some community members were concerned about their water leaving a "white residue or deposit."

Evaluation of Community Concerns

To find out whether contamination from the BF Goodrich Site could have been linked to the concerns voiced by the community, CDPH looked at scientific information about health problems known to be caused by perchlorate or TCE.

Perchlorate has not been shown to cause thyroid disease, however perchlorate can affect the thyroid in women who do not get enough iodine from their food. In those women, perchlorate can cause the thyroid to make too little thyroid hormone. The levels of perchlorate in the drinking water would not have been high enough to cause a woman's thyroid gland to make less thyroid hormone.

Babies and children need thyroid hormone to develop normally. Too little thyroid hormone can affect how a child learns, including when a child learns to talk. The amount of perchlorate in the drinking water from West Valley Water District Well No. 22 in some months in 1981, 1982, 1985, 1987, and 1988, and in the City of Rialto Well No. 02 from 1979 to 1997, might have been high enough to decrease the level of thyroid hormone in young children or babies who drank tap water. If so, this could have theoretically played a role in their learning to talk later than other children.

Perchlorate and TCE have not been linked to allergies, skin rashes, miscarriages, stillbirths, or birth defects.

Perchlorate has not been shown to cause ADHD. Studies show a possible link between TCE and ADHD. Rats born to mothers that drank water with TCE in it before, during, and after birth showed behavior similar to ADHD. The levels of TCE used in the rat study, however, were much higher than levels seen in the community's drinking water.

Perchlorate has not been linked to kidney cancer. Both animal and human studies have linked TCE with kidney cancer, although there is not a good understanding of the amount that causes or is associated with kidney cancer.

There is no scientific information about whether perchlorate or TCE could cause tumors in fish. Some germs or parasites cause lumps in fish. Other fish develop cysts (water-filled lumps) for no known reason.

The white residue that people see when water dries up on a surface is caused by minerals, such as calcium and magnesium, in the water. Water that has more minerals in it is called "hard" water. This is a common water condition. Hard water is not harmful nor is it linked to any health problems. Neither perchlorate nor TCE leaves a white residue.

Recommendations

Based on what we learned about the BF Goodrich site, CDPH and ATSDR recommend:

- Groundwater contamination at the site continue to be characterized;
- Actions be taken to prevent exposures to contaminants in the two former burn pits;
- Actions be taken to prevent exposures to contaminated groundwater; and
- Adults who were children or infants and lived near West Valley Water District's Well No. 22 during the 1980s or the City of Rialto's Well No. 02 from 1979 to 1997, and who have concerns about their potential exposures and possible health impacts should consult their health-care provider.

Next Steps

- CDPH will distribute the findings of this public health assessment and discuss the results with members of the Rialto community at a future public meeting.
- CDPH will provide information in English and Spanish to the community and nearby business owners about exposure and health concerns related to the BF Goodrich site.

2.0 Background and Statement of Issue

In this public health assessment (PHA), the California Department of Public Health (CDPH) and the Agency for Toxic Substances and Disease Registry (ATSDR) will determine whether health effects are likely to have occurred due to past, current, or future exposure to BF Goodrich site contaminants and, if so, will recommend actions to reduce or prevent potential exposures. ATSDR, located in Atlanta, Georgia, is a federal agency within the U.S. Department of Health and Human Services and is authorized by the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 to conduct PHAs at hazardous waste sites.
The conclusions of this PHA for the BF Goodrich Site are made on the basis of a review of available environmental data, various environmental reports, community concerns, information obtained from site visits, and consultations with involved parties and the public.

On September 3, 2008, the U.S. Environmental Protection Agency (EPA) proposed adding the B.F. Goodrich Site to its National Priorities List (NPL). The NPL, part of the EPA's Superfund Program, is a list of hazardous waste sites eligible for federal funds to carry out site cleanup activities. EPA investigates NPL sites to determine if they pose risks to public health or the environment and works to eliminate those risks, whenever possible. On September 23, 2009, the BF Goodrich Site was officially placed on the NPL. Prior to the EPA's involvement, the Santa Ana Regional Water Quality Control Board (Regional Board) was the lead agency overseeing the site investigation and monitoring.

The environmental investigation of the BF Goodrich Site examines contamination of groundwater with perchlorate, an oxidizer used in rocket fuel, and trichloroethylene (TCE), an organic solvent. As of January 2011, 16 municipal wells located downgradient (i.e., in the direction of groundwater flow) of the BF Goodrich Site had been contaminated by perchlorate. As a result, one has been abandoned, four have been shut down, and 11 have been modified with perchlorate treatment systems.

3.0 Site Description and History

The BF Goodrich Site is approximately 160 acres in size and located in the City of Rialto, San Bernardino County, California (Appendix B, Figure B1).

In 1942, the U.S. Army purchased approximately 2,822 acres of undeveloped land in northern Rialto to store and distribute ammunition to the Port of Los Angeles. The Army developed approximately 740 acres of this property for use as an inspection, consolidation, and storage facility for railcars transporting bombs, ammunition and other ordnance to Los Angeles, California. The developed land included the future 160-acre square-shaped BF Goodrich Site located in the northeast corner of these 740 acres. In 1946, the army sold the 740 acres. Since that time a variety of defense contractors, firework manufacturers and other commercial industrial operations have used portions of the property [1].

From 1952 to 1957, the West Coast Landing Company (WCLC) used the 160-acre area to manufacture and test various explosive devices [1]. The manufacturing process used and disposed of perchlorate salt, used in solid propellant for rocket motors and fireworks, and TCE, used as a degreasing and cleansing agent. According to testimony from a former WCLC employee and from records recovered by the Regional Board, perchlorate wastes were cleaned up with water by employees using rags, mops, and buckets. The content of the buckets were routinely dumped onto the bare ground at the site [2]. Records also indicate that perchlorate was dried on metal trays at WCLC and used to manufacture photoflash devices. The metal trays were sprayed with water over bare ground to clean the residual perchlorate. Testimony of former WCLC employees also indicate that rags soaked in TCE were used to clean mixers, and then wrung out over the bare ground. According to the testimony, empty solvent drums were buried onsite. Employees also testified that TCE and perchlorate were disposed of in burn pits at the site. Perchlorate and TCE are believed to have entered the ground from these sources and eventually mixed with groundwater beneath the BF Goodrich Site.

In 1957, WCLC sold the property to the BF Goodrich Corporation (also referred to as BF Goodrich). BF Goodrich became Goodrich Corporation (Goodrich) in 2001, making Goodrich the successor to BF Goodrich. From 1957 to 1964, BF Goodrich manufactured rockets and missiles for the U.S. Department of Defense, and conducted rocket propellant research for the U.S. Government [3]. BF Goodrich used various chemicals, including perchlorate and TCE in the manufacture of rockets and missiles. Testimony by former BF Goodrich employees and records obtained by the Regional Board indicate that BF Goodrich disposed of the production waste at the 160-acre area into two open unlined earthen pits, to be burned. Chemical waste included cleaning solvents, such as TCE, and perchlorate salts. Unburned chemical residues were left in the pit, open to the elements. Any rainwater that entered the pit would have eventually flowed down through the soil and mixed with groundwater beneath the 160-acre area (Appendix B, Figure B1).

West Coast Loading Company, mid-1950s (Courtesy of the City of Rialto)

Since 1964, multiple landowners have operated at the site. One such landowner, Pyrotronics Corporation, manufactured fireworks from 1968 to 1988. Records and former employee testimony indicate that the pyrotechnic powder mix that had been used to make fireworks included perchlorate. Former employee testimony also indicates that at the end of each shift, the manufacturing room was hosed down with water and the excess waste water, which likely included spilled powder mix, flowed out the door and onto the bare ground. In addition, every two hours waste powder mix was swept from the manufacturing room and disposed of into a concrete-lined disposal pond, known as the "McLaughlin Pit", built by Pyrotronics in 1971. Pyrotronics, and beginning in 1979, Pyro Spectacular Incorporated (Pyro Spectacular), used the pond to keep waste perchlorate submerged in water for long periods of time. Records indicate that the pond overflowed at least once onto the bare ground during rainy weather. In 1987, Pyro Spectacular backfilled and closed the pond (Appendix B, Figure B2) [4].

Regional Board records indicate that at least two major fires and explosions occurred at Pyrotronics, and large amounts of water were used to suppress the fires. The water used likely mixed with the remaining perchlorate and moved it into the soil and to the groundwater [5] .

Pyro Spectaculars also stored and disposed of pyrotechnic waste. According to the Regional Board, there were also several fires and explosions during Pyro Spectaculars' operations at the property, and that the water which was used for fire suppression, which would have mobilized perchlorate into the soil and toward the groundwater [4].

In 1997, perchlorate was detected in two municipal groundwater wells located downgradient (southeast) from the site: West Valley Water District (WVWD) Well No. 22 and City of Rialto Well No. 02 (Rialto No. 02) [6]. WVWD Well No. 22 was reported to have perchlorate levels of 325 parts per billion (ppb) and Rialto Well No. 02 had 57 ppb. WVWD Well No. 22 had already been off-line since 1990 and was permanently abandoned, and Rialto No. 02 was immediately shut down [7]. At that time, CDPH's Division of Drinking Water and Environmental Management (DDWEM) had instituted an "action level," now called a notification level,[2] of 18 ppb for perchlorate in drinking water [6].

Rialto Well No. 02 closed

In January 2002, DDWEM lowered the notification level for perchlorate to 4 ppb [6]. This resulted in the closure of more municipal wells owned and operated by the WVWD, the City of Rialto, and additionally, the City of Colton, (located immediately to the southeast of Rialto) due to perchlorate levels above 4 ppb. In March 2004, DDWEM revised the notification level to 6 ppb, when the California Office of Environmental Health Hazard Assessment (OEHHA) established the public health goal for perchlorate. Use of the notification level ended when CDPH adopted a maximum contaminant level (MCL) for perchlorate of 6 ppb, effective October 2007. In January 2011, OEHHA revised the public health goal for perchlorate from 6 ppb to 1 ppb. Table 1 presents the California perchlorate notification and regulation values from 1997 to 2011.

Table 1. History of California Perchlorate Health Comparison Values: 1997-2011

Year	Action	Media-Specific Health Comparison Value
September 1997	First testing of perchlorate in drinking water wells in California. CDPH instituted a perchlorate action level	Action level- 18 ppb
January 2002	CDPH revises notification level (previously called an action level) for perchlorate following the release of the USEPA daily reference dose	Notification level- 4 ppb

[2]A notification level is a health-based advisory level established by CDPH for chemicals in drinking water that lack a maximum contaminant level. They may be established when a chemical is found in or threatens drinking water sources [8].

Table 1. History of California Perchlorate Health Comparison Values: 1997-2011

Year	Action	Media-Specific Health Comparison Value
March 2004	OEHHA established a perchlorate public health goal	Public health goal- 6 ppb
October 2007	CDPH establishes drinking water standard for perchlorate	Maximum contaminant level (MCL)- 6 ppb
January 2011	OEHHA revised perchlorate public health goal	Public health goal- 1 ppb

Source [8]
A detection level <1 ppb was available but has not been certified by the Division of Drinking Water and Environmental Management. Presently, all data are reported with a detection level of 4 ppb.
ppb: parts per billion
CDPH: California Department of Public Health
USEPA: United States Environmental Protection Agency
OEHHA: California Office of Environmental Health Hazard Assessment

4.0 Land Use

The 160-acre BF Goodrich Site is located in the City of Rialto, San Bernardino County; it is bounded to the north by West Casa Grande Drive, to the east by North Locust Avenue, to the west by North Alder Avenue, and to the south by an unpaved extension of Summit Avenue (Appendix B, Figure B2). Adjacent to the site along the western edge is the Target Corporation distribution center, along the northern and eastern edges are residential homes, and along the southern edge are the Eagle Roofing Company and the 420-acre San Bernardino County Mid-Valley Sanitary Landfill (MVSL).

The site is currently occupied by Rialto Concrete Products, TNT Fireworks, Pyro Spectaculars, and B&B Plastics Incorporated (Appendix B, Figure B2). Rialto Concrete Products manufactures, stores, and distributes concrete sewer drain piping. TNT Fireworks, which also operates under the name American Promotional Events, stores and distributes fireworks. Pyro Spectaculars stores, distributes, and designs large firework display shows. B&B Plastics Incorporated collects and distributes waste plastics for recycling to other facilities.

Residential development around the BF Goodrich Site was slow until the mid-1980s. From aerial photographs of the site and surrounding vicinity, we know that sparse residential housing existed in the 1950s (Appendix B, Figures B3-B6). Some additional housing (approximately 50 acres of development) was constructed in the 1960s and 1970s. From the mid-1980s to the mid-1990s, rapid residential development occurred. During that time, approximately 1,600 acres of land located immediately to the north, east, and south of the site were developed. According to the US Census Bureau, the population of Rialto rose from 37,862 in 1980 to 72,791 in 1990. From the mid-1990s until 2002, the rate of development slowed and an area of approximately 640 acres was developed.

4.1 Nearby Hazardous Waste Sites

The nearby area contains four contaminated sites which have either been cleaned, are being cleaned or will be cleaned of perchlorate and volatile organic compound (VOC) contamination in soil and groundwater (Appendix B, Figure B7): 1) the former Broco facility, located southwest of the BF Goodrich Site and within the San Bernardino County planned Mid-Valley Sanitary Landfill (MVSL); 2) the former Broco/Denova facility located to the west of the BF Goodrich Site; and 3) the Stonehurst property, located approximately 2,000 feet south of the BF Goodrich Site.

The former Broco office included administrative buildings and a receiving area for the Broco facility. Fireworks debris was removed from the Broco facility in December 2003, and some soil was removed in June 2004.

The former Bronco facility was a waste transfer, storage, and disposal facility, as well as an open burn detonation facility that operated to the southwest of the BF Goodrich Site [9]. Various hazardous wastes such as explosives, oxidizers, and corrosives were placed at the Broco facility. The facility is located within the west-central portion of the San Bernardino County planned MVSL Unit 5 expansion area and is adjacent to an active portion of the landfill. MVSL is owned and operated by the County of San Bernardino. Currently, investigation and cleanup of the former Broco facility is under the supervision of the Regional Board.

The waste transfer, storage, and disposal portion of the Broco facility was moved after a large explosion occurred in 1987. The facility was moved immediately north to a separate parcel and named Broco/Denova. That property is now part of the Target Corporation distribution center located west of the BF Goodrich Site. In 2002, the California Department of Toxic Substances Control (DTSC) ordered the Broco/Denova Company to terminate operations due to repeated violations of hazardous waste control laws. EPA conducted an Emergency Removal Action from May 2002 through April 2003, during which approximately 1,070 cubic yards of impacted soil containing perchlorate were removed.

In 2002, the Regional Board issued a clean-up and abatement order to the County of San Bernardino due to levels of perchlorate and volatile organic compounds (VOCs) that were detected in groundwater immediately downgradient of the planned MVSL Unit 5 expansion area [10]. Perchlorate was also detected in samples from groundwater monitoring wells located immediately upgradient of the City of Rialto’s Well No. 03, resulting in the well being taken off-line in July 2004 [10]. In June 2006, the well was modified with a treatment system and placed back on-line.

The Stonehurst Site refers to the 5-acre area located approximately 2,000 feet south of the BF Goodrich Site at 2298 West Stonehurst Drive. In February 2003, DTSC detected perchlorate at the Stonehurst Site. In April 2004, the Regional Board issued a clean-up and abatement order to Pyro Spectaculars for the investigation and cleanup of perchlorate [4]. Groundwater investigation and cleanup of the Stonehurst Site is under the supervision of the Regional Board.

4.2 Site Hydrology

In the area of the site, groundwater generally moves in ancient buried river beds (water-bearing units). Groundwater flow generally originates from the mountains and moves to the southeast. If contamination gets into the groundwater it will spread by moving through the river beds.

The BF Goodrich Site is located within the Rialto-Colton Basin, a 40-square-mile groundwater basin with widths of 3.5-miles in the northwest border and 1.5 miles in the southeast border [11]. The Rialto-Colton Basin is bounded by geologic faults and mountains. It shares borders with the Bunker Hill Basin to the east and the Chino Basin to the west.

Groundwater flows in the Rialto-Colton Basin through four separate water-bearing layers located at varying depths in the Rialto-Colton Basin [12]. Water in the middle layer is found approximately at a 400-foot depth beneath the site and moves from approximately one to several feet per day in a southeasterly direction. This layer is the main source of water for the municipal wells in the Rialto-Colton Basin. Beginning at the northern end of the Basin, the middle water-bearing layer is separated into two parts by a horizontal clay layer, or aquitard. Both parts gradually join together approximately 1.5 miles southeast from the BF Goodrich Site. A former water supply well located where the middle layer is divided pumped water from both parts of the middle layer when it had been active.

4.2.1 Public Water Suppliers Operating in the Rialto-Colton Basin

Five public utility companies distribute groundwater from the Rialto-Colton Basin to residents of Rialto, Colton, Fontana, and Bloomington (unincorporated): West Valley Water District (WVWD, public utility) Fontana Water Company (private utility), City of Rialto (public utility), City of Colton (public utility), and the Terrace Water Company (private utility). In addition, the Arrowhead Medical Facility, located in the City of Colton, manages one groundwater well for hospital needs. The following paragraphs briefly describe features of the Terrace Water Company and the Arrowhead Medical Facility. Features of the other providers are described later in the Environmental Contamination/Pathway Analysis/Toxicological Evaluation section.

4.2.2 Terrace Water Company

The Terrace Water Company is a private water utility company that currently services 600 locations located within the City of Colton. All water is obtained from two groundwater wells located downgradient from the BF Goodrich Site and stored in two reservoirs for distribution to customers. The Terrace Water Company began testing for perchlorate in 2008 and TCE in the late 1980s. As of January 14, 2010, no perchlorate or TCE had been detected [Tobi Ritarita, General Manager, Terrace Water Company, personal communication, February 2, 2010].

4.2.3 Arrowhead Medical Center

The Arrowhead Medical Facility manages one well for drinking and hospital-related needs (Appendix B, Figure B1). In 2003, the well tested positive for perchlorate levels above the then media-specific health comparison value (4 ppb) and was immediately placed off-line. The Arrowhead Medical Facility modified the well with a perchlorate treatment system and placed it back on-line in September 2009. Currently, the well water is diluted with water from the City of Colton due to elevated levels of nitrates [Randy Rigidati, Facilities Manager, personal communication, January 2010].

5.0 Site Visit

CDPH staff visited the site on August 10, 2009. During the visit, which was guided by a staff member from the Santa Ana Regional Board, CDPH staff walked the site and visited with two of the four companies currently operating onsite.

The site is predominantly covered with sandy soils, generally flat, with plants typical of arid California environments. Most of the original buildings that were built and used by the West Coast Loading Company and the BF Goodrich Corporation are in differing stages of decay. There are a number of known or suspected former disposal burn pits at the site. CDPH visually inspected the concrete slabs that cover two of the known former pits, the former BF Goodrich Pit located beneath the Rialto Concrete Products building, and the former McLaughlin Pit located in the Rialto Concrete Products yard. The concrete slabs were found to be in good condition and free of significant cracking.

The site is fenced in on all sides and the four onsite companies manage the entrances and exits of the BF Goodrich site. TNT Fireworks monitors the unused former West Coast Loading Company structures.

6.0 Demographics

BF Goodrich is located within Census Tract 0027, which spans approximately 8.5 miles north and includes most of northern Rialto, with an estimated population of 9,400. The ethnic make-up is roughly 45% White, 37% Hispanic or Latino, 21% African American, and 4% Asian [13].

Twelve census tracts compose the Cities of Rialto, Colton, Fontana and the unincorporated area of Bloomington. Some residents of the three cities and Bloomington receive water from the Rialto-Colton Basin. The combined estimated population of all twelve census tracts is approximately 347,242 (as of 2000). The Rialto ethnic make-up is roughly 51% Hispanic or Latino, 39% White, 22% African American and 3% Asian. The ethnic make-up of Colton is roughly 65% Hispanic or Latino, 40% White, 11% African American, and 5% Asian.
The ethnic make-up of Fontana is roughly 65% Hispanic or Latino, 39% White, 12% African American, and 5% Asian.[3]

[3] Race is a self-identification data item. Respondents may choose more than one race with which they most closely identify and therefore, may be counted more than once. As a result, the sum total of races will be greater than the total population [13].

7.0 Environmental Contamination/Pathway Analysis/Toxicological Evaluation

In this section, CDPH examines the pathway for exposure to contamination resulting from the BF Goodrich Site. CDPH determines whether contamination is present and if people in the community are exposed to the contamination. If people are exposed to contamination, we evaluate whether there is enough exposure to pose a public health hazard.

In order for a target population to be exposed to an environmental contaminant, a mechanism must exist that brings the contaminant into direct contact with the target population. This mechanism is called an exposure pathway. An exposure pathway consists of five parts:

- A source and mechanism of chemical release to the environment
- A contaminated environmental medium (air, soil, or water)
- A point where someone contacts the contaminated medium (known as the exposure point)
- An exposure route, such as inhalation (breathing), dermal absorption (skin contact), or ingestion (swallowing during eating or drinking)
- People that may be exposed

All five parts must be present in order for exposure from an environmental contaminant to occur. When all five parts are present, the exposure pathway is designated as completed.

Potential completed exposure pathways are either 1) not currently complete but could become complete in the future, or 2) indeterminate due to lack of information. If one or more of the five parts are eliminated or missing, the pathway is eliminated.

CDPH evaluated five pathways of possible exposure related to the BF Goodrich Site (Appendix C, Table C1). Presenting the information based on exposure pathways allows an individual to read those sections that are most relevant to his or her situation. For instance, for an individual who lives in northern Rialto and is a customer of the WVWD, the most important and relevant exposure pathways are presented in section 7.4.

7.1 Environmental Screening Criteria

The following section briefly discusses the method CDPH uses to identify contaminants of concern (COCs), which are further evaluated to determine whether levels of contaminants in various environmental media pose a health hazard from adverse non-cancer or cancer health effects.

As a preliminary step in assessing the potential health risks associated with contaminants at the BF Goodrich Site, CDPH compared contaminant concentrations with media-specific environmental guideline comparison values. Those contaminants with concentrations that exceed the comparison values are identified as COCs for further evaluation of potential health effects. ATSDR, EPA, and California Environmental Protection Agency's comparison values are media-specific concentrations representing estimates of a daily human exposure unlikely to cause cancer or non-cancer (health effects other than cancer) adverse effects. CDPH applied the following comparison values in the current evaluation:

- Cancer Risk Evaluation Guide (CREG). CREGs are media-specific comparison values used to identify concentrations of cancer-causing substances that are unlikely to result in a significant increase of cancer rates in a population exposed over an entire lifetime. CREGs are derived from EPA's cancer slope factors, which indicate the relative potency of cancer-causing chemicals. Not all chemicals are considered carcinogenic and not all carcinogenic compounds have a CREG.

- Environmental Media Evaluation Guide (EMEG). EMEGs are estimates of chemical concentrations in air, soil, and water that are not likely to cause an appreciable risk of harmful, non-cancer health effects for fixed durations of exposure. EMEGs might reflect several different types of exposure: acute (1-14 days), intermediate (15-364 days), and chronic (365 or more days). EMEGs are based on ATSDR's Minimal Risk Levels (MRLs) (see Glossary in Appendix A for a more complete description of EMEGs) [14].

- Reference Dose Media Evaluation Guides (RMEGs). RMEGs are estimates of chemical concentrations in soil and water that are not likely to cause an appreciable risk of non-cancer health effects for chronic exposure. RMEGs are based on EPA's Reference Doses (RfDs) (see Glossary in Appendix A for a more complete description of EMEGs) [15].

- Maximum Contaminant Level (MCL). CDPH and EPA MCLs are the maximum concentrations of chemicals allowed in public drinking water systems. MCL values are based on considerations of preventing impacts on human health and on economic costs of applying clean-up treatment technologies [15]. For perchlorate, the MCL also includes a relative source contribution value of 60% to account for levels of perchlorate the Food and Drug Administration has measured in produce and some dairy products. Refer to Appendix E for a more detailed explanation.

- California Human Health Screening Levels (CHHSLs). California Environmental Protection Agency (Cal/EPA) CHHSLs are screening levels for chemicals in soil and soil gas used to aid in clean-up decisions based on the protection of public health and safety [16].

When a contaminant is found at levels greater than a media-specific health comparison value, it is designated as a COC. Contaminants designated as COCs do not necessarily represent a risk to public health. For each COC, a toxicological evaluation is performed to better determine its potential adverse impact to public health.

7.2 Description of Toxicological Evaluation

In a toxicological evaluation, CDPH evaluates the exposure pathway to the COCs on the basis of the most current studies we can find in the scientific literature. There is not enough available information to completely evaluate exposure to multiple chemicals or possible cancer and noncancer adverse effects from exposure to low levels of contaminants over long periods of time. Some introductory information follows to help clarify how we evaluate the possible health effects that may occur from exposure to the contaminants identified for follow up.

When individuals are exposed to a hazardous substance, several factors determine whether harmful effects will occur and the type and severity of those health effects. These factors include the dose (how much), the duration (how long), the route by which they are exposed (breathing, eating, drinking, or skin contact), the other contaminants to which individuals may be exposed, and their individual characteristics such as age, sex, nutrition, family traits, lifestyle, and state of health. The scientific discipline that evaluates these factors and the potential for a chemical exposure to adversely impact health is called toxicology.

In a toxicological evaluation, an exposure dose is estimated for each COC. An exposure dose estimates how much contaminant a person swallowed, breathed, or touched per day divided by the person's weight. These values are used to examine the potential noncancer and cancer exposure in greater detail.

7.2.1 Approach to Noncancer Health Comparison Evaluation

To further examine whether COC exposures might result in human health effects, CDPH uses the exposure doses calculated for non-cancer exposure and compares them with the following health-based values or health guidelines:

- Minimal Risk Level (MRL). MRLs are estimates of daily human exposure to a substance that is likely to be without an appreciable risk of adverse, non-cancer health effects over a specified duration of exposure. MRLs are based on the no-observed effect level (NOEL) , no-observed-adverse-effect level (NOAEL), or the lowest-observed-adverse-effect level (LOAEL) identified in toxicological studies or, less often, in human exposure studies (see Glossary in Appendix A for description of NOAEL and LOAEL) [14].

- Reference Dose (RfD). RfDs are estimates of daily human exposure to a substance that is likely to be without an appreciable risk of adverse, non-cancer health effects over a specified duration of exposure. RfDs are based on the NOEL, NOAEL, or LOAEL.

If the estimated dose exceeds the MRL or RfD, the health guidelines (i.e., NOEL, NOAEL, LOAEL) are used to help evaluate whether potential COC exposures may have occurred above or below levels that have been identified as not posing appreciable non-cancer health risks. All health comparison values are determined from toxicity studies usually conducted on adult animals or adult human volunteers (typically worker populations).

Chemicals can interact in the body resulting in effects that might be additive, greater than additive, or less than additive. To calculate the risk from exposure to chemicals that might interact additively, the additive approach or a hazard index is estimated. A hazard index sums the hazard quotients for each chemical to determine if the sum is greater than one. The hazard quotient is the dose divided by the MRL or RfD. A sum greater than one indicates that additive effects could occur, and a sum less than one indicates no additive adverse (noncancer) health effects are expected to occur.

7.2.2 Approach to Cancer Health Comparison Evaluation

The National Toxicology Program, the International Agency for Research on Cancer, and the EPA have reviewed data from human and animal studies to determine whether certain chemicals are likely to cause cancer in humans [14,15,17]. The cancer risk posed by exposure to a given chemical is evaluated by estimating the incremental probability of an individual's developing cancer over a lifetime as the result of exposure. To calculate a cancer risk, exposure doses similar to those described above for the non-cancer health evaluation are estimated, except that the dose is typically averaged over the theoretical human lifetime (70 years), not over the period of actual exposure. The lifetime exposure doses are then multiplied by an individual chemical's calculated potential for causing cancer, a potency value known as the cancer slope factor.

OEHHA and EPA have developed cancer slope factors for many carcinogens [15,18]. A cancer slope factor is usually derived from a study where the exposure was applied over the lifetime of an animal; thus, it is appropriate to calculate cancer risks from long periods of exposure. For regulatory purposes when evaluating current or future short-term exposure from a site or facility, OEHHA recommends using a 9 year minimum exposure duration for calculating increased cancer risks [19]. This method is appropriate and useful when the goal is to provide information to support regulatory decisions affecting public health. However, calculating a cancer risk from short-term exposures (less than 9 years) that occurred in the past may not provide useful or scientifically valid information. According to Halmes et al., estimating theoretical increased cancer risk for short-term exposures is likely to result in an underestimation of cancer risk [20]. Halmes reviewed the cancer studies of 11 chemicals that had included animals that received less-than-lifetime exposures in addition to animals receiving the typical, lifetime exposure. He found that cancer slope factors derived from lifetime studies and applied to less-than-lifetime exposures would likely underestimate the risk of shorter exposures. In one case, the dose in a less-than-lifetime exposure that caused an increase in tumors was at least 100-fold lower than the dose that caused the same tumor effect in animals treated for a lifetime. In addition to the problems with the use of cancer slope factors derived for a lifetime exposure scenario, the method for calculating the dose for the particular hazardous waste site exposure involves dividing the exposure dose by 70 years, the theoretical lifetime of an individual. This assumes that the body responds to an estimated amount of exposure in the same way, whether the exposure occurred all at one time, for example, or over 70 years. The cancer studies discussed above do not support this assumption.

In the following pages we describe our evaluation of the four pathways of possible exposure related to the BF Goodrich Site. A brief summary of the toxicological characteristics of the compounds found at levels above health comparison values are presented in Appendix D. The toxicological evaluation of the completed pathways involves the use of exposure assumptions. The authors first use high-end estimates and assumptions to ensure that any potential public health hazards from the chemicals are recognized. The summary of the toxicological evaluation for each pathway, along with the assumptions used in the calculations, are presented in Appendix C, Table C2. The following paragraphs describe evaluations to exposure pathways from the BF Goodrich Site.

7.3 Exposure to Onsite Contaminants

CDPH evaluated exposure to onsite environmental contamination only for adult onsite workers from 1952 to the present. The BF Goodrich Site is located in an industrially zoned area. It is fenced on all sides, and has three controlled entrances and exits. When CDPH visited the site, we did not observe any children or signs of children's activities within the site. According to the TNT Fireworks Plant Manager, the areas where BF Goodrich and the West Coast Loading Company used to operate are monitored daily for trespassers. Given that these areas are fenced and located in a remote location, CDPH deemed it unlikely that trespassing occurs. Therefore, we considered only adults who currently work at one of the four active companies at the site in evaluating possible exposure associated with onsite air, soil and soil gas contamination. Due to the historical method of using large burns and detonations to dispose of waste on the site, CDPH attempted to assess past possible exposure to soil, soil gas, and air contaminants.

Groundwater beneath the site is contaminated with perchlorate and VOCs at levels of health concern. However, the groundwater is located several hundred feet below the surface and therefore does not pose a risk from vapor intrusion[4]. In addition, the groundwater is not brought to the surface for municipal water use and therefore does not present a health hazard from drinking or skin contact.

7.3.1 Onsite Soil and Soil Gas

To evaluate the potential from exposure to contaminated soil or soil gas, CDPH first evaluated available data to see if contamination existed at levels above media-specific health comparison values in the soil or soil gas. GeoSyntec Consultants, ENVIRON Corporation, and CH2MHill conducted studies that collected soil and soil gas samples and analyzed for perchlorate and VOCs in the former West Coast Loading Company and former Goodrich Corporation locations. Sampling locations in the studies were chosen on the basis of where perchlorate and VOCs, such as TCE, were formerly used or disposed [21,22] . Soil samples collected at shallow depths (0-2 feet) detected perchlorate in two areas. The detections (0.1 ppm, 12 ppm) were well below media-specific health comparison values for soil (40 ppm) [21,23]. At shallow depths, no TCE was detected in any of the areas. Soil samples collected at deeper depths, 6 and 12 feet, detected perchlorate well below media-specific health comparison values for soil [22]. At deeper depths, no TCE was detected in any of the areas. Trace amounts of VOCs were detected at levels well below media specific health comparison values for soil.

Soil gas samples collected in the former West Coast Loading Company and former Goodrich Corporation locations detected TCE at three locations at the former BF Goodrich burn pit location [22]. The highest of the three concentrations (316 ppb) does not exceed the California media-specific health comparison value for soil gas (329 ppb). The comparison value is for commercial/industrial land use only [16]. If future residential development should occur, soil gas should be reevaluated using appropriate residential comparison values. VOCs (xylenes) were detected in six soil gas samples at concentrations ranging from 1.2 to 2.4 ppb, well below the media-specific health comparison values [16,21].

7.3.2 Onsite Air

Currently, no airborne releases of chemicals occur from manufacturing or mass disposal of fireworks. Airborne releases of perchlorate at the site were possible in the past. Former records and employee testimony indicate that perchlorate-related wastes were treated regularly by detonation and burning [10]. However, there was no monitoring or sampling of the air during burns or detonations to evaluate air emissions. CDPH identified a 2007 study conducted by the EPA's Office of Research and Development in which perchlorate levels were measured in a

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[4] Vapor intrusion: a process by which volatile organic compounds (VOCs) move from contaminated soil or groundwater into indoor air of buildings.

body of water before and after a large fireworks display was conducted over the water. The study found that, within 14 hours after the fireworks display, the levels of perchlorate in the lake rose 24 to 1,028 times background levels and returned to normal after 20 to 80 days [24]. This suggests that perchlorate can be emitted from fireworks explosions and also perhaps from fireworks testing or perchlorate detonation.

Perchlorate has a low vapor pressure and therefore does not have a tendency to remain airborne if released. However, if perchlorate were ejected into the air and attached to particles in air, breathing the particles could occur. Therefore, it is likely that an exposure from breathing airborne perchlorate could have existed in the past when the facilities were producing and disposing of fireworks and munitions. The possible exposure was likely limited to onsite workers; however, it is not possible to determine the amount or estimate a dose that may have occurred.

Airborne releases of TCE at the site were likely in the past. Based on former employee testimony, TCE was used in the past as a cleaning agent [2]. TCE evaporates quickly and begins to break down when exposed to ambient air [25]. Onsite workers were likely exposed to levels of TCE in the air, however, no air monitoring or air sampling of TCE occurred at or within the vicinity of the site to determine if airborne levels of TCE were high enough to pose a health concern to former workers or to individuals in areas located near the site.

7.4 Exposure to West Valley Water District's Municipal Water

Currently, the West Valley Water District (WVWD) obtains its water from 25 groundwater wells, surface water sources originating in the San Gabriel Mountains, and water purchased from the California State Water Project and from the San Bernardino Valley Municipal Water District [26]. The service area is separated into eight zones divided into two systems, a north system and a south system, which are located to the north and south of Rialto, respectively (Appendix B, Figure B8) [27]. The north and south systems obtain water from the sources mentioned above, but water is not exchanged from system to system.

WVWD drinking water is a blend of 69% groundwater, 20% treated surface water, and 11% purchased water [26]. Drinking water is stored in 23 reservoirs located throughout the service area. Booster pump stations operate between the zones to move and replenish reservoir water as needed.

WVWD has detected perchlorate in six groundwater wells. One or more of these wells contains perchlorate from the BF Goodrich site. One well is located in the north system and the remaining five are located in the south system. WVWD took the well in the north system, WVWD Well No. 22, off-line to WVWD customers in 1989, due to the detection of TCE. It was later converted into a monitoring well due to the detection of perchlorate in September 1997 [Tom Crowley, Assistant General Manager, West Valley Water District, personal communication, Sept. 2009]. WVWD deactivated the five wells in the south system at various times from 1997 to 2007 due to perchlorate. From 2003 to 2010, WVWD modified all five wells with perchlorate treatment systems. Currently all five wells are on-line. Table 2 provides an overview of the WVWD wells that have been impacted by perchlorate and /or TCE.

Table 2. West Valley Water District (WVWD) Wells Affected by Perchlorate or Trichloroethylene (TCE) Rialto, California

WVWD Well (Status as of 1/2011)	Year Perchlorate First Detected	Year TCE First Detected	Raw Water has Exceeded Media-Specific Health Comparison Value?*	Perchlorate Treatment (yes/no)	Well Information
WVWD Well No. 22 **(Off-line)**	1997	1989	Yes (perchlorate and TCE)	No	Off-line to WVWD customers in 1/1989 for TCE and then converted into a monitoring well in 9/1997 for perchlorate.
WVWD Well No. 11 **(On-line)**	2004	Not Detected	Yes (perchlorate)	Yes	Off-line in 8/1998 to 8/2002 due to elevated nitrates. 8/2002 kept off-line due to perchlorate. Back on-line 1/2010 with perchlorate treatment system.
WVWD Well No. 16 **(On-line)**	2008	Not Detected	No	Yes	Off-line in 2/2007 for perchlorate. On-line for one month with perchlorate treatment system in 2/2008. Currently on-line
WVWD Well No. 17 **(On-line)**	2005	Not Detected	No	Yes	Off -line in 8/1986 to 5/2006 for solvents. 8/2007 modified with perchlorate treatment. Currently on-line.
WVWD Well No. 18a **(On-line)**	2000	Not Detected	Yes (perchlorate)	Yes	Off-line in 2/2002 for perchlorate. 5/2003 modified with perchlorate treatment system. Currently on-line.
WVWD Well No. 42 **(On-line)**	2002	Not Detected	No	Yes	Off-line in 11/1993 to 7/2002 for Endangered Species Act. Not on-line until 5/2003 after modified with perchlorate treatment system.

Source [28]

**Media-specific health comparison values: See Table 1 for perchlorate values; MCL for TCE= 5 ppb.*

CDPH reviewed all available data from municipal wells of the WVWD and determined that perchlorate and TCE were COCs from one drinking water well, WVWD Well No. 22.

WVWD Well No. 22 was built in 1929 as an agricultural well. The WVWD took over the well in the 1960s [7]. Until 1981, WVWD used the well only for agricultural irrigation. Beginning in 1981, WVWD used the well for municipal drinking water purposes during high demand usage times.

In January 1989, WVWD sampled and analyzed Well No. 22 for VOCs. WVWD detected TCE at a level of 9.7 ppb, which is above the maximum contaminant level (MCL) of 5 ppb, set for drinking water [7]. Due to this detection, WVWD removed the well from service in January 1989. In June 1989, WVWD sampled the well again; TCE was not detected above the MCL. WVWD reactivated the well in June 1989.

In September 1997, WVWD detected perchlorate in WVWD Well No. 22 that was above the then-media-specific health comparison value (18 ppb) at 322 ppb and again in October 1997, at 325 ppb. At that time, WVWD had not detected perchlorate above 18 ppb in any other WVWD well.

CDPH evaluated exposures from perchlorate and TCE. To evaluate the water usage of WVWD Well No. 22 before 1997, CDPH used historical pumping records and sampling records when available. Pumping records were used to identify when water from WVWD Well No. 22 was served to WVWD customers. The records show that water was only pumped from WVWD Well No. 22 during high-demand periods and only in 1981, 1982, 1985, 1987, 1988 and 1990 [7]. High-demand periods were approximately 2 to 6 months in length, from May through October.

WVWD did not distribute water from WVWD Well No. 22 to its customers in 1989 and 1990, but sold the water to the Fontana Water Company [7]. CDPH examines this further in section 7.5, *Exposure to Fontana Water Company's Municipal Water (1989 and 1990).*

CDPH evaluated four potential routes of exposure to perchlorate and TCE in WVWD Well No. 22 from May through October in 1981, 1982, 1985, 1987, and 1988. First, CDPH considered if users or visitors were exposed to potentially harmful levels of perchlorate or TCE from drinking and from incidental swallowing while swimming. Second, CDPH considered if users or visitors were exposed to potentially harmful levels of perchlorate or TCE from eating fruits or vegetables in private gardens irrigated with WVWD Well No. 22 water. Third, CDPH considered if WVWD Well No. 22 users or visitors were exposed to TCE from breathing vapors while showering. Fourth, CDPH considered if WVWD Well No. 22 users or visitors were exposed to TCE from absorption by skin contact while swimming or showering.

When WVWD used groundwater pumped from WVWD Well No. 22 as a drinking water source, there is no document indicating water was served directly from the wellhead without blending. According to representatives of WVWD, when the purveyor used water from WVWD Well No. 22 in the 1980s, it was likely pumped to a reservoir and mixed with both surface and WVWD municipal well water that was free of perchlorate contamination prior to distribution [Tom Crowley, Assistant General Manager, West Valley Water District personal communication, September 2009]. However, WVWD representatives also acknowledge that WVWD Well No. 22 water could have been served directly from the wellhead unblended. If WVWD Well No. 22

water was served without blending, it would have likely been delivered to residents who lived close to the well, limiting the number of people potentially exposed. Therefore, in order to evaluate the pathways of exposure, CDPH used the most conservative or worst-case scenario approach and assumed that the water was not blended with other sources prior to consumption.

7.4.1 Exposure to Perchlorate Prior to 1997 from West Valley Water District Municipal Water

Prior to 1997, perchlorate was not identified as a concern in California and was therefore not monitored in the Rialto area. WVWD first discovered perchlorate in WVWD Well No. 22 in September 1997, and it was most likely present prior to discovery. Exposures to perchlorate in water can occur from drinking water, cooking with water, and from incidental swallowing of water while swimming.

To obtain exposure estimates before 1997, CDPH used the only source currently available that models how much perchlorate could have been in the groundwater downgradient from the site prior to that time. This source is a GeoLogic Associates report titled, *Hydrogeologic Model of Perchlorate Transport Conditions in the Northern Rialto-Colton Basin*, which was prepared for the County of San Bernardino.[5] GeoLogic Associates used a modeling program called MODFLOW to simulate the perchlorate plume migration, which includes the BF Goodrich Site. MODFLOW is a computer-based software program developed by the U.S. Geologic Survey that models groundwater flow in three-dimensions [29].

GeoLogic Associates compiled data from drilling logs, historical groundwater data from monitoring and municipal wells, and previous contamination investigations [30]. The model simulates groundwater and perchlorate flow in the northern Rialto-Basin in five-year increments from 1960 to 2020.

To approximate the time when perchlorate first entered groundwater beneath the site, as well as when it first encountered WVWD Well No. 22, the model used the hydraulic conductivity or rate of groundwater movement from the site. The model also used historical perchlorate data from the City of Rialto Well No. 06, located approximately four miles downgradient. Using this approach, GeoLogic Associates estimated that perchlorate first entered groundwater beneath the site around 1970, and reached WVWD Well No. 22 by 1979.

As mentioned above, the middle water-bearing unit located in the vicinity and beneath the site is split into two parts. WVWD Well No. 22 is located in this area of the Rialto-Colton Basin and according to its drilling log, the well obtained water from both parts [7]. CDPH used well profile

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[5] CDPH used the GeoLogic Associates report, Hydrogeologic Model of Perchlorate Transport Conditions in the Northern Rialto-Colton Basin, which was not specifically conducted to better the understanding of the perchlorate plume emanating from the BF Goodrich Site. Rather, as the president of GeoLogic Associates stated in a declaration to the attorneys representing the Goodrich Corporation, the objective of the report was "to better characterize the existing and potential future chemical migration of perchlorate in the Rialto-Colton Basin that originates from the County's Mid-Valley Sanitary Landfill" [28]. Therefore, CDPH used the model as only a means to estimate and not for obtaining a specific concentration. CDPH used estimations of contamination from the model as a means to best approximate what the perchlorate concentrations could have been in the past and roughly gauge how long the contamination may have affected the drinking water wells.

information to estimate the percentage of water obtained from the upper part (which was located at a shallower depth and was more contaminated) and the lower part (located beneath the upper part and was less contaminated). The well profile details the depths at which the well is perforated or screened to pump or take in water. Approximately 17% of the water was obtained from the upper part and 83% from the lower.

GeoLogic Associates estimated perchlorate concentrations for both parts of the middle water-bearing units in five-year increments. As shown in Appendix B, Figures B9-B16, the model calls the upper part the 'intermediate aquifer,' and the lower part the 'regional aquifer.' Perchlorate concentrations are provided as a range (50-99, 100-299, 600-999, etc.). CDPH used the most conservative or highest concentration of each range to fit its worst-case scenario (most health protective). Using the highest possible concentrations with the estimated ratio of 17% upper and 83% lower water-bearing units, CDPH estimated possible perchlorate concentrations in WVWD Well No. 22 for 1981, 1982, 1985, 1987, and 1988. Results are presented in Appendix C, Table C3.

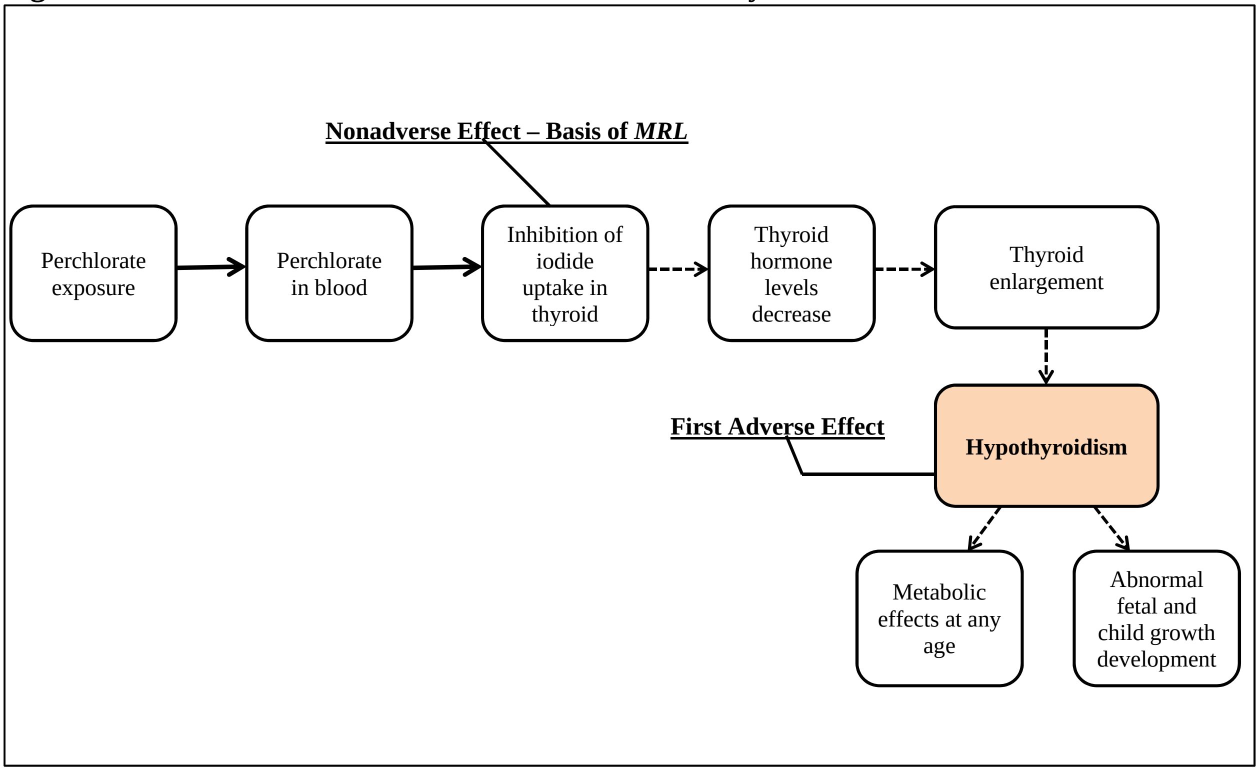
Exposure to perchlorate in water can occur from drinking water, cooking with water, and from incidental swallowing of water from swimming. CDPH calculated adult and child exposure doses to perchlorate for two separate time periods. One time period included the years 1981, 1982, and 1985. The other time period included the years 1987 and 1988. CDPH used an estimated perchlorate concentration of 252 ppb to determine the exposure doses for the years 1981, 1982, and 1985. CDPH used an estimated perchlorate concentration of 185 ppb to calculate the exposure doses for the years 1987 and 1988.

CDPH calculated exposure doses for an adult and child for two different time periods by adding the exposure doses resulting from the following activities: drinking and using water for cooking, incidental swallowing from swimming, and swallowing perchlorate from the diet. CDPH compared the total dose with the MRL (health comparison value developed by ATSDR).
As presented in Appendix C, Table C2, the total estimated perchlorate doses for adults and children during the two time periods (1981, 1982, 1985 and 1987, 1988) exceed the MRL of 0.0007 mg/kg/day. CDPH reviewed the basis of the MRL to better understand the likelihood that these doses, which exceed the MRL, may be associated with potentially harmful health effects.

The MRL (0.0007 mg/kg/day) for perchlorate is based on a 2002 adult human study. Adult volunteers swallowed different doses of perchlorate and the researchers looked for the effects that perchlorate had on their thyroid gland's ability to absorb or uptake iodine. The smallest perchlorate dose that showed a measurable effect on thyroid iodine uptake was 0.007 mg/kg/day. The effect was not statistically significant, and was designated a no-observed-effect level (NOEL).

The 0.007 mg/kg/day NOEL value was used as the basis for the MRL, not for demonstrating an adverse health effect, but for signifying the first key event that could potentially precede possible adverse health effects from perchlorate exposure. An uncertainty factor of 10 was applied to the NOEL to account for sensitive groups, particularly fetuses, infants, children and pregnant or lactating women. Figure 1 below illustrates the process leading to an "adverse" health effect from perchlorate exposure.

Figure 1: Mode of Action Model of Perchlorate Toxicity in Humans



Source [31]

The adult dose estimated from May to October for 1981, 1982, and 1985 (0.0032 mg/kg/day) and from May to October for 1987 and 1988 (0.0024 mg/kg/day) are between one-third and one-half of the NOEL, and therefore, CDPH determined that perchlorate intake at those doses (unblended WVWD Well No. 22 water) are not likely to present harmful health effects to adult men and adult women who are not pregnant or lactating. A 2006 study by Braverman et al., reported that adults with healthy functioning thyroid glands given perchlorate doses similar to those estimated in this document for a six month period, showed no inhibition of iodine uptake or negative effects on thyroid function [32].

CDPH evaluated the potential health effects for a pregnant or lactating woman by comparing the perchlorate dose with the findings of Clewell et al.

Clewell et al. modeled the percent of thyroid iodine uptake inhibition by perchlorate across life stages. They found that iodine uptake inhibition in a pregnant or lactating woman, as well as a fetus, infant and child, could occur at a dose six to seven times (0.001 mg/kg/day) less than the NOEL (0.007 mg/kg/day) [33].

In the Clewell study, it was determined that a pregnant or lactating woman would have a decrease in iodine uptake by the thyroid gland at both of the estimated adult perchlorate dose levels described above. However, the percent level of decrease (1-10%) would not have a significant clinical effect on normal thyroid hormone levels in pregnant or lactating women [33]. The Clewell study also concluded that a fetus could have a 1.1-10% decrease in thyroid iodine uptake if the mother received perchlorate at a level equivalent to the dose estimated by CDPH for a pregnant woman.

The findings of Clewell et al. were also used to evaluate the potential health effects for an infant and child. Applying the Clewell et al. findings, CDPH determined that the child perchlorate dose estimated from May to October for 1981, 1982, and 1985 (0.0069 mg/kg/day) and the dose estimated from May to October for 1987 and 1988 (0.0051 mg/kg/day) could have resulted in a 0.3 to 3% decrease in iodine uptake by the thyroid gland [33]. Clewell et al., predicted similar to larger decreases of iodine uptake from an equivalent dose for an infant (0.9-8%).

The significance of small percentage decreases in iodine uptake by the thyroid gland for a fetus, infant and child is not known (i.e., the potential magnitudes of effect on thyroid hormone levels due to specific percentage decreases in thyroid uptake of iodine). However, it is well known in the medical literature that thyroid hormone is critical for normal growth and development.

What is the Thyroid Gland?

The thyroid gland is a small butterfly-shaped organ in the front of the neck.

The thyroid gland uses iodine from the diet to make thyroid hormones.

Thyroid hormones help maintain the body's metabolism and temperature, and are especially important during pregnancy and childhood because they are necessary for normal physical growth and brain development.

A decrease in thyroid hormone during these stages can cause problems of growth and brain development.

In conclusion, adults, including pregnant and lactating women who drank unblended water from WVWD Well No. 22, would not have experienced adverse health effects from exposure to perchlorate. The estimated level of exposure to a fetus, infant or child could have inhibited iodine uptake by the thyroid gland, leading to lower levels of thyroid hormone and therefore, the potential for certain neurological and growth effects. It is important to note that the estimated level of perchlorate used in this evaluation is based on conservative (health-protective) assumptions and likely overestimates the actual level of perchlorate consumed by customers living near WVWD Well No. 22.

The International Agency for Research has not identified perchlorate to be carcinogenic [23]; therefore, CDPH did not conduct a cancer risk evaluation.

7.4.2 Exposure to TCE Prior to 1989 from West Valley Water District Municipal Water

WVWD first detected TCE in WVWD Well No. 22 in January 1989. Prior to 1989, TCE had not been tested for, but could have been present. As stated previously, WVWD served water from Well No. 22 to its customers from May to October in 1981, 1982, 1985, 1987, and 1988. After January 1989, WVWD stopped serving water from Well No. 22 to its customers.
Exposures to TCE in water prior to 1989 could have occurred from drinking the water, contact with the skin, breathing TCE vapors while showering, incidental ingestion and skin contact while swimming in a pool filled with water from Well No. 22.

CDPH estimated adult and child exposure doses to TCE using the maximum level (9.7 ppb) measured in 1989 (Appendix C, Table C2). Based on TCE data collected between 1989 through 2008, we would not expect the TCE levels to have been higher than the 1989 measurement because levels higher than 9.7 ppb were not measured until after 1997.

CDPH combined the drinking water, incidental swallowing while swimming, and skin contact with the water exposure routes into one "ingestion" dose. As presented in Table C2, Appendix C, the CDPH estimated ingestion dose for an adult (0.0001 mg/kg/day) or child (0.0003 mg/kg/day) from exposure to TCE in WVWD Well No. 22 water does not exceed the non-cancer minimum risk level (MRL) value for TCE ingestion (0.2 mg/kg/day). This means that non-cancer health effects would not be expected to have occurred in children or adults from exposures to WVWD Well No. 22 water during 1981, 1982, 1985, 1987, and 1988.

CDPH also estimated the concentration of TCE in air during showering with unblended WVWD Well No. 22 water. The estimated concentration of TCE in air (14 parts per billion volume (ppbv)) does not exceed the non-cancer inhalation MRL of (100 ppbv) (Appendix C, Table C2). This means that non-cancer health effects would not be expected to occur from breathing TCE vapors while showering with unblended WVWD Well No. 22 water during 1981, 1982, 1985, 1987, and 1988.

In conclusion, on the basis of available data, non-cancer adverse health effects should not have occurred in children or adults from exposure to TCE from WVWD Well No. 22 water during 1981, 1982, 1985, 1987, and 1988 (Appendix C, Table C2).

The International Agency for Research on Cancer has identified TCE as a probable human carcinogen [25]. To evaluate the potential for cancer health effects, CDPH estimated the theoretical increased cancer risk from exposure to TCE in water from WVWD Well No. 22.

CDPH estimated theoretical increased cancer risk for an adult and child based on the same exposure pathways used to evaluate the non-cancer health effects (see above). The estimated increased cancer risk for a child is 2 in 1,000,000 and 1 in 1,000,000 for an adult. The exposure parameters and calculations used in estimating the increased cancer risks are presented in Appendix F.

7.4.3 Exposure to Perchlorate and TCE from Eating Food Grown in Private Gardens Irrigated with West Valley Water District Municipal Water

CDPH evaluated whether perchlorate and TCE could be absorbed by fruits and vegetables if unblended water from WVWD Well No. 22 was used to irrigate private garden plants.

The U.S. Food and Drug Administration (FDA) has detected perchlorate in commercial fruits and vegetables irrigated with water containing perchlorate. Research investigating perchlorate exposure from food crops produced in the lower Colorado River region has shown that green leafy vegetables tend to uptake and store more perchlorate than other fruits and vegetables [34]; however, there is limited data concerning perchlorate uptake rates and perchlorate storage concentration of specific fruit and vegetable species. According to Yu et al., uptake rates of perchlorate and the threshold concentration, or the maximum amount of perchlorate plants can store in their vascular plant tissue, will greatly differ based on the plant species [35]. Prior to 1989, perchlorate could have been present in vegetables and fruits of private gardens watered with unblended WVWD Well No. 22 water. However, CDPH could not further investigate this pathway due to the lack of sufficient data concerning how much perchlorate specific fruits or vegetables will uptake and store.

Research concerned with the uptake and accumulation of TCE in trees, fruits and vegetables grown in TCE contaminated soil and irrigated with TCE contaminated water have detected TCE in tree trunks, but very little, in leaves, fruits or in vegetables [36,37]. The studies indicate that TCE rapidly transpires or evaporates out of fruit and vegetable plants. Based on these studies, it is unlikely that consuming garden plants irrigated with unblended water from WVWD Well No. 22 at selected time periods before 1989 exposed people to unhealthy levels of TCE.

7.4.4 Combined Exposure from Perchlorate and TCE Prior to 1997 from the West Valley Water District

CDPH was not able to find any studies that specifically examined the combined exposure of TCE and perchlorate in the scientific literature. TCE and perchlorate are not considered to be additive since they affect different parts of the body in different ways. Perchlorate can affect the thyroid, whereas TCE can affect the liver, kidney, lung, heart and nervous system [23,25]. Therefore, potential toxicity from combined exposure to TCE and perchlorate was not considered to be additive and thus a hazard index was not calculated.

7.4.5 Exposures to Perchlorate after 1997 from West Valley Water District Municipal Water

When perchlorate first came to be a concern for monitoring in drinking water in California and elsewhere in 1997, WVWD Well No. 22 was reported to have the highest levels of perchlorate of any well in the Rialto area. However, because of the discovery of TCE in January 1989, the well was not in use in 1997. Thus, there was no exposure to TCE in water served by the WVWD. West Valley Water District municipal well data are presented in Appendix B, Figures B17-B23 and Appendix C, Table C4.

Since 1997, WVWD detected perchlorate in five other wells located downgradient from the BF Goodrich Site: WVWD Well No. 11, WVWD Well No. 16, WVWD Well No. 17, WVWD Well No. 18a and WVWD Well No. 42 (Table 2, Section 7.4 above).

WVWD deactivated Well No. 11 in August 1998 due to nitrate levels near the nitrate media-specific health comparison level [28]. In August 2002, WVWD slated the well for reactivation, but kept it out of service after detecting low levels of perchlorate in August 2002. In 2009, WVWD modified the well with a perchlorate treatment system and in January 2010, placed it on-line to deliver potable water.

WVWD deactivated Well No. 16 in February 2007 to modify the well with a perchlorate treatment system. WVWD detected low levels of perchlorate in 1997, 2004, 2005, 2006, and 2007 (prior to deactivation) [28]. WVWD reactivated the well in February 2008. In March 2008, WVWD deactivated the well again due to excessive amounts of sand. The well was placed back on-line by 2010.

WVWD had deactivated Well No. 17 from August 1986 to May 2006 due to the presence of the solvent perchloroethylene (PCE). WVWD was permitted to reactivate the well in May 2006; however WVWD kept the well out of service due to the low level detection of perchlorate. WVWD modified the well with a perchlorate treatment system in August 2007. The well was placed back on-line by 2010.

WVWD constructed Well No. 18a in May 1997, and began using it for potable water in approximately June 1999 [28]. WVWD deactivated the well in February 2002 due to the detection of perchlorate. In May 2003, WVWD modified the well with a perchlorate treatment system and reactivated the well in January 2004. WVWD deactivated the well in September 2009 for maintenance. The well was placed back on-line in 2010.

WVWD deactivated Well No. 42 from November 1993 to July 2002 for issues related to the Endangered Species Act [28]. WVWD was permitted to reactivate the well in July 2002; however, the well was kept off-line and modified with a perchlorate treatment system. WVWD reactivated the well and began using it for potable water in May 2003.

WVWD has monitored all wells for perchlorate and, as required, has reported all results to CDPH Division of Drinking Water and Environmental Management since September 1997. No exposure levels above media-specific health comparison values have been reported from West Valley Water District public water since 1997. If a well is reported to have a level above the media-specific health comparison value, it is immediately taken off-line. If a well reports a value at or above the current laboratory detection limit of 4 ppb, it is monitored more frequently to determine if perchlorate levels are increasing and, if so, it will be placed off-line prior to levels exceeding the media-specific health comparison value.

In conclusion, on the basis of available data, non-cancer adverse health effects should not have occurred in children or adults from exposure to perchlorate in West Valley Water District municipal water served after 1997.

7.5 Exposure to Fontana Water Company's Municipal Water (1989 and 1990)

Currently, the Fontana Water Company (FWC) obtains water from 38 groundwater wells, surface streams originating in the San Gabriel Mountains, and water purchased from the California State Water Project and the San Bernardino Valley Municipal Water District [38]. The service area is contained within the city of Fontana, which is west of the City of Rialto (Appendix B, Figure B24). FWC drinking water is composed of 85% groundwater, 14% surface water, and 1% purchased water. Water is stored in reservoirs and distributed via booster station pumps [39].

FWC has detected perchlorate in some of its municipal wells. However, the BF Goodrich Site is not considered the source of contamination, therefore investigating contaminated FWC wells is beyond the scope of this document [40]. CDPH examined the time period when FWC municipal water may have contained water known to have been contaminated by perchlorate and TCE from the BF Goodrich Site.

FWC purchased and blended WVWD Well No. 22 water from June through October of 1989, and from June through November of 1990 [7]. In January 1989, WVWD detected TCE in Well No. 22 at 9.7 ppb, which is above the health screening value (MCL) of 5 ppb. In June, September, and December of 1989, WVWD sampled Well No. 22 and did not detect TCE above the health screening level [7]. In February and from June through December of 1990, WVWD sampled Well No. 22 and did not detect TCE above media-specific health screening levels.

Based on the sampling data from 1989 and 1990, CDPH determined that TCE was not at levels of concern when FWC purchased WVWD Well No. 22 water and therefore did not investigate further.

In 1997, WVWD detected perchlorate in WVWD Well No. 22 at 325 ppb, which is far above the then-health screening value of 18 ppb. Although it was not analyzed for perchlorate in 1989 or 1990, perchlorate was likely in WVWD Well No. 22 water during those years. Exposure to perchlorate in water can occur from drinking water, cooking with water, and from incidental swallowing of water from swimming.

To obtain exposure estimates of perchlorate levels in 1989 and 1990, CDPH used the only source currently available that models how much perchlorate could have been in the groundwater downgradient from the BF Goodrich Site prior to 1997. This source is a GeoLogic Associates report titled, *Hydrogeologic Model of Perchlorate Transport Conditions in the Northern Rialto-Colton Basin,* which was prepared for the County of San Bernardino. For a detailed explanation of this report, please refer to section 7.4.1 of this document. Based on this report, water modeling levels of perchlorate in WVWD No. 22 for 1989 and 1990 are above media-specific health comparison levels. As a result, CDPH determined perchlorate to be a potential COC.

CDPH estimated monthly perchlorate concentrations possibly present in FWC municipal water blended with WVWD Well No. 22 using the estimated perchlorate concentrations from the GeoLogic Associates model and historical FWC monthly pumping records for 1989 and 1990. Average perchlorate concentrations were estimated for June through October of 1989 and June through November of 1990.

CDPH estimated that the average concentration of perchlorate in the FWC water in 1989 was 10 ppb. CDPH estimated that the average concentration of perchlorate in the FWC water in 1990 was 21 ppb. Both amounts exceed the media-specific health comparison value of 6 ppb. These estimations are presented in Appendix C, Table C5.

As presented in Appendix C, Table C2, the estimated 1989 adult dose (0.00012 mg/kg/day) and 1989 child dose (0.00027 mg/kg/day) do not exceed the MRL of 0.0007 mg/kg/day. The estimated 1990 adult dose (0.00031 mg/kg/day) and 1990 child dose (0.00069 mg/kg/day) do not exceed the MRL of 0.0007 mg/kg/day.

In conclusion, on the basis of available data, non-cancer adverse health effects should not have occurred in children or adults from exposure to perchlorate in the FWC municipal water served in 1989 and 1990.

The International Agency for Research has not identified perchlorate to be carcinogenic [23]; therefore, CDPH did not conduct a cancer risk evaluation.

7.5.1 Exposure to Perchlorate from Eating Food Grown in Private Gardens Irrigated with Water from the FWC Municipal Water (1989 and 1990)

CDPH evaluated whether perchlorate could be absorbed by fruits and vegetables if FWC municipal water in 1989 from June through October and in 1990 from June through November was used to irrigate private garden plants.

The U.S. Food and Drug Administration (FDA) has detected perchlorate in commercial fruits and vegetables irrigated with water containing perchlorate. Research investigating perchlorate exposure from food crops produced in the lower Colorado River region has shown that green leafy vegetables tend to uptake and store more perchlorate than other fruits and vegetables [34]; however, there is limited data concerning perchlorate uptake rates and perchlorate storage concentration of specific fruit and vegetable species. According to Yu et al., uptake rates of perchlorate and threshold concentration or the maximum amount of perchlorate plants can store in their vascular plant tissue will greatly differ based on the plant species [35]. In 1989 from June through October and in 1990 from June through November, perchlorate could have been present in vegetables and fruits of private gardens watered by FWC municipal water. However, CDPH could not further investigate this pathway due to the lack of sufficient data concerning how much perchlorate specific fruits or vegetables will uptake and store.

7.6 Exposure to the City of Rialto's Municipal Water

The City of Rialto obtains water from fourteen groundwater wells, surface streams originating in the San Gabriel Mountains, and water purchased from the California State Water Project and the San Bernardino Valley Municipal Water District [41]. The service area is within the City of Rialto, but does not include the entire city (Appendix B, Figure B25) [42].

Currently, Rialto drinking water is a blend of 67% groundwater and 33% treated surface or purchased water [42]. Water is stored in five reservoirs located throughout the service area. Water is moved as needed to replenish the reservoirs using booster pump stations.
The City of Rialto has detected perchlorate in six municipal wells and TCE in four of those six wells. One or more of these wells contains perchlorate or TCE from the BF Goodrich Site [10]. In October 1997, the City of Rialto detected perchlorate levels in Well No. 02 that were above the then media-specific health comparison value of 18 ppb [43]. The City of Rialto immediately deactivated the well after the detection. From 1997 to 2005, the City of Rialto detected perchlorate in five more municipal wells. The city deactivated each of the five wells after perchlorate was detected. None of the perchlorate was detected above the media-specific health comparison value. Two of the wells, Chino Well No. 02 and Chino Well No. 01, were modified with a perchlorate treatment system and reactivated for use as a potable water source in October 2003 (Chino Well No. 02) and December 2004 (Chino Well No. 01).

Table 3 provides an overview of the City of Rialto wells investigated by CDPH in this document that have been affected by perchlorate and/or TCE.

Table 3. City of Rialto Wells Affected by Perchlorate or Trichloroethylene (TCE), Rialto, California

City of Rialto Well (Status as of 1/2011)	Year Perchlorate First Detected	Year TCE First Detected	Raw Water has Exceeded Media-Specific Health Comparison Value?*	Perchlorate Treatment (Yes/No)	Well Information
Rialto Well No. 01 **(Off-line)**	2003	2003	Yes (perchlorate)	No	Off-line in 9/2005 due to perchlorate.
Rialto Well No. 02 **(Off-line)**	1997	1994	Yes (perchlorate) Yes (TCE)	No	Off-line in 10/1997 due to perchlorate.
Rialto Well No. 04 **(Off-line)**	2002	2006	Yes (perchlorate) No (TCE)	No	Off-line in 11/2002 due to perchlorate.
Rialto Well No. 06 **(Off-line)**	2000	2001	Yes (perchlorate) Yes (TCE)	No	Off-line in 10/2000 due to perchlorate.
Chino Well No. 01 **(On-line)**	1998	2001	Yes (perchlorate) No (TCE)	Yes	Off-line in 1/2002 due to perchlorate; on-line in 12/2004 with perchlorate treatment system.
Chino Well No. 02 **(On-line)**	2001	1998	Yes (perchlorate) No (TCE)	Yes	Off-line in 1/2002 due to perchlorate; on-line in 10/2003 with treatment system.

Source [43,44]

**Media-specific health comparison values- See Table 1 for perchlorate values; MCL for TCE= 5 ppb.*

The City of Rialto modified one of its municipal wells, Rialto Well No. 03, with a perchlorate and VOC treatment system. TCE and perchlorate were detected in monitoring wells located immediately north from the well. The source of the perchlorate and TCE is not believed to have originated from the BF Goodrich Site [45]. Further analysis of this well is beyond the scope of this document.

In October 1997, the City of Rialto detected perchlorate levels of 57 ppb in Rialto Well No. 02 [43]. The concentration was above the then-media-specific health comparison value of 18 ppb and was immediately placed off-line. CDPH reviewed all available data of City of Rialto municipal wells and established that perchlorate was a COC before 1997.

In June 1994, the City of Rialto detected TCE in Rialto Well No. 02 at a concentration of 1.3 ppb. The City of Rialto sampled the well again in December 1995 and December 1996 and found concentrations had increased slightly to 1.7 ppb and 1.8 ppb respectively. None of these concentrations were above the media-specific health comparison value (MCL, 5 ppb). In June 1998, the City of Rialto detected TCE in Rialto Well No. 02 at a concentration of 6.2 ppb, which is above the media-specific health comparison value. However, the City of Rialto deactivated the well in October 1997. On the basis of available information, CDPH determined that there was no completed exposure pathway of TCE from City of Rialto Well No. 02 water.

Prior to 1997, perchlorate was not identified as a concern in California and was therefore not monitored in Rialto. To obtain an estimate of what the perchlorate concentration could have been in City of Rialto Well No. 02 before 1997, CDPH used the only source currently available that models how much perchlorate could have been in the groundwater downgradient from the BF Goodrich Site prior to 1997. This source is a GeoLogic Associates report titled, *Hydrogeologic Model of Perchlorate Transport Conditions in the Northern Rialto-Colton Basin,* which was prepared for the County of San Bernardino. For a detailed explanation of this report, refer to 7.4.1 section of this document.

CDPH utilized the GeoLogic Associates model to estimate the possible exposure risk from Rialto Well No. 02 water. According to the model, the perchlorate plume reached Rialto Well No. 02 groundwater in approximately 1979 at a concentration range of 50-99 ppb [30]. For the next 15 years, the model estimates the possible concentration in Rialto Well No. 02 to be within the range of 50-99 ppb. To be the most health protective, CDPH uses the highest concentration (99 ppb) of perchlorate in estimating doses. The GeoLogic Associates models used by CDPH are presented in Appendix B, Figures B9 through B16.

CDPH calculated adult and child exposure doses to perchlorate from 1979 to 1997. Exposure to perchlorate in water can occur from drinking water, cooking with water and incidental ingestion of water while swimming.

CDPH calculated exposure doses for adults and children by adding the exposure doses resulting from the following activities: drinking and using water for cooking, incidental swallowing from swimming, and swallowing perchlorate from the diet. CDPH compared the total dose with the MRL (health comparison value developed by ATSDR).

When the City of Rialto used Rialto Well No. 02 as a drinking water source from 1979 to 1997, there is no document indicating water was served directly from the wellhead without blending. If Rialto Well No. 02 water was served without blending it would have likely been delivered to residents who lived close to the well. Therefore, to evaluate the exposure risk to perchlorate, CDPH used the most conservative approach, or worst-case scenario, and assumed that water was not blended with other sources prior to consumption.

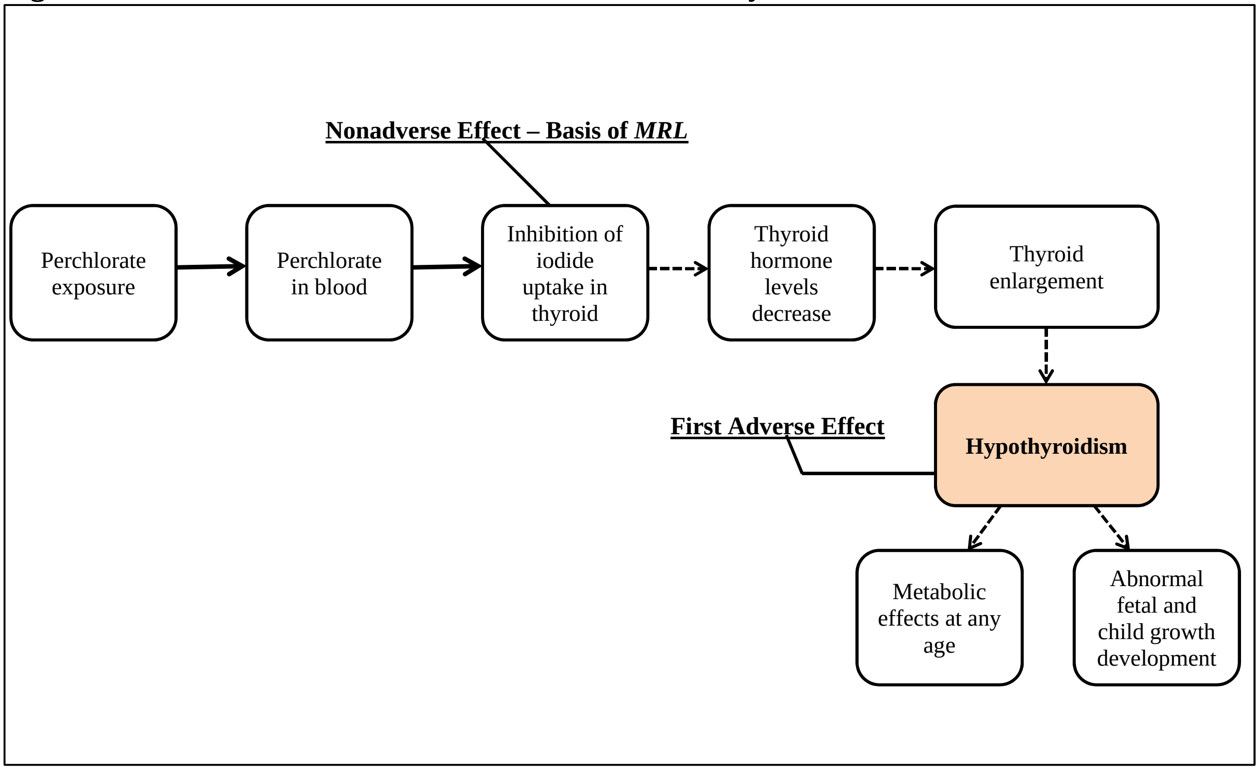
As shown in Appendix C, Table C2, the total estimated perchlorate dose for an adult (0.0029 mg/kg/day) and child dose (0.0064 mg/kg/day) from 1979 to 1997 exceed the MRL of 0.0007 mg/kg/day. CDPH reviewed the basis of the MRL to better understand the likelihood that these doses, which exceed the MRL, may be associated with potentially harmful health effects.

The MRL (0.0007 mg/kg/day) for perchlorate is based on a 2002 adult human study. Adult volunteers swallowed different doses of perchlorate and the researchers looked for the effects that perchlorate had on their thyroid gland’s ability to absorb or uptake iodine. The smallest perchlorate dose that showed a measurable effect on thyroid iodine uptake was 0.007 mg/kg/day. The effect was not statistically significant, and was designated a no-observed-effect level (NOEL).

The 0.007 mg/kg/day NOEL value was used as the basis for the MRL not for demonstrating an adverse health effect, but for signifying the first key event that could potentially precede possible adverse health effects from perchlorate exposure. An uncertainty factor of 10 was applied to the

NOEL to account for sensitive groups, particularly fetuses, infants, children and pregnant or lactating women. Figure 1 below illustrates the process leading to an 'adverse' health effect from perchlorate exposure.

Figure 1: Mode of Action Model of Perchlorate Toxicity in Humans



Source [31]

The adult dose estimated from 1979 to 1997 (0.0029 mg/kg/day) is roughly one-third of the NOEL, and therefore, CDPH determined that perchlorate intake (unblended Rialto Well No. 02 water) is not likely to pose harmful health effects to adult men and adult women who are not pregnant or lactating. A 2006 study by Braverman et al., reported that adults with healthy functioning thyroid glands given perchlorate doses similar to those estimated in this document for a six month period, showed no inhibition of iodine uptake or negative effects on thyroid function [32].

CDPH evaluated the potential health effects for a pregnant or lactating woman by comparing the perchlorate dose with the findings of Clewell et al.

Clewell et al. modeled the percent of thyroid iodine uptake inhibition by perchlorate across life stages. They found that iodine uptake inhibition in a pregnant or lactating woman, as well as a fetus, infant and child, could occur at a dose six to seven times (0.001 mg/kg/day) less than the NOEL (0.007 mg/kg/day) [33].

In the Clewell study, it was determined that a pregnant or lactating woman would have a decrease in iodine uptake by the thyroid gland at the estimated adult perchlorate dose level described above. However, the percent level of decrease (1-10%) would not have a significant clinical effect on normal thyroid hormone levels in pregnant or lactating women [33]. The

Clewell study also concluded that a fetus could have a 1.1-10% decrease in thyroid iodine uptake if the mother received perchlorate at a level equivalent to the dose estimated by CDPH for a pregnant woman.

The findings of Clewell et al., were also used to evaluate the effect for a child. Applying the Clewell et al., findings, CDPH determined that the child perchlorate dose estimated from 1979 to 1997 (0.0064 mg/kg/day) could have resulted in a 0.3 to 3% decrease in iodine uptake by the thyroid gland [33]. Clewell et al., predicted similar to larger decreases of iodine uptake from an equivalent dose for an infant (0.9-8%).

The significance of small percentage decreases in iodine uptake by the thyroid of a fetus, infant and child is not entirely known (i.e., the potential magnitude of effect on thyroid hormone levels due to specific percentage decreases in thyroid uptake of iodine). However, it is well known in the medical profession that thyroid hormone is critical for normal neurological development.

In conclusion, adults, including pregnant and lactating women who drank unblended water from Rialto Well No. 02, would not have experienced adverse health effects from exposure to perchlorate. The estimated level of exposure to a fetus, infant or child could have inhibited iodine uptake by the thyroid gland, leading to lower levels of thyroid hormone and the potential for certain neurological effects. It is important to note that the estimated level of perchlorate used in this evaluation is based on conservative (health-protective) assumptions and likely overestimates the actual level of perchlorate consumed by customers living near Rialto Well No. 02.

What is the Thyroid Gland?

The thyroid gland is a small butterfly-shaped organ in the front of the neck.

The thyroid gland uses iodine from the diet to make thyroid hormones.

Thyroid hormones help maintain the body's metabolism and temperature, and are especially important during pregnancy and childhood because they are necessary for normal physical growth and brain development.

A decrease in thyroid hormone during these stages can cause problems of growth and brain development.

The International Agency for Research has not identified perchlorate to be carcinogenic [23]; therefore, CDPH did not conduct a cancer risk evaluation.

7.6.1 Exposure to Perchlorate from Eating Food Grown in Private Gardens Irrigated with Water from City of Rialto Municipal Water

CDPH evaluated whether perchlorate could be absorbed by fruits and vegetables if unblended water from Rialto Well No. 02 was used to irrigate private garden plants.

The U.S. Food and Drug Administration (FDA) has detected perchlorate in commercial fruits and vegetables irrigated with water containing perchlorate. Research investigating perchlorate exposure from food crops produced in the lower Colorado River region has shown that green leafy vegetables tend to uptake and store more perchlorate than other fruits and vegetables [34]; however, there is limited data concerning perchlorate uptake rates and perchlorate storage concentration of specific fruit and vegetable species. According to Yu et al., uptake rates of perchlorate and threshold concentration or the maximum amount of perchlorate plants can store in their vascular plant tissue will greatly differ based on the plant species [35]. From 1979 to 1997, perchlorate could have been present in vegetables and fruits of private gardens watered by unblended Rialto Well No. 02 water. However, CDPH could not further investigate this pathway due to the lack of sufficient data concerning how much perchlorate specific fruits or vegetables will uptake and store.

7.6.2 Exposures to Perchlorate after 1997 from the City of Rialto's Municipal Water

After 1997, the City of Rialto has monitored all wells for perchlorate and as required, has reported all results to CDPH Division of Drinking Water and Environmental Management. No exposure above health comparison values from City of Rialto public water occurred after 1997. If a well was reported to have a level above the health comparison value, it was immediately taken off-line. If a City of Rialto well is reported to have a value at or above the current laboratory detection limit of 4 ppb, the City of Rialto will place the well off-line as directed in its zero-tolerance perchlorate policy that was implemented in 2005 [46]. Well data are presented in Appendix C, Table C6 and Appendix B, Figures B26-B36.

In conclusion, on the basis of available data, non-cancer adverse health effects should not have occurred in children or adults from exposure to perchlorate in the City of Rialto's municipal water served after 1997.

7.7 Exposure to Perchlorate from the City of Colton's Municipal Water

Currently, the City of Colton obtains water from thirteen groundwater wells and water purchased from both the City of San Bernardino and West Valley Water District [47]. The service area is within the city of Colton (Appendix B, Figure B37). Drinking water is stored and distributed from reservoirs.

The City of Colton has detected perchlorate in three municipal wells, where one or more could contain perchlorate from the BF Goodrich Site [10]. The City of Colton detected perchlorate in two of the three wells, Colton Well No. 15 and Colton Well No. 24, in 1997 and again in 2001 at levels that were below the then media-specific health comparison value of 18 ppb [48]. In March 2002, the City of Colton detected perchlorate in Colton Well No. 17 at levels above the then media-specific health comparison value of 4 ppb and deactivated the well. The City of Colton also deactivated Colton Well No. 15 in March 2002 and Colton Well No. 24 in February 2002 due to the perchlorate detections above the then media-specific health comparison value of 4 ppb (enacted 1/2002) [Mike Medina, General Manager, City of Colton Water Department , personal communication, January 20, 2011]. In October 2003, the City of Colton reactivated all three wells after each were modified with a perchlorate treatment system [48].

The City of Colton has not detected trichloroethylene (TCE) in any of its municipal groundwater wells. Table 4 provides an overview of the wells that have been affected by perchlorate.

Table 4. City of Colton Wells Affected by Perchlorate or Trichloroethylene (TCE), Contamination at the BF Goodrich Site, Rialto, California

City of Colton Well (Status as of 1/2011)	Year Perchlorate First Detected	TCE	Raw Water has Exceeded Media-Specific Health Comparison Values?*	Perchlorate Treatment (Yes/No)	Well Information
Colton Well No. 15 **(On-line)**	1997	Not Detected	Yes (perchlorate)	Yes	Off-line in 3/2002 due to perchlorate; on-line on 10/2003 with perchlorate treatment system.
Colton Well No. 17 **(On-line)**	2002	Not Detected	Yes (perchlorate)	Yes	Off-line in 4/2002 due to perchlorate; on-line on 10/2003 with perchlorate treatment system.
Colton Well No. 24 **(On-line)**	1997	Not Detected	Yes (perchlorate)	Yes	Off-line in 2/2002 due to perchlorate; on-line in 10/2003 with perchlorate treatment system

Source [48]
**Media-specific health comparison values- See Table 1 for perchlorate values; MCL for TCE= 5 ppb.*

Prior to 1997, perchlorate was not identified as a concern in California and was therefore not monitored in Colton. CDPH did not have monitoring or groundwater modeling data to determine what the perchlorate concentrations could have been in Colton Wells No. 15 and 24 before 1997. Therefore, CDPH used the first concentrations of perchlorate detected in both wells in 1997. In November 1997, the City of Colton detected perchlorate in Colton Well No. 24 at 5 ppb [48]. This concentration is below the current MCL (6 ppb) and does not pose a risk to public health. In September 1997, the City of Colton detected perchlorate in Colton Well No. 15 at 7 ppb. This concentration is above the current MCL (6 ppb) and is evaluated further.

Exposure to perchlorate in water could have occurred from drinking water, cooking with water and incidental ingestion of water while swimming.

The City of Colton likely blended Colton Well No. 15 with other wells and surface water where perchlorate contamination was not found. However, the City of Colton has no records detailing if Colton Well No. 15 water was blended in 1997. City of Colton Well No. 15 water could have been served directly from the wellhead unblended. If water was served without blending, it would have likely been delivered to residents who lived close to the well. Therefore, to evaluate the exposure risk to perchlorate, CDPH used the most conservative approach, or worst-case scenario and assumed that water was not blended with other sources prior to consumption.

CDPH estimated adult and child exposure doses to perchlorate using the concentration detected in September 1997 of 7 ppb.

CDPH calculated exposure doses for adults and children by adding the exposure doses resulting from the following activities: drinking and using water for cooking, incidental swallowing from swimming, and swallowing perchlorate from the diet. CDPH compared the total dose with the MRL (health comparison value developed by ATSDR).

The total estimated perchlorate dose for an adult (0.00020 mg/kg/day) or child (0.00045 mg/kg/day) does not exceed the MRL of 0.0007 mg/kg/day and thus not expected to cause non-cancer adverse health effects.

In conclusion, on the basis of available data, non-cancer adverse health effects should not have occurred in children or adults from exposure to perchlorate in the City of Colton's municipal water that was served in 1997.

7.7.1 Exposure to Perchlorate from Eating Food Grown in Private Gardens Irrigated with City of Colton Municipal Water

CDPH evaluated whether perchlorate could be absorbed by fruits and vegetables if unblended water from City of Colton Well No. 15 was used to irrigate private garden plants in 1997.

The U.S. Food and Drug Administration (FDA) has detected perchlorate in commercial fruits and vegetables irrigated with water containing perchlorate. Research investigating perchlorate exposure from food crops produced in the lower Colorado River region has shown that green leafy vegetables tend to uptake and store more perchlorate than other fruits and vegetables [34]; however, there is limited data concerning perchlorate uptake rates and perchlorate storage concentration of specific fruit and vegetable species. According to Yu et al., uptake rates of perchlorate and threshold concentration or the maximum amount of perchlorate plants can store in their vascular plant tissue will greatly differ based on the plant species [35]. Prior to 1997, perchlorate could have been present in vegetables and fruits of private gardens watered by unblended Colton Well No. 15. However, CDPH could not further investigate this pathway due to the lack of sufficient data concerning how much perchlorate specific fruits or vegetables will uptake and store.

7.7.2 Exposure to Perchlorate after 1997 from the City of Colton Water System

After detecting perchlorate in Colton Wells No. 15 and 24 in 1997, the City of Colton continued to monitor all wells for perchlorate. In March 2002, the city detected perchlorate in Colton Well 17 at 9.4 ppb, above the then media-specific comparison value of 4 ppb (enacted 1/2002) and deactivated the well [48]. In the same year, the city deactivated Colton Wells No. 15 and 24 after it detected perchlorate above 4 ppb. Colton Well No. 15 was deactivated in March, Colton Well No. 24 in February. In October 2003, all three wells were reactivated after perchlorate treatment systems were installed.

The City of Colton regularly sampled Colton Well No. 15 after September 1997. In March 2002, the city deactivated the well after detecting perchlorate at 5.7 ppb, which was above the then media-specific health comparison value of 4 ppb [48]. From September 1997 to March 2002, the city had collected 10 water samples. The majority of perchlorate detections were either non-detects (<4 ppb) or 5 ppb and the highest detection was 7.8 ppb (September 2001). Comparison values used in determining human health effects from drinking perchlorate are based on exposures occurring for at least one year or longer (chronic). CDPH averaged the ten perchlorate concentrations to evaluate the chronic risk from drinking Colton Well No. 15 water from September 1997 to March 2002. The average concentration of perchlorate is 5.5 ppb. This concentration is less than the current drinking water standard and thus perchlorate is not a considered a COC.

The City of Colton regularly sampled Colton Well No. 24 after September 1997. In February 2002, the City deactivated Colton Well No. 24 after detecting perchlorate at 4.5 ppb, above the then media-specific health comparison of 4 ppb [48]. From September 1997 to February 2002, the city had collected five samples. The majority of perchlorate detections were 4.5 ppb, and the highest detection was 6 ppb (September 2001). CDPH averaged the five perchlorate concentrations to evaluate the chronic risk from drinking Colton Well No. 24 water from September 1997 to February 2002. The average concentration of perchlorate is 4.8 ppb. This concentration is less than the current drinking water standard and thus perchlorate is not considered a COC.

The City of Colton detected perchlorate in Colton Well 17 in March 2002 first at 9.2 ppb and after re-sampling, at 9.4 ppb [48]. This resulted in the city deactivating the well. From September 1997 to March 2002, the city had sampled the well a total of seven times. All samples were non-detect until March 2002. CDPH averaged the five perchlorate concentrations to evaluate the chronic risk from drinking Colton Well No. 17 water from September 1997 to February 2002. The average concentration of perchlorate is 5.5 ppb. This concentration is less than the current drinking water standard and thus perchlorate is not considered a COC.

In conclusion, on the basis of available data, non-cancer adverse health effects should not have occurred in children or adults from exposure to perchlorate in the City of Colton's municipal water served after 1997.

Data showing results of perchlorate testing for each well listed above can be found in Appendix C, Table C7, and Appendix B, Figures B38-B40.

8.0 Limitations of Evaluation

The identification and analysis of environmental exposure is difficult and inexact. This PHA was prepared using different sources of information. There are differing amounts of uncertainty associated with each source of information. Described below are three examples of some of these uncertainties.

8.1 Environmental Data Limitations

CDPH relied on information provided by the EPA, the Office of Environmental Health Hazard Assessment, the CDPH Division of Drinking Water and Environmental Management, the U.S. Food and Drug Administration, the West Valley Water District, the City of Rialto, the City of Colton, the Fontana Water Company, the California Cancer Registry, GeoLogic Associates, and the ENVIRON Corporation. CDPH assumes that quality control measures were adequately followed with regard to chain of custody, laboratory procedures, and data reporting. The validity of the analysis and conclusions reported in this PHA depend on the completeness and reliability of the referenced information. There are data gaps in understanding past exposure which can no longer be filled.

8.2 Exposure Assessment Limitations

CDPH used exposure assumptions to estimate exposure doses. The exposure assumptions used in the PHA are meant to provide conservative (health-protective) results for the exposure estimates.

CDPH estimated past exposure doses using GeoLogic's modeled perchlorate concentration in groundwater. The GeoLogic modeled concentrations are a range of perchlorate values. CDPH estimated possible exposure doses from drinking perchlorate from 1979-1997 using the upper range values of GeoLogic's modeled perchlorate concentrations. If the mid or lower end GeoLogic modeled perchlorate concentration in groundwater values are used, instead of the upper end, to estimate the same doses, the dose quantities would decrease by 20-40%. These lower dose quantities would still exceed the predicted exposure dose levels modeled by Clewell et.al, which could cause inhibition of iodine into the thyroid gland to the same sensitive populations, i.e., the CDPH findings in this document would not change.

The GeoLogic modeled perchlorate concentrations in groundwater imply that large levels of perchlorate had reached the WVWD Well No. 22 in the 1980s. However the measured perchlorate concentrations collected from WVWD Well No. 22 from 1997 to 2000 suggest that large levels of perchlorate could have first impacted the well in the 1990's. The average perchlorate measured in 1997 is 298 ppb, in 1999 is 621 ppb, and in 2000 is 760 ppb.

CDPH assumed that tap water is the only water source when estimating exposure doses. CDPH did not consider alternative sources, such as bottled water, that could have had lower or no levels of perchlorate. It should be noted, that food testing by the U.S. Food and Drug Administration in 2004 did find low levels of perchlorate in bottled water [49].

8.3 Limitations Chemical Toxicity Information

Toxicity information for the COCs was generated mostly from limited human adult studies for perchlorate and high-dose animal studies for TCE. We really do not know what effects result from low-level human exposure.

9.0 Community Health Concerns and Evaluation

9.1 Introduction and Purpose

The collection, documentation, and responses to community health and exposure concerns are a vital part of the PHA process. This section describes outreach efforts and characterizes past and present exposure and health concerns reported to CDPH. In addition, this section includes an evaluation of the community's health concerns based on available scientific literature and is within the framework and limitations of the PHA.

9.1.1 Process for Gathering Current Community Health Concerns

CDPH staff gathered community health and exposure concerns in person and via telephone beginning in December 2009. CDPH coordinated outreach activities with EPA. In December 2009, CDPH and EPA held a community meeting in the City of Rialto. CDPH and EPA included an announcement of this meeting in the water bills of the different water utilities companies of the Cities of Rialto, Colton and Fontana. More than 168,000 customers received the announcement with their water bills. The meeting was also announced on television channels and/or websites of the Cities of Fontana, Rialto, and Colton, and through other community stakeholders.

In January 2010, CDPH hosted a public availability meeting for residents to listen to their health and exposure concerns about the BF Goodrich Site and contamination. CDPH collaborated with a community group to outreach to residents living near the BF Goodrich Site.

9.1.2 Exposure Concerns

The concerns expressed by community members were centered on water usage and water quality. People were concerned that they may have come in contact with perchlorate by drinking, showering, and cooking from municipal water. Community members were also concerned about the health of pets from drinking public water and the safety of their plants and vegetables watered with public water. Community members were also concerned about public water leaving a "white residue" on hard surfaces.

The community members that CDPH met with expressed distrust of both their local government and water supplier. They related a disbelief that their water is safe to drink, despite reassurances from city officials and their water company.

9.1.3 Evaluation of Community Exposure Concerns

CDPH evaluated environmental data, specifically the drinking water quality data, and found there is no current exposure to perchlorate or TCE in public water at levels of health concern for adults, children, or animals. Public water is safe to drink, bathe with, use for cooking, share with pets, and water plants.

Health Effects from Chemical Exposure

It is important to note that the current scientific understanding of exposure to chemicals and related health effects is limited. Most of the information has been derived from studies on animals or workers who have received much higher levels of exposure than typically seen at sites where environmental contamination exists. This is further complicated by the fact that most studies look at chemicals on an individual basis, not as mixtures (exposure to multiple chemicals). These limitations add uncertainty to the conclusions about potential health impact as a result of exposure to contaminants.

The "white residue" concern is likely a result of "hard water." Water that contains high levels of minerals—usually calcium and magnesium—is often referred to as "hard water" [50]. Hard water leaves a white deposit or residue on surfaces it comes in contact with, such as windows, faucets, showers, etc. Water hardness is a common condition that does not represent a health risk. The World Health Organization noted that there is no convincing evidence linking water hardness to adverse health effects in humans [51].

9.1.4 *Health Concerns*

The health concerns gathered from community members by CDPH include both noncancer and cancer effects. The noncancer concerns were thyroid malfunction, migraines, attention deficit hyperactivity disorder (ADHD), allergies, skin rashes, delayed speech development in children, miscarriages, stillbirths, and congenital anomalies. The cancer concerns were kidney cancer in humans and tumors in fish living in artificial or home-made ponds.

CDPH evaluated community health concerns by investigating their known causes, including environmental or chemical agents. CDPH could not establish a direct connection between the health concerns expressed by community members and contaminants from the BF Goodrich Site for the following reasons: the toxicological information on chemicals is limited; there is limited understanding of the effects from exposure to multiple chemicals; and there are many factors that contribute to the causation of a disease, making it almost impossible to identify a specific or single factor, such as an environmental exposure. Table 5 below presents the community concerns into cancer and noncancer effects.

Table 5. Cancer and Noncancer Health Concerns and Effects Reported to CDPH

Cancer Concerns/Effects	**Noncancer Concerns/Effects**
Kidney cancer Tumors in fish	Attention Deficit Hyperactivity Disorder (ADHD) Allergies Congenital anomalies Migraines Miscarriages Skin rashes Speech delay Stillbirths Thyroid disorders

9.1.5 *Evaluation of Community Health Concerns*

CDPH evaluated potential environmental links to the illnesses expressed by community members by conducting database searches for scientific publications. CDPH also reviewed reports from recognized authoritative organizations about the diseases of concern and potential linkages between these diseases and exposure to trichloroethylene and perchlorate.

9.1.5.1 Cancer

The community concerns about cancer centered on kidney cancer. The kidneys are a pair of organs located in the lower abdomen, on either side of the spinal column. They are part of the urinary tract and remove waste and extra water from the blood, turning this excess into urine

[52]. Several types of cancer can start in the kidney; the most common type in adults is called renal adenocarcinoma or hypernephroma, which is a cancer that begins in the lining of the renal tubules in the kidney, and the transitional cell carcinoma, which begins in the renal pelvis (where the kidneys meet the ureter). In children, Wilms' tumor is the most common type of kidney cancer [52]. Cancer of the kidneys occurs most often in people over 40. The causes of kidney cancer are unknown, but some risk factors include smoking, obesity, high blood pressure, long-term use of dialysis, Von Hippel-Lindau syndrome (a disease that runs in some families), occupational exposure to chemicals such as asbestos and cadmium, and even gender, as males are more likely to be diagnosed with kidney cancer than females [52]. There is limited information suggesting a possible association between exposure to trichloroethylene and kidney cancer [53]. However, the available cancer slope factors used for estimating increased cancer risks are based on the occurrence of liver cancer in animals. Thus, we are unable to estimate the increased risk of developing kidney cancer.

Perchlorate is not listed on the State of California's Office of Environmental Health Hazard Assessment Proposition 65 (Prop 65) list as being a carcinogen and thus, according to the State of California, exposure to perchlorate is not considered to be associated with kidney cancer [54]. Similarly, EPA has classified perchlorate as not likely to be carcinogenic to humans [15] .

CDPH did not find information detailing the exact cause of tumors in fish. Some lumps or raised areas in the bodies of fish are caused by bacteria or parasites. Other fish may develop cysts or fluid-filled lumps caused by an injury or for unknown reasons [55].

Noncancer health effects

9.1.5.2 Attention Deficit Hyperactivity Disorder (ADHD)

ADHD is a common childhood disorder that can continue through adolescence and adulthood. Symptoms include difficulty focusing and paying attention, difficulty controlling behavior, hyperactivity, inattentiveness, and impulsivity. ADHD causes are unknown, but studies have linked ADHD to food additives, such as artificial colors and preservatives, genes, and exposure to lead during early life [56]. ADHD has also been associated with exposures to polychlorinated biphenyls (PCBs) and alcohol [57].

ATSDR developed a minimal risk level (MRL) of 0.2 mg/kg/day, for trichloroethylene (TCE) based on behavioral changes in mouse offspring from 7 days of ingestion TCE starting at day 10 after birth. Supporting evidence for the MRL came from an animal study in which rat offspring had increased exploratory behavior after maternal ingestion of trichloroethylene before conception, during gestation, and weaning [58]. The dose levels in the mouse studies were all considerably higher than the exposure levels related to BF Goodrich; however, since the effects were seen at all the dose levels used in the mouse study, it is not clear if increased exploratory behavior would occur at lower doses of trichloroethylene, such as those that occurred from exposure from the BF Goodrich contamination.

CDPH did not find an association between perchlorate exposure and ADHD in published peer reviewed literature or reported by any authoritative body [15,59,60].

9.1.5.3 Allergies

Allergic and immunologic diseases are very common chronic conditions that affect 50 million people living in the U.S. An allergy is a reaction by the body's immune system to many common and nontoxic substances (also called 'allergens') that people can be exposed to from breathing, swallowing, or skin contact. Some allergens include pollen, mold spores, dust mites, foods, medications, and insect stings. Allergic symptoms may be mild, moderate or severe. Mild symptoms include sneezing, watery and/or itchy eyes, and a constant runny nose. Moderate allergic reactions may include symptoms that spread to other parts of the body, such as itchiness or difficulty breathing. A severe reaction (anaphylaxis) is a life-threatening emergency in which the allergic reaction is sudden and affects the entire body.

CDPH did not find an association between TCE or perchlorate exposure and allergies in published peer reviewed literature or reported by any authoritative body [15,59,60].

9.1.5.4 Congenital Anomalies

Congenital anomalies, which are also commonly called 'structural birth defects,' are physical defects or problems that occur in the developing fetus. One of every 33 babies born in America has some type of structural birth defect. In the United States, congenital anomalies are the leading cause of infant death [61]. Birth defects vary from mild to severe and can affect the way the body looks, works, or both. Most birth defects are diagnosed at birth, such as cleft lip or palate, spina bifida, Down syndrome, or limb defects, while others are diagnosed after medical testing, such as heart defects or hearing loss.

Prenatal exposure to substances such as tobacco smoke, alcohol or drugs can cause some congenital anomalies. Other birth defects are caused by infections during pregnancy. Anesthetic gases and ionizing radiation are associated with congenital anomalies [62]. However, the causes of most birth defects are unknown [63].

Trichloroethylene or perchlorate are not listed on the State of California Prop 65 list as being developmental toxicants, therefore, exposure to perchlorate or trichloroethylene is not considered to be associated with congenital anomalies [54].

9.1.5.5 Migraines

A migraine is a type of severe headache. Migraines are typically characterized by pulsating or throbbing pain on one side of the head, and can be accompanied by nausea, vomiting, and sensitivity to light, sound or movement, and visual disturbances [64]. Migraines are three times more common in women than in men [65].

CDPH did not find an association between TCE or perchlorate exposure and migraines in published peer reviewed literature or reported by any authoritative body [15,23,25,59,60,66].

9.1.5.6 Miscarriages

A miscarriage, also called a ‘spontaneous abortion’, is defined as the spontaneous loss of a fetus before the 20th week of pregnancy. Some causes for miscarriages include chromosome or hormone problems, infections, lack of prenatal care, physical problems with the mother’s reproductive organs, and chronic diseases of the mother, such as diabetes. Women who are older than 35 or who have a history of miscarriages are at risk of miscarriages. Exposures to anesthetic gases, alcohol, ethylene glycol ethers, ethylene oxide, ionizing radiation, nicotine, and tobacco smoke are associated with toxic effects to the fetus, which can include miscarriage [62].

ATSDR concludes, “based on available evidence, exposure to trichloroethylene in air, water, or soil at hazardous waste sites is not expected to adversely affect human reproduction” [25].

CDPH did not find an association between perchlorate exposure and stillbirths in published peer reviewed literature or reported by any authoritative body [15,23,59,60,67].

9.1.5.7 Skin Rashes

Contact dermatitis, including both irritant and allergic contact dermatitis, is the most common cause of skin rashes. Irritant contact dermatitis is caused by skin exposure with an irritating substance, such as kerosene. Allergic contact dermatitis is caused by exposure to allergens, such as poison oak, certain medications, rubber or latex, detergents, perfumes, some fabrics, and some metals.

CDPH did not find an association between TCE and perchlorate exposure and skin rashes in published peer reviewed literature or reported by any authoritative body [15,23,25,59,60,68].

9.1.5.8 Speech Delay

Children who reach speaking milestones at a later age than expected may be considered to have a speech delay problem. Most children will start saying their first words at 18-24 months of age and their first phrases before their third birthday. Risk factors for speech delay include hearing loss, brain lesions, seizures, mental retardation, emotional disorders, bilingualism, and late maturation [69].

CDPH did not find an association between TCE exposure and speech delay in published peer reviewed literature or reported by any authoritative body [15,25,59,60].

Perchlorate exposure can potentially affect the development of the fetus, infant, and child because of its potential to inhibit iodine uptake by the thyroid gland which could result in a lowering of thyroid hormone levels in a fetus, infant and child. Thyroid hormone is important in both in utero and early childhood development. As previously described in Section 7.4.2 fetuses, infants and children who were exposed to unblended water from the West Valley Water District municipal Well No. 22 during the periods of May to October of 1981, 1982, 1985, 1987, and 1988 or the City of Rialto’s Well No. 02 from 1979 to 1997 could have ingested perchlorate. Studies suggest that the perchlorate concentrations comparable to those estimated in those time periods, could have inhibited iodine uptake by the thyroid gland of fetuses, infants and children

[33]. Interference with iodine uptake in fetuses, infants and children can potentially lead to lower thyroid hormone levels, which is critical for normal growth and development including speech.

With the exception of the water purveyors and time periods referenced above, municipal water served by the water purveyors discussed in this document would not have had perchlorate at levels high enough to cause health effects, including speech delay.

9.1.5.9 Stillbirths

A stillbirth is defined as fetal death after 20 weeks of pregnancy or at birth. Causes for stillbirth include birth defects, chromosomal abnormalities, infection in the mother or fetus, hemorrhage, cardiac arrest, uterine problems, or medical conditions in the mother such as diabetes, epilepsy or hypertension. However, 25 to 35% of stillbirths do not have an explanation [70]. Exposure to anesthetic gases, alcohol, ethylene glycol ethers, ethylene oxide, ionizing radiation, nicotine, and tobacco smoke are associated with toxic effects to the fetus, which can include miscarriage [62].

ATSDR concludes, “based on available evidence, exposure to trichloroethylene in air, water, or soil at hazardous waste sites is not expected to adversely affect human reproduction” [25].

CDPH did not find an association between perchlorate exposure and stillbirths in published peer reviewed literature or reported by any authoritative body [15,23,59,60,70].

9.1.5.10 Thyroid Disorders

The thyroid is a gland located at the base of the neck, just above the chest. The thyroid makes hormones that regulate growth and how the body uses energy [71]. Common thyroid disorders include hypothyroidism (an underactive thyroid gland), hyperthyroidism (an overactive thyroid gland), thyroid nodules (lumps in the thyroid gland), cancer, thyroiditis (swelling of the thyroid gland), or goiter (enlargement of the thyroid gland) [72]. Known causes of thyroid disorders include autoimmune disease, surgical removal of part or all the thyroid gland, radiation treatment, congenital hypothyroidism, thyroiditis, some medicines (such as amiodarone, lithium, interferon alpha, and interleukin-2) that interfere with the thyroid gland’s ability to effectively produce hormones, increased or decreased consumption of iodine, or damage to the pituitary gland [73]. The cause of an individual’s thyroid problem is often not known.

Perchlorate can inhibit iodine uptake into the thyroid, altering the thyroid’s ability to make thyroid hormone, potentially causing a disruption in the thyroid hormone balance [74]. As previously described in Section 7.4.2, the highest exposure level estimated for the community surrounding the BF Goodrich Site from 1979 to 1997 would not have caused thyroid disorders in healthy adults. A 2006 study by Braverman et al., reported that adults with healthy functioning thyroid glands given perchlorate doses similar to those estimated in this document for a six month period, showed no inhibition of iodine uptake or negative effects on thyroid function [32]. However, as previously described in Section 7.4.2 fetuses, infants and children who were exposed to unblended water from the West Valley Water District municipal Well No. 22 during the periods of May to October of 1981, 1982, 1985, 1987, and 1988 or the City of Rialto’s Well No. 02 from 1979 to 1997 could have ingested perchlorate in water. Studies suggest that the perchlorate concentrations comparable to those estimated in those time periods, could have inhibited iodine uptake by the thyroid gland of fetuses, infants and children [33]. Interference with iodine uptake in fetuses, infants and children can potentially affect the thyroid gland by disrupting thyroid hormone production.

With the exception of the water purveyors and time periods referenced above, municipal water served by the water purveyors discussed in this document would not have had perchlorate at levels high enough to cause health effects, including effects to the thyroid gland.

CDPH did not find an association between TCE exposure and thyroid disorders in published peer reviewed literature or reported by any authoritative body [15,25,59,60,71].

10.0 Children's Health Considerations

CDPH and ATSDR recognize that, in communities with contaminated water, soil, air, or food (or all of these combined, depending on the substance and the exposure situation), infants and children can be more sensitive than adults to chemical exposures. This sensitivity results from several factors: 1) children might have higher exposures to environmental toxins than adults because, pound for pound of body weight, children drink more water, eat more food, and breathe more air than adults; 2) children play indoors and outdoors close to the ground, which increases their exposure to toxins in dust, soil, surface water, and ambient air; 3) children have a tendency to put their hands in their mouths, thus potentially swallowing contaminated soil particles at higher rates than adults (some children even exhibit an abnormal behavior known as "pica," which causes them to swallow non-food items, such as soil); 4) children's bodies are rapidly growing and developing, and they can sustain permanent damage if toxic exposures occur during critical growth stages; and 5) children and teenagers disregard no trespassing signs and wander onto restricted property more readily than adults. Children were considered in the pathways evaluated in this PHA.

11.0 Conclusions

CDPH evaluated the ways (exposure pathways) people could have come into contact with contaminants from the BF Goodrich Site. All conclusions were based on site visits and review of all available data and reports. The conclusions of this evaluation are presented below.

1. CDPH and ATSDR conclude that employees currently working on the BF Goodrich Site could possibly be exposed to perchlorate and TCE but the amounts are below levels of health concern.

2. CDPH and ATSDR conclude that drinking public municipal water from the West Valley Water District, City of Rialto, City of Colton, and Terrace Water Company after 1997 may have resulted in exposure to TCE or perchlorate, but these exposures are not expected to cause any adverse health effects.

3. CDPH and ATSDR conclude that exposure to TCE in the West Valley Water District municipal well, WVWD Well No. 22, prior to 1997, would not have resulted in adverse non-cancer health effects. The estimated theoretical increased cancer risk for a child was 2 in 1,000,000 and 1 in 1,000,000 for an adult.

4. CDPH and ATSDR conclude that from May to October of 1981, 1982, 1985, 1987, and 1988, drinking unblended water from the West Valley Water District municipal well, WVWD Well No. 22, would not have resulted in adverse health effects in adults. Drinking unblended water from this well could have inhibited the uptake of iodine by the thyroid gland in fetuses, infants and children. The significance of this potential inhibition is not known. Inhibition of iodine uptake can result in lowering the level of thyroid hormone in fetuses, infants and children, potentially impairing neurological and growth development. Potential exposure to unblended water would have been limited to residents who lived near WVWD Well No. 22, as water from this well may not have been blended with other water sources.

5. CDPH and ATSDR conclude that, from June to October of 1989 and June to November of 1990, drinking municipal water from the Fontana Water Company would not be expected to have caused adverse health effects.

6. CDPH and ATSDR conclude that, from 1979 to 1997, drinking unblended water from the City of Rialto municipal Well No. 02 would not have resulted in adverse health effects in adults. Drinking unblended water from this well could have inhibited the uptake of iodine by the thyroid gland in fetuses, infants and children. The significance of this potential inhibition is not known. Inhibition of iodine uptake can result in lowering thyroid hormone levels in fetuses, infants and children, potentially impairing their growth and development. Potential exposure to unblended water would have been limited to residents who lived near Well No. 02, as water from this well may not have been blended with other water sources.

7. CDPH and ATSDR conclude that in 1997, drinking unblended municipal water from the City of Colton’s Well No. 15 would not be expected to have caused adverse health effects.

8. CDPH and ATSDR could not estimate exposure from eating fruits or vegetables grown in a private garden irrigated with perchlorate-contaminated water due to insufficient information.

CDPH conducted outreach activities to collect and understand the health concerns community members believe are related to contamination at the BF Goodrich Site. In the PHA, CDPH researched data to identify whether there is published literature to support associations between perchlorate and TCE to expressed health concerns.

12.0 Recommendations

- CDPH and ATSDR recommend that the groundwater contamination from the site continue to be characterized. (EPA)

- CDPH and ATSDR recommend that actions be taken to prevent exposures to contaminants in the two former burn pits. (EPA or local regulatory agency)

- CDPH and ATSDR recommend that actions be taken to prevent exposures to groundwater contaminated at the BF Goodrich Site.

- CDPH and ATSDR recommend that groundwater continued to be monitored and evaluated so that if needed, appropriate actions to prevent exposure can be implemented.

- Adults who were children or infants and lived near West Valley Water District's Well No. 22 during the 1980s or the City of Rialto's Well No. 02 from 1979 to 1997, and who have concerns about their potential exposures and possible health impacts should consult their health-care provider.

13.0 Public Health Action Plan

The Public Health Action Plan (PHAP) for this site contains a description of actions to be taken, or under consideration by ATSDR and CDPH or others, at or near the site. The purpose of the PHAP is to ensure that this PHA not only identifies public health hazards, but also provides a plan of action designed to mitigate and prevent adverse human health effects resulting from exposure to hazardous substances in the environment. Below is a list of the completed and ongoing actions.

13.1 Actions Completed

- CDPH gathered community concerns through public availability meetings with local residents and community groups (December 2, 2009 and January 13, 2010).

- CDPH held a public meeting informing community members about the public health process. (December 2, 2009).

- EPA added the BF Goodrich Site to the National Priorities List (September 23, 2009).

- EPA held a public meeting informing community members of its proposed plan to begin cleanup of contaminated groundwater (February 10, 2010). EPA accepted comments on its proposed plan (March 8, 2010).

- EPA adopted a plan to begin cleanup of contaminated groundwater at the BF Goodrich Site (September 30, 2010).

13.2 Ongoing Actions

- CDPH will disseminate the findings of this PHA and discuss the results in a future public meeting.

- CDPH will continue to provide health outreach in English and Spanish to the community and nearby business owners as needed.

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Certification

This public health assessment, Evaluation of Exposure to Contamination at the BF Goodrich Superfund Site, Rialto, San Bernardino County, California, was prepared by the California Department of Public Health under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the public health assessment was begun. Editorial review was conducted by the cooperative agreement partner.

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The Division of Public Health Assessment and Consultation, ATSDR, has reviewed this health consultation and concurs with the findings.

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Appendix A. Glossary of Terms

Absorption
How a chemical enters a person's blood after the chemical has been swallowed, has come into contact with the skin, or has been breathed in.

Acute Exposure
Contact with a chemical that happens once or only for a limited period of time. ATSDR defines acute exposures as those that might last up to 14 days.

Adverse Health Effect
A change in body function or the structures of cells that can lead to disease or health problems.

ATSDR
The Agency for Toxic Substances and Disease Registry (ATSDR) is a federal public health agency with headquarters in Atlanta, Georgia, and ten regional offices in the United States. ATSDR's mission is to serve the public by using the best science, taking responsive public health actions, and providing trusted health information to prevent harmful exposures and diseases related to toxic substances. ATSDR is not a regulatory agency, unlike the U.S. Environmental Protection Agency, which is the federal agency that develops and enforces environmental laws to protect the environment and human health.

Aquitard
A geologic layer that is incapable of transmitting large amounts of water under normal hydraulic conditions.

Aquifer
A saturated formation that contains permeable material to yield significant amounts of water for wells and springs

Background Level
An average or expected amount of a chemical in a specific environment or amounts of chemicals that occur naturally in a specific environment.

California Human Health Screening Levels (CHHSLs)
Cal/EPA CHHSLs are screening levels for chemicals in soil and soil gas used to aid in clean-up decisions based on the protection of public health and safety

California State Water Project (SWP)
The SWP is a state-built water storage and delivery system consisting of reservoirs, lakes, hydroelectric plants, and several hundred miles of open canal. Monitored by the California Department of Water Resources, the SWP conveys water to approximately 20 million people and 650,000 acres of irrigated farmland

Cancer Risk
The potential for exposure to a contaminant to cause cancer in an individual or population is evaluated by estimating the probability of an individual developing cancer over a lifetime as the result of the exposure. This approach is based on the assumption that there are no absolutely "safe" toxicity values for carcinogens. The U.S. Environmental Protection Agency and the California Environmental Protection Agency have developed cancer slope factors and inhalation unity risk factors for many carcinogens.

A slope factor is an estimate of a chemical's carcinogenic potency, or its potential for causing cancer.

If adequate information about the level of exposure, frequency of exposure, and length of exposure to a particular carcinogen is available, an estimate of excess cancer risk associated with the exposure can be calculated using the slope factor for that carcinogen. Specifically, to obtain risk estimates, the estimated chronic exposure dose (which is averaged over a lifetime or 70 years) is multiplied by the slope factor for that carcinogen.

Cancer risk is the theoretical chance of getting cancer. In California, 41.5% of women and 45.4% of men (about 43% combined) will be diagnosed with cancer in their lifetime. This is referred to as the "background cancer risk." The term "excess cancer risk" represents the risk above and beyond the "background cancer risk." A "one-in-a-million" excess cancer risk from a given exposure to a contaminant means that if one million people are chronically exposed to a carcinogen at a certain level, over a lifetime, then one cancer above the background risk may appear in those million persons from that particular exposure. For example, in a million people, it is expected that approximately 430,000 individuals will be diagnosed with cancer from a variety of causes. If the entire population was exposed to the carcinogen at a level associated with a one-in-a-million cancer risk, 430,001 people may get cancer, instead of the expected 430,000.
Cancer risk numbers are a quantitative or numerical way to describe a biological process (development of cancer). In order to take into account the uncertainties in the science, the risk numbers used are plausible upper limits of the actual risk, based on conservative assumptions.

Chronic Exposure
A contact with a substance or chemical that happens over a long period of time. The Agency for Toxic Substances and Disease Registry considers exposures of more than 1 year to be chronic.

Concern
A belief or worry that chemicals in the environment might cause harm to people.

Concentration
How much or the amount of a substance present in a certain amount of soil, water, air, or food.

Contaminant
See Environmental Contaminant.

CREG (ATSDR's Cancer Risk Evaluation Guide for 1 in 1,000,000 increased cancer risk)
CREGS are screening values for air, soil and water, developed by ATSDR. To derive water and soil CREGs, ATSDR uses CSFs developed by the U.S. Environmental Protection Agency and reported in the Integrated Risk Information System (IRIS). The IRIS summaries, available at http://www.epa.gov/iris, provide detailed information about the derivation and basis of the CSFs for individual substances. ATSDR derives CREGs for lifetime exposures, and therefore uses exposure parameters that represent exposures as an adult. An adult is assumed to consume 2 liters per day of water and weigh 70 kilograms. For soil, ATSDR assumes a soil swallowing rate of 100 milligram per day, for a lifetime (70 years) of exposure.

Like EMEGs, water CREGs are derived for potable water used in homes, including water used for drinking, cooking, and food preparation. Soil CREGs apply only to soil that is swallowed.

A theoretical increased cancer risk is calculated by multiplying the dose and the cancer slope factor. When developing CREGs, the target risk level (10^{-6}), which represents a theoretical risk of one excess cancer case in a population of one million, and the CSF are known. The calculation seeks to find the substance concentration and dose associated with this target risk level.

Dermal Contact
A chemical getting onto your skin. See Route of Exposure.

Dose
The amount of a substance to which a person may be exposed, usually on a daily basis. Dose is often explained as the "amount of substance(s) per body weight per day."

Downgradient
In a direction toward which groundwater flows; similar to downstream for surface water.

Duration
The amount of time (days, months, and years) that a person is exposed to a chemical.

EMEG (ATSDR's Environmental Media Evaluation Guide)
EMEGs are screening values based on noncancer health endpoints, developed by ATSDR. EMEGS have been developed for air, soil and water. Water EMEGs are derived for potable water used in homes. Potable water includes water used for drinking, cooking, and food preparation. Exposures to substances that volatilize from potable water and are breathing, such as volatile organic compounds, released during showering, are not considered when deriving EMEGs.

To derive water EMEGs, ATSDR uses the chronic oral MRLs from the Toxicological Profiles; available at http://www.atsdr.cdc.gov/toxprofiles/index.asp . Ideally, the MRL is based on an experiment in which the chemical was administered in water. However, in the absence of such data, an MRL based on an experiment in which the chemical was administered by gavage or in food may have been used. The Toxicological Profiles for individual substances provide detailed information about the MRL and the experiment on which it was based.

Children are usually assumed to constitute the most sensitive segment of the population. Water intake per unit of body weight is greater than the adults' rate. An EMEG for a child is calculated assuming a daily water swallowing rate of 1 liter per day for a 10-kilogram child. For adults, an EMEG is calculated assuming a daily water swallowing rate of 2 liters per day and a body weight of 70 kg.

For soil EMEGS, ATSDR uses the chronic oral MRLs from its Toxicological Profiles. Many chemicals bind tightly to organic matter or silicates in the soil. Therefore, the bioavailability of a chemical is dependent on the media in which it is administered. Ideally, an MRL for deriving a soil EMEG should be based on an experiment in which the chemical was administered in soil. However, data from this type of study is seldom available. Therefore, often ATSDR derives soil EMEGs from MRLs based on studies in which the chemical was administered in drinking water, food, or by gavage using oil or water as the vehicle. The Toxicological Profiles for individual substances provide detailed information about the MRL and the experiment on which it was based.

Children are usually assumed to be the most highly exposed segment of the population because their soil ingestion rate is greater than adults' rate. Experimental studies have reported soil ingestion rates for children ranging from approximately 40 to 270 milligrams per day, with 100 milligrams per day representing the best estimate of the average intake rate. ATSDR calculates an EMEG for a child using a daily soil ingestion rate of 200 milligrams per day for a 10-kg child.

Environmental Contaminant
A substance (chemical) that gets into a system (person, animal, or environment) in amounts higher than those found in Background Level, or what would be expected.

Environmental Media
Usually refers to the air, water, and soil in which chemicals of interest are found. Sometimes refers to the plants and animals that are eaten by humans. Environmental Media is the second part of an Exposure Pathway.

Exposure
Coming into contact with a chemical substance. For the three ways people can come in contact with substances, see Route of Exposure.

Exposure Assessment
The process of finding the ways people come in contact with chemicals, how often, and how long they come in contact with chemicals, and the amounts of chemicals with which they come in contact.

Exposure Frequency
How often a person is exposed to a chemical overtime; for example, every day, once a week, or twice a month.

Exposure Pathway
A description of the way that a chemical moves from its source (where it began), to where, and how people can come into contact with (or get exposed to) the chemical. ATSDR defines an exposure pathway as having five parts: 1) a source of contamination, 2) an environmental media and transport mechanism, 3) a point of exposure, 4) a route of exposure, and 5) a receptor population. When all five parts of an exposure pathway are present, it is called a Completed Exposure Pathway.

Hazard Index
The sum of the Hazard Quotients (see below) for all contaminants of concern identified, to which an individual is exposed. If the Hazard Index (HI) is calculated to be less than 1, then no adverse health effects are expected as a result of exposure. If the Hazard Index is greater than 1, then adverse health effects are possible. However, an HI greater than 1 does not necessarily suggest a likelihood of adverse effects. The HI cannot be translated to a probability that adverse effects will occur, and is not likely to be proportional to risk.

Hazard Quotient
The ratio of estimated site-specific exposure to a single chemical from a site over a specified period to the estimated daily exposure level, at which no adverse health effects are likely to occur. If the Hazard Quotient is calculated to be less than 1, then no adverse health effects are expected as a result of exposure. If the Hazard Quotient is greater than 1, then adverse health effects are possible. The Hazard Quotient cannot be translated to a probability that adverse health effects will occur, and is unlikely to be proportional to risk. It is especially important to note that a Hazard Quotient exceeding 1 does not necessarily mean that adverse effects will occur.

Hazardous Waste
Substances that have been released or thrown away into the environment and, under certain conditions, could be harmful to people who come into contact with them.

Health Comparison Value
Media-specific concentrations that are used to screen contaminants for further evaluation.

Health Effect
ATSDR deals only with Adverse Health Effects (see definition in this glossary).

Hydrology
The science that deals with global water.

Ingestion
Swallowing something, as in eating or drinking. It is a way a chemical can enter your body (see Route of Exposure).

Inhalation
Breathing. It is a way a chemical can enter your body (see Route of Exposure).

LOAEL (Lowest-Observed-Adverse-Effect Level)
LOAEL is the lowest dose of a chemical in a study (animals or people), or group of studies, that produces statistically or biologically significant increases in the frequency or severity of adverse effects between the exposed population and its appropriate control.

Noncancer Evaluation, ATSDR's Minimal Risk Level (MRL), U.S. EPA's Reference Dose (RfD) and Reference Concentration (RfC), and California EPA's Reference Exposure Level (REL)
MRL, RfD, RfC, and REL are estimates of daily exposure to the human population (including sensitive subgroups), below which noncancer adverse health effects are unlikely to occur. MRL, RfD, RfC, and REL only consider noncancer effects. Because they are based only on information currently available, some uncertainty is always associated with MRL, RfD, RfC, and REL. “Uncertainty” factors are used to account for the uncertainty in our knowledge about their danger. The greater the uncertainty, the greater the “uncertainty” factor and the lower MRL, RfD, RfC, or REL.

When there is adequate information from animal or human studies, MRLs and RfDs are developed for the ingestion exposure pathway and RELs, MRLs and RfCs are developed for the inhalation exposure pathway.

Separate noncancer toxicity values are also developed for different durations of exposure. ATSDR develops MRLs for acute exposures (less than 14 days), intermediate exposures (from 15 to 364 days), and for chronic exposures (greater than 1 year). The California EPA develops RELs for acute (less than 14 days) and chronic exposure (greater than 1 year). EPA develops RfDs and RfCs for acute exposures (less than 14 days), and chronic exposures (greater than 7 years). Both MRL and RfD for ingestion are expressed in units of milligrams of contaminant per kilograms body weight per day (mg/kg/day). REL, RfC, and MRL for inhalation are expressed in units of milligrams per cubic meter (mg/m^3).

NOAEL (No-observed-Adverse-Effect-Level)
NOEL is the highest dose of a chemical at which there were no statistically or biologically significant increases in the frequency or severity of adverse effects seen between the exposed population (animals or people) and its appropriate control. Some effects may be produced at this dose, but they are not considered adverse, nor precursors to adverse effects.

NOEL (No-Observed -Effect-Level)
NOEL is the highest dose of a chemical at which there were no statistically or biologically significant increases in the frequency of effects seen between the exposed population (animals or people) and its appropriate control. Some effects may be produced at this dose, but they are not considered adverse, nor precursors to adverse effects.

PHA (Public Health Assessment)
A report or document that looks at chemicals at a hazardous waste site and determines if people could be harmed from coming into contact with those chemicals. The PHA also recommends possible further public health actions if needed.

Plume
A line or column of air or water containing chemicals moving from the source to areas further away. A plume can be a column or clouds of smoke from a chimney, contaminated underground water sources, or contaminated surface water (such as lakes, ponds, and streams).

Point of Exposure
The place where someone can come into contact with a contaminated environmental medium (air, water, food, or soil). For example, the area of a playground that has contaminated dirt, a contaminated spring used for drinking water, the location where fruits or vegetables are grown in contaminated soil, or the backyard area where someone might breathe contaminated air.

Population
A group of people living in a certain area or the number of people in a certain area.

PRG (U.S. Environmental Protection Agency's Preliminary Remediation Goals)
PRGs, now known as Regional Screening Levels, are tools for evaluating and cleaning up contaminated sites. They are risk-based concentrations that are intended to assist risk assessors and others in initial screening-level evaluations of environmental measurements.

Public Health Hazard Categories (ATSDR)

Depending on the specific properties of the contaminant(s), the exposure situations, and the health status of individuals, a public health hazard may occur. Using data from public health assessments, sites are classified using one of the following public health hazard categories:

Urgent Public Health Hazard

This category applies to sites that have certain physical hazards or evidence of short-term (less than 1 year), site-related exposure to hazardous substances that could result in adverse health effects. These sites require quick intervention to stop people from being exposed. ATSDR will expedite the release of a health advisory that includes strong recommendations to immediately stop or reduce exposure to correct or lessen the health risks posed by the site.

Public Health Hazard

This category applies to sites that have certain physical hazards or evidence of chronic (long-term, more than 1 year), site-related exposure to hazardous substances that could result in adverse health effects. ATSDR will make recommendations to stop or reduce exposure in a timely manner to correct or lessen the health risks posed by the site. ATSDR may recommend any of the following public health actions for sites in this category:

- Cease or further reduce exposure (as a preventive measure)
- Community health/stress education
- Health professional education
- Community health investigation

Indeterminate Public Health Hazard

This category applies to sites where critical information is lacking (missing or has not yet been gathered) to support a judgment regarding the level of public health hazard. ATSDR will make recommendations to identify the data or information needed to adequately assess the public health risks posed by this site.

No Apparent Public Health Hazard

This category applies to sites where exposure to site-related chemicals might have occurred in the past or is still occurring, but the exposures are not at levels likely to cause adverse health effects.

No Public Health Hazard

This category applies to sites where no exposure to site-related hazardous substances exists. ATSDR may recommend community health education for sites in this category. For more information, consult Chapter 9 and Appendix H in the 2005 ATSDR Public Health Assessment Guidance Manual available at http://www.atsdr.cdc.gov/HAC/PHAManual/.

Qualitative Description of Estimated Increased Cancer Risks

Quantitative Risk Estimate	Qualitative Interpretation
Less than 1 in 100,000	No apparent increased risk
1 in 100,000 to 9 in 100,000	Very low increased risk
1 in 10,000 to 9 in 10,000	Low increased risk
1 in 1,000 to 9 in 1,000	Moderate increased risk
Greater than 9 in 1,000	High increased risk

Receptor Population
People who live or work in the path of one or more chemicals, and who could come into contact with them (see Exposure Pathway).

RMEG (Reference Dose Media Evaluation Guides)
ATSDR develops RMEGs using EPA's reference doses (RfDs), available at http://www.epa.gov/iris, and default exposure assumptions, which account for variations in intake rates between adults and children. EPA's reference concentrations (RfCs), available at http://www.epa.gov/iris, serve as RMEGs for air exposures. Like EMEGs, RMEGs represent concentrations of substances (in water, soil, and air) to which humans may be exposed without experiencing adverse health effects. RfDs and RfCs consider lifetime exposures, therefore RMEGs apply to chronic exposures.

Route of Exposure
The way a chemical can get into a person's body. There are three exposure routes: 1) breathing (also called inhalation), 2) eating or drinking (also called ingestion), and 3) getting something on the skin (also called dermal contact).

Sensitive Populations
People who may be more sensitive to chemical exposures because of certain factors such as age, sex, occupation, a disease they already have, or certain behaviors (cigarette smoking). Children, pregnant women, and older people are often considered special populations.

Soil Gas
Gas in the small spaces between particles of soil beneath the soil surface.

Source (of Contamination)
The place where a chemical comes from, such as a smokestack, landfill, pond, creek, incinerator, tank, or drum. Contaminant source is the first point of an exposure pathway.

Toxic
Harmful. Any substance or chemical can be toxic at a certain dose (amount). The dose determines the potential harm of a chemical and whether it would cause someone to get sick.

Toxicology
The study of harmful effects of chemicals on humans or animals.

Vapor Intrusion
The movement of volatile chemicals and gases from the soil and groundwater into the indoor air of overlying buildings.

Volatile Organic Compounds (VOCs)
Substances containing carbon and different proportions of other elements such as hydrogen, oxygen, fluorine, chlorine, bromine, sulfur, or nitrogen. These substances easily volatilize (become vapors or gases) into the atmosphere. A significant number of VOCs are commonly used as solvents (paint thinners, lacquer thinner, degreasers, and dry-cleaning fluids).

Appendix B. Figures

Figure B1. Location of BF Goodrich Site Showing Approximate Locations of Municipal Wells, BF Goodrich Site, Rialto, California

Source [1]

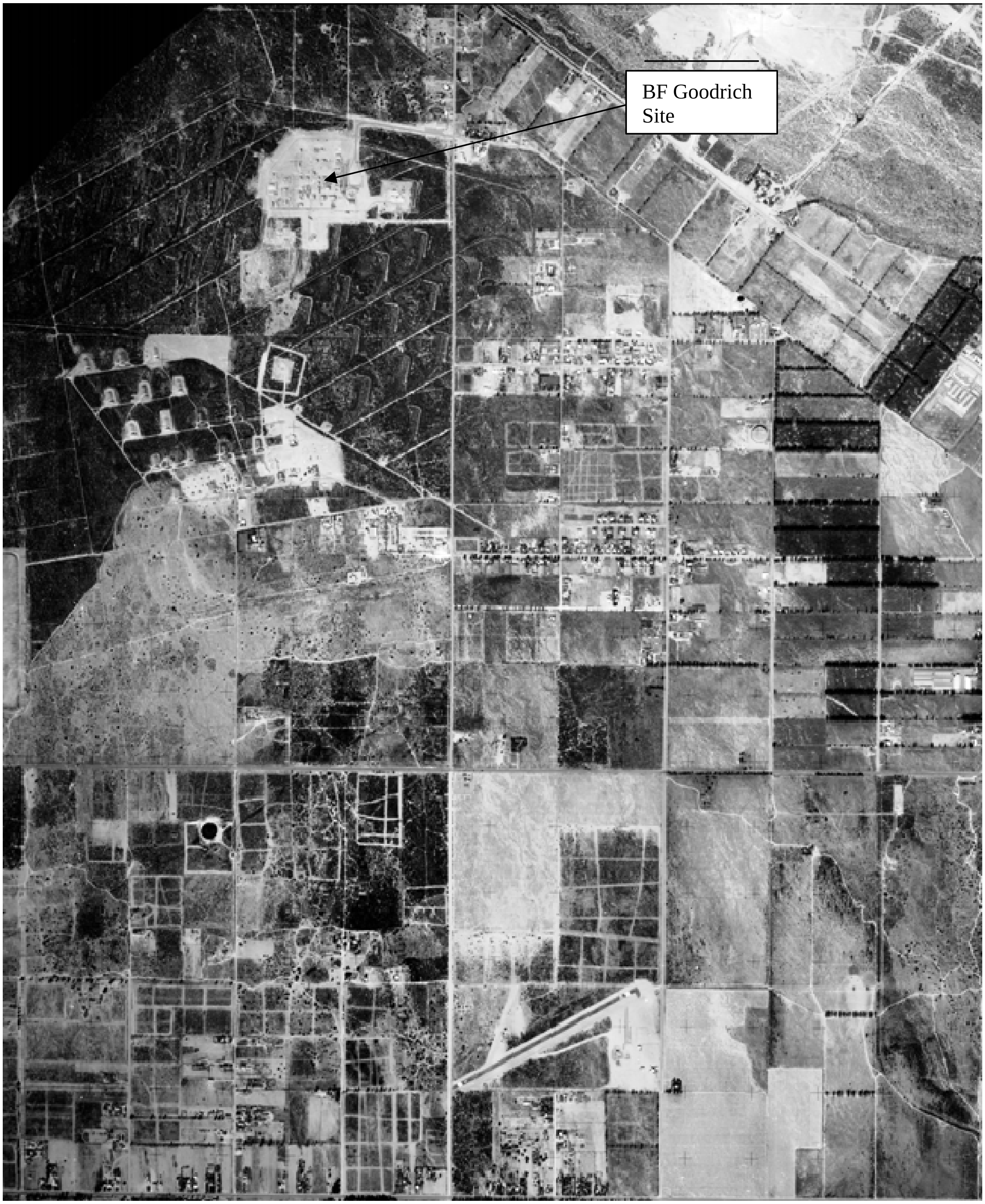
Figure B2. BF Goodrich Site Showing Former Burn Pits and Current Onsite and Nearby Companies, BF Goodrich Site, Rialto, California

Source [1,75]

Figure B3. Aerial Photo from 1953 Showing the BF Goodrich Site, BF Goodrich Site, Rialto, California

Source [45]

Figure B4. Aerial Photo from 1966 Showing the Bf Goodrich Site, BF Goodrich Site, Rialto, California



Source [45]

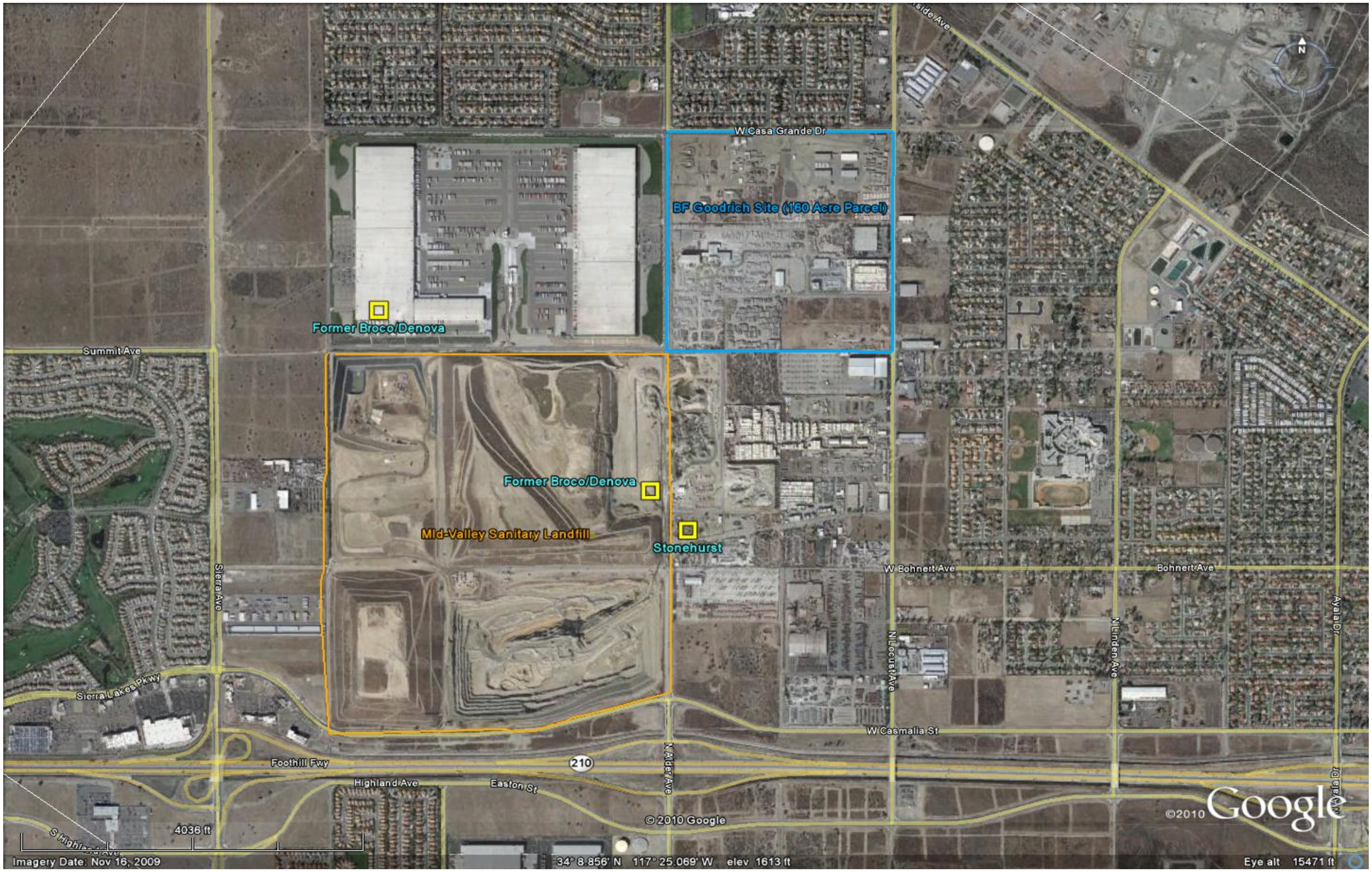
Figure B5. Aerial Photo from 1994 Showing the BF Goodrich Site, BF Goodrich Site, Rialto, California

Source [45]

Figure B6. Aerial Photo from 2002 Showing BF Goodrich Site, BF Goodrich Site, Rialto, California

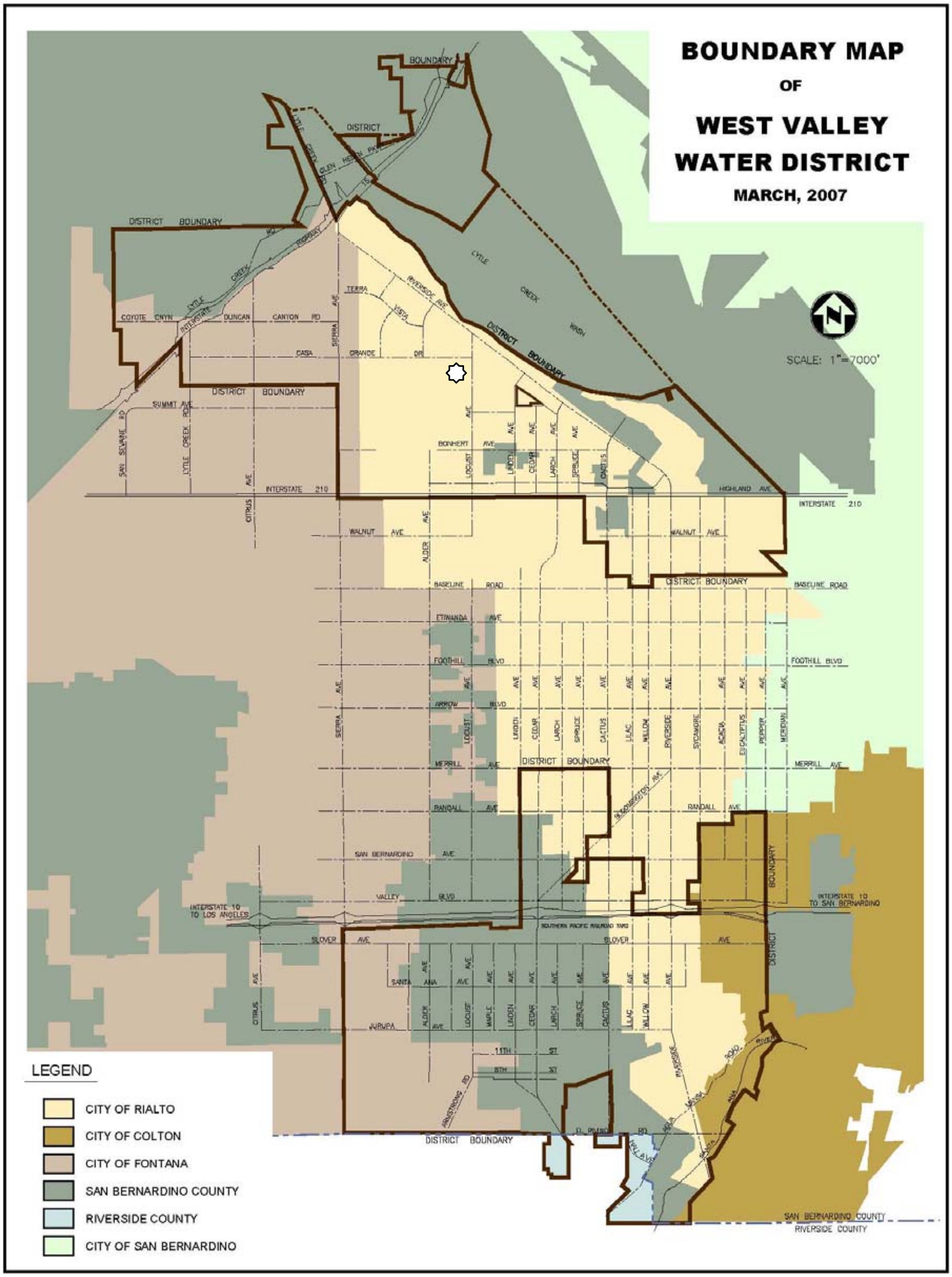
Source [45]

Figure B7. Hazardous Waste Sites Located Near the BF Goodrich Site, Rialto, California



Source [45]

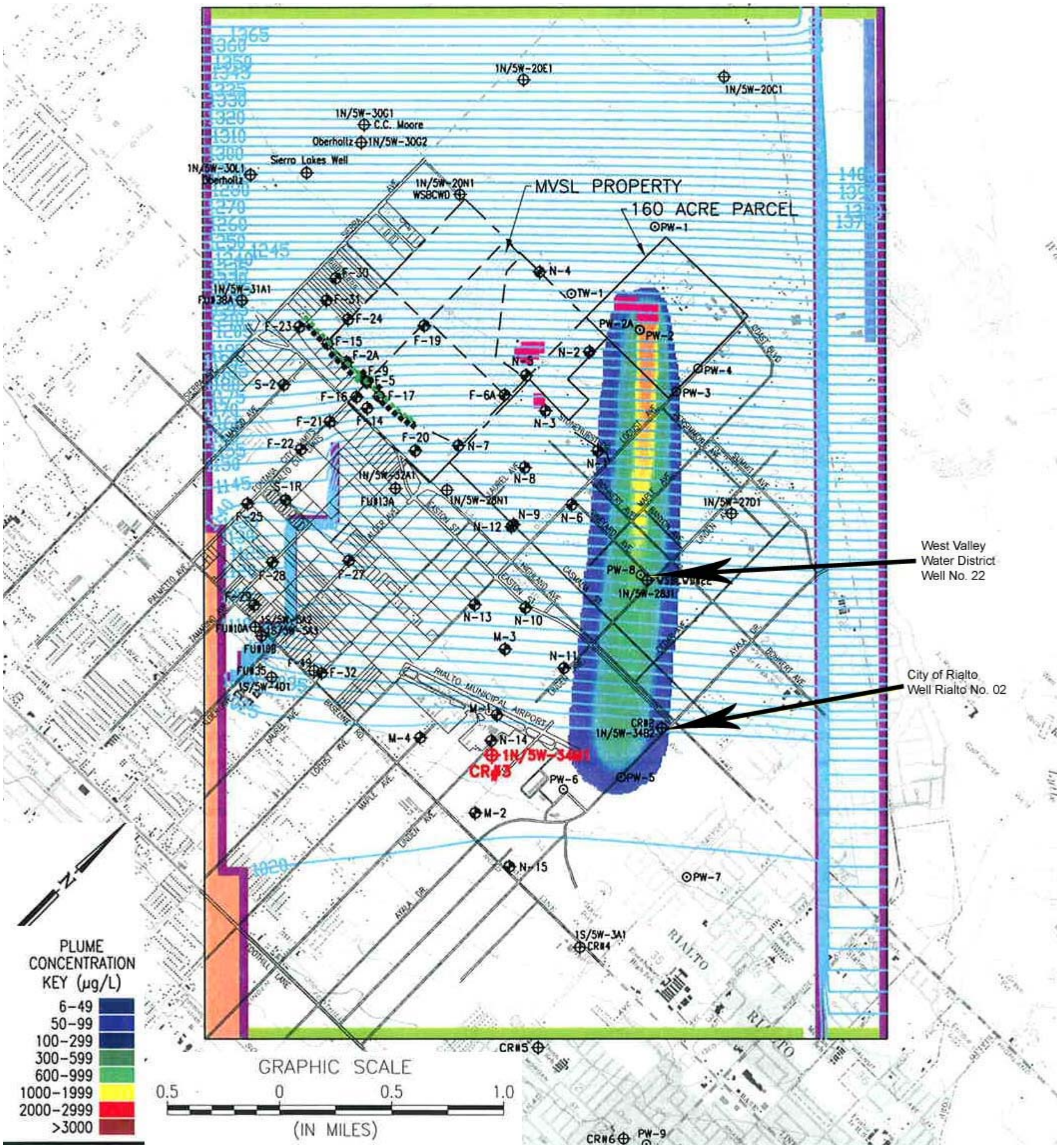
Figure B8. West Valley Water District Service Area, BF Goodrich Site, Rialto, California



Source [27]

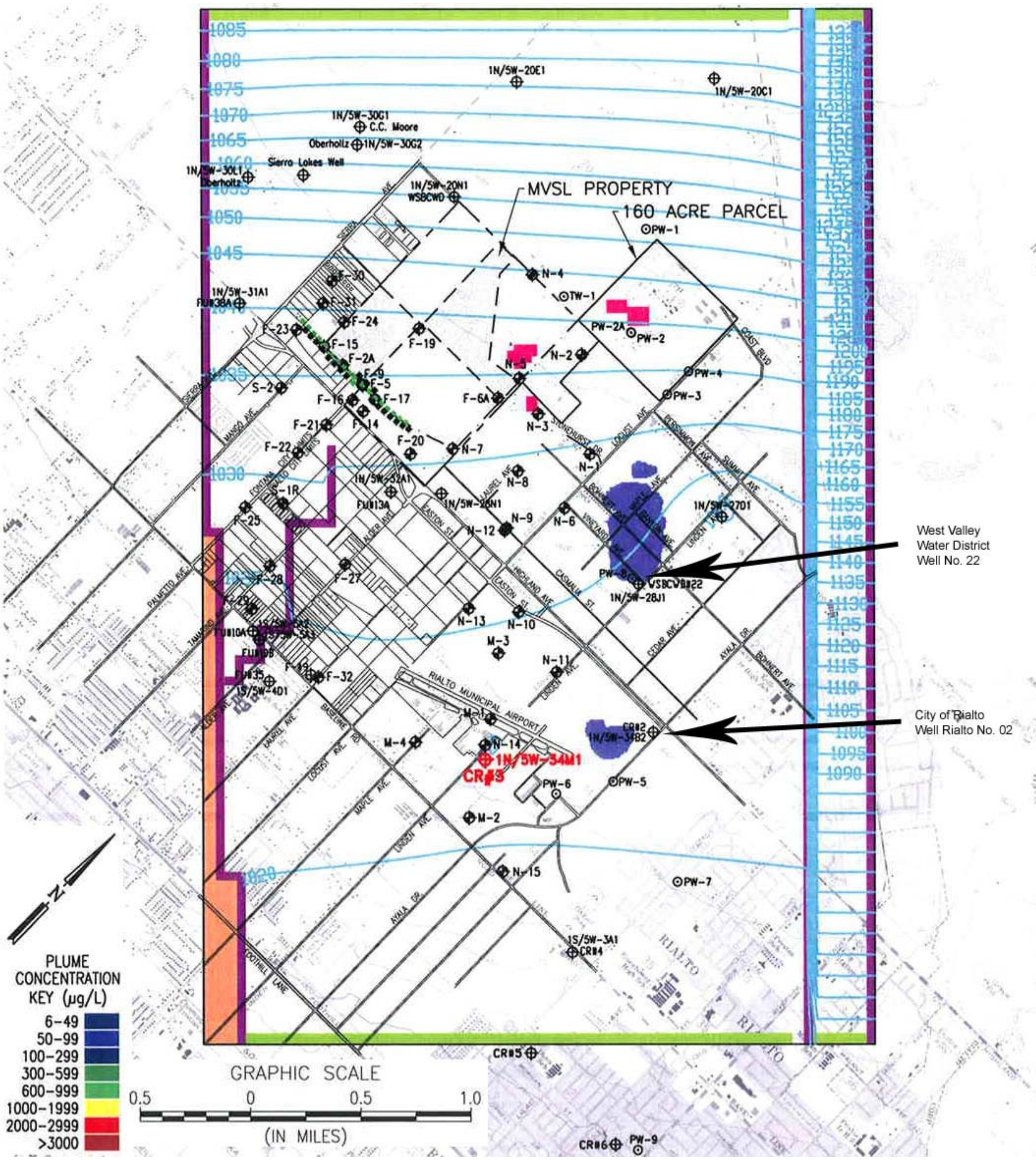
BF Goodrich Site

Figure B9. GeoLogic Associates Model of Possible Perchlorate Concentrations, Intermediate Aquifer, 1980, BF Goodrich Site, Rialto, California



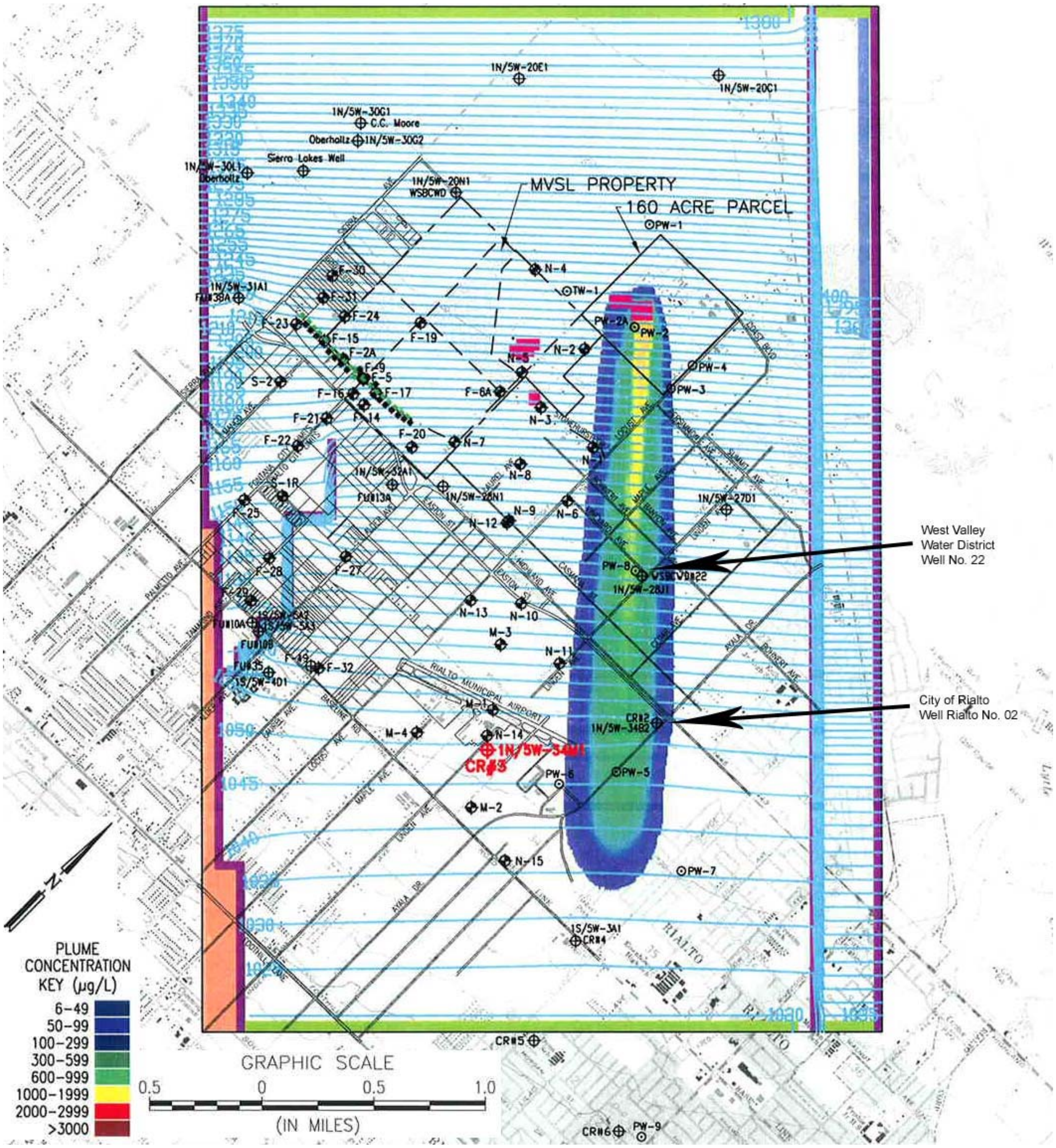
Source [30]

Figure B10. GeoLogic Associates Model of Possible Perchlorate Concentrations, Regional Aquifer, 1980, BF Goodrich Site, Rialto, California



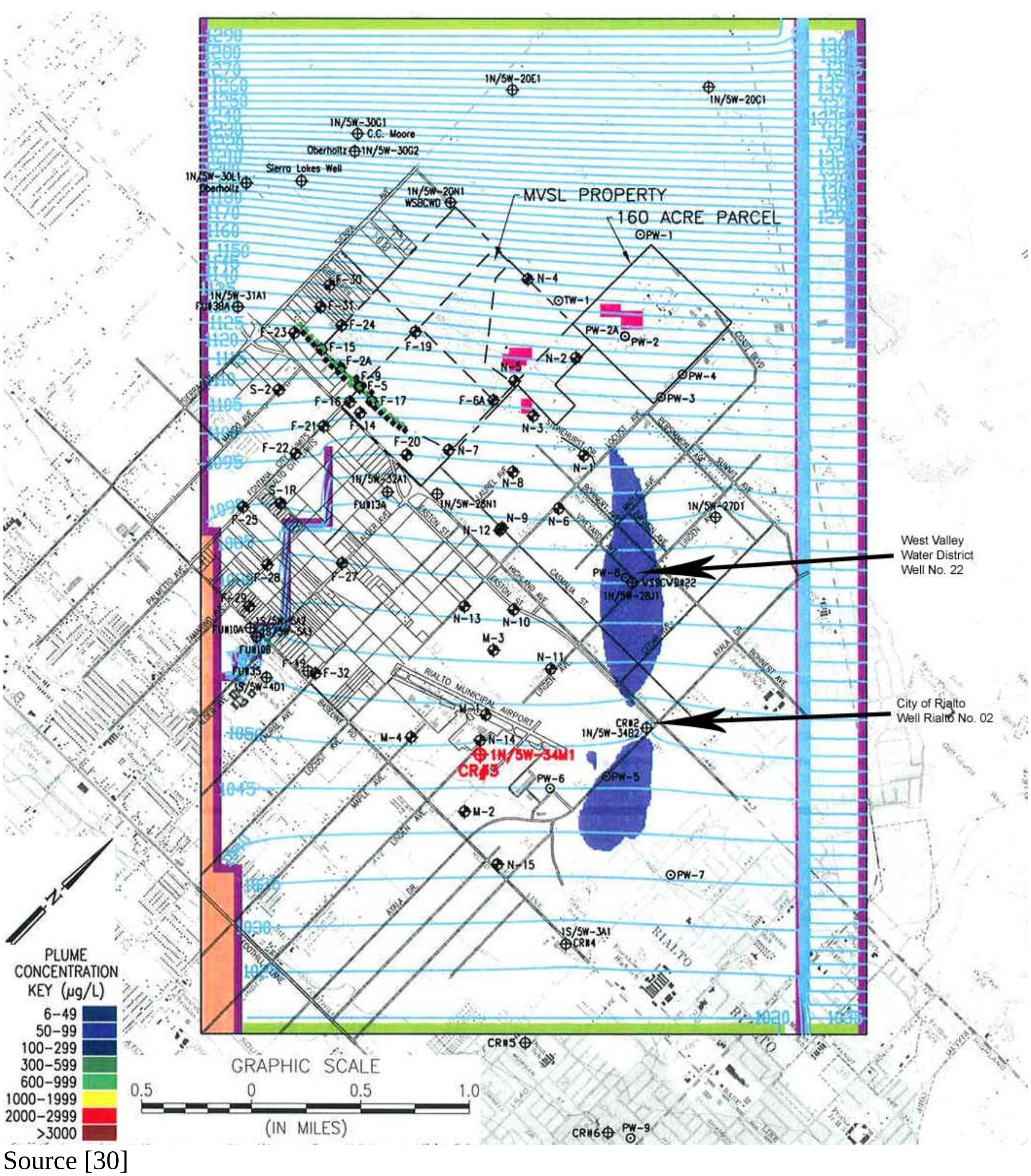
Source [30]

Figure B11. GeoLogic Associates Model of Possible Perchlorate Concentrations, Intermediate Aquifer, 1985, BF Goodrich Site, Rialto, California



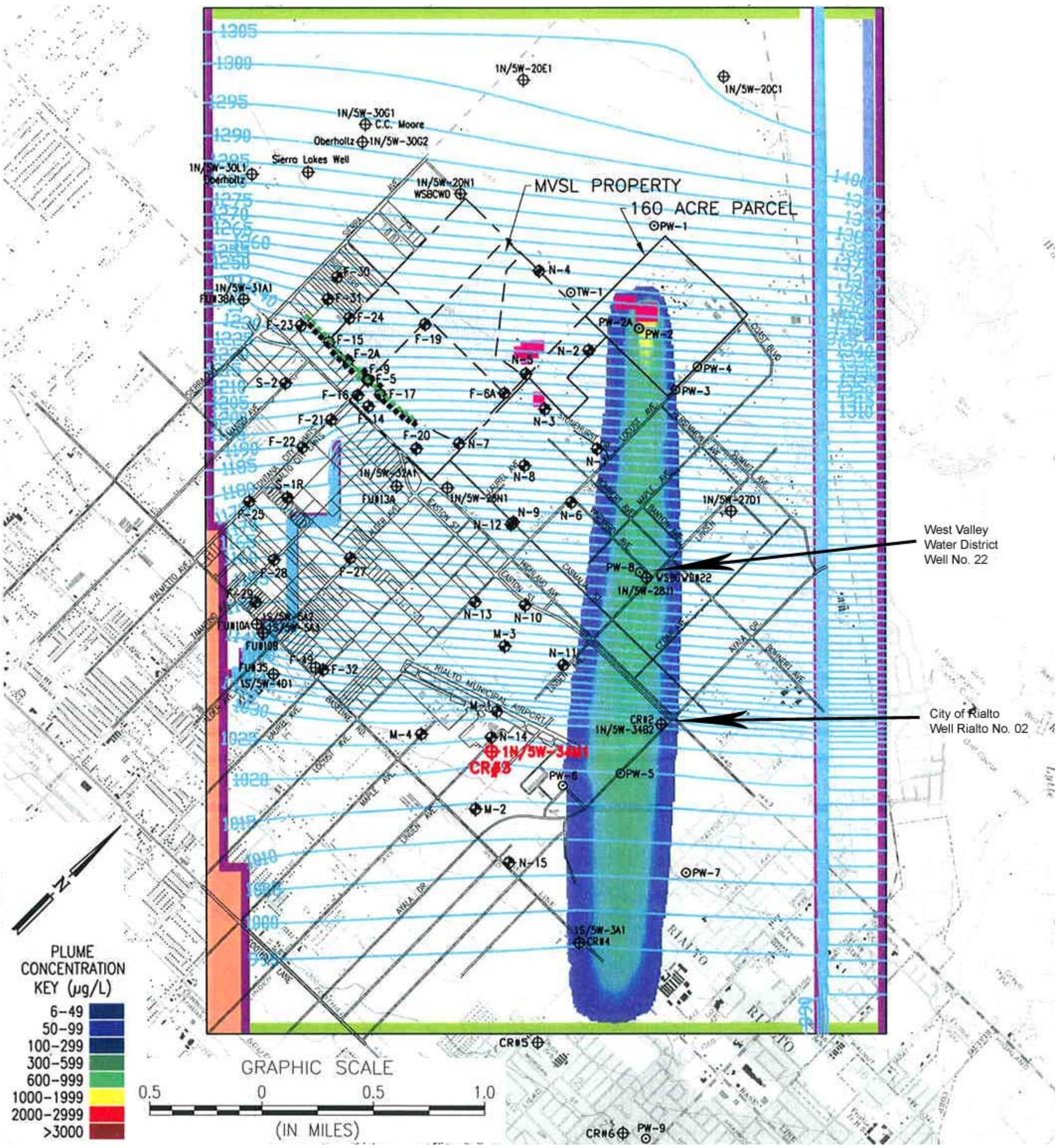
Source [30]

Figure B12. GeoLogic Associates Model of Possible Perchlorate Concentrations, Regional Aquifer, 1985, BF Goodrich Site, Rialto, California



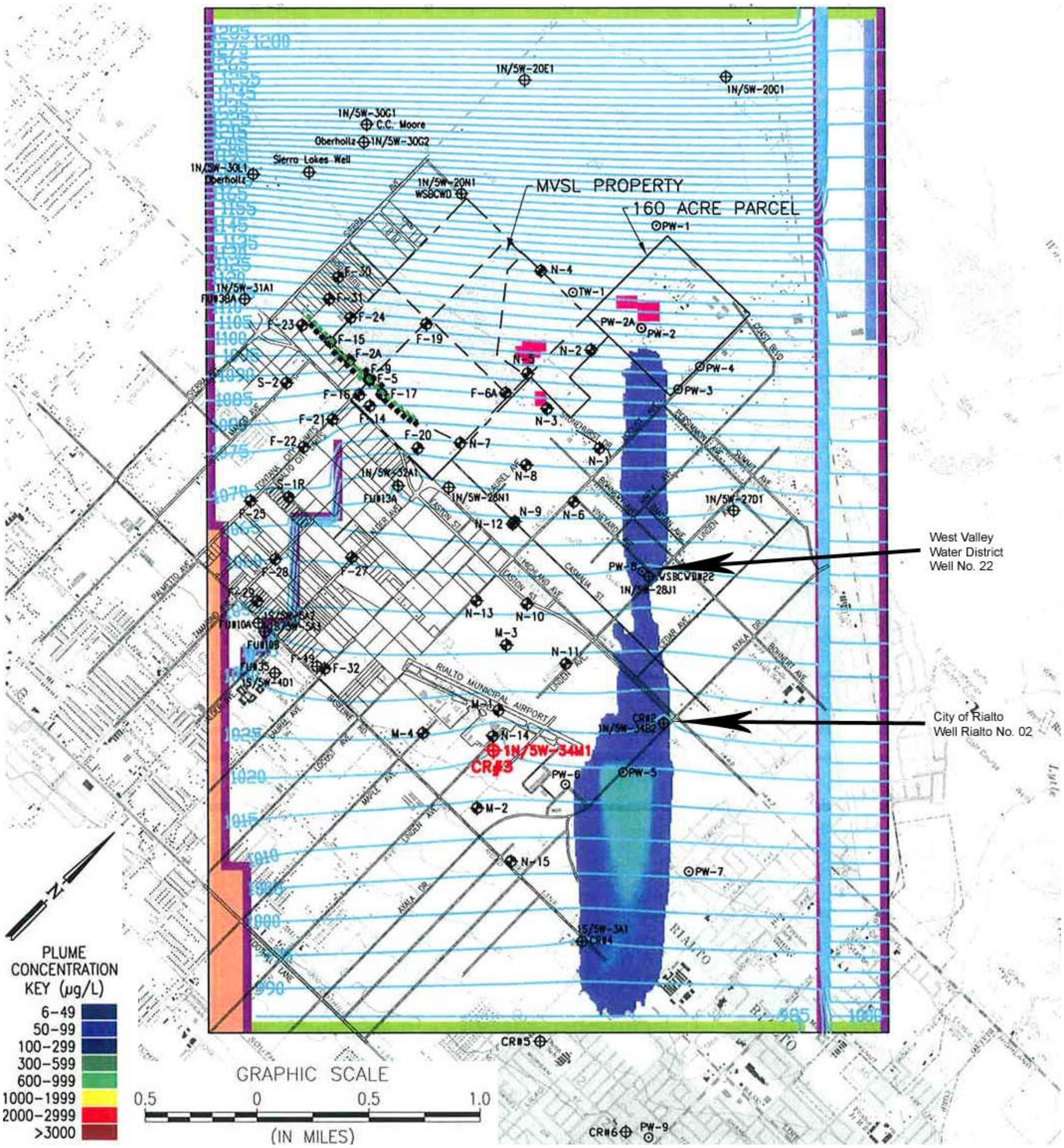
Source [30]

Figure B13. GeoLogic Associates Model of Possible Perchlorate Concentrations, Intermediate Aquifer, 1990, BF Goodrich Site, Rialto, California



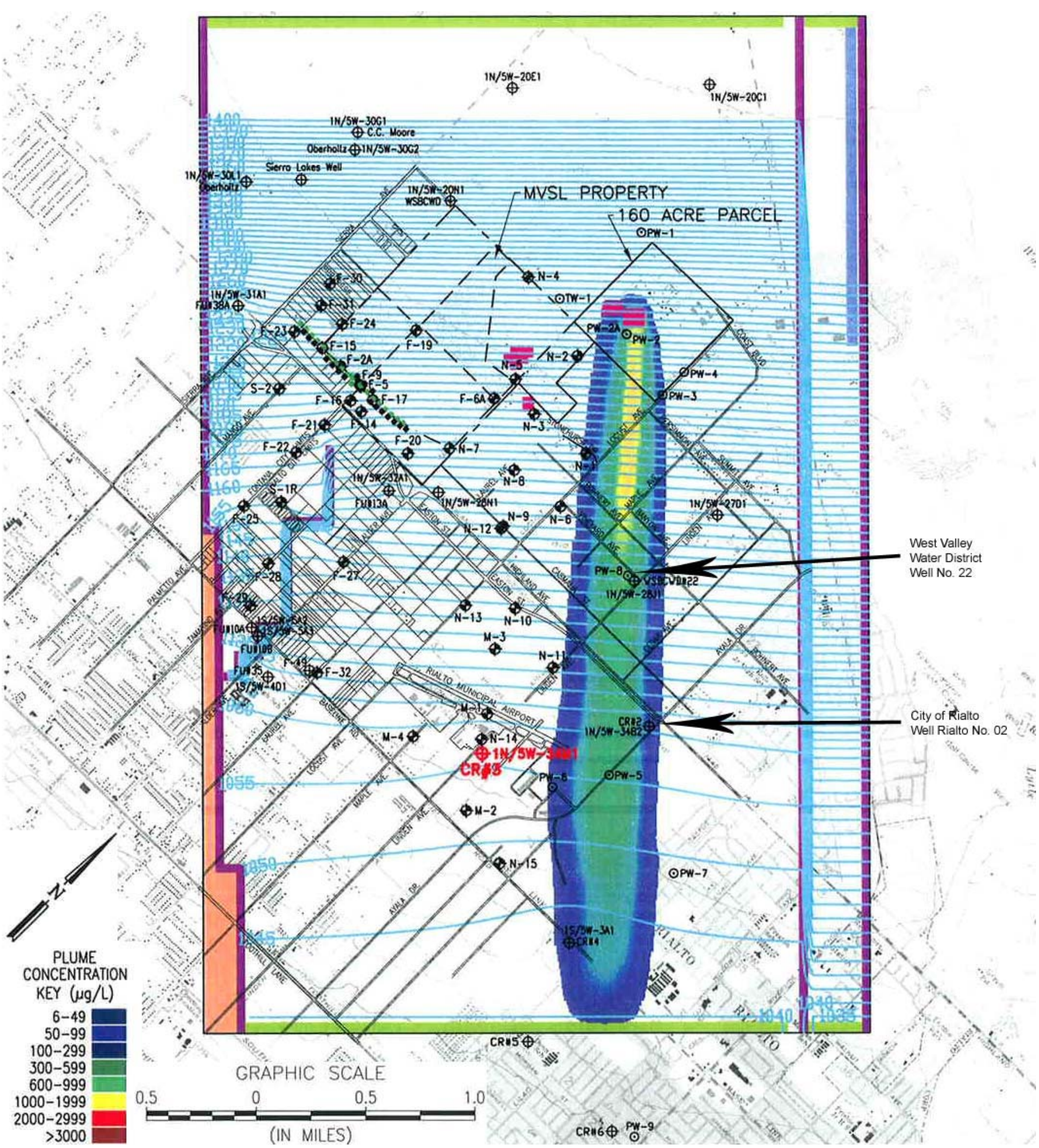
Source [30]

Figure B14. GeoLogic Associates Model of Possible Perchlorate Concentrations, Regional Aquifer, 1990, BF Goodrich Site, Rialto, California



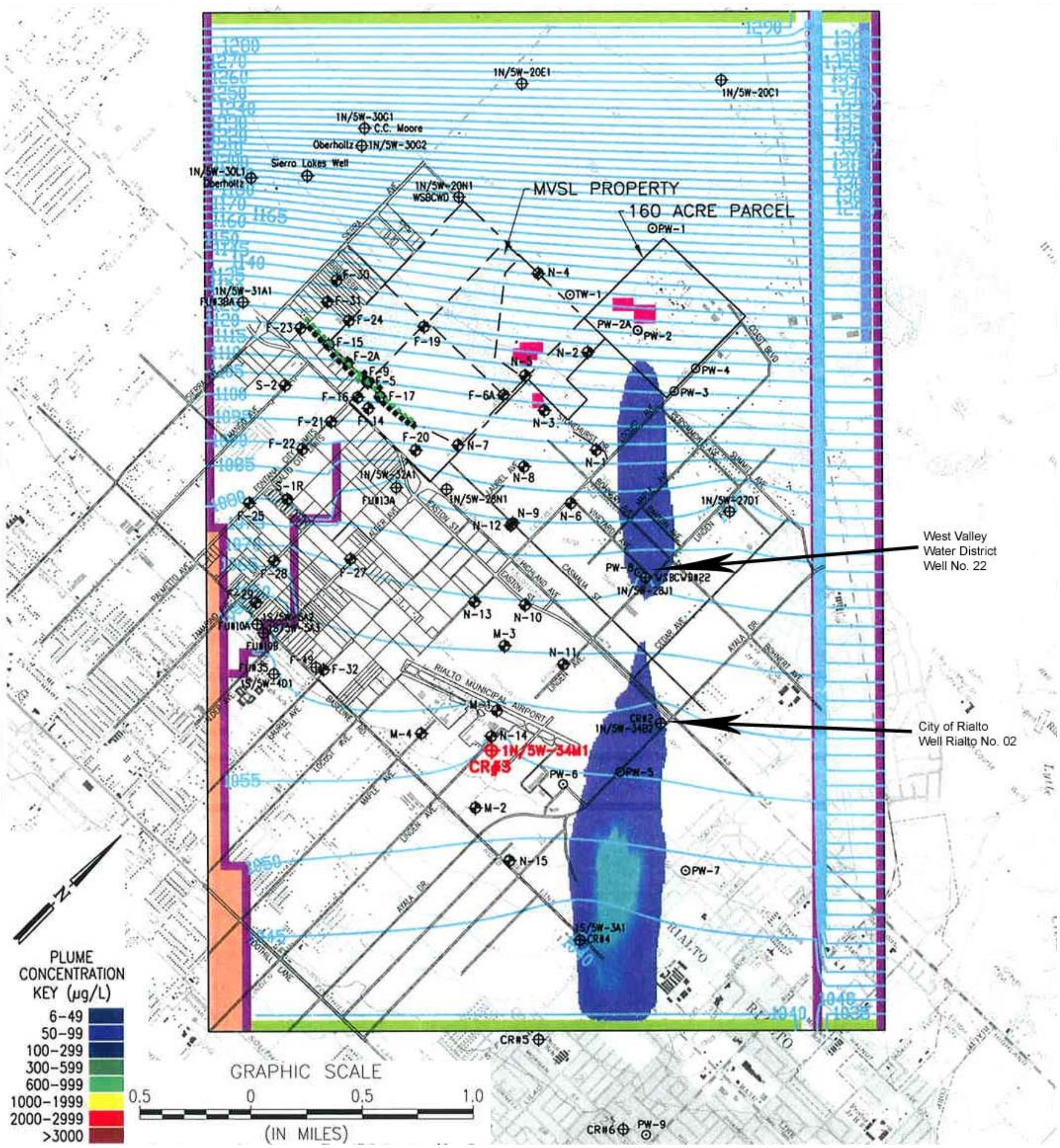
Source [30]

Figure B15. GeoLogic Associates Model of Possible Perchlorate Concentrations, Intermediate Aquifer, 1995, BF Goodrich Site, Rialto, California



Source [30]

Figure B16. GeoLogic Associates Model of Possible Perchlorate Concentrations, Regional Aquifer, 1995, BF Goodrich Site, Rialto, California



Source [30]

Figure B17. Perchlorate Concentrations Over Time, West Valley Water District, WVWD Well No. 22, BF Goodrich Site, Rialto, California

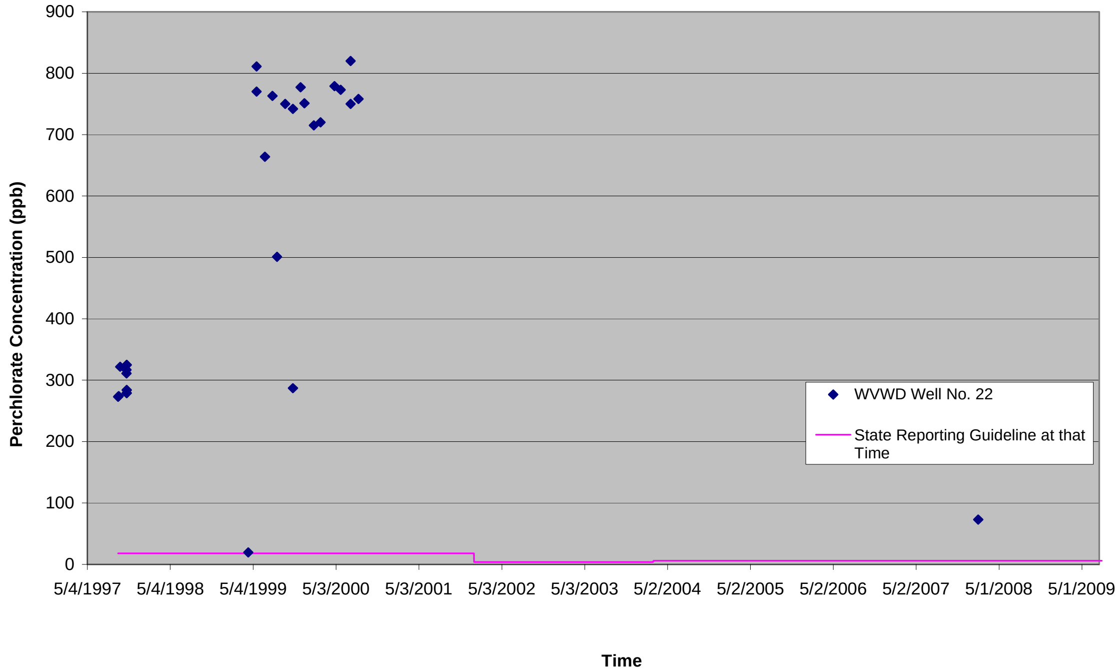


Figure B18. Perchlorate Concentrations Over Time, West Valley Water District, WVWD Well No. 11, BF Goodrich Site, Rialto, California

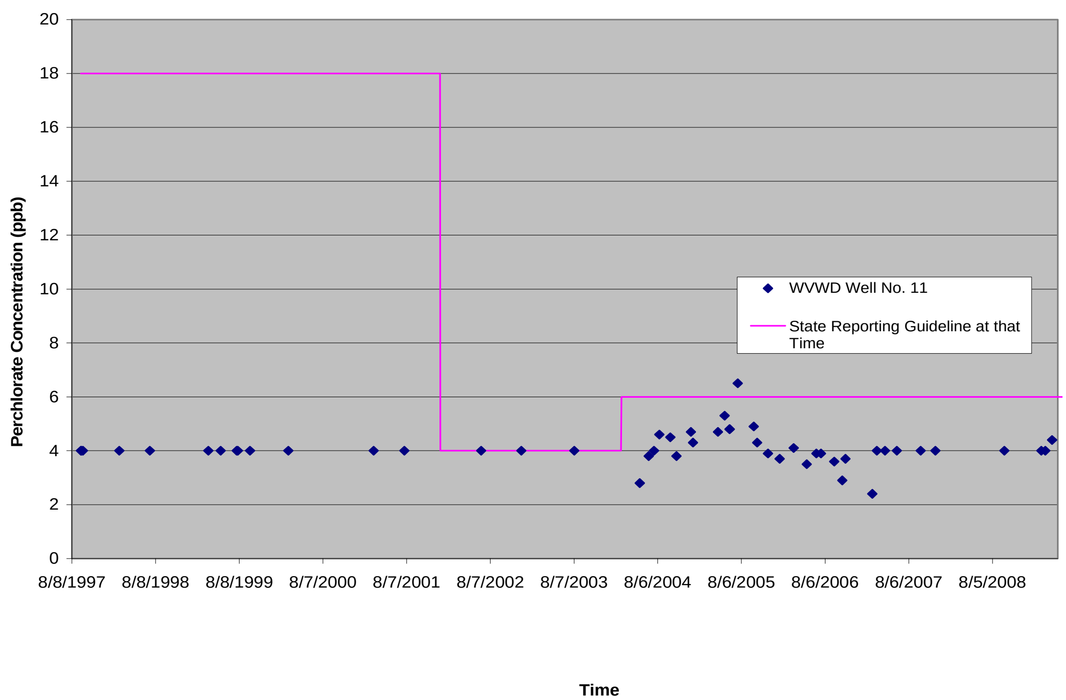


Figure B19. Perchlorate Concentrations Over Time, West Valley Water District, WVWD Well No. 16, BF Goodrich Site, Rialto, California

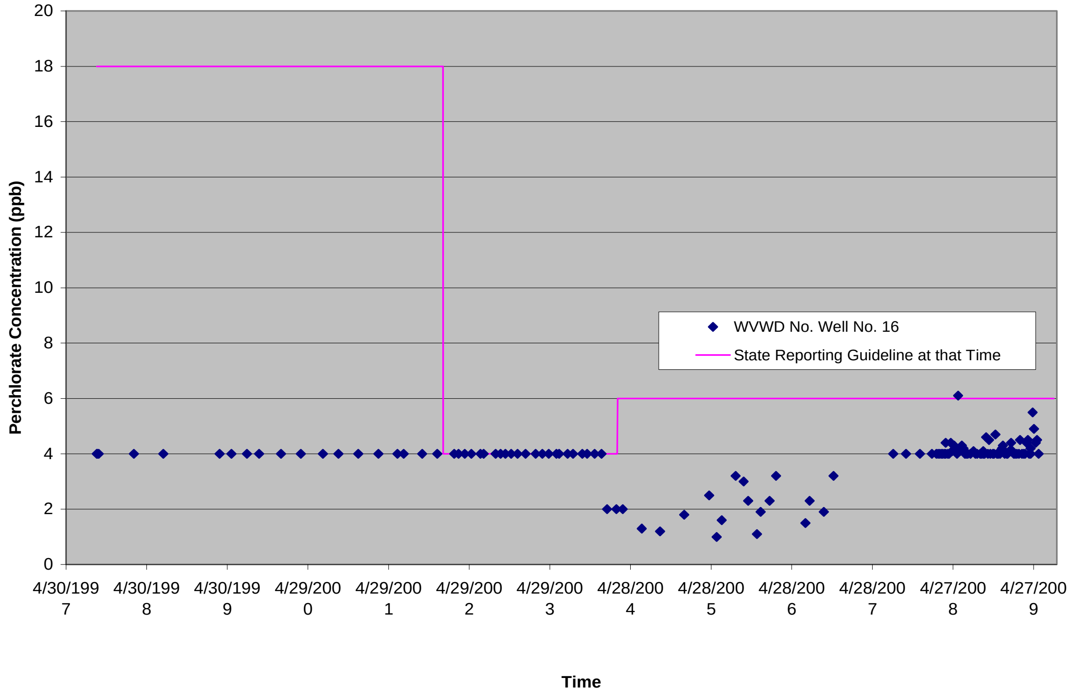


Figure B20. Perchlorate Concentrations Over Time, West Valley Water District, WVWD Well No. 17, BF Goodrich Site, Rialto, California

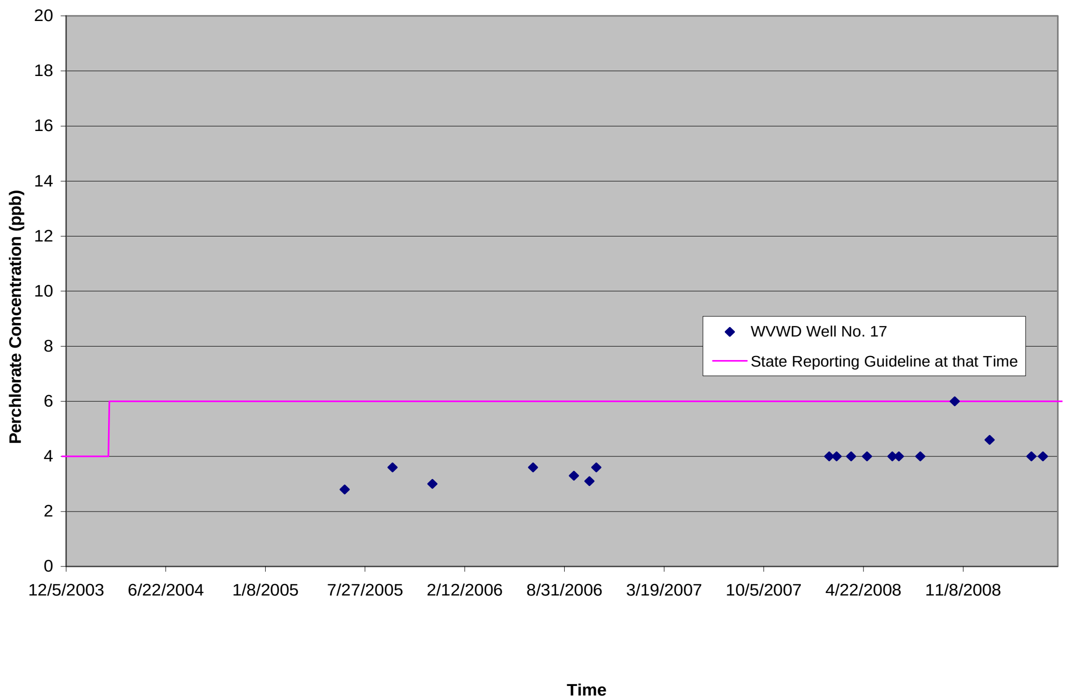


Figure B21. Perchlorate Concentrations Over Time, West Valley Water District, WVWD Well No. 18a, BF Goodrich Site, Rialto, California

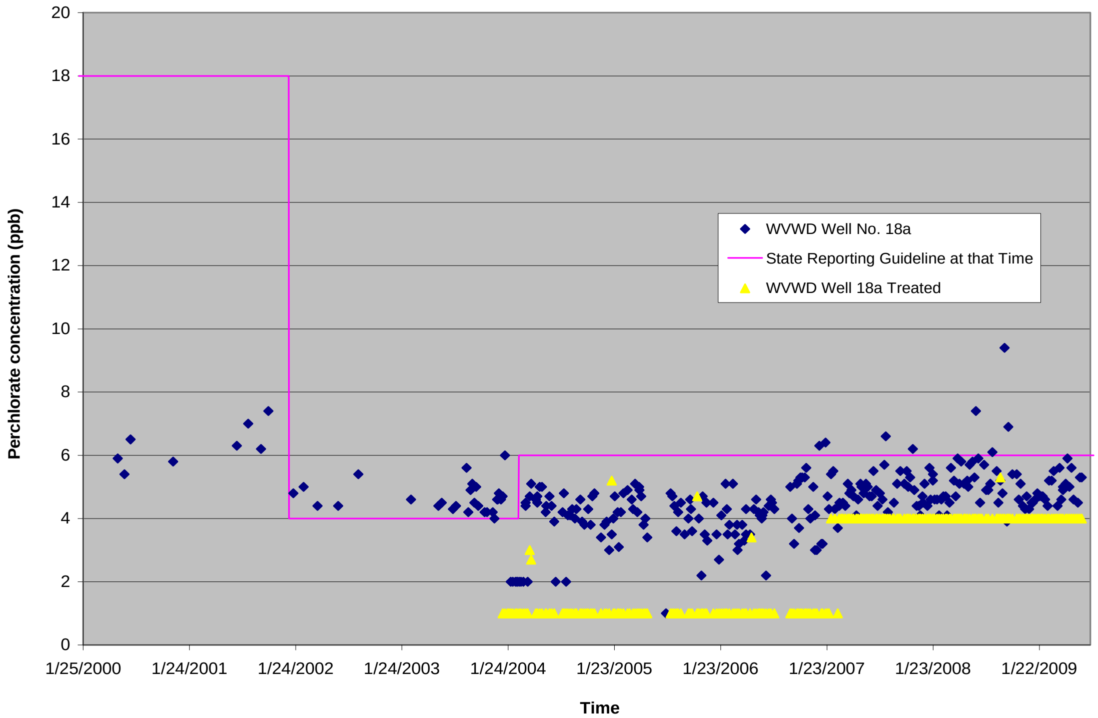


Figure B22. Perchlorate Concentrations Over Time, West Valley Water District, WVWD Well No. 42, BF Goodrich Site, Rialto, California

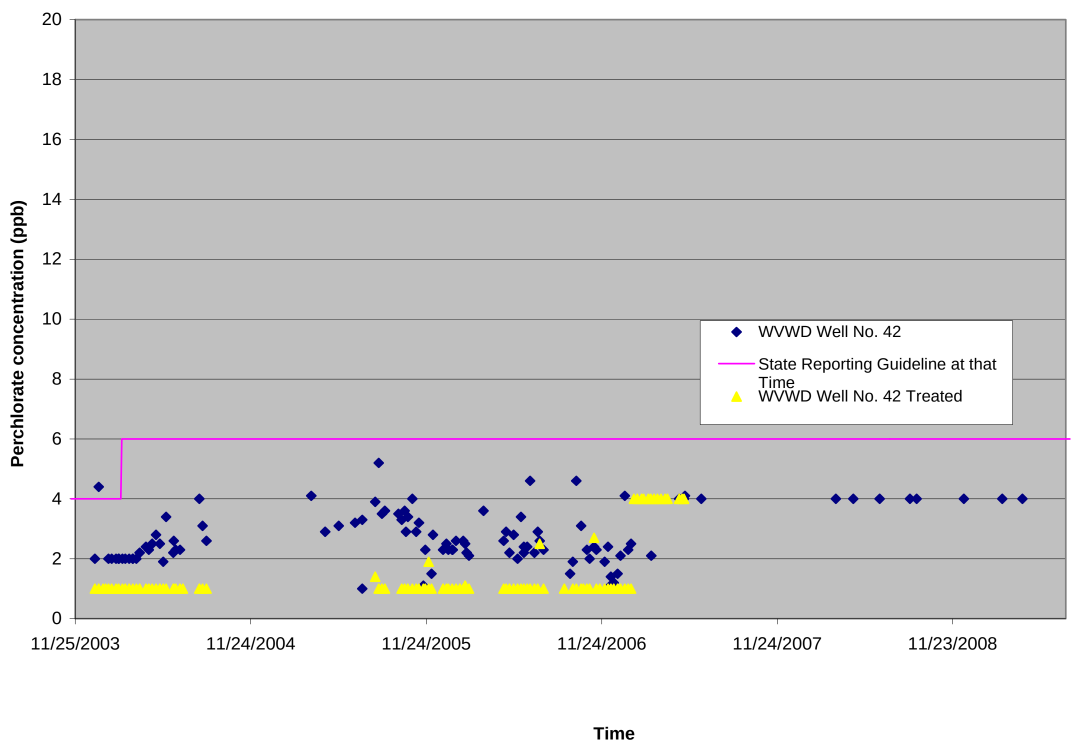
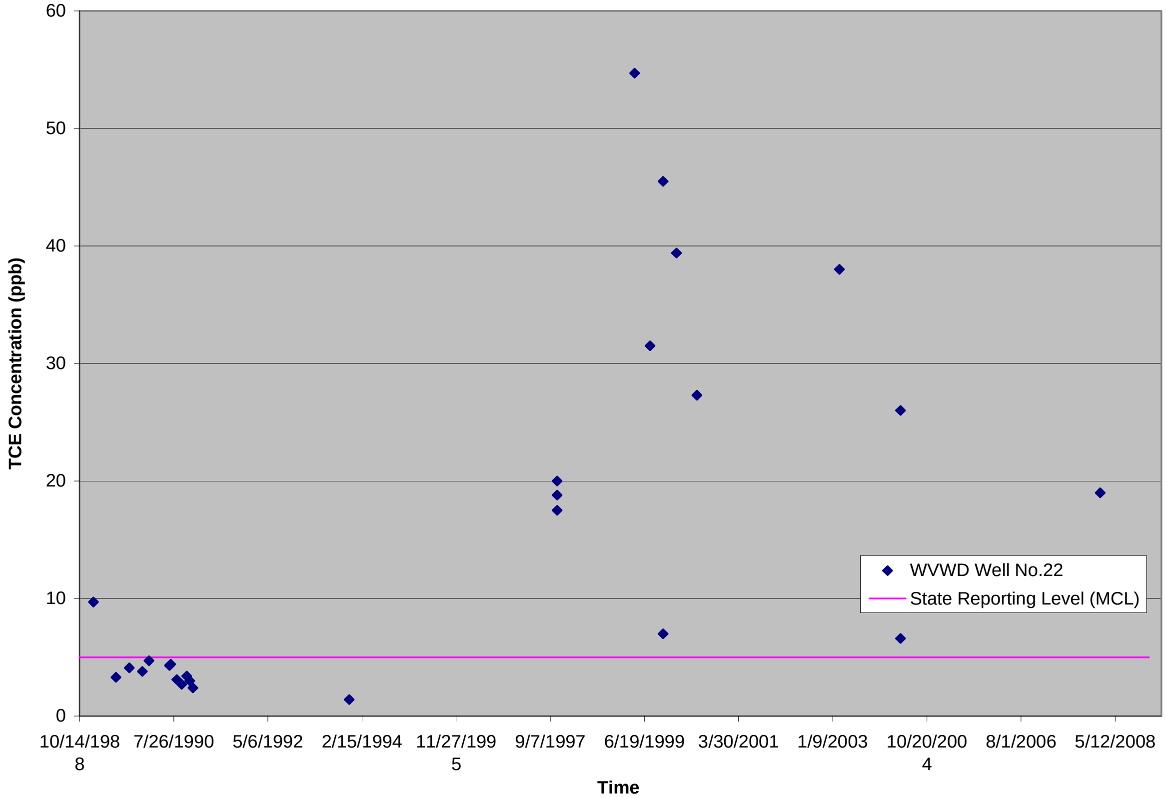
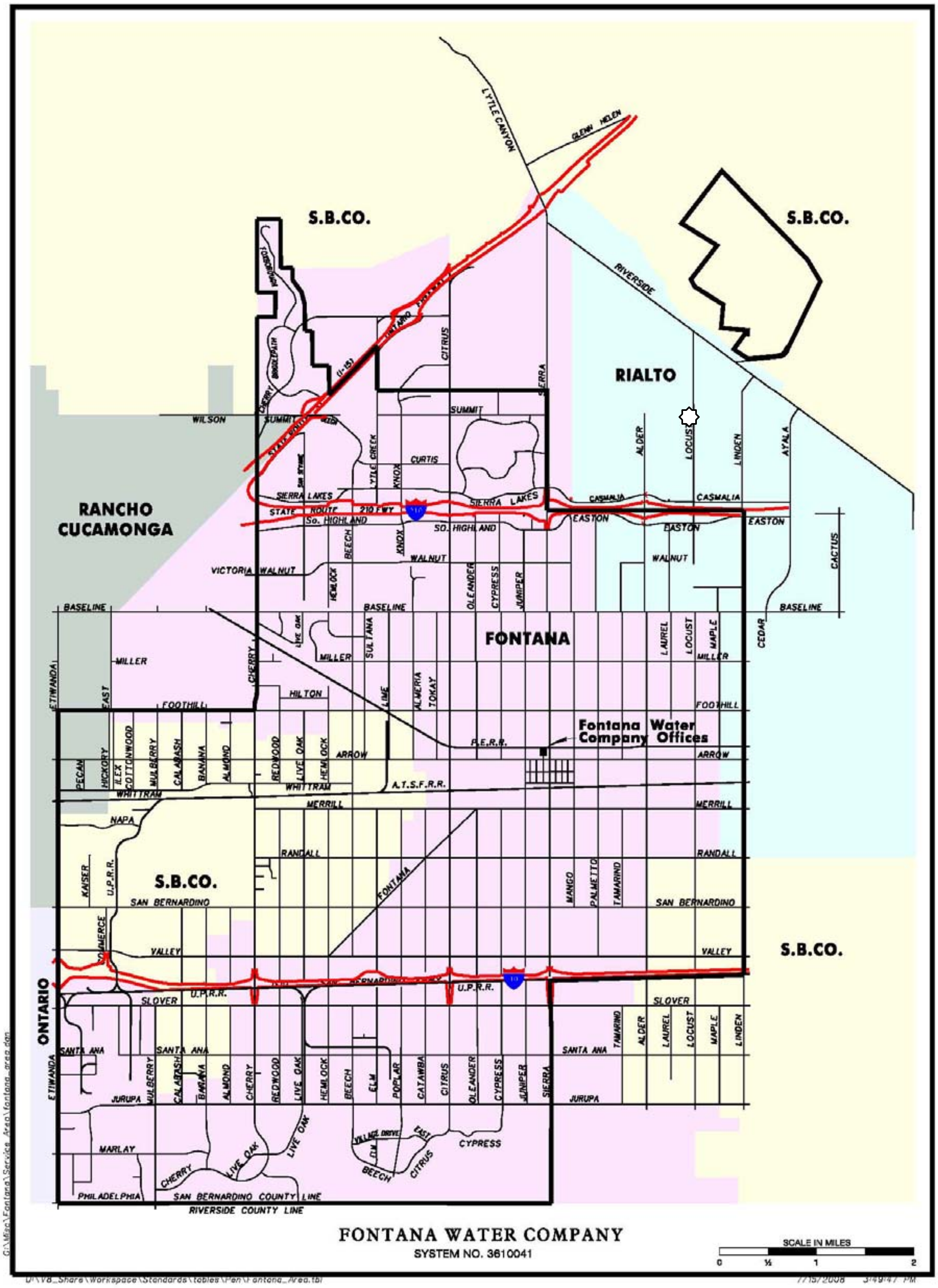


Figure B23. Trichloroethylene (TCE) Concentrations Over Time, West Valley Water District, WVWD Well No. 22, BF Goodrich Site, Rialto, California



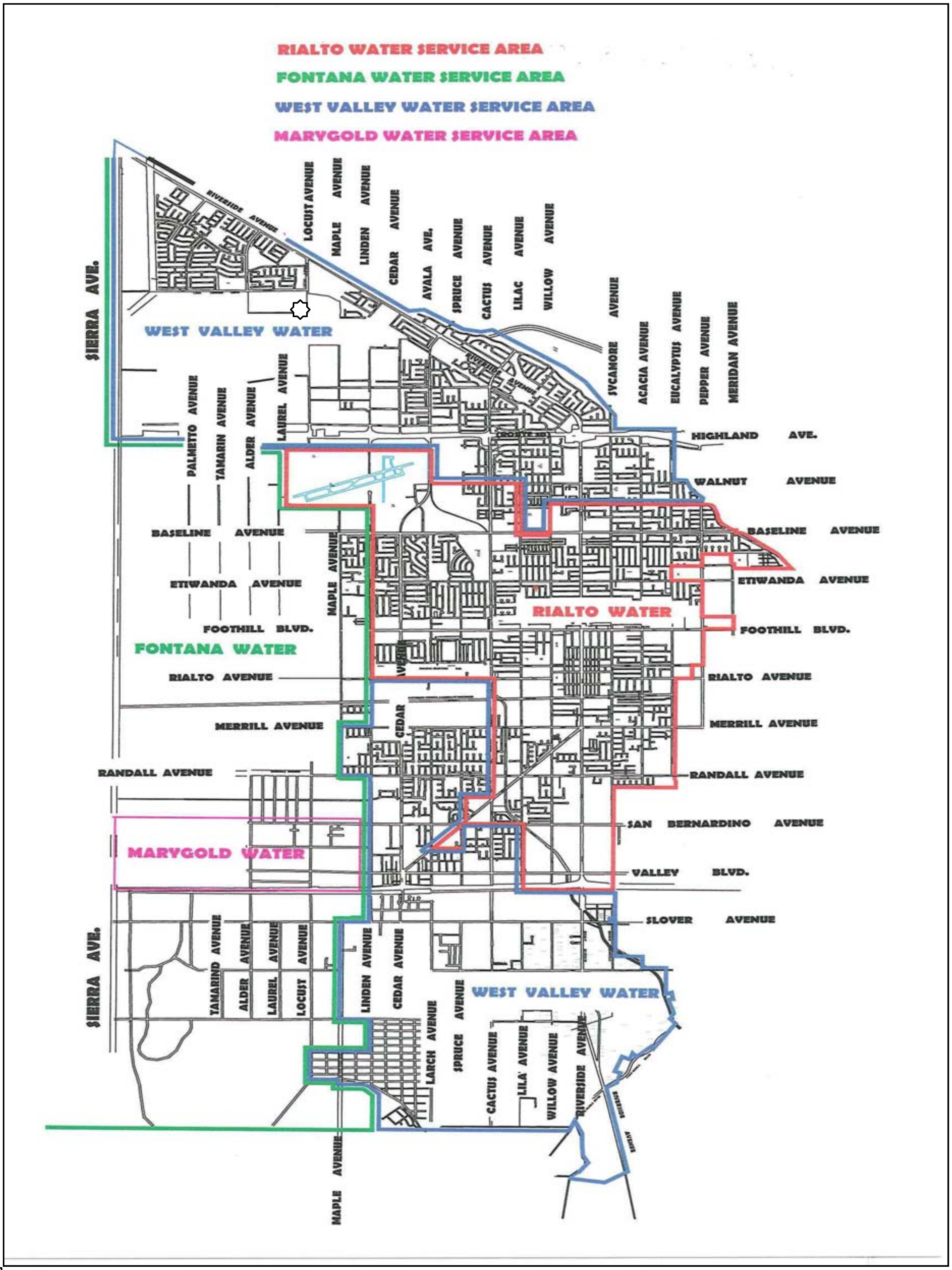
MCL: Maximum Contaminant Level for drinking water (state and federal)

Figure B24. Fontana Water Company Service Area, BF Goodrich Site, Rialto, California



Source [39] BF Goodrich Site

Figure B25. City of Rialto Water District Service Area, BF Goodrich Site, Rialto, California



BF Goodrich Site
Source [38]

Figure B26. Perchlorate Concentrations Over Time, City of Rialto, Rialto Well No. 01, BF Goodrich Site, Rialto, California

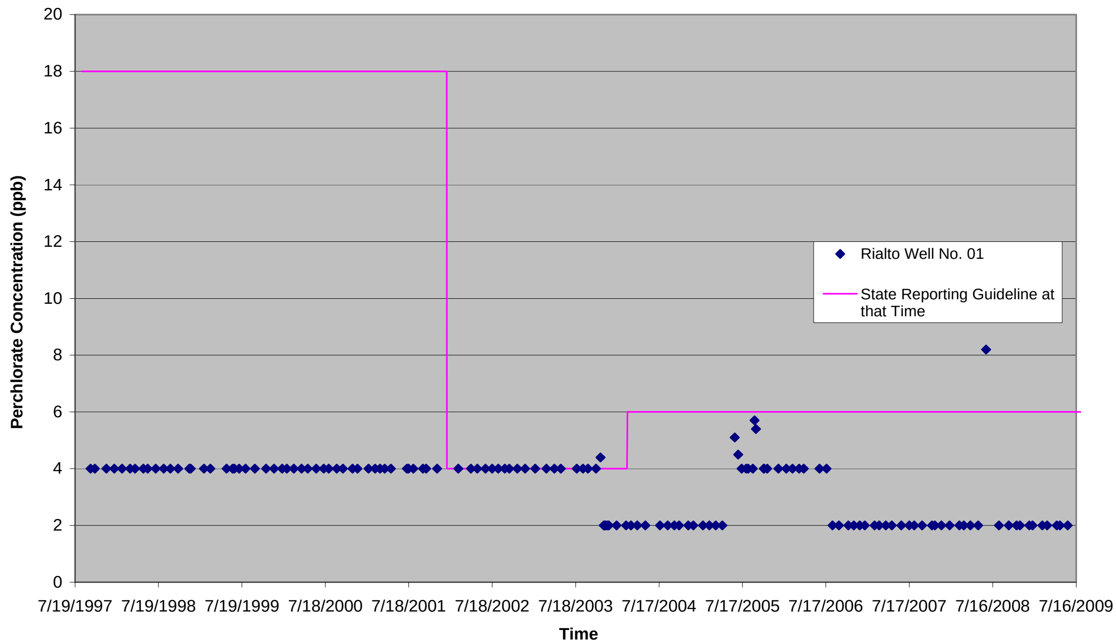


Figure B27. Perchlorate Concentrations Over Time, City of Rialto, Rialto Well No. 02, BF Goodrich Site, Rialto, California

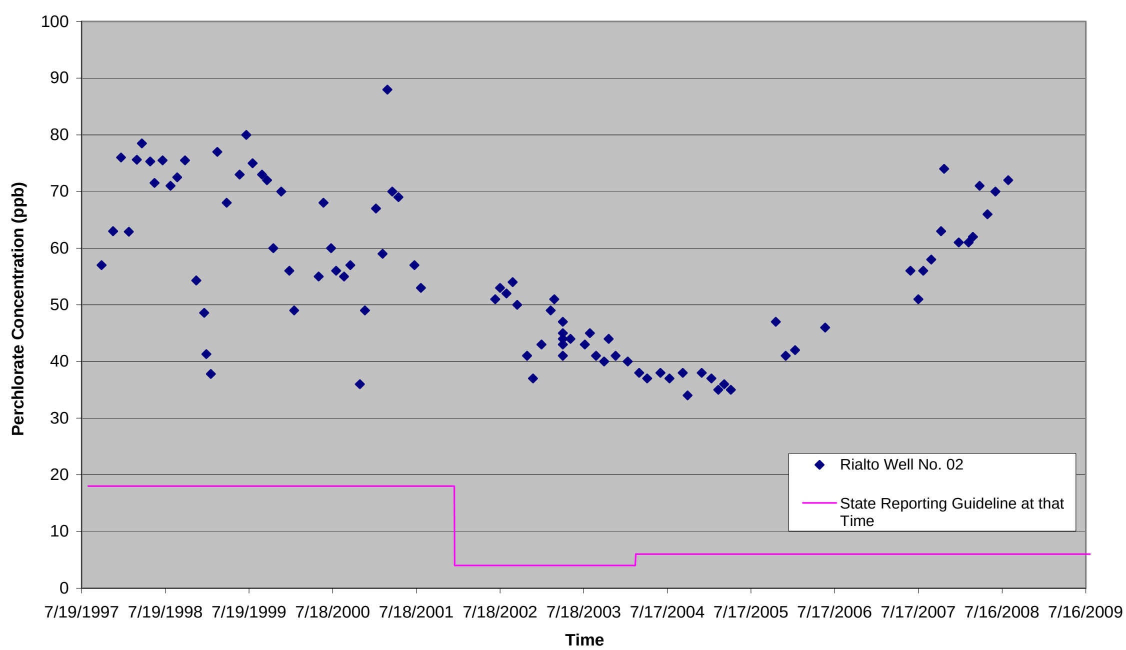


Figure B28. Perchlorate Concentrations Over Time, City of Rialto, Rialto Well No. 04, BF Goodrich Site, Rialto, California

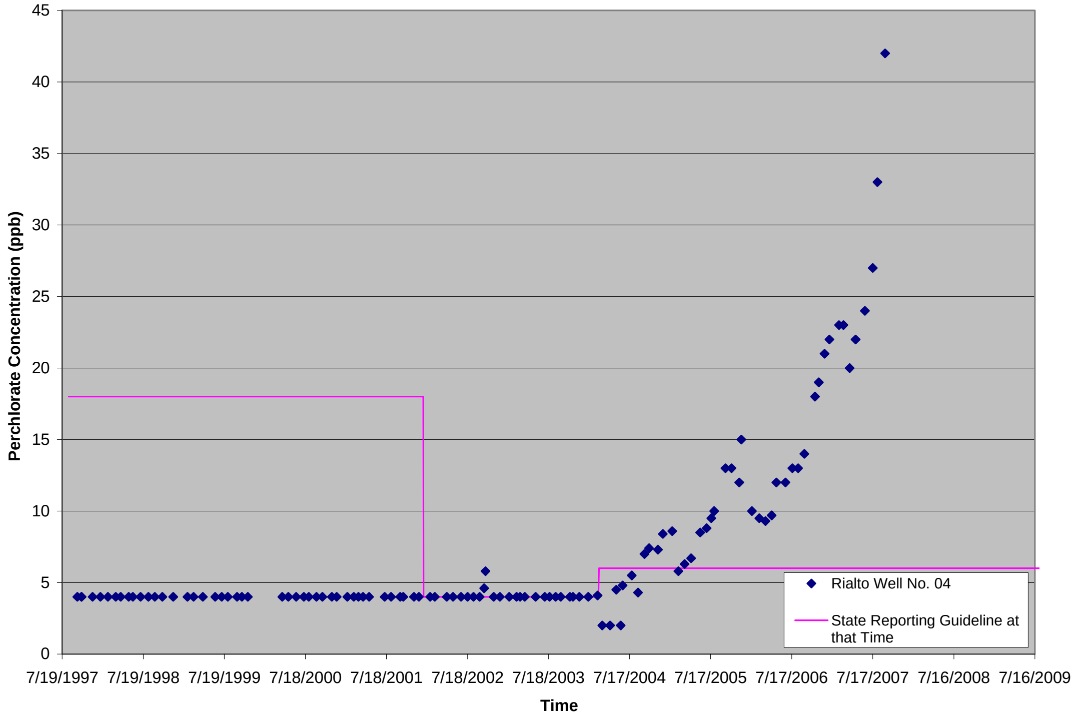


Figure B29. Perchlorate Concentrations Over Time, City of Rialto, Rialto Well No. 06, BF Goodrich Site, Rialto, California

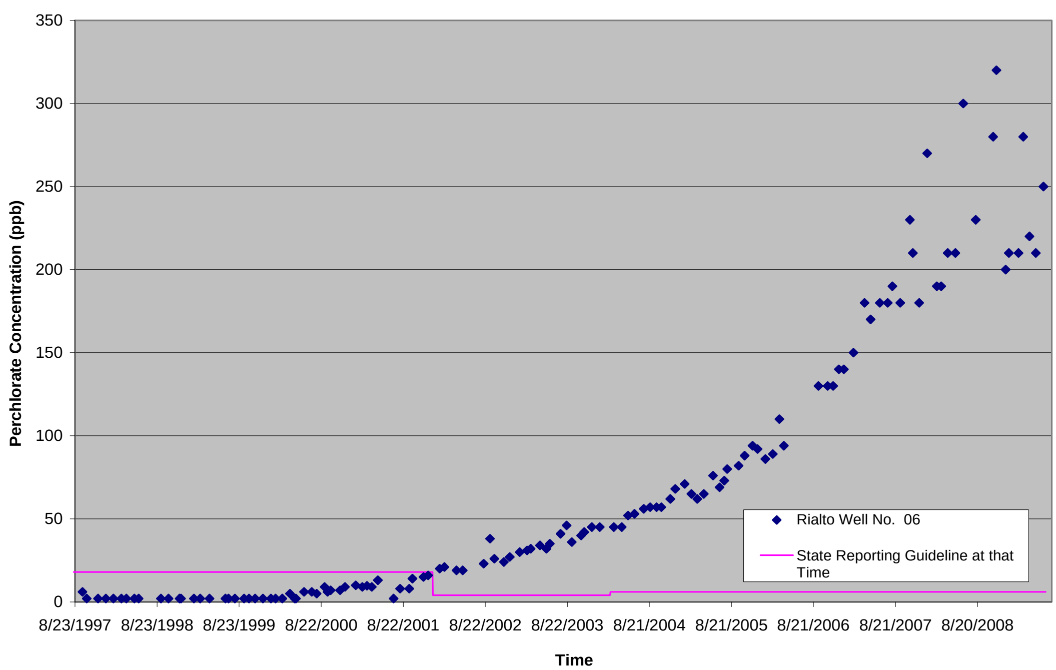


Figure B30. Perchlorate Concentrations Over Time, City of Rialto Chino Well No. 01, BF Goodrich Site, Rialto, California

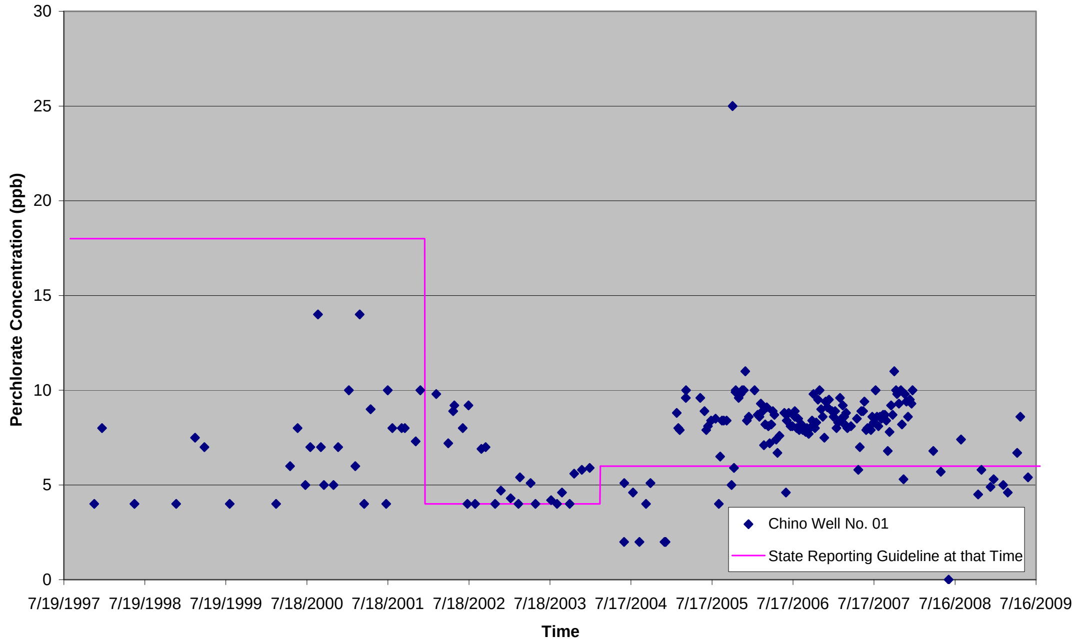


Figure B31. Perchlorate Concentrations Over Time, City of Rialto, Chino Well No. 02, BF Goodrich Site, Rialto, California

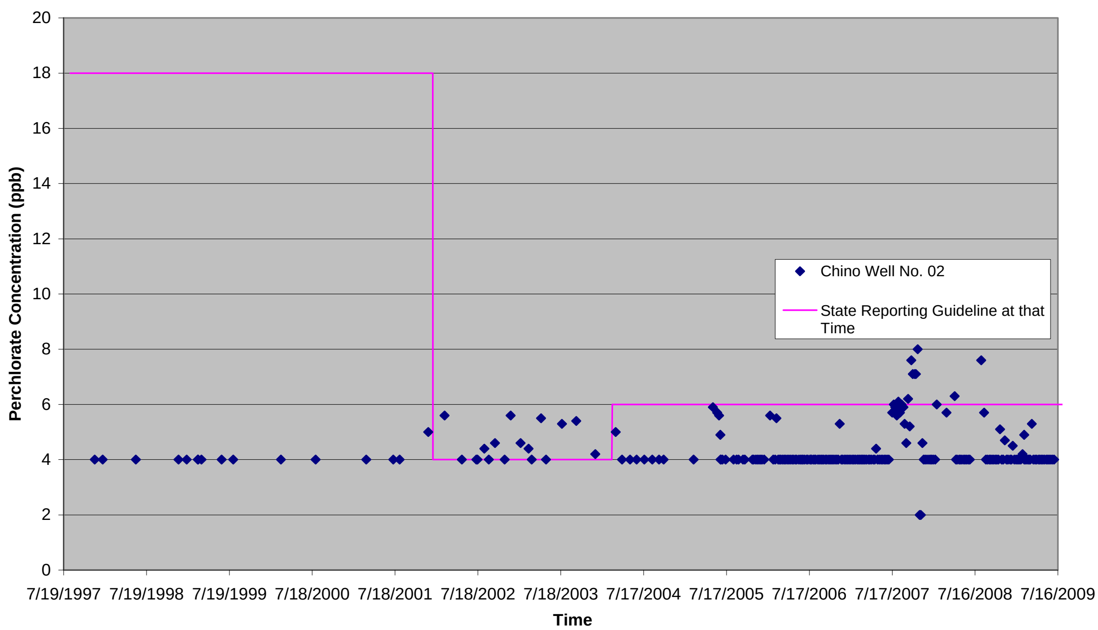


Figure B32. Trichloroethylene (TCE) Concentrations Over Time, City of Rialto, Rialto Well No. 01, BF Goodrich Site, Rialto, California

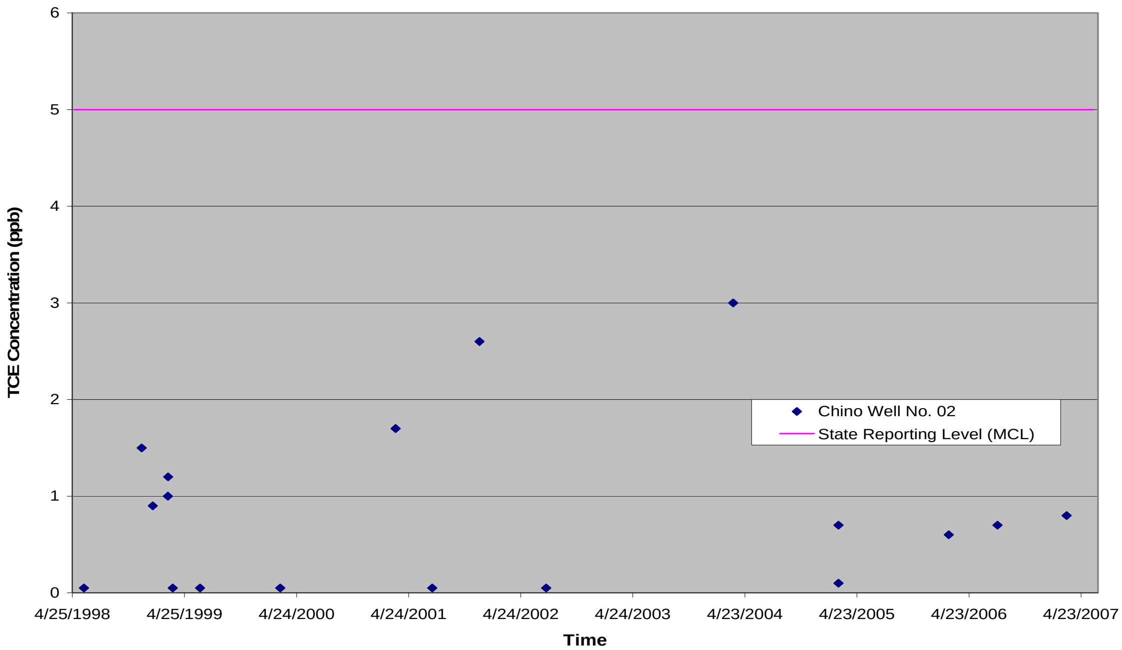
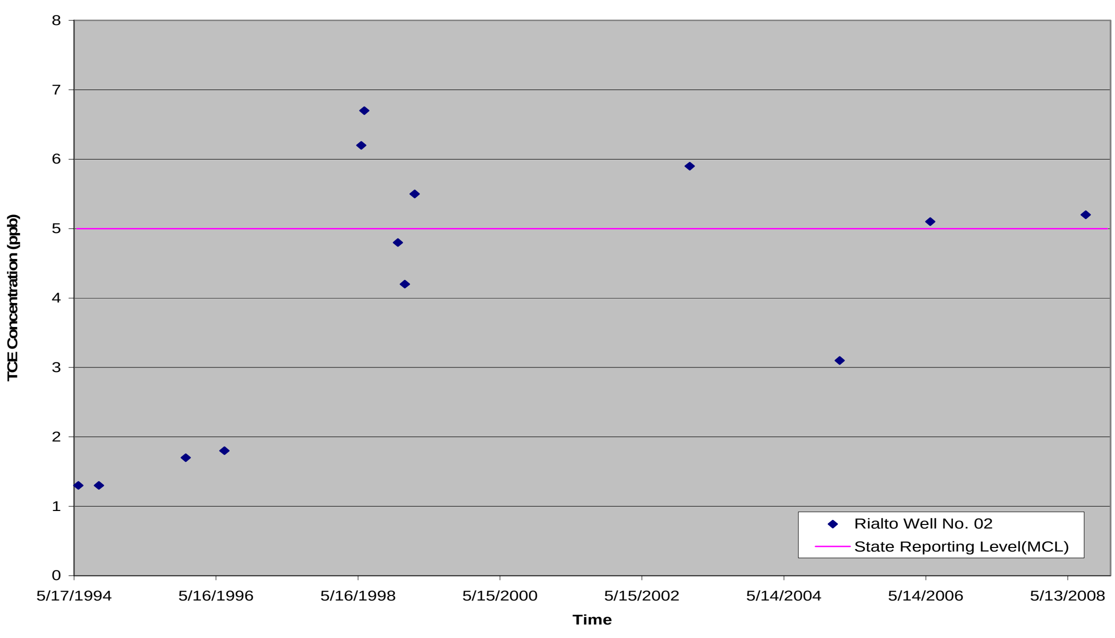


Figure B33. Trichloroethylene (TCE) Concentrations Over Time, City of Rialto, Rialto Well No. 02, BF Goodrich Site, Rialto, California



MCL: Maximum Contaminant Level for drinking water (state and federal)

Figure B34. Trichloroethylene (TCE) Concentrations Over Time, City of Rialto, Rialto Well No. 06, BF Goodrich Site, Rialto, California

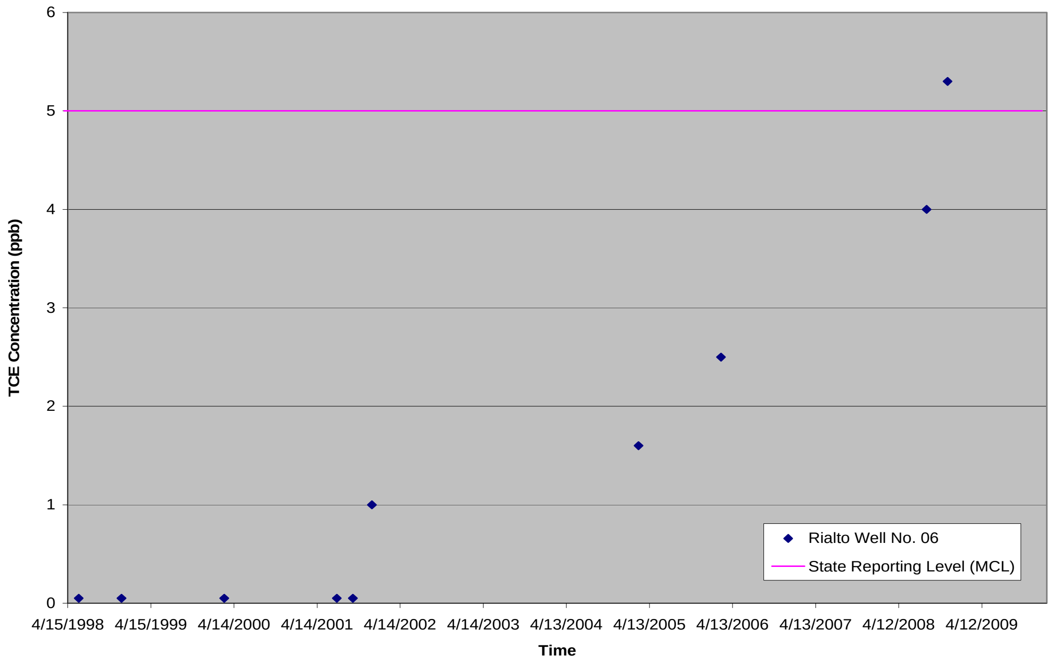
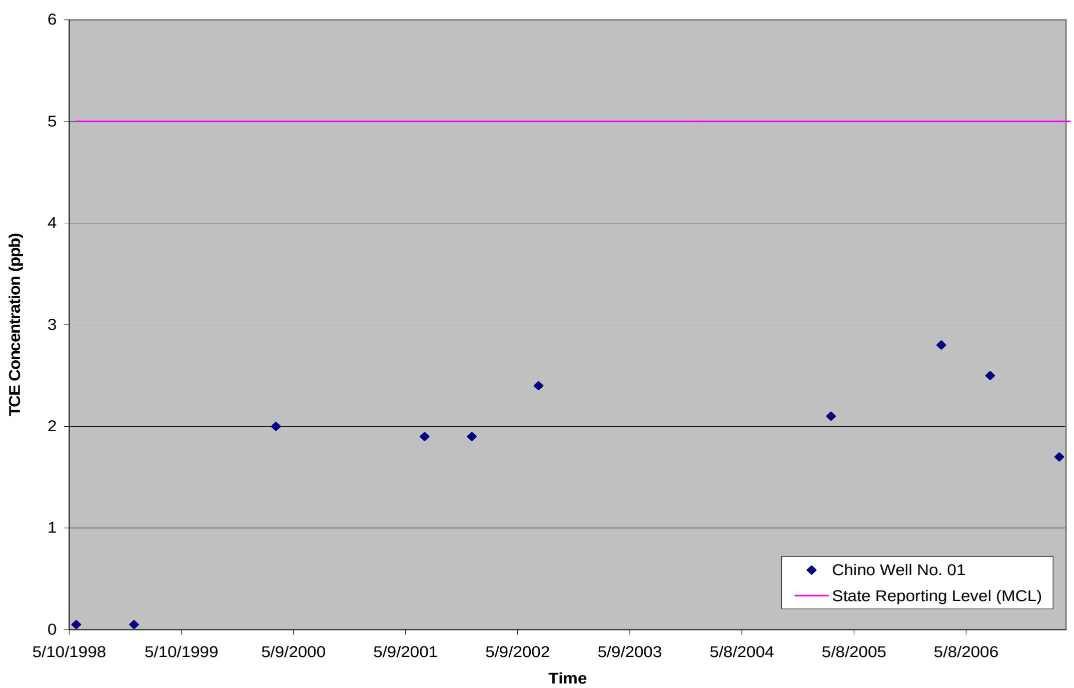
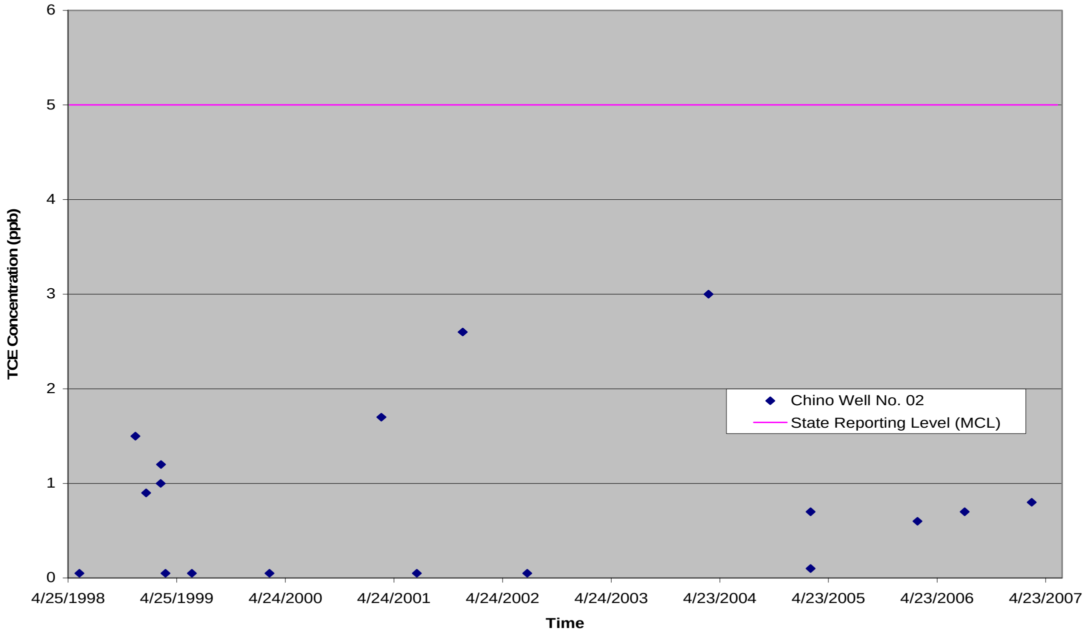


Figure B35. Trichloroethylene (TCE) Concentrations Over Time, City of Rialto, Chino Well No. 01, BF Goodrich Site, Rialto, California



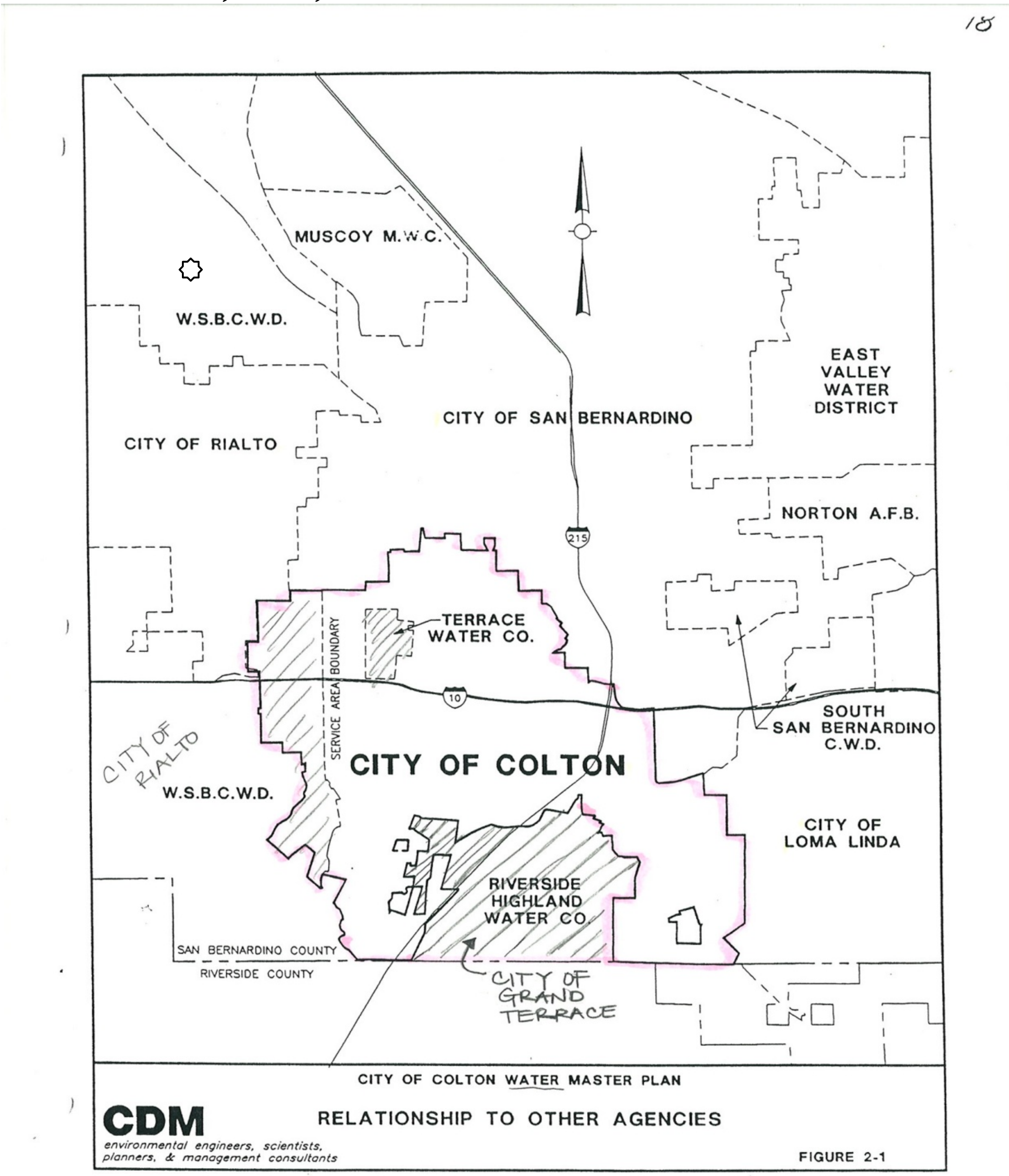
MCL: Maximum Contaminant Level for drinking water (state and federal)

Figure B36. Trichloroethylene (TCE) Concentrations Over Time, City of Rialto, Chino Well No. 02, BF Goodrich Site, Rialto, California



MCL: Maximum Contaminant Level for drinking water (state and federal)

Figure B37. Boundary Map, City of Colton Water District and Terrace Water Company, BF Goodrich Site, Rialto, California



✧ BF Goodrich Site

Figure B38. Perchlorate Concentrations Over Time, City of Colton, Colton Well No. 15, BF Goodrich Site, Rialto, California

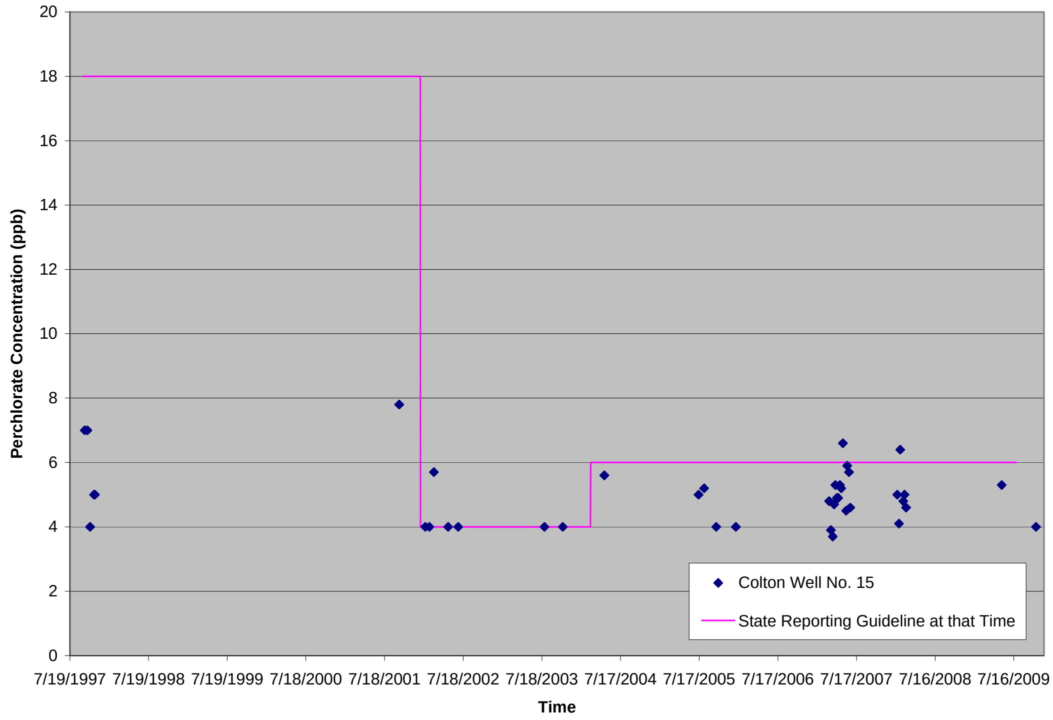


Figure B39. Perchlorate Concentrations Over Time, City of Colton, Colton Well No. 17, BF Goodrich Site, Rialto, California

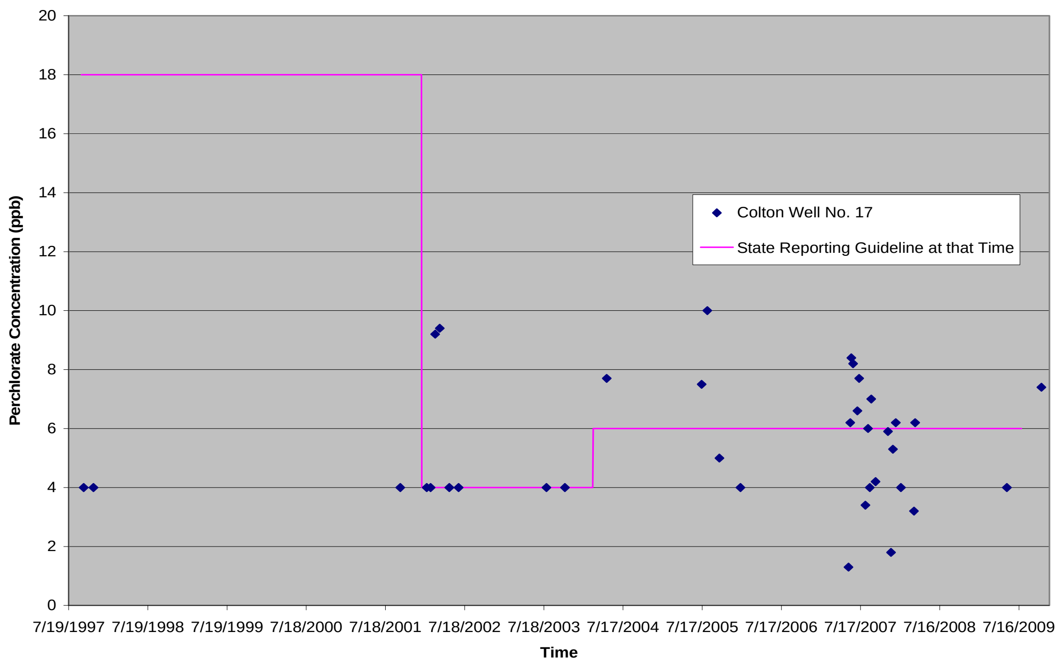
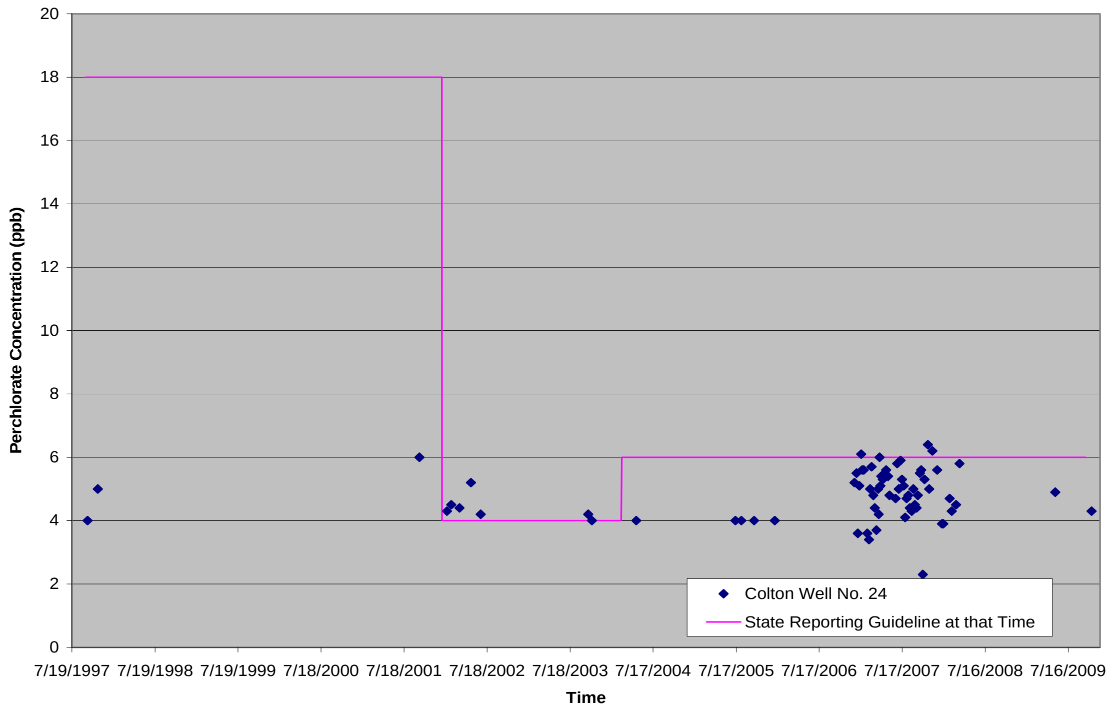


Figure B40. Perchlorate Concentrations Over Time, City of Colton, Colton Well No. 24, BF Goodrich Site, Rialto, California



Appendix C. Tables

Table C1. Completed and Potential Exposure Pathways, BF Goodrich Site, Rialto, California

Pathway Name	Media	Point of Exposure	Route of Exposure	Potentially Exposed Population	Time Period of Exposure
Exposure to perchlorate and trichloroethylene while working at the BF Goodrich Site	Soil, soil gas, air	Working onsite	Swallowing dust, breathing	On site workers	Current
Exposure to perchlorate and trichloroethylene from unmixed WVWD Well No. 22 water to WVWD customers	Municipal groundwater	Tap, swimming or showering, vegetables and fruits from private garden	Swallowing, skin contact, breathing, eating fruits and vegetables from garden	Residents who obtained water directly from WVWD well No. 22	1981, 1982, 1985, 1987, 1988
Exposure to perchlorate and trichloroethylene from WVWD Well No. 22 water when delivered and mixed into Fontana Water Company water system	Municipal groundwater	Tap, swimming, or showering, vegetables and fruits from private garden	Swallowing, skin contact, and breathing, eating fruits and vegetables from garden	Customers of the Fontana Water Company	1989-1990
Exposure to perchlorate from unmixed City of Rialto Well No. 02 water	Municipal groundwater	Tap, swimming, vegetables and fruits from private garden	Swallowing, and eating fruits and vegetables from garden	Residents who obtained water directly from Rialto Well No. 02	1979-1997
Exposure to perchlorate from unmixed City of Colton Well No. 15 water	Municipal groundwater	Tap, swimming, vegetables and fruits from private garden	Swallowing, and eating fruits and vegetables from garden	Residents who obtained water directly from Rialto Well No. 02	1997

Table C2. Noncancer Dose Estimates for Contaminants Exceeding Screening Values, BF Goodrich, Rialto, California

Contaminants	Noncancer Dose Estimates Child						Noncancer Dose Estimates Adult						Health Comparison Value
Perchlorate	WVWD (1981,1982, 1985) Swallowing **0.0069** (mg/kg/day)	WVWD (1987, 1988) Swallowing **0.0051** (mg/kg/day)	FWC (1989) Swallowing 0.00027 (mg/kg/day)	FWC (1990) Swallowing 0.00069 (mg/kg/day)	Rialto (1979-1997) Swallowing **0.0064** (mg/kg/day)	Colton (1997) Swallowing 0.00045 (mg/kg/day)	WVWD (1981,1982, 1985) Swallowing **0.0031** (mg/kg/day)	WVWD (1987, 1988) Swallowing **0.0022** (mg/kg/day)	FWC (1989) Swallowing 0.00012 (mg/kg/day)	FWC (1990) Swallowing 0.00031 (mg/kg/day)	Rialto (1979-1997) Swallowing **0.0029** (mg/kg/day)	Colton (1997) Swallowing 0.00020 (mg/kg/day)	0.0007 (mg/kg/day) (MRL) 0.007 (mg/kg/day) (NOEL)
TCE	WVWD (1981,1982, 1985, 1987, 1988) Ingestion (includes drinking and skin contact) 0.0004 (mg/kg/day)	No municipal wells providing potable water has TCE levels above health comparison levels since 1989					WVWD (1981,1982, 1985, 1987, 1988) Ingestion (includes drinking and skin contact) 0.0001 (mg/kg/day)	No municipal wells providing potable water has TCE levels above health comparison levels since 1989					0.2 (mg/kg/day) (MRL)
	WVWD (1981,1982, 1985, 1987, 1988) Breathing 14 (ppbv)						WVWD (1981,1982, 1985, 1987, 1988) Breathing 14 (ppbv)						100 (ppbv) (MRL)

Data source [76]
mg/kg/day: milligrams per kilogram per day
TCE: trichloroethylene
WVWD: West Valley Water District
MRL: ATSDR's minimal risk level [23,25]
NOEL: No-Observed Effect Level [23]

Equations and assumptions for dose estimates presented on the following page(s).
All swallowing dose estimates include incidental swallowing while swimming
Perchlorate ingestion dose estimates include a dietary component (see Appendix E).
FWC: Fontana Water Company
Bolded dose estimates exceed minimal risk level.
ppbv = parts per billion volume

Equation and exposure assumptions used in estimating ingestion dose from perchlorate

Equation: (CW)(IR)(ET)(EF)(ED)/(BW)(AT) +(Diet Dose: Adult= 0.00011 mg/kg/day; Child food component dose=0.00039 mg/kg/day)
CW= concentration in water
IR= ingestion (swallowing) rate (Drinking: adult 2 liters/day, child 1 liter/day) (Incidental swimming: 50 milliliters/hour)
ET= exposure time (1 hour a day for swimming)
EF=exposure time (days-183 days (FWC),150 days (WVWD, 365 days (Rialto and Colton) for ingestion, 100 days for swimming)
ED= exposure duration (years)
BW= body weight (kg) – (for adult 70 kg: average of women and men) (for a child16 kg: 50th percentile of females and males ages 1-6)
AT= averaging time (183 (or 150) days/year * ED)

Equation and exposure assumptions used in estimating ingestion dose from TCE

Equation: (CW)(IR)(ET)(EF)(ED)/(BW)(AT) + (Skin Contact)
CW= concentration in water
IR= ingestion (swallowing) rate (liters/day) – (adult 2 liters/day, child 1 liter/day)
ET= exposure time (1 hour a day for swimming)
EF=exposure time (days)-150 days for ingestion and 100 days for swimming
ED= exposure duration (years)
BW= body weight (kg) – (for adult 70 kg: average of women and men) (for a child16 kg: 50th percentile of females and males ages 1-6)
AT= averaging time (150 days/year * ED)

Exposure assumptions used in estimating skin contact dose from TCE

Equation: (CW)(SA)(PC)(ET)(EF)(ED)(CF)/(BW)(AT)
CW= concentration in water (mg/L)
SA= skin surface area (cm^2) – (19,400 for adult, 9,310 for child)
PC= Skin permeability constant (cm/hr) = 0.029
ET= exposure time (hr/day) – (swimming 1 hour, shower 10 minutes)
EF= exposure frequency (days) – (150 for showering and 100 days for swimming)
ED= exposure duration (years)
CF= volumetric conversion for water (1 liter/1000 cm^3)
BW=body weight (kg)- (for adult 70 kg: average of women and men) (for a child16 kg: 50th percentile of females and males ages 1-6)
AT= averaging time (150 days/year * ED)

Equation and exposure assumptions used in estimating TCE concentration while showering

CA= concentration of TCE in air (0.078 mg/m^3 or 14 ppbv)
Equation: CA= (CW)(K)(FW)(t)(VB)
CW= concentration in water (0.0097 mg/L)
K= volatile mass transfer coefficient (unit less: 0.8)
FW= shower water flow (10 L/min.)
t= actual time in shower (10 min.)
VB= volume of typical bathroom (10 m^3)

Data source [30,77]

Table C3. Estimated Perchlorate Concentrations in WVWD Well No. 22 from 1981 to 1990, BF Goodrich Site, Rialto, California

Year(s) WVWD Well No. 22 Was Used from 1980-1990	Representative Model Year Used for Perchlorate Concentration	Estimated Perchlorate Concentration (ppb) for Upper Part Water-bearing Unit	Estimated Perchlorate Concentration (ppb) for Lower Part Water-bearing Unit	Possible WVWD Well No. 22 Perchlorate Concentration (ppb)
1981, 1982, 1985	1980	999	99	252
1987, 1988, 1989, 1990	1990	599	99	185

Data Source [30]

Years were grouped based on the nearest year modeled in the GeoLogic Associates report, *Hydrogeologic Model of Perchlorate Transport Conditions in the Northern Rialto-Colton Basin.* Refer to 7.4.2 section of this document for more information.

Table C4. West Valley Water District (WVWD) Municipal Well Trichloroethylene (TCE) and Perchlorate Data, BF Goodrich Site, Rialto, California

Year	Average TCE (ppb)	Maximum Detected TCE (ppb) (Date)	Number of Samples	Average Perchlorate (ppb)	Maximum Detected Perchlorate (ppb) (Date)	Number of Samples	Well Status at Time of Sampling
WVWD Well No. 22							
1989	5.2	9.7 (1/17/1989)	4	Perchlorate not monitored for until 1997			Off-line in 1/1989. On-line from 6/1989-10/1989
1990	3.5	4.7 (2/5/1990)	8				On-line from 6/1990-11/1990
1993	1.4	1.4 (11/18/1993)	1				Off-line
1997	19	20 (10/24/1997)	2	298	325 (10/24/1997)	6	Off-line in 11/1997 for perchlorate
1999	34.7	54.7 (4/12/1999)	4	621	777 (11/29/1999)	10	Off-line in 11/1997 for perchlorate
2000	33.4	39.4 (1/26/2000)	3	760	820 (7/6/2000)	7	Off-line in 11/1997 for perchlorate
2003	38	38 (2/24/2003)	1	-	-	-	Off-line in 11/1997 for perchlorate
2004	16	26 (4/21/2004)	2	-	-	-	Off-line in 11/1997 for perchlorate
2008	19	19 (1/30/2008)	1	73	73 (1/30/2004)	1	Off-line in 11/1997 for perchlorate

Table C4. West Valley Water District (WVWD) Municipal Well Trichloroethylene (TCE) and Perchlorate Data, BF Goodrich Site, Rialto, California

Year	Average TCE (ppb)	Maximum Detected TCE (ppb) (Date)	Number of Samples	Average Perchlorate (ppb)	Maximum Detected Perchlorate (ppb) (Date)	Number of Samples	Well Status at Time of Sampling
WVWD Well No. 11							
1997	<0.05	<0.05	1	<4.0	<4.0	3	On-line
1998	<0.05	<0.05	1	<4.0	<4.0	2	Off-line in 8/1998 due to nitrate levels
1999	<0.05	<0.05	1	<4.0	<4.0	5	Off-line in 8/1998 due to nitrate levels
2000	1.0	1.0	1	<4.0	<4.0	1	Off-line in 8/1998 due to nitrate levels
2001	<0.05	0.05	1	<4.0	<4.0	2	Off-line in 8/1998 due to nitrate levels
2002	<0.05	0.05	1	<4.0	<4.0	2	Well reactivated, but kept off-line due to perchlorate in 8/2002
2003	-	-	-	<4.0	<4.0	1	Off-line in 8/2002
2004	-	-	-	3.6	4.6 (8/13/2004)	8	Off-line in 8/2002
2005	0.5	0.5 (7/21/2005)	1	4.5	6.5 (7/21/2005)	10	Off-line in 8/2002
2006	-	-	-	3.7	**3.9 (7/16/2006)	8	Off-line in 8/2002

Table C4. West Valley Water District (WVWD) Municipal Well Trichloroethylene (TCE) and Perchlorate Data, BF Goodrich Site, Rialto, California

Year	Average TCE (ppb)	Maximum Detected TCE (ppb) (Date)	Number of Samples	Average Perchlorate (ppb)	Maximum Detected Perchlorate (ppb) (Date)	Number of Samples	Well Status at Time of Sampling
WVWD Well No. 11							
2007	-	-	-	3.5	4.0 (7/15/2007)	7	Off-line in 8/2002
2008	-	-	-	4.0	4.0 (9/28/2008)	1	Off-line in 8/2002
2009	0.5	0.5 (7/9/2009)	1	4.1	4.4 (4/22/2009)	3	Temporarily off-line and in process of connecting to perchlorate treatment; well on-line in 1/2010
WVWD Well No. 16							
1997	<0.05	<0.05	1	2.0	4.0 (9/19/1997)	4	On-line
1998	<0.05	<0.05	1	<4.0	<4.0	2	On-line
1999	<0.05	<0.05	1	<4.0	<4.0	5	On-line
2000	<0.05	<0.05	1	<4.0	<4.0	5	On-line
2001	<0.05	<0.05	1	<4.0	<4.0	5	On-line

Table C4. West Valley Water District (WVWD) Municipal Well Trichloroethylene (TCE) and Perchlorate Data, BF Goodrich Site, Rialto, California

Year	Average TCE (ppb)	Maximum Detected TCE (ppb) (Date)	Number of Samples	Average Perchlorate (ppb)	Maximum Detected Perchlorate (ppb) (Date)	Number of Samples	Well Status at Time of Sampling
WVWD Well No. 16							
2002	-	-	-	<4.0	<4.0	11	On-line
2003	-	-	-	<4.0	<4.0	11	On-line
2004	-	-	-	1.7	2.0 (3/24/2004)	6	On-line
2005	0.5	0.5 (7/21/2005)	1	2.1	3.2 (8/17/2005)	6	On-line
2006	-	-	-	2.4	3.2 (11/3/2006)	6	On-line
2007	-	-	-	4.0	4.0 (7/31/2007)	3	Off-line in 2/2007
2008	0.5	0.5 (3/25/2008)	2	4.1	4.7 (11/5/2008)	48	On-line in 2/2008 with perchlorate treatment, off-line in 3/2008 due to high amounts of sand
2009	-	-	-	4.3	4.9 (4/28/2009)	20	Off-line in 3/2008 for well development

Table C4. West Valley Water District (WVWD) Municipal Well Trichloroethylene (TCE) and Perchlorate Data, BF Goodrich Site, Rialto, California

Year	Average TCE (ppb)	Maximum Detected TCE (ppb) (Date)	Number of Samples	Average Perchlorate (ppb)	Maximum Detected Perchlorate (ppb) (Date)	Number of Samples	Well Status at Time of Sampling
WVWD Well No. 17							
2004	<0.05	<0.05	5	<4.0	<4.0	24	Off-line in 8/1986 due to detections of solvents
2005	0.5	0.5 (7/16/2005)	2	3.1	3.6 (9/20/2005)	3	Off-line in 8/1986 due to detections of the solvent , perchloroethylene
2006	-	-	-	3.4	3.6	4	Reactivated in 5/2006 but off-line due to perchlorate
2007	-	-	-	<4.0	<4.0	1	Off-line in 5/2006 with perchlorate treatment installed in 8/2007, but off-line for well development
2008	0.5	0.5 (2/28/2008)	3	4.3	4.6 (12/31/2008)	8	Off-line in 8/2007 for well development
2009	-	-	-	4.0	4.0 (4/17/2009)	2	Off-line in 8/2007 for well development
WVWD Well No. 18a							
2000	-	-	-	5.9	6.5 (7/6/2000)	4	On-line

Table C4. West Valley Water District (WVWD) Municipal Well Trichloroethylene (TCE) and Perchlorate Data, BF Goodrich Site, Rialto, California

Year	Average TCE (ppb)	Maximum Detected TCE (ppb) (Date)	Number of Samples	Average Perchlorate (ppb)	Maximum Detected Perchlorate (ppb) (Date)	Number of Samples	Well Status at Time of Sampling
WVWD Well No. 18a							
2001	-	-	-	6.7	7.4 (10/22/2001)	4	On-line
2002	-	-	-	4.7	5.4 (8/27/2002)	5	Off-line (2/2002)
2003	-	-	-	4.6	5.6 9/3/2003	20	On-line with treatment in 5/2003
2004	-	-	-	3.7	5.1 (4/12/2004)	45	On-line with treatment in 5/2003
2005	0.5 (7/26/2005)	0.5 (7/26/2005)	1	3.9	5.1 (4/4/2005)	40	On-line with treatment in 5/2003
2006	-	-	-	4.0	6.3 (12/28/2006)	49	On-line with treatment in 5/2003
2007	0.5	0.5 (7/12/2007)	1	4.8	6.6 (8/13/2007)	53	On-line with treatment in 5/2003
2008	0.5	0.5 (3/24/2008)	1	5.1	6.9 (10/7/2008)	54	Temporarily off-line in 7/2009 for well development
2009	0.5	0.5 (3/5/2009)	2	4.8	5.9 (4/28/2009)	24	Temporarily off-line in 7/2009 for well development

Table C4. West Valley Water District (WVWD) Municipal Well Trichloroethylene (TCE) and Perchlorate Data, BF Goodrich Site, Rialto, California

Year	Average TCE (ppb)	Maximum Detected TCE (ppb) (Date)	Number of Samples	Average Perchlorate (ppb)	Maximum Detected Perchlorate (ppb) (Date)	Number of Samples	Well Status at Time of Sampling
WVWD Well No. 42							
2004	2.5	2.5 (4/13/2004)	1	2.4	4.4 (1/13/2004)	28	On-line with treatment in 5/2003
2005	0.5	0.5 (7/21/2005)	1	2.9	3.9 (8/10/2005)	24	On-line with treatment in 5/2003
2006	-	-	-	2.4	4.6 (7/28/2006)	38	On-line with perchlorate treatment in 5/2003
2007	-	-	-	3.7	4.1 (5/16/2007)	20	On-line with treatment in 5/2003
2008	-	-	-	4	4 (5/25/2008)	6	On-line with treatment in 5/2003
2009	0.5	0.5 (7/26/2009)	1	4	4 (5/6/2009)	3	On-line with treatment in 5/2003

Data source [28,78]
ppb: parts per billion
On-line indicates water from that well is being distributed and served to customer
Off-line indicates that water from that well is not being distributed or served to customers
' - ' no TCE sample collected for that year. TCE laboratory reporting limit= 0.05 ppb
<4.0 indicates level below state laboratory reporting limit of 4 ppb. Non detects were valued at 2 ppb to calculate averages

Table C5. Estimated Perchlorate Concentrations in FWC Municipal Water After Blending with Water from WVWD Well No. 22, in 1989 and 1990, BF Goodrich Site, Rialto, California

Date	Pumped from WVWD Well No. 22 (acre/feet)	Estimated Perchlorate Concentration (ppb)	Total Water from All Blending Sources per Month (acre/feet)	Total Water (acre/feet)	Percentage of Well 22 Water to Total Water (%)	Estimated Perchlorate Concentration (ppb)
June 1989	39.9	185	937.8	977.6	4.1	8
July 1989	113.6	185	1154.8	1268.4	9.0	16
August 1989	103.3	185	1093.1	1196.4	8.6	16
September 1989	61.4	185	1032.9	1094.3	5.6	10
October 1989	13.6	185	1009.0	1022.5	1.3	2
					1989 Year Average	**10**
June 1990	17.5	185	896.5	914.0	1.9	4
July 1990	55.4	185	868.4	923.8	6.0	11
August 1990	137.5	185	730.8	868.3	11.8	29
September 1990	102.1	185	603.8	705.9	14.5	27
October 1990	85.4	185	512.7	598.1	14.3	26
November 1990	78.8	185	390.7	469.5	17.0	31
					1990 Year Average	**21**

Data source [28] [30]
ppb: parts per billion
FWC: Fontana Water Company
acre/feet indicates volume of water
WVWD: West Valley Water District

Table C6. City of Rialto Municipal Well Trichloroethylene (TCE) and Perchlorate Data, BF Goodrich Site, Rialto, California

Year	Average TCE (ppb)	Maximum Detected TCE (ppb) (Date)	Number of Samples	Average Perchlorate (ppb)	Maximum Detected Perchlorate (ppb) (Date)	Number of Samples	Well Status
Rialto Well No. 01							
1997	-	-	-	<4.0	<4.0	3	On-line
1998	<0.05	<0.05	2	<4.0	<4.0	12	On-line
1999	-	-	-	<4.0	<4.0	10	On-line
2000	<0.05	<0.05	1	<4.0	<4.0	12	On-line
2001	<0.05	<0.05	2	<4.0	<4.0	11	On-line
2002	<0.05	<0.05	1	<4.0	<4.0	10	On-line
2003	<0.05	<0.05	1	2.0	4.4 (11/4/2003)	14	On-line
2004	0.7	0.7 (2/24/2004)	2	<4.0	<4.0	11	On-line
2005	0.95	0.95 (2/22/2005)	1	3.5	5.7 (9/8/2005)	12	Off-line in 9/2005

Table C6. City of Rialto Municipal Well Trichloroethylene (TCE) and Perchlorate Data, BF Goodrich Site, Rialto, California

Year	Average TCE (ppb)	Maximum Detected TCE (ppb) (Date)	Number of Samples	Average Perchlorate (ppb)	Maximum Detected Perchlorate (ppb) (Date)	Number of Samples	Well Status
Rialto Well No. 01							
2006	1.2	1.2 (2/21/2006)	2	3	4 (1/25/2006)	11	Off-line in 9/2005
2007	0.8	0.8 (3/7/2007)	1	<4.0	<4.0	12	Off-line in 9/2005
2008	0.8	1.0 (11/12/2008)	2	2.6	8.2 (6/17/2008)	11	Off-line in 9/2005
2009	-	-	-	<4.0	<4.0	6	Off-line in 9/2005
Rialto Well No. 02							
1994	1.3	1.3 (6/8/1994)	2	-	-	-	On-line
1995	1.7	1.7 (12/12/1995)	1	-	-	-	On-line
1996	1.8	1.8 (6/28/1996)	1	-	-	-	On-line
1997	-	-	-	60	63 (12/2/1997)	2	Off-line in 10/1997

Table C6. City of Rialto Municipal Well Trichloroethylene (TCE) and Perchlorate Data, BF Goodrich Site, Rialto, California

Year	Average TCE (ppb)	Maximum Detected TCE (ppb) (Date)	Number of Samples	Average Perchlorate (ppb)	Maximum Detected Perchlorate (ppb) (Date)	Number of Samples	Well Status
Rialto Well No. 02							
1998	5.9	6.7 (6/17/1997)	3	71.7	78.5 (4/8/1998)	11	Off-line in 10/1997
1999	4.9	5.5 (3/3/1999)	2	65	80 (7/7/1999)	12	Off-line in 10/1997
2000	5.9	5.9 (1/15/2003)	1	54	68 (6/8/2000)	10	Off-line in 10/1997
2001	3.1	3.1 (2/24/2005)	1	66	88 (3/14/2001)	7	Off-line in 10/1997
2002	5.1	5.1 (6/5/2006)	1	48	54 (9/11/2002)	7	Off-line in 10/1997
2003	5.2	5.2 (8/12/2008)	1	44	51 (3/12/2003	15	Off-line in 10/1997
2004	5.9	6.7 (6/17/1997)	3	38	40 (1/26/2004)	8	Off-line in 10/1997
2005	4.9	5.5 (3/3/1999)	2	39	47 (11/2/2005)	6	Off-line in 10/1997
2006	5.9	5.9 (1/15/2003)	1	44	46 (6/5/2006)	2	Off-line in 10/1997

Table C6. City of Rialto Municipal Well Trichloroethylene (TCE) and Perchlorate Data, BF Goodrich Site, Rialto, California

Year	Average TCE (ppb)	Maximum Detected TCE (ppb) (Date)	Number of Samples	Average Perchlorate (ppb)	Maximum Detected Perchlorate (ppb) (Date)	Number of Samples	Well Status
Rialto Well No. 02							
2007	3.1	3.1 (2/24/2005)	1	60	74 (11/6/2007)	6	Off-line in 10/1997
2008	5.1	5.1 (6/5/2006)	1	66	72 (8/12/2008)	7	Off-line in 10/1997
Rialto Well No. 04							
1997	-	-	-	<4.0	<4.0	4	On-line
1998	<0.05	<0.05	2	<4.0	<4.0	9	On-line
1999			-	<4.0	<4.0	9	On-line
2000	<0.05	<0.05	2	<4.0	<4.0	9	On-line
2001	<0.05	<0.05	3	<4.0	<4.0	11	On-line
2002	<0.05	<0.05	1	2.5	5.8 (10/7/2002)	12	Off-line in 10/2002
2003	-	-	-	<4.0	<4.0	12	Off-line in 10/2002

Table C6. City of Rialto Municipal Well Trichloroethylene (TCE) and Perchlorate Data, BF Goodrich Site, Rialto, California

Year	Average TCE (ppb)	Maximum Detected TCE (ppb) (Date)	Number of Samples	Average Perchlorate (ppb)	Maximum Detected Perchlorate (ppb) (Date)	Number of Samples	Well Status
Rialto Well No. 04							
2004	<0.05	<0.05	2	4.7	8.4 (12/14/2004)	9	Off-line in 10/2002
2005	<0.50	<0.50	2	10	15 (12/2/2005)	12	Off-line in 10/2002
2006	-	-	-	13	21 (12/12/2006)	12	Off-line in 10/2002
2007	<0.05	<0.05	1	26	42 (9/11/2007)	9	Off-line in 10/2002
Rialto Well No. 06							
1997	-	-	-	3	6 (9/25/1997)	3	On-line
1998	<0.05	<0.05	2	<4.0	<4.0	10	On-line
1999	-	-	-	<4.0	<4.0	10	On-line
2000	<0.05	<0.05	1	5	9 (9/6/2000)	14	On-line
2001	0.4	1.0 (12/11/2001)	3	10	16 (12/11/2001)	10	Off-line-1/2001

Table C6. City of Rialto Municipal Well Trichloroethylene (TCE) and Perchlorate Data, BF Goodrich Site, Rialto, California

Year	Average TCE (ppb)	Maximum Detected TCE (ppb) (Date)	Number of Samples	Average Perchlorate (ppb)	Maximum Detected Perchlorate (ppb) (Date)	Number of Samples	Well Status
Rialto Well No. 06							
2002	-	-	-	24	38 (9/12/2002)	9	Off-line-1/2001
2003	-	-	-	37	46 (8/19/2003)	12	Off-line-1/2001
2004	-	-	-	50	68 (12/14/2004)	11	Off-line-1/2001
2005	1.6	1.6 (2/24/2005)	1	76	94 (11/23/2005)	12	Off-line in 1/2001
2006	2.5	2.5 (2/21/2006)	1	114	140 (12/12/2006)	8	Off-line in 1/2001
2007	-	-	-	181	230 (10/24/2007)	11	Off-line in 1/2001
2008	4.7	5.3 (11/12/2008)	2	240	320 (11/12/2008)	10	Off-line in 1/2001
2009	-	-	-	230	280 (3/11/2008)	6	Off-line in 1/2001

Table C6. City of Rialto Municipal Well Trichloroethylene (TCE) and Perchlorate Data, BF Goodrich Site, Rialto, California

Year	Average TCE (ppb)	Maximum Detected TCE (ppb) (Date)	Number of Samples	Average Perchlorate (ppb)	Maximum Detected Perchlorate (ppb) (Date)	Number of Samples	Well Status
Chino Well 01							
1997	-	-	-	<4.0	<4.0	1	On-line
1998	<0.05	<0.05	2	4	8 (1/7/1998)	3	On-line
1999	-	-	-	5.5	7.5 (3/2/1999)	3	On-line
2000	-	-	-	7	14 (9/6/2000)	9	On-line
2001	2.0	2.3 (3/13/2001)	3	8	14 (3/13/2001)	10	Off-line in 7/2002
2002	2.4	2.4 (7/16/2002)	1	6.4	9.8 (2/21/2002)	9	Off-line in 7/2002
2003	-	-	-	4.1	5.8 (12/9/2003)	8	Off-line in 7/2002
2004	-	-	-	3.6	5.9 (1/13/2004)	5	On-line with treatment in 12/2004
2005	2.1	2.1 (2/22/2005)	1	9	25 (10/18/2005)	29	On-line with treatment in 12/2004

Table C6. City of Rialto Municipal Well Trichloroethylene (TCE) and Perchlorate Data, BF Goodrich Site, Rialto, California

Year	Average TCE (ppb)	Maximum Detected TCE (ppb) (Date)	Number of Samples	Average Perchlorate (ppb)	Maximum Detected Perchlorate (ppb) (Date)	Number of Samples	Well Status
Chino Well 01							
2006	2.7	2.8 (2/16/2006)	2	8	10 (11/14/2006)	47	On-line with treatment in 12/2004
2007	1.7	1.7 (3/7/2007)	1	8	11 (10/16/2007)	48	Off-line in 12/2007
2008	-	-	-	6	10 (1/7/2008)	8	Off-line in 12/2007
2009	-	-	-	5.9	8.6 (5/6/2009)	6	Off-line in 12/2007
Chino Well 02							
1997	-	-	-	<4.0	<4.0	1	On-line
1998	0.8	1.5 (12/7/1998)	2	<4.0	<4.0	3	On-line
1999	0.6	1.2 (needs date)	3	<4.0	<4.0	6	On-line
2000	-	-	-	<4.0	<4.0	2	On-line
2001	1.5	2.6 (12/11/2001)	3	3	5 (12/11/2001)	4	On-line

Table C6. City of Rialto Municipal Well Trichloroethylene (TCE) and Perchlorate Data, BF Goodrich Site, Rialto, California

Year	Average TCE (ppb)	Maximum Detected TCE (ppb) (Date)	Number of Samples	Average Perchlorate (ppb)	Maximum Detected Perchlorate (ppb) (Date)	Number of Samples	Well Status
Chino Well 02							
2002	<0.05	<0.05	1	3.4	5.6 (12/2/2002)	4	Off-line in 12/2002
2003	-	-	-	4.2	5.5 (4/22/2003)	6	On-line with treatment in 10/2003
2004	3	3 (3/16/2004)	1	2	5 (3/16/2004)	8	On-line with treatment in 10/2003
2005	0.4	0.7 (2/22/2005)	2	4.2	5.9 (5/18/2005)	22	On-line with treatment in 10/2003
2006	0.6	0.7 (7/25/2006)	2	3.2	5.6 (1/25/2006)	50	On-line with treatment in 10/2003
2007	0.8	0.8 (3/7/2007)	1	3.5	8.0 (11/6/2007)	52	On-line with treatment in 10/2003
2008	-	-	-	2.8	7.6 (8/12/2008)	37	On-line with treatment in 10/2003
2009	-	-	-	2.3	5.3 (3/23/2009)	28	On-line with treatment in 10/2003

Data source [44,78]
"-"indicates no TCE detection to date.
<4.0 indicates level below state laboratory reporting limit of 4 ppb for perchlorate
On-line indicates water from that well is being distributed and served to customers;
Off-line indicates that water from that well is not being distributed or served to customers
TCE laboratory reporting limit= 0.05 ppb
Non detects were valued at 2 ppb to calculate averages for perchlorate ppb: parts per billion

Table C7. City of Colton Municipal Well Perchlorate Data, BF Goodrich Site, Rialto, California

Year	Average Perchlorate (ppb)	Maximum Detected Perchlorate (ppb) (date)	Number of Samples	Well Status
Colton Well 15				
1997	4.7	7.0 (9/26/1997)	3	On-line
2001	7.8	7.8 (9/24/2001)	1	On-line
2002	2.6	5.7 (3/4/2002)	6	Off-line in 3/2002
2003	<4.0	<4.0	3	On-line with treatment in 10/2003
2004	5.6	5.6 (5/3/2004)	1	On-line with treatment in 10/2003
2005	4.1	5.2 (8/9/2005)	3	On-line with treatment in 10/2003
2006	<4.0	<4.0	1	On-line with treatment in 10/2003
2007	5.0	6.6 (5/15/2007)	14	On-line with treatment in 10/2003
2008	5.0	6.4 (2/5/2008)	6	On-line with treatment in 10/2003
2009	3.7	5.3 (5/21/2009)	2	On-line with treatment in 10/2003

Table C7. City of Colton Municipal Well Perchlorate Data, BF Goodrich Site, Rialto, California

Year	Average Perchlorate (ppb)	Maximum Detected Perchlorate (ppb) (date)	Number of Samples	Well Status
Colton Well 17				
1997	<4.0	<4.0	2	On-line
2001	<4.0	<4.0	1	On-line
2002	4.4	9.4 (3/25/2002)	6	Off-line in 4/2002
2003	<4.0	<4.0	1	On-line with Treatment in 10/2003
2004	7.7	7.7 (5/3/2004)	1	On-line with Treatment in 10/2003
2005	8	10 (8/9/2005)	3	On-line with treatment in 10/2003
2006	<4.0	<4.0	1	On-line with treatment in 10/2003
2007	5.3	8.4 (6/4/2007)	14	On-line with treatment in 10/2003
2008	3.8	6.2 (3/24/2008)	3	On-line with treatment in 10/2003
2009	4.7	7.4 (10/27/2009)	2	On-line with treatment in 10/2003

Table C7. City of Colton Municipal Well Perchlorate Data, BF Goodrich Site, Rialto, California

Year	Average Perchlorate (ppb)	Maximum Detected Perchlorate (ppb) (date)	Number of Samples	Well Status
Colton Well 24				
1997	4	5 (11/10/1997)	2	On-line
2001	6	6 (9/24/2001)	1	On-line
2002	4.5	5.2 (5/8/2002)	5	Off-line in 2/2002
2003	3.1	4.2 (10/6/2003)	2	On-line with Treatment in 10/2003
2004	<4.0	<4.0	1	On-line with Treatment in 10/2003
2005	<4.0	<4.0	3	On-line with Treatment in 10/2003
2006	<4.0	<4.0	1	On-line with Treatment in 10/2003
2007	4.9	6.4 (11/7/2007)	44	On-line with Treatment in 10/2003
2008	4.5	5.8 (3/25/2008)	6	On-line with Treatment in 10/2003
2009	4.6	4.9 (5/20/2009)	2	On-line with Treatment in 10/2003

Data source [79]
Trichloroethylene has not been detected in Colton wells 15, 17, and 24
ppb: parts per billion
<4.0 indicate level below state laboratory reporting limit of 4 ppb. Non -detects were valued at 2 ppb to calculate averages.
On-line indicates water from that well is being distributed and served to customers
Off-line indicates that water from that well is not being distributed or served to customer

Appendix D. Toxicological Summaries

This appendix provides background information from toxicological profiles published by the Agency for Toxic Substances and Disease Registry (ATSDR), information developed by the California Environmental Protection Agency, Office of Environmental Health Hazard Assessment (OEHHA), and the U.S. Environmental Protection Agency (EPA) [54]. It highlights the toxicological effects of contaminants of concern (exceeding health comparison or screening values) detected in groundwater from the BF Goodrich Site.

Acronyms and Units of Measure Used in this Appendix
ppb: parts per billion
mg/kg/day: milligram per kilogram per day
$\mu g/m^3$: micrograms per cubic meter

Perchlorate [23]

- Inorganic compound joined to an alkali or alkaline earth metals such as ammonium and potassium to form a colorless salt.
- Formed naturally in the atmosphere and is manufactured in large amounts, colorless and odorless, dissolves readily into water.
- Stable at room temperatures, but very reactive at high temperatures,
- Used primarily for rocket fuel and pyrotechnics,
- Primarily enters the body when swallowing contaminated food or water. Can also enter the body by breathing air with dust or droplets containing perchlorate.
- Targets the thyroid gland where it can block its ability to uptake iodine from the blood.
- Chronic oral minimum risk level, RfD = 0.0007 mg/kg/day (based on iodine inhibition study in humans).
- Not likely to pose a risk to thyroid cancer in humans, at least at doses necessary to alter thyroid hormone homeostasis (EPA).

Trichloroethylene (TCE) [25]

- Synthetic chemical, liquid at room temperature; most commonly used as a degreaser, also used in some household products.
- Evaporates readily from surface soil, water; breaks down in air to form phosgene, a lung irritant; breaks down more slowly from in deep soils, groundwater.
- Can enter body from breathing, swallowing, and skin contact
- Adverse health effects due to chronic exposure possibly include childhood leukemia, kidney effects, liver effects, heart defects, nervous system effects, and other birth defects.
- Acute inhalation minimal risk level = 2,000 parts per billion (10,700 $\mu g/m^3$) (based on neurological effects in humans).
- Intermediate inhalation minimal risk level = 100 parts per billion (540 $\mu g/m^3$) (based on neurological effects in rats).
- Acute oral minimal risk level = 0.2 mg/kg/day (based on developmental effects in mice).
- Classified as a probable human carcinogen by the EPA (inadequate human, sufficient animal evidence); probable human carcinogen by the International Agency for Research on Cancer (limited human, sufficient animal evidence); may reasonably be anticipated to be a human carcinogen by the U.S. Department of Health and Human Services.
- Cancer slope factors: Ingestion from drinking or swimming is 0.0059 and inhalation from breathing fumes or vapors is 0.007.

Appendix E. Perchlorate in Food

Background

In 1997, the U.S. EPA detected perchlorate in Lake Mead, a reservoir of the Colorado River located in Southern Nevada. The water from Lake Mead is the primary source of agricultural irrigation water for food crops grown in Southern California and Southwestern Arizona. The source of contamination was traced to two perchlorate manufacturing facilities that had operated in Southern Nevada from the early 1950s to 1990 [80]. Reported levels of perchlorate in the lower Colorado River have ranged from 2 to 9 parts per billion (ppb).

Exploratory Survey on Perchlorate in Food, 2004-2005

In 2004 and 2005, due to the perchlorate contamination in the Lower Colorado River, the U.S. Food and Drug Administration (FDA) conducted an exploratory survey of individual food products to determine if crops were absorbing the perchlorate in the irrigation water [49]. The survey was conducted in two parts. For the first part, the FDA gathered samples from select foods that are high in water content (lettuce, tomatoes, spinach, carrots, and cantaloupe) and from bottled water located in the Southwest United States, which are known to be contaminated with perchlorate. The data were used to determine the need for future monitoring or strategies. The second part was done to expand the scope of items surveyed in the first part. In addition to tomatoes, carrots, spinach, and cantaloupe, the FDA sampled apples, oranges, grapes, cucumbers, green beans, farmed fish, shrimp, various grain products, and milk. Food was sampled from several agricultural areas in the United States (from 22 different states) and included imports from Mexico, Chile, Canada, and Southeast Asia. Results of the sampling are presented in table E1 below.

Survey Data on Perchlorate in Food, 2005 and 2006

In order to evaluate the potential risk from perchlorate in food, the FDA included perchlorate analysis as part of its on-going Total Diet Survey (TDS) in 2005 and 2006. The FDA worked to expand their understanding of perchlorate levels to a wider variety of foods from different locations [81]. Approximately 285 core foods of the U.S. food supply were sampled for various chemicals and nutrients. The TDS is conducted 4 times a year (sampling the same core foods) in four different regions of the United States (i.e., West, North, South, and East). The survey detected perchlorate in 59% of all samples. Of the 285 foods sampled, 211 had at least one positive detection for perchlorate [23].

The FDA used the data from the TDS to approximate dietary exposure doses to perchlorate for different age groups.

The estimated perchlorate dietary intake for adults aged 25 to over 70 years ranged from 0.00008 to 0.00012 micrograms per kilogram per day (mg/kg/day), and ranged from 0.00026 to 0.00039 mg/kg/day for infants (6-months old) and children aged 2 to 10.

Table E1. Perchlorate Results from 2004-2005 FDA Studies

Food Groups	Number of Data Points	Average Perchlorate (ppb)
Lettuce	137	10.3
Milk	125	5.81
Tomatoes	73	13.7
Carrots	59	15.8
Spinach	36	115
Cantaloupes	48	28.6
Apples	9	0.15*
Grapes	12	8.58
Oranges	10	3.47
Strawberries	19	2.14
Watermelon	19	1.96
Fruit juices (apple and orange)	14	2.31
Broccoli	14	8.49
Cabbage	13	8.80
Greens	14	92.4
Cucumber	20	6.64
Green beans	19	6.12
Onions	12	0.53
Potatoes	6	0.15*
Sweet potatoes	6	1.24
Corn meal	22	1.16
Oatmeal	22	3.96
Rice (brown and white)	19	0.50*
Whole wheat flour	19	4.27
Catfish	7	1.02
Salmon	11	1.06
Shrimp	5	19.83
Total	**775**	-

*Averages are ½ Limit of Detection due to perchlorate. Results for these foods were all non-detects [82]

Appendix F. Exposure Assumptions and Equations for Estimating Increased Cancer Risk and Cancer Slope Factors.

Equation and exposure assumptions used for estimating increased cancer risk from TCE ingestion exposure
Equation: (CW)(IR)(ET)(EF)(ED)/(BW)(AT)
CW= concentration in water (0.0097mg/L)
IR= ingestion (swallowing) rate (liters/day) – (adult 2 liters/day, child 1 liter/day)
ET= exposure time (1 hour a day for swimming)
EF=exposure time – (days) - (150 days for ingestion and 100 days for swimming)
ED= exposure duration (2.5 years)
BW= body weight (kg) – (for adult 70 kg: average of women and men) (for a child16 kg: 50th percentile of females and males ages 1-6)
AT= AT= average lifetime (365 days* 70 years)
Office of Environmental Health Hazard Assessment Ingestion Cancer slope factor = 0.00059 mg/kg-day

An early life adjustment factor of 10 was applied to the child estimated increased cancer exposure risk.

Equation and exposure assumptions used for estimating increased cancer risk from TCE while showering exposure
Equation: (CA)(IR)(ET)(EF)(ED)/(BW)(AT)
CA= (CW)(K)(FW)(t)(VB) =(0.078 mg/m^3 or 14 ppbv)
IR= inhalation rate (0.6 m^3/hr; EPA Risk Assessment guidance for Superfund Vol 1)
ET= exposure time (0.33 hour/day)
EF= exposure time (150 days)
ED= exposure duration (2.5 years)
BW= body weight (kg) – (for adult 70 kg: average of women and men) (for a child16 kg: 50th percentile of females and males ages 1-6)
AT= averaging lifetime (365 days* 70 years)
Office of Environmental Health Hazard Assessment Inhalation Cancer slope factor = 0.007 mg/kg-day

An early life adjustment factor of 10 was applied to the child estimated increased cancer exposure risk.

Data source [77,83,84]