INVESTIGATION OF BIRTH DEFECTS AND COMMUNITY EXPOSURES IN KETTLEMAN CITY, CA

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EXECUTIVE SUMMARY

BACKGROUND

In January 2010, Governor Arnold Schwarzenegger directed the California Environmental Protection Agency (Cal/EPA) and the California Department of Public Health (CDPH) to investigate an apparent increase in the number of infants born with birth defects after 2006 in Kettleman City. Kettleman City community members had raised concerns about birth defects and questioned whether there was a link to a nearby hazardous waste landfill or other environmental exposures. Also, the California Birth Defects Monitoring Program (CBDMP) within CDPH had previously reviewed the state's registry for birth defects in Kettleman City from 1987 to 2008, reporting that there were more children born in the year 2008 with birth defects than would have been expected based on the historical pattern for the area.

The Governor directed Cal/EPA to assess possible environmental contaminants in the air, water and soil that could cause birth defects. CDPH was tasked with conducting a more extensive investigation of the reported birth defects as a follow-up to CBDMP's earlier review, which had been undertaken at the request of the Kings County Health Officer.

The Cal/EPA investigation used experts from each of the Agency's boards and departments -- the Office of Environmental Health Hazard Assessment (OEHHA), the Department of Toxic Substances Control (DTSC), the Air Resources Board (ARB), the Department of Pesticide Regulation (DPR), and the State Water Resources Control Board (SWRCB). Led by OEHHA and in consultation with CDPH and the U.S. Environmental Protection Agency (U.S. EPA), the Boards and Departments assessed potential contaminants and tested for chemicals that could cause birth defects and other adverse health effects. Tests were conducted in the summer of 2010 and the samples analyzed in September and October.

The CDPH Environmental Health Investigations Branch (EHIB), working with CBDMP, initiated the follow-up investigation in January 2010. CDPH conducted in-depth interviews with mothers of infants born with birth defects and reviewed their medical records in the spring of 2010.

This investigation represented an unprecedented effort by multiple programs within U.S. EPA, Cal/EPA and CDPH to examine specific public health concerns within an individual community. Experts from various scientific disciplines worked collaboratively to investigate a wide range of medical, environmental and other factors that might plausibly be associated with the reported birth defects.

Although the overall investigation found levels of pollutants in the air, water and soil of Kettleman City, the comprehensive investigation did not find a specific cause or environmental exposure among the mothers that would explain the increase in the number of children born with birth defects in Kettleman City.

CDPH INVESTIGATION

In general, the causes of most birth defects are unknown, although some conditions and exposures ("risk factors") are known to increase the risk of specific types of birth defects. CDPH conducted detailed in-person interviews with mothers of affected children in Kettleman City to search for known or suspected genetic, medical or pregnancy-related risk factors; known or suspected behavioral and lifestyle risk factors; and environmental and occupational exposures that could potentially increase the risk of birth defects.

CDPH sought to identify all cases of birth defects, including potential cases reported by community members. A total of 11 eligible children were identified who were born with major, structural birth defects between 2007 through March 31, 2010 to mothers who had lived in Kettleman City during their pregnancies. The birth defects occurring during this expanded time period confirmed the 2008 excess in Kettleman City previously reported by CBDMP. The mothers of six affected children consented to be interviewed, three declined, and two could not be reached. CDPH supplemented the interviews with a review of the mothers' and children's medical records. CBDMP experts examined the records of all affected children to evaluate whether there were any highly unusual cases or patterns that might point to potential causes.

Scientifically rigorous studies of causes of human birth defects generally require evaluation of hundreds of birth defects or more. In an investigation of fewer than a dozen cases, CDPH's objectives had to be more limited, and focused largely on evaluating known or suspected risk factors. CDPH also evaluated the presence of any unusual types of birth defects, patterns of occurrence, or commonalities between the birth defects, which could potentially suggest a common source.

Thus, this investigation offered an opportunity to identify or rule out recognized risk factors as a potential cause of the increase in birth defects generally. However, it could not definitively identify the cause of any individual birth defect in the absence of a strong known risk factor.

Overall, CDPH did not find a specific cause or environmental exposure among the mothers that would explain the increase in the number of children born with birth defects in Kettleman City. Some children had multiple abnormalities, while others had single birth defects. CDPH found that all the birth defects represented different underlying conditions, although a few shared some features. The reported birth defects were of types often seen in birth defects surveillance in California and elsewhere. These observations, coupled with the lack of any shared unusual exposures, suggest that the birth defects in Kettleman City did not have a common cause.

CDPH found that maternal medical, family, and pregnancy risk factors were unlikely to explain the occurrence of birth defects between 2007 and 2010. Generally, the mothers received adequate health care, appeared to be free of known health conditions that would create a risk for birth defects, and experienced few other potentially significant

risk factors. None of the mothers interviewed used alcohol, drugs, or tobacco; therefore, these potential risk factors were not found to be a cause of these birth defects.

The mothers interviewed reported a variety of concerns about possible exposures to environmental contaminants, including outdoor air and odors, pesticides, and drinking water quality. Most of these issues were addressed by the Cal/EPA investigation.

Community residents also expressed concerns about potentially elevated rates of cancer in Kettleman City. In response, CDPH's California Cancer Registry (CCR) completed an evaluation of cancer in the Kettleman City area from 1996 through 2008, the most recent year for which data were complete. Overall, the census tract that includes Kettleman City experienced the same types of cancers as found elsewhere and fewer cancer cases than what would be expected for the area.

Concerns were also specifically raised about childhood cancers, particularly acute lymphocytic leukemia. Among children less than 15 years of age in the census tract, five cancers were diagnosed during the 12-year time period reviewed while fewer than three childhood cancers would be anticipated. Acute lymphocytic leukemia comprised the majority of these childhood cancers, and there were fewer than five cases of acute lymphocytic leukemia observed. The children with acute lymphocytic leukemia resided in other areas of the census tract outside of Kettleman City.

CAL/EPA INVESTIGATION

As a first step, Cal/EPA scientists developed a list of chemicals and pesticides that may cause birth defects and may be present in Kettleman City. Cal/EPA also identified potential sources of these chemicals. They included agricultural operations, the nearby Chemical Waste Management Kettleman Hills hazardous waste landfill facility (KHF), former industrial and commercial operations, the town's drinking water, petroleum sources, illegal dumping, and the age and condition of homes in Kettleman City.

In addition to information on chemicals that are known or suspected of causing birth defects, the sampling also provided information on chemicals that can cause other kinds of health effects.

Extensive testing of air, water, soil, and soil gas did not find any exposures to hazardous chemicals likely to be associated with birth defects. Similarly, historical records of facilities that operated in the area and investigations of possible illegal dumping of hazardous materials did not find evidence of chemical releases into the community that could pose risks of birth defects.

Cal/EPA's overall investigation found levels of environmental pollutants in the air, water and soil of Kettleman City comparable to those found in other San Joaquin Valley communities. Based on these findings, Cal/EPA does not believe there is anything

unique about environmental conditions in Kettleman City that poses special health risks to residents.

The Cal/EPA test results identified several instances in which specific chemicals should either be further investigated or reduced. Specific findings and recommendations are as follows:

Agricultural Operations

DPR compiled information for 19 pesticides used within five miles of Kettleman City between late 2006 and 2009. DPR then estimated airborne pesticide levels in the community during that period. In the summer of 2010, DPR also tested air for 27 pesticides, including four that could cause birth defects.

The results showed that it is very unlikely that pesticides caused the birth defects. There was one day during 2006 through 2009 when the estimated air concentration of one pesticide, methyl isothiocyanate (MITC), was higher than DPR's "screening level" for birth defects. Estimated air concentrations of chlorpyrifos and diazinon during this period also exceeded DPR screening levels for nervous system effects on several days. However, the risk of toxic effects from pesticide exposures is probably lower than in other Central Valley towns where pesticide use is greater. DPR is conducting comprehensive evaluations of chlorpyrifos and diazinon to determine if additional reductions in exposure are needed. Also, DPR is already taking statewide measures concerning MITC that should reduce exposures in Kettleman City and elsewhere to this pesticide.

Finally, tests of agricultural soil found no evidence of pesticide levels that pose a health risk concern.

Kettleman Hills Hazardous Waste Facility

ARB monitored air at two sites immediately upwind and downwind of KHF, which is located about 3.5 miles from Kettleman City, and also at the Kettleman City Elementary School.

The air monitoring found contaminant levels similar to those in Fresno and Bakersfield. ARB's review of KHF air-monitoring records between 2007 and 2009 did not find any indication that emissions from the facility affected air quality in the community during those years. Therefore, it is unlikely that airborne contaminants measured in this study at KHF pose health risks to the residents of Kettleman City.

Further, the KHF is on geological formations that divert groundwater flow away from the town. Wastewater from the facility cannot affect the wells that supply Kettleman City's drinking water.

Industrial Operations and Petroleum Sources

Historical records and testing of soil gas samples from industrial and commercial properties showed no evidence of contaminants entering the community through

groundwater or air. There was no evidence that the oil pipeline, former natural gas wells, gas stations or other petroleum sources contaminated the town. Soil samples showed no elevated levels of heavy metals that would indicate oil contamination. Estimated levels of traffic-related diesel exhaust are lower in Kettleman City than in the rest of Kings County and neighboring Kern County.

Water Wells

Two wells supply the town's water. The elementary school's water comes from a third well. Testing found elevated levels of arsenic both in the wells and in water from home taps. However, it is unlikely that arsenic (a known developmental toxin) in drinking water could have been a factor in the recent birth defects based on the concentrations measured and on CDPH's findings that most mothers of children with birth defects who were interviewed did not drink tap water. There is still a need to reduce arsenic levels in the drinking water to meet regulatory standards, which would lower risks of other health effects that have been associated with arsenic exposures in other populations.

In addition, lead was detected in the school's well and one of the municipal wells, though below the regulatory action level and at levels commonly found in California. This finding may be the result of laboratory error, as other tests unrelated to Cal/EPA's investigation have not detected lead in the wells. The lead finding merits further sampling to see if it can be verified. Lead is a nervous system toxin that can particularly harm children's mental and intellectual development.

Untreated well water contained high levels of benzene (a carcinogen and a developmental toxicant), but treatment removed the chemical before it reached home taps. Elevated levels of airborne benzene were detected near one of the well treatment units and merit further investigation by ARB and the San Joaquin Valley Air Pollution Control District (SJVAPCD).

Homes

Soil and soil gas samples from homes did not contain significant levels of contaminants. The only exception was one home where soil in the yard had elevated levels of the banned pesticide chlordane (which was likely used to treat termites). Although this is not a threat to the community, DTSC will investigate and make any needed corrections at that home.

Arsenic levels in soil were similar to those in other Central Valley towns.

There was no evidence that illegal dumping of household trash or cars exposed the town to contaminants.

In developing the sampling plan for Kettleman City, Cal/EPA determined that sampling indoor dust and air in the homes of the women who had had children with birth defects would provide information only on recently accumulated dust and not on exposures immediately before or during pregnancies from prior years. However, U.S. EPA plans to measure indoor dust pesticide levels in some homes in the community to provide a

general indication of pesticide levels inside Kettleman City homes. DPR, OEHHA and CDPH staff are available to assist U.S. EPA in evaluating any data collected on pesticides in house dust.

California Aqueduct and Irrigation Canals

Levels of arsenic below the state's drinking water standard were detected in water from the California Aqueduct and a nearby drainage canal. Water in the canal, but not the aqueduct, also contained a detectable level of lead; however, it was below state and federal regulatory action levels. Sediment from the canal contained arsenic levels similar to those in Kettleman City residents' yards.

RECOMMENDATIONS

The comprehensive investigation did not find a specific cause or environmental exposure among the mothers that would explain the increase in the number of children born with birth defects in Kettleman City. The state will continue to monitor birth defects in the area. Additionally, although no association with the birth defects was found, the state will work with the community to improve current environmental health conditions. Follow-up actions will include:

1. CDPH will continue monitoring birth defects for the next few years. Although in recent years there have been more children with birth defects born to mothers living in Kettleman City than would be expected, in many of the years between 1987 and 2006, there were no children with birth defects born there. This pattern does not suggest a long-standing exposure that would increase the community's risk for birth defects. Continued surveillance will determine whether the number of cases returns to the earlier pattern or whether the excess persists.

2. Regulatory agencies will continue efforts to reduce arsenic levels in the town's drinking water, either through an alternative water source or improved treatment. Using funding provided by CDPH, the local water district is analyzing treatment options to ensure a sustainable solution to bring drinking water into compliance with all drinking water standards.

3. While lead was detected in the school and municipal wells, the findings were not consistent with previous tests of the well water. DTSC will conduct follow-up sampling for detectable lead in the water from two wells.

4. DPR will continue implementing plans for statewide assessments of chlorpyrifos and diazinon, and mitigation for MITC. This work will benefit farming communities throughout the state.

5. The ARB will work with the SJVAPCD to investigate elevated benzene emissions from a treatment unit at the southwest Kettleman City drinking water well. While these emissions do not appear to pose a threat to the community, they could be

unnecessarily exposing people near the well to benzene. If the SJVAPCD confirms these findings, ARB will work with the district to evaluate the need for mitigation measures.

6. DTSC will investigate and take any needed actions to address elevated levels of chlordane in one home's soil. High chlordane levels at only one house are not a threat to the community, but they merit further attention.

Part 1

Investigation of Birth Defects in Kettleman City

by the
California Department of Public Health

Investigation of Birth Defects in Kettleman City

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INTRODUCTION

In July 2009, at the request of the Kings County Health Officer, the California Birth Defects Monitoring Program (CBDMP) initiated a review of the number of birth defects in Kettleman City from 1987 to 2008, using data from a statewide birth defects registry.[1] The Health Officer was responding to concerns raised by members of the Kettleman City community and environmental advocates about an apparent increase in the number of infants born with birth defects after 2006. The community also raised concerns about a nearby hazardous waste facility and whether environmental exposures from that facility or other potential sources in the area may have been linked to birth defects. The CBDMP review found that the number of children born in 2008 with birth defects was higher than might be expected, based on the historical pattern.

In January 2010, Governor Schwarzenegger directed the California Environmental Protection Agency (Cal/EPA) and the California Department of Public Health (CDPH) to conduct a more extensive investigation of the reported birth defects and the Kettleman City environment. In response to the Governor's directive, the Environmental Health Investigations Branch (EHIB) within CDPH initiated a health investigation of the birth defects in Kettleman City, working in concert with CBDMP staff. At the same time, the boards and departments in Cal/EPA began an evaluation of environmental exposures.

The follow-up health investigation of birth defects had a broader scope than the initial evaluation by CBDMP. The primary purpose of the earlier review was to examine the rate of birth defects in the community, based only on information contained in the state registry. To conduct this follow-up investigation, it was necessary to interview the mothers of the affected children to obtain detailed information about their medical histories, their pregnancies, potential risk factors, and possible exposures that are not collected for the birth defects registry. This report summarizes the information obtained

from in-person interviews of those mothers who agreed to participate in this investigation.

BACKGROUND

What is a birth defect?

A birth defect is an abnormality present when a child is born that results in physical or mental disabilities or death.[2,3] Birth defects may affect just one part of the body, such as the heart or lip, or may involve many different parts. Defects can involve abnormal structures that can be seen at birth, such as a cleft lip or club foot, but may also include abnormalities that are not visible, such as hearing problems or developmental disabilities. The CBDMP registry and this investigation focus on structural birth defects. Birth defects affecting the heart are common.[3] Other common problems include neural tube defects, which are abnormalities of the spine and brain that can be life-threatening. Birth defects can affect the upper lip and roof of the mouth. These are called cleft lip and cleft palate, which can occur alone, together, or in combination with defects in other parts of the body.

What does CDBMP do to monitor and prevent birth defects?

CBDMP collects information on children with birth defects. The program helped to develop national guidelines used by the U.S. Centers for Disease Control and Prevention (CDC), and reports information on a yearly basis, which allows birth defects in California to be compared with those in other states. CBDMP uses the data to monitor trends and help plan prevention strategies to reduce the number of birth defects in California (See Appendix 1). CBDMP does not collect data on miscarriages and low birth weight, or on development problems (such as autism), which were not included in this investigation.

What causes birth defects?

The causes of most birth defects are unknown. They may occur because of an inherited (genetic) condition, or because of exposures to the developing fetus or nutritional deficiencies during pregnancy. An example of exposure to the developing fetus is when a mother is given medicine that is transferred across the placenta to the baby. Some exposures to non-genetic factors during pregnancy that are known to cause birth defects include certain viruses, such as Rubella, as well as a limited number of medications.

Everyone inherits half of their genes from their mother and half from their father, with the genes organized into 23 chromosomes from each parent. Some birth defects happen because the baby inherited a gene that had a mutation (that is, the gene was damaged). Other defects can be caused because of a problem with the number or structure of chromosomes. Down syndrome is an example of a chromosome defect. Down syndrome children have an extra chromosome 21 in all of their cells. Other examples of birth defect syndromes involve an extra copy of chromosome 13 or 18. Babies with chromosome problems can have many problems. The main known risk factor for chromosomal birth defects is older maternal age.

What is a "risk factor"?

A risk factor is any influence or condition that can increase the risk (or the chance) that a disease or other health problem will happen. For instance, smoking cigarettes is a well known risk factor for lung cancer. Obesity is a risk factor for diabetes. Risk factors for birth defects and related developmental problems include alcohol consumption, cigarette smoking, exposure to certain viruses, specific medications, and some chemical exposures during pregnancy.

Cleft lip and palate – causes and risk factors

Cleft lip and palate occur when the upper lip and the roof of the mouth do not completely close together during fetal development, leaving a gap or "cleft." Cleft lip (alone, or with cleft palate) can occur as a condition in itself (isolated cleft lip), or as one part of at least 400 different conditions. Cleft palate is a separate condition, and usually occurs alone, but occasionally it is part of a genetic disorder. The cause of clefts is mainly unknown, but is thought to usually represent a combination of genetic and environmental effects. Exposures that have been linked to the risk of cleft lip or palate include maternal alcohol or tobacco exposure and certain anti-seizure medications, and maternal deficiency of the vitamin folic acid, which is found in green leafy vegetables, citrus fruits, beans and liver, and is added as a supplement to many cereals and bread.

Kettleman City: Residents and environment

Kettleman City is a community of about 1620 residents in Kings County,[4] located near the Interstate 5 freeway in the San Joaquin Valley. Agricultural fields and orchards surround the town, and nearby there is an extensive area of natural gas and oil extraction and production. The majority of residents are from Mexico and are Spanish-speaking.[5] In the 2000 Census, the median household income was $22,409 and 43.7 % of the population was living below the poverty level.[6] Compared to the US population, Kettleman City residents are younger, and are more likely to rent rather than own their homes.[5] During public meetings in Kettleman City, residents expressed their perception that environmental exposures faced by their community have not been adequately addressed.[7] Residents have raised a number of specific environmental concerns, as discussed in the following paragraphs.

Pesticides. The surrounding agricultural fields raise community concerns about exposures to pesticides. Residences on the perimeter of Kettleman City are immediately adjacent to the fields, and all homes are not much further away, as the entire town encompasses only 0.2 square miles. The accompanying Cal/EPA exposure assessment discusses the types of pesticides that have been applied to these fields and the potential for residential exposure due to drift.

Drinking water. Community members expressed concerns about their drinking water. Kettleman City is served by two public water systems: Kettleman City Community Services District (CSD), which serves all residents, and the Kettleman City Elementary School water system. Although benzene is known to be present in CSD water, the water district has met drinking water standards for many years through use of treatment systems (Gary Yamamoto, Chief, CDPH Division of Drinking Water and Environmental Management (DDWEM), personal communication, 10/11/2010). Cal/EPA measured benzene in untreated water at two municipal wells at concentrations exceeding the drinking water standard of 1 µg/L. However, benzene was not detected at the well serving the school or in any household tap water samples.

Arsenic occurs naturally in the soil and is found in drinking water sources throughout California.[8] CSD wells were recently found to have levels of arsenic about 16 parts per billion (ppb), which is above the recently promulgated state drinking water standard of 10 ppb.[9,10] The previous standard was 50 ppb, but was revised downwards in 2006 to incorporate scientific data published after the earlier standard was established.[11] CSD is not unique in this regard: drinking water testing from 2002-2005 showed that about 600 active and standby sources had peak levels exceeding the standard.[12] The Elementary School drinking water well meets the arsenic drinking water standard.[13] Currently, CDPH is funding CSD to conduct a study to analyze water treatment alternatives to ensure future compliance with all drinking water standards. The CSD has submitted a

draft report to DDWEM, which is currently being reviewed. (Gary Yamamoto, Chief, CDPH DDWEM, personal communication, 10/5/2010).

Hazardous waste. The Chemical Waste Management Kettleman Hills Facility (KHF) is located approximately 3.5 miles southwest of Kettleman City. The landfill facility covers 1,600 acres, which includes a municipal landfill as well as about 500 acres which are permitted for hazardous waste treatment, storage and disposal.[14] KHF has been used as a waste disposal facility since 1975. The company has applied to the California Department of Toxic Substances Control (DTSC) in Cal/EPA for a permit to expand its existing hazardous waste landfill and to the U.S. Environmental Protection Agency to continue disposing of polychlorinated biphenyl (PCB) waste.

Air pollution. The San Joaquin Valley (SJV) air basin is surrounded by mountains, which facilitate the build-up of air pollution in the Valley. In the SJV, pollutants generated by human activity, combined with natural geographic and weather conditions, result in some of the worst air pollution in the United States.[15,16] The SJV air basin concentrations for ozone and fine particulate matter are well above state and federal air quality standards.[17]

Health risks from exposure to air and drinking water contaminants

Cal/EPA's sections of this report present an evaluation of environmental contaminants in Kettleman City's air, water, and soil, focusing on chemicals that could potentially cause birth defects. Cal/EPA's investigation included outdoor air monitoring for a variety of chemicals, including some pesticides. They also examined past records of pesticides applied in the area, and analyzed samples of soil, soil gas, drinking water, and surface water. The potential health risks from exposure to air and drinking water in Kettleman City are addressed separately in those sections.

Evaluating potential relationships between birth defects and environmental conditions

As noted above, the causes of most birth defects are unknown, largely because causal relationships are very difficult to study and research in this area has lagged behind efforts for other disease conditions. There are many types of birth defects, and different exposures can cause either multiple or single birth defects. Some exposures cause unique patterns involving multiple kinds of birth defects. For instance, maternal infection with German measles virus during pregnancy causes a distinctive pattern of birth defects (or syndrome), while exposure to the acne drug isotretinoin causes another.[18] Scientifically rigorous epidemiological studies of causes of human birth defects generally require the evaluation of hundreds of birth defects or more. In an investigation of fewer than a dozen cases, our objectives had to be more limited, and focused largely on evaluating known or suspected risk factors, as well as the presence of unusual types of, or patterns or commonalities between the birth defects, which could potentially suggest a common source.

Thus, this investigation offered an opportunity to identify or rule out recognized risk factors as a potential cause of the increase in birth defects generally. However, it could not definitively identify the cause of any individual birth defect in the absence of a strong known risk factor. Moreover, the investigation could not effectively identify factors capable of only slightly increasing the risk of a birth defect, especially if the factor affected few of the mothers.

METHODS

The objectives of this investigation were to evaluate the following potential risk factors for birth defects occurring in Kettleman City:

1. the presence of known or suspected *genetic, medical or pregnancy-related risk factors;*
2. the presence of known or suspected *behavioral and lifestyle risk factors;*
3. the potential for *environmental and occupational exposures* that may be associated with an increased risk of birth defects.

Attaining these objectives involved identifying which children and families would be included, developing a structured interview questionnaire with input from the community about local environmental concerns, interviewing the mothers who consented to participate, reviewing their medical records to provide supplemental data, and analyzing and summarizing the information obtained.

Children in the investigation

In this follow-up field investigation, we conducted interviews with the Kettleman City mothers of the affected children born from 2007 through March 31, 2010. To do this, we expanded our inquiry to: (1) identify all mothers in Kettleman City who had had children with major structural birth defects during the time period of interest, and (2) focus on mothers who had lived and spent time in Kettleman City during their pregnancies and/or the time immediately preceding conception. The time frame encompassed the period reviewed by CBDMP staff in their earlier report and expanded it up to the point at which we initiated the interview phase of the investigation. Since then, CBDMP has expedited its process for identification and review of all possible cases of birth defects identified in Kings County. (See Appendix 2 for eligibility criteria.)

When CBDMP conducted its 2009 review of birth defects based on information in the statewide registry, complete data were available for the years 1987 through 2006. At the time of their review, data collection was still in progress for births occurring in 2007 and 2008. CBDMP staff examined all records of children with major birth defects born to women residing in five Central Valley counties (Kings, Fresno, Madera, Kern and Tulare), in order to be able to make comparisons between Kettleman City, Kings County, and the five-county region. The CBDMP report concluded that across the twenty-year period, there was no elevation in the rate of birth defects in Kettleman City, compared to regional rates.[19] However, there were four children born with birth defects in 2008, which was more than would be expected based on the historical pattern.

In order to be as thorough and responsive to community concerns as possible, we extended the scope of the inquiry to ensure that we identified all potentially relevant cases of birth defects. This broader scope encompassed the following areas:

- We included any birth defects that occurred from 2007 to March 31, 2010. This extended the time-frame to encompass births beyond what had been available to CBDMP in 2009.
- We reviewed any instances in which children with birth defects were reported to us by community members or parents to determine if they met the criteria for inclusion.

Whenever we were able to determine that a child had been born with a birth defect, and that the mother had resided in Kettleman City at the time the baby was born, we attempted to locate and interview the mother. CDPH staff made multiple attempts to contact families, if needed. Also, if we learned about additional mothers of children with birth defects who had not resided in Kettleman City at delivery, but who had lived there during their pregnancies, we included them if they consented to be interviewed. In some

situations, it turned out the child had a physical condition that was not a birth defect, or the mother had not lived in Kettleman City.

Through this process, CBDMP identified five cases born in either 2007 or 2008. (See flow chart in Appendix 3.) Another four children born between 2009 and March 31, 2010, were identified prior to interviews in the spring. Subsequently a fifth child born before March 31, 2010 was diagnosed with a structural defect that was not obvious at birth; that child's family was also offered an interview. We also evaluated reports from community members of another five children for possible inclusion in the investigation. Of these 15 potentially eligible children, 11 met our expanded eligibility criteria. No additional cases born since March 31, 2010 have been detected.

For the 11 children identified as having birth defects and who had been born from 2007 through March 31, 2010, the mothers of six were interviewed, three declined to participate and two could not be reached. The in-depth interviews with the mothers who agreed to participate provided a reasonable basis for evaluating whether there was an identifiable exposure contributing to the birth defects; however, we recognize that the lack of detailed information for the remaining families limits the interpretation that can be applied to all 11 children.

Analysis of rates of birth defects and medical records of children with birth defects

We reviewed the number of birth defects from 2007 through March 31, 2010, in comparison with what would be expected based on historical rates for Kettleman City. CBDMP experts further reviewed the medical records of all children with birth defects, not just those whose mothers were interviewed. Similarities in the types of birth defects reported, or the presence of multiple cases of an unusual type of birth defect, could suggest the possibility of a common cause.

Field investigation and questionnaire

We developed a questionnaire to use in the interviews to ensure that we covered critical information about the mothers' medical histories, as well as information about the local environment. Many of the questions were taken from a survey that has been used in a large national study of birth defects.[20] We added questions to address environmental exposures and other specific concerns of Kettleman City residents, as the national survey was not designed for this kind of investigation.

To make sure that the interviews would include the community's environmental concerns, CDPH staff also asked community members to voice any concerns at a public meeting in Kettleman City on April 15, 2010. Community members expressed concerns about the hazardous waste landfill facility, their tap water (odor, taste and color); air pollution; smoke or exposures from grilling meat/barbecues; diesel exhaust; oil fields, and herbicides in the nearby California Aqueduct. We added questions to address any relevant new topics raised. However, local residents' water does not come from the aqueduct, so we did not add any questions on that topic.

Interviews were conducted in mothers' homes or another convenient location. The questionnaire was administered in Spanish by trained bilingual interviewers. Most interviews required several hours to complete. Although most questions were close-ended, we also solicited supplemental information that the mothers deemed relevant in an open-ended portion of the interview.

While the causes of most birth defects cannot be identified, a number of risk factors are known to increase the risk of some kinds of birth defects. The questionnaire focused on known and suspected risk factors related to the topics described in the following paragraphs.

Known or suspected genetic, medical, and pregnancy-related risk factors

Maternal age is one of the few risk factors with clear evidence of an association with birth defects. Risk increases among older mothers and among women under age 20.[21] In particular, the frequency of chromosomal birth defects, the most common of which is Down syndrome, increases with maternal age.[22] For example, the chances of a 25-year old mother having a child with Down syndrome is 1 in 1,250, but the chance increases to 1 in 400 at age 30, and 1 in 30 at age 45.[22] Risks for some non-chromosomal birth defects also increase with maternal age.[21]

Genetic risk factor questions focused on whether the woman herself had had any other pregnancies involving children with birth defects, spontaneous abortions, or stillbirths. The questionnaire also asked whether she or the affected child's father had any relatives who had birth defects, spontaneous abortions, or stillbirths.

Medical risk factors include exposure to ionizing radiation from medical or diagnostic x-rays, computed tomography (CT) scans or other radiological tests during pregnancy. Also, a number of specific medications (listed in Appendix 4) have been found or are suspected to cause birth defects.

We also asked about medical conditions that may pose risks during pregnancy, including inadequately controlled diabetes and high blood pressure. Although 90% of women with epilepsy will have healthy babies, such women are at greater risk for having a child with

a birth defect.[23] Thyroid disorders in pregnant women, if untreated, are associated with preterm birth and developmental disorders.[24] Kidney disorders pose a risk, as some can cause high blood pressure; this could adversely impact fetal growth and development, possibly leading to preterm birth, miscarriage or stillbirth.[25]

Other pregnancy-related risk factors include excessive weight gain and obesity. We calculated a standard measure called body mass index (BMI), which is used by public health agencies and medical researchers, to determine if a woman was overweight or obese. Finally, significant maternal injury during pregnancy may also influence birth outcomes.

Known or suspected behavioral and lifestyle risk factors

Of the few risk factors known to be associated with birth defects, several are associated with behaviors that are typically stigmatized, such as smoking cigarettes, drinking alcohol or taking drugs. While these can be classified as medical risk factors as well, they are often designated as lifestyle or behavioral risk factors. Community members expressed concern that the public would make incorrect, negative assumptions about the mothers' lifestyles, so it was important to be able to provide information about these risk factors.

Potential environmental and occupational risk factors

In identifying environmental and occupational risk factors for this analysis, we used several approaches. We sought to include all environmental exposures specific to Kettleman City (incorporating input from community members), which encompassed a range of potential air, water, and soil exposures. In order for a chemical in the environment to cause a health problem, there must be some direct contact or exposure

from eating, drinking, inhaling or touching the substance. Therefore, the questionnaire examined multiple possible routes of exposure to a variety of contaminants that the women may have been exposed to in the environment or because of their (or the children's fathers') jobs. We included a number of environmental exposures of concern to the community, even though for some there was no previously published scientific evidence linking them with birth defects. In this general topic area, the major potential exposures the questionnaire covered included:

- pesticides in the home, at work, or from agricultural drift
- drinking water
- exposures on the job (mother and father both)
- the hazardous waste landfill
- indoor air quality (for example, cigarette smoke)
- unusual odors
- hobbies that might involve chemical exposures
- exhaust from motor vehicles traveling on State Highway 41 and Interstate 5
- disturbance of potentially contaminated soils
- oil fields near Kettleman City
- the presence of nearby industries or businesses that could release contaminants, including vehicle exhaust (e.g., gas stations, warehouses, parking lots).

Because most birth defects originate during the first three months of pregnancy, we asked about exposures that might have occurred during the three months before conception through the first trimester. The mother, and in some instances the father, participated in the interviews.

Review of maternal medical records

Because it is often hard for people to recall details of past medical information, CBDMP supplemented the information obtained in the interviews by reviewing medical records for the mothers of the children with birth defects. In some cases, mothers provided the names of additional doctors they had seen and requested that those records be reviewed as well. When available, these records were used to supplement the information obtained through interviews.

Analysis

Information from the questionnaire was evaluated for each respondent. We looked at whether and how many of the mothers we interviewed reported different risk factors or exposures of concern. Unlike some investigations involving larger numbers of cases, we did not conduct statistical evaluations of associations between potential risk factors or exposures and birth defects, because such analyses involving small numbers of subjects can give imprecise and misleading results due to chance alone. This report provides instead primarily a descriptive, qualitative assessment based on information from this small case-series. In evaluating whether a risk factors could be responsible for the community-wide excess, we looked for factors that could be plausible causes of birth defects and were shared by all or almost all of the cases.

RESULTS

Privacy statement

To safeguard the privacy of the affected families and to comply with strict state laws protecting individuals' confidential medical information, this report does not include

information that could identify any specific individual. Rather, we provide summary information only, including presenting data in ranges in several tables.

Review of types of birth defects

CBDMP expert review of the medical details of the 11 children with birth defects found that they all represented different underlying conditions, although some shared the same features. Some children had specific syndromes involving multiple birth defects, and others had single defects. A syndrome is a condition with a characteristic pattern of multiple defects. The pattern may include one or more major birth defects, including facial features. Cleft lip (with or without cleft palate) may occur as part of a syndrome, and this is different than cleft lip/palate appearing with no other birth defects. Overall, the birth defects in these 11 children were similar in type to those typically observed by birth defects surveillance programs.

Birth defects numbers and trends

Analysis of the number of birth defects occurring from 2007 to March 31, 2010, confirmed the excess in Kettleman City previously reported by CBDMP for the year 2008. It was clear that the number of birth defects exceeded what would be expected based on historical patterns, as is illustrated in Table 1, below. In the earliest five years of CBDMP data collection (1987 – 1991), there were five birth defects, followed by one occurring during the 15 years from 1992 through 2006. During the 3 ¼-year period of this investigation, 11 children were born with major structural birth defects whose mothers lived in Kettleman City during at least part of their pregnancies.

Table 1. Number of children born with major structural birth defects, Kettleman City, 1987 – March 31, 2010.

Year of birth	Number of cases of birth defects
1987-1991	5
1992-1996	One birth defect occurred during this 15-year period
1997-2001	
2002-2006	
2007- March 31, 2010*	11

* 3 ¼ - year period; previous periods are 5 years.

We also looked for but did not detect any patterns in the seasons in which the birth defects occurred.

Since the beginning of the investigation, CBDMP has expedited review of all possible cases of birth defects identified in Kings County. No additional birth defects were identified in any Kettleman City children born between March 31, 2010 and the time that this report was prepared in October 2010.

Analysis of data from interviews with mothers

All subsequent results in this report are based on information obtained from the six mothers who participated in the interviews. These results are focused more on identifying or ruling out specific risk factors for this smaller group of participants, in contrast with the overall trend results presented above.

Review of genetic, medical, and pregnancy factors

We examined a broad list of known or potential risk factors for birth defects, including lack of prenatal care, not taking prenatal vitamins, having medical treatments to help get pregnant, having twins (or triplets), gaining excessive weight during pregnancy, or x-rays during pregnancy. Overall, we did not find that these factors presented a risk among this

group of Kettleman City mothers, as very few of these factors were experienced by any of the mothers.

We also asked about several medical conditions that may pose risks during pregnancy, such as diabetes, high blood pressure, epilepsy, infections (especially those accompanied by high fever), and certain other chronic conditions. Some of these are more directly associated with an increased risk of birth defects than others. After detailed review of the specific conditions and circumstances reported, we did not find any of these to be likely to have increased the risk for birth defects among these mothers. Thus, we conclude that none of the mothers experienced medical conditions that would have posed a significant risk for birth defects.

Several medicines are known to cause birth defects when used during pregnancy.[26] Generally, we would not expect any of these to be given to a woman known to be pregnant. Also, some of these are not used anymore. Still, because they include some of the few known substances that cause birth defects, we asked about these potential exposures. None of the mothers used any of these medications during their pregnancies or in the three months before they became pregnant.

In our investigation we asked questions about the mother's pregnancy history and risk factors that involved other family members, such as whether the latter had birth defects, or a history of spontaneous abortion or stillbirth. A family history of any of these events might mean that there was a common genetic influence in the family that could increase the risk of birth defects. We found that none of the mothers had another child with a birth defect and/or health problem diagnosed at birth. Most of the mothers had had previous pregnancies and had delivered healthy children while living in Kettleman City. Though a family history of possible birth defects was reported by a couple of mothers, it was not clear whether these reported instances were in fact birth defects or another type

of health issue. Moreover, because the family members reported to have had these problems were neither siblings nor direct ancestors of the affected Kettleman City children, we believe that family genetic influences were not likely to have been important risk factors.

Review of lifestyle and behavioral factors

Our investigation found that none of the mothers had used tobacco, alcohol, or illicit drugs. We also asked about other factors that have been associated with increased risks of birth defects. These include significant caffeine use, not having enough food (which could result in inadequate nutrition), and stressful life events. We asked about mothers' caffeine intake because some research has linked high caffeine intake to an increased risk of miscarriage and stillbirth. However, a recent study of oral clefts did not find an association with caffeine.[27] Similarly, not having enough nutritious food during pregnancy has also been associated with an increased risk of birth defects.[28] Research has suggested that stressful life events may also contribute to premature births or infants with low birth weight, although a connection to birth defects is less certain. However, these factors were not generally experienced by the Kettleman City mothers, so we do not believe that these were related to the increased number of birth defects in Kettleman City.

Maternal occupational exposures

Chemical exposures on the job tend to be much higher than those in the general environment, so it was important to investigate occupational risk factors. We asked about what types of jobs the mothers had, and whether they involved any chemical exposures. Not all mothers were employed outside the home. Some worked in agricultural occupations that involved planting, sorting and pruning, but not handling

pesticides. None had direct contact with chemicals on the job, either in agriculture or another industry.

There has been limited scientific data suggesting that maternal employment in agriculture during pregnancy can increase risks for birth defects.[29] Therefore, in consultation with the California Department of Pesticide Regulation (DPR), we reviewed the specific types of occupational agricultural activities reported in order to assess potential exposures to pesticides. When pesticides are applied to fields during the growing season, there is a period during which re-entry into the field is restricted until the pesticide concentrations decline to acceptable levels. These intervals are set by the United States Environmental Protection Agency and DPR, and are specific to each active ingredient (Sue Edmiston, DPR, personal communication, October 11, 2010). Employers are required to adhere to guidelines with respect to pesticide application and worker protections. When crops are processed, such as in a packing shed or cannery prior to consumer distribution, pesticide residue levels are expected to be low to meet legal residue tolerance limits for dietary consumption.[30] Because of these requirements for growers, it would not be expected that pesticide levels on such produce would be hazardous. By this logic, we would not anticipate significant occupational pesticide exposures for these mothers. Still, pesticides are inherently toxic, and scientific knowledge about impacts of pesticides is continually evolving, making it unrealistic to ever declare the absolute safety of a product. DPR maintains a pesticide illness surveillance database; every year pesticide-related illnesses among agricultural workers are reported to DPR. Of the mothers interviewed, few could have had any occupational pesticide exposure and, based on descriptions of their work and on an assumption that pesticide use restrictions were adhered to, those potential exposures would likely have been minimal. However, we could not retrospectively validate the extent of compliance with pesticide use restrictions.

Paternal and other household member occupational exposures

Most of the fathers worked in agriculture. In some cases another person in the household worked in the agricultural sector. A few fathers had occupations that involved exposure to chemicals, either within the agricultural industry (handling pesticides) or in another industry. Most of the mothers whose partners' work involved chemical or pesticide exposures reported that the father used personal protective equipment, though we could not assess the adequacy of that equipment. Those fathers having direct contact with pesticides or other chemicals did not wear their work clothes or shoes in the home (which was also true for other persons in the household who worked in agriculture). This would have reduced the potential for exposure to other family members, including the mothers.

Little is known about paternal pesticide exposure and the risk of birth defects. Studies of paternal exposures that have examined pesticides or other chemicals have mainly focused on reduced fertility.[31] Laboratory studies suggest that male exposure to pesticides and other chemicals may influence the occurrence of birth defects in offspring, although the evidence in humans is limited.[31,32,33,34] In view of the sparse published data on potential effects of paternal pesticide exposures, it is not possible to make a definitive statement about whether these potential paternal exposures to pesticides played any role in any of the birth defects in Kettleman City.

Home and yard pesticide exposures

All pesticides are toxic to varying degrees, and there is insufficient scientific evidence to assess whether use of common home pest-control products poses a risk during pregnancy.[35] Some mothers reported that pesticides were used to control insects or weeds at their residences. However, most applications occurred outside in the yard. We reviewed the descriptions of pesticide uses reported in consultation with experts at DPR.

Based on the mothers' responses, we do not believe that the limited extent of residential pesticide exposures can explain the increase in birth defects.

Pesticide exposures from nearby agricultural fields

The community and mothers expressed concern about pesticide exposures from the nearby fields and whether those exposures could have posed a risk. A number of mothers in the group reported either seeing or smelling pesticides being applied to fields surrounding the community.

In the accompanying Cal/EPA exposure assessment, DPR estimated potential pesticide drift exposures to Kettleman City residents from September 2006 through December 2009 to examine whether such exposures may have posed a risk for birth defects. In brief, they estimated levels of pesticides in ambient air by combining data about the types of pesticides that had been applied in nearby fields,with information about wind patterns. Cal/EPA concluded that drift-related exposures during this time were generally likely to have been low, except for one day when the concentration of the pesticide methyl isothiocyante was estimated to have exceeded a pre-determined health-based screening value.

Water

We asked the mothers about sources of water they used for drinking, cooking and bathing during three-month period preceding through the first trimester of their pregnancies. (See Table 2.) All received water at home from the public water supply. Mothers expressed concerns about the odor, taste and appearance of tap water. Chemical contaminants cannot necessarily be detected by smell or appearance. Also, problems with odor or appearance of water may be due in part to an individual home's plumbing system.

Perceived odors included rotten egg, sewage, and chlorine, and they noted the presence of an aftertaste, and the taste of bleach. Water was described as yellow, brown, dirty, and muddy. Presumably related to these perceptions was the finding that most used bottled water instead of drinking tap water at home, and most did not cook with tap water either. At times bottled water was used to wash pots and pans, because the mothers were not confident that the tap water was clean enough for this purpose. All of the mothers who worked outside of the home during this period drank bottled water at work. People can also be exposed to contaminants in water while showering and bathing; [36] all of the women used the public water supply for these activities.

Because the mothers' use of tap water was limited, drinking water would not be expected to be a cause of the increase in birth defects. However, water quality is a community-wide public health issue, Cal/EPA evaluated the risk applicable to any local residents who drink and use water from the public water system. Cal/EPA's risk assessment methodology accounts for multiple routes of exposure, so specific risks from showering and bathing were not calculated separately. Cal/EPA concluded that, even if a pregnant woman in Kettleman City drank tap water regularly, this exposure would not be likely to have posed an increased risk for having a child with a birth defect.

Table 2. Water sources reported by Kettleman City mothers

Water Source	Number of mothers			
	0	1-2	3-4	5-6
Public water supply				✓
Drinking water at home				
Bottled water				✓
Tap water/Public water		✓		
Drinking water at work (if mother works outside the home)				
Bottled water			✓	
Tap water/Public water	✓			
Water for bathing				
Bottled water	✓			
Tap water/Public water				✓

Indoor household exposures

Many different exposures may occur inside the home. We inquired about several cultural practices that could potentially result in exposures relevant to this investigation. Sometimes people practice good luck or religious ceremonies or rituals that involve chemical substances.[37] One home ritual we asked about was the use of "azogue" for good luck. "Azogue" is toxic metallic mercury (or elemental mercury, found in non-digital thermometers). Mercury can harm the developing fetus, causing neurological problems such as delayed development or learning problems.[38,39] However, none of the mothers had used azogue. We asked about other ritual practices that may have involved hazardous exposures. We asked about use of candles, as there have been cases reported of candle wicks covered with mercury for religious or decorative purposes.[37] While we learned that candles were burned at church and at times at home, we have no information about whether any of these candles contained mercury.

We asked about several other possible maternal activities and exposures during pregnancy, including use of a hot tub or sauna, eating non-food items, and hobbies. Hot tub use during pregnancy can increase the risk of miscarriage and birth defects because excessive heat can damage the fetus.[40] "Pica" behavior is characterized by craving and consuming non-food substances or food in a non-consumable form (e.g., uncooked flour).[41] Pica may occur during pregnancy, and may be a symptom of a nutritional deficiency such as a lack of iron.[42] We also asked about the mothers' hobbies that may have involved chemical exposures. None had any of these exposures before or during pregnancy.

We also asked about other potential household chemical exposures, including others' hobbies, air quality issues related to using a gas stove to heat the home, and second-hand tobacco smoke. Three of the mothers had at least one of these factors in her home environment. After close examination of the specific activities, however, we did not find that these exposures were likely to have significantly affected this group of mothers.

Fish consumption

We also inquired about fish consumption because of the potential for exposure to methylmercury, another form of mercury. Methylmercury can be present in fish caught by individuals and sport fishers in California streams, lakes and other bodies of water, as well as in fish bought in stores and restaurants.[43,44] Methylmercury can impair the development of the brain and nervous system in the developing fetus and young children.[45] We asked about how much fish mothers ate, the types and sources of fish, and whether mothers ate any fish caught by friends or family. However, we did not find that Kettleman City mothers consumed greater than the recommended allowable amounts for pregnant women for any of the types of fish exposure categories. Also, no mothers

reported eating fish caught recreationally, which would have included any caught in the California Aqueduct.

Other environmental exposures

We also evaluated the mothers' potential exposures to local environmental sources of pollution, including outdoor air quality and exposures in specific locations in the Kettleman City area (see Table 3). Local environmental exposures may have affected mothers over time, as most had lived in Kettleman City at least five years prior to this pregnancy. Mothers consistently reported concerns about outdoor air quality, describing odors of sewage, burning, diesel, chemicals, dead animals, garbage, and rotten eggs. These smells were frequent, especially during the summer. Spending time near a freeway could be related to exposure to exhaust, including diesel. Other sources of chemical exposures could be gas stations. Mothers reported getting gas from the stations by Interstate 5, as well as walking near or driving by the gas pump in Kettleman City. Although no mothers spent time at or near the hazardous waste landfill, they expressed concern about the exhaust from the numerous trucks going to and from the waste site. Activities involving contact with the nearby oil fields could potentially have led to chemical exposures, depending on the activities and the exposure pathways. However, none of the mothers reported spending any time in an activity that would involve contact with the oil fields. Additionally, the Cal/EPA exposure assessment found no evidence of chemicals from oil fields or leaking gas tanks or of other industrial chemicals contaminating the water or soil in Kettleman City. The air concentrations of industrial chemicals measured by Cal/EPA were typical of levels seen in other parts of the state.

Table 3. Exposures outside the home reported by Kettleman City mothers

Exposures outside the home	# Among Interviewed Mothers			
	0	1-2	3-4	5-6
Outdoor air quality concerns				✓
Mother reported often spending time at or near freeway (for example, worked or spent time at businesses near freeway)		✓		
Mother reported often spending time at or near the oil fields in an activity that could involve contact with dirt or soil there (for instance, walking, riding bikes or ATVs)	✓			
Mother reported spending time at or near the hazardous waste landfill facility	✓			

Evaluation of potential for past shared exposures

We also considered whether the mothers may have had some other past exposure(s) in common that occurred elsewhere by asking whether they had come from the same geographic area prior to moving to Kettleman City, but we did not find this to be the case. Many had lived in Mexico, but none had lived near each other before moving to Kettleman City.

Finally, we asked whether there were any activities the mothers had in common that might have resulted in shared exposures. Although some of the mothers knew one another previously, no common group activity could be identified.

DISCUSSION AND SUMMARY

We conducted an extensive investigation with the goal of identifying factors that could be related to birth defects occurring in recent years in Kettleman City. In addition to investigating known risk factors for birth defects, particularly medical or family history, we explored many environmental and occupational factors. These included risks we considered plausible based on previous scientific studies, as well as environmental

concerns raised by local local community members. Our investigation was conducted in parallel with and informed by data gathered by another state agency, Cal/EPA. They conducted an extensive exposure assessment of the types of chemical and pesticide exposures present in Kettleman City.

An initial step of the investigation included a review by CBDMP experts of the types of birth defects. The birth defects that occurred were all different from one another, and were all were similar in type to those typically observed by birth defects surveillance programs.

We attempted to rule out or assess the likelihood of various factors or exposures representing a plausible cause for these birth defects. We also considered whether a factor could have contributed to increasing risk in any one instance, although it may not have been a cause of the birth defects in the group as a whole. Factors evaluated ranged from those that are known to be very likely to cause a birth defect, such as taking certain medications during pregnancy, to those which may only slightly increase the risk of a birth defect or are generally considered unhealthy during pregnancy.

One area of heightened concern from the mothers' perspective was that they could be "blamed" for their children's birth defects, as questions about alleged cigarette and drug use were discussed in the media. **Therefore, we considered it an important outcome of the investigation that we were able to report that alcohol, tobacco, and drugs were not exposures experienced by the mothers.**

Maternal age and family history of a previous birth defect or adverse pregnancy outcome are among the risk factors with the clearest evidence of an association with birth defects. Although we did find that older maternal age and family history could have been relevant for a couple of the mothers, they were not risk factors for the others. **In general,**

mothers received adequate health care, practiced appropriate health behaviors during pregnancy, and appeared to have been without health conditions that would pose a risk to their pregnancies.

None of the mothers spent any time at or near the hazardous waste landfill facility. Our review of other potential sources of hazardous chemicals in the local Kettleman City environment, such as contact with the abandoned oil fields or spending time near the freeway, similarly did not find evidence of significant exposures. As noted in the Results section, Cal/EPA reported no evidence of industrial chemicals contaminating the water or soil in Kettleman City. The air concentrations of industrial chemicals measured by Cal/EPA were typical of levels seen in other parts of the state.

Most of the mothers did not report any household (indoor air quality, hobbies) or dietary (mercury in fish) exposures that might have elevated the risk of birth defects. Some mothers worked in agriculture, but their job descriptions suggested that significant pesticide exposure would have been unlikely. Most of the fathers had worked in agriculture, and a few had held jobs involving pesticide or chemical exposure, but did not wear their work clothes or shoes at home. We do not believe that the limited extent of residential pesticide exposures can explain the increase in birth defects. **Thus, household and occupational pesticide exposures did not seem to have been a likely cause of this group of birth defects.**

The mothers expressed considerable concern about appearance and safety of their drinking water. However, because mothers did not generally drink tap water, we would not expect drinking Kettleman City water to be a cause of the birth defects for the group. Nevertheless, the safety of the water is a relevant question for other mothers-to-be, as well as the community generally. Scientific knowledge about arsenic exposure during pregnancy is limited. Inorganic arsenic is considered a developmental toxicant.[46,47]

However, the effects of low-level exposures and developmental outcomes in humans is less clear. Some information is available from studies in areas with naturally high levels of arsenic, where adverse obstetric outcomes may have been increased, including decreased birth weight, spontaneous abortion, and stillbirth.[48,49] Exposures in these areas are much higher than what is found in California, often exceeding 200 ppb, including levels as high as 800 ppb (Chile), 1700 ppb (Bangladesh), and 3500 ppb (Taiwan).[50]

Cal/EPA's exposure assessment determined that exposure to municipal water sources would not be likely to result in an increased risk for having a child with a birth defect. We discussed concerns about reported water taste, smell, appearance with the local water district engineer who designed the water treatment system in Kettleman City. Water is currently screened to eliminate particles greater than 50 to 100 microns in diameter, but smaller particles may remain, which could result in a cloudy appearance at times. (Summers Engineering, contractor to Community Services District; Brian Skaggs, personal communication, October 18, 2010). Perceived odors could be related to hydrogen sulfide (a chemical with a rotten-egg odor), which is known to be present in both drinking water and local groundwater. In a background review of data to establish guidelines for drinking water quality, the World Health Organization has concluded that it would be unlikely that a harmful dose of hydrogen sulfide could be consumed in drinking water, so they have not proposed a health-based guideline value.[51] However, because this chemical does have a low odor threshold, it can be easily detected as it volatilizes into air from water. The local water district is analyzing surface water and groundwater treatment and consolidation options to ensure a sustainable solution to bring drinking water into compliance with all health-based standards.

Because the mothers all reported concerns about outdoor air quality, particularly a variety of odors, we consulted with experts at DPR about the possible relationship of some of these odors to pesticides. Metam-sodium, which has several odorous breakdown

products, including one with a rotten-egg odor,[52] is applied in fields near Kettleman City. Chlorpyrifos is another product used on nearby fields, and it has odors of sulfur compounds such as rotten eggs, onions, garlic and skunks. [53] Another potential source of odors may be decomposing crops left in the fields after harvest.

Research about air pollution and birth defects is limited, and results from different studies are not consistent.[54,55,56] Air pollution from ozone affects much of the Central Valley and the Los Angeles Basin.[57,58] Given the vast extent of ozone exposure, and the fact that ozone concentrations have declined statewide since the 1980s, it would not be expected to be a cause of the Kettleman City birth defects. Although one epidemiological study of birth defects and air pollution in Southern California has found an association of ozone with an increased risk for certain birth defects,[57] it is not at this time considered to be a developmental toxicant.[59] That study also found other birth defects to be associated with carbon monoxide exposure, although results were inconclusive for particulate matter and nitrogen dioxide. The California Air Resources Board conducted air monitoring in Kettleman City, which is reported in the Cal/EPA exposure assessment section of this report.

Kings County continues to experience violations of national ambient air quality standards for ozone and fine particles (PM2.5), although the air quality with respect to these two pollutants has improved by 15 to 20 percent over the past decade.[60] Under the federal Clean Air Act, California developed a statewide emissions reduction strategy to attain the national standards. [61] As part of the state plan, the San Joaquin Valley Air Pollution Control District has adopted ozone[62] and PM2.5[63] plans intended to provide the remaining reductions needed for attainment.

Cal/EPA's exposure assessment further characterized air quality concerns, finding estimated pesticide exposures to Kettleman City residents during this time to be generally

low. However, modeling past air exposures to pesticides is subject to considerable uncertainty, as explained in the Cal/EPA section of this report. Another method to assess pesticide exposure would involve obtaining household dust samples, as some airborne pesticides can deposit and accumulate indoors. While such samples would not necessarily reflect past exposures when the mothers were pregnant, they could give an indication of the types of exposures that may be present in Kettleman City residences currently. As noted in the Cal/EPA report, the United States Environmental Protection Agency (US EPA) is tentatively planning to conduct such sampling for agricultural pesticides in the near future in a limited number of Kettleman City homes.

Recognizing specific health conditions that are caused by environmental exposures is challenging. Unlike an infectious disease, for which we can sometimes test for a specific type of bacteria or virus, it is rarely possible to distinguish what caused a particular birth defect. An exception would be if the type of birth defect is uniquely recognizable and/or the exposure is very specific, and the association is biologically plausible. For example, taking the drug thalidomide during early pregnancy can result in a characteristic pattern of birth defects involving short or missing limbs.

That this investigation did not identify a common risk factor among the cases is not unusual. Specific causes for the vast majority of such localized birth defects clusters are rarely found.[64, 65] The number of birth defects that appear year by year in any given region can fluctuate for reasons unrelated to environmental exposures. Most experts on clusters believe they appear in neighborhoods far more often than most people realize.[66] If the thousands of communities throughout California are considered, we would expect that some will have higher than normal rates of a particular condition on occasion.

CONCLUSIONS

This report summarizes an investigation by CDPH to obtain detailed information regarding known causes of birth defects, as well as to explore potential local environmental exposures of concern to Kettleman City mothers and residents. Reviewing the state's birth defects registry data, CBDMP determined that there has been a recent excess in the number of children with birth defects born to mothers who had lived in Kettleman City. This follow-up investigation was based on in-person interviews with mothers of the children with birth defects, supplemented by medical records review.

A broad exposure assessment of contaminants, including pesticides, in the air, water, and soil of Kettleman City, conducted in parallel by Cal/EPA, further informed the analysis and conclusions regarding birth defects:

- *The number of children born with birth defects in the time period of investigation, 2007 to March 31, 2010, was in excess of what would be expected for the number of births in Kettleman City based on the historical pattern.*

- *Maternal medical, family, and pregnancy risk factors are unlikely to explain the increased numbers of birth defects seen from 2007 - 2010.* Generally, the mothers received adequate health care, practiced appropriate health behaviors during pregnancy, appeared free of significant health conditions that would create a risk for birth defects, and experienced few significant risk factors.

- *None of the mothers interviewed used alcohol, drugs, or tobacco; therefore, these potential risk factors were not found to be a cause of these birth defects.*

- *The observed birth defects did not represent a unique pattern nor were they all of the same type – characteristics that would be expected with a common underlying cause.* All had different underlying conditions, although some shared the same features. The birth defects were of the types commonly seen in birth defects surveillance. These observations suggest that they did not have a common cause.

- *No specific environmental exposure was identified as a likely cause of the increase in birth defects.* A review of a variety of environmental exposures did not identify any that would be likely to have caused the birth defects under investigation.

- *Environmental concerns expressed by mothers reflect exposures relevant to Kettleman City residents.* The mothers articulated consistent concerns about water and air quality in Kettleman City. Any exposures to mothers living in Kettleman City would apply to other residents as well.

  Water.

  Arsenic levels in drinking water exceed the recently updated standard, as is true in several areas of California. Arsenic is considered a developmental toxicant. While levels in Kettleman City water are below what would be expected to cause a birth defect or other health problem, they are out of compliance with the current standard. Standards are designed to have a "margin of safety," so exceeding the standard slightly does not necessarily mean that the water is dangerous to drink. Nevertheless, CDPH believes all California residents should have drinking water that meets current standards. Using funding provided by CDPH, the local water district is analyzing options to ensure a sustainable solution to achieve compliance with the new standard.

Although benzene is known to be present in CSD water at levels exceeding drinking water standards, Cal/EPA found no benzene in any water samples in kitchen faucets.

Air.

Air quality in Kings County violates federal air pollution standards, although improvements of 15 to 20 percent have been achieved over the past decade. California has a statewide emissions reduction strategy to achieve the national standards, which encompasses plans by the San Joaquin Valley Air Pollution Control District to reduce emissions from local sources.

Pesticides.

In the accompanying Cal/EPA report, DPR's historical analysis of pesticide air levels in Kettleman City concluded that such exposures were not likely to have been high enough to cause birth defects. The Cal/EPA exposure assessment provides greater details about this analysis.

- *CDPH supports the tentative plans of the U.S. Environmental Protection Agency to sample indoor dust for pesticides in a limited number of homes in Kettleman City.* Although limited in its ability to inform the investigation of birth defects because of the passage of time, such sampling could increase understanding of the types of current exposures experienced by residents of Kettleman City and other similar agricultural communities.

- *CDPH recommends continued monitoring of birth defects for the next few years.* CBDMP determined in its review that there had been a recent excess number of children with birth defects born to mothers who had lived in Kettleman City. In many of the years between 1987 and 2006, however, there were no children with birth

defects born to mothers living in Kettleman City. This pattern of birth defects does not suggest a long-standing exposure that would increase the community's risk for birth defects. Continued surveillance will determine whether the number of cases returns to the earlier pattern or whether the excess persists.

APPENDIX 1: The California Birth Defects Monitoring Program

How does the California Birth Defects Monitoring Program (CBDMP) monitor birth defects in California?

To improve the health of babies born in California, a law was passed in 1982 to establish a birth defects registry. The registry is a system for recording and tracking birth defects in California. The registry is a database of medical and demographic information. CBDMP sends well trained staff to hospitals with maternity and pediatric services, genetics clinics, and cytogenetic laboratories to review medical records to identify children born with birth defects and collect detailed case information. To maximize the registry's effectiveness, CBDMP focuses on gathering complete data on conditions with significant medical and public health impact—about 60% of all newborns with birth defects have at least one of these conditions. Birth defects included in the CBDMP registry consist of structural malformations. Live births, stillbirths occurring after 20 weeks gestation, and medically indicated terminations are included in the registry. Information is collected on children from birth to one year of age because approximately 95% of the birth defects are recognized by the time a child turns one. For example, the data for 2008 includes a child that was born in December 2008 and diagnosed with a birth defect at birth or at any time before his first birthday in December 2009. If a child with a birth defect has been treated at several facilities or has had many hospital admissions, CBDMP merges all the records for that child into a single case file. Case files are linked to Vital Statistics records (birth or fetal death certificates) which supply demographic information, including parents' races, ages, and residence. Generally speaking, it takes 18 months or more from the end of the birth year to officially complete data collection for that year. Thus, for birth defects occurring in children born anytime in 2009, the official data collection process should be completed by the end of June 2011.

What are the most common birth defects?

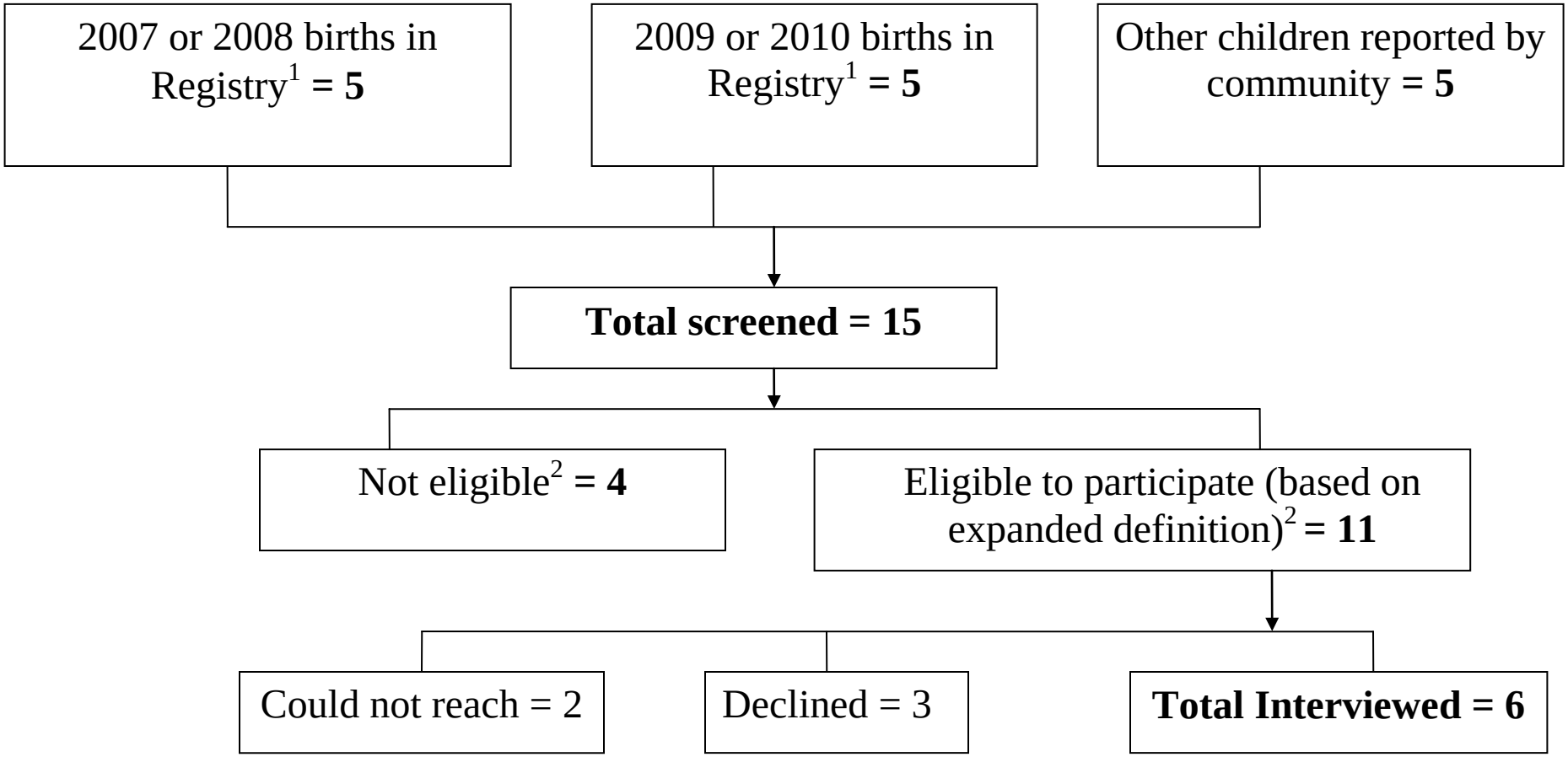
One in every 33 babies in the United States is born with a birth defect.[67] The CDC estimates that around 1 in every 100 to 200 babies is born with a heart defect. Neural tube defects occur in about 1 in every 1000 pregnancies. Birth defects of the lip and roof of the mouth (orofacial clefts), are also common.[67] In many places of the world, orofacial clefts affect about 1 in 700 to 1,000 babies.[67]

Appendix 2: Eligibility criteria for birth defects investigation

1) CDPH used the following criteria as a basis for contacting mothers regarding their willingness to be interviewed:
   - Major structural birth defect (such as cleft lip and/or palate, heart defect, Down syndrome);
   - Child born between January 1, 2007, and March 31, 2010; AND
   - Mother's residence as noted in the CBDMP registry at time of child's birth was in Kettleman City.

2) For any mother who identified herself to CDPH and requested to be interviewed, CDPH used the following criteria:
   - Major structural birth defect (such as cleft lip and/or palate, heart defect, Down syndrome);
   - Child born between January 1, 2007, and March 31, 2010; AND
   - Mother spent more than seven days in Kettleman City during the three months prior to conception and first three months of pregnancy. If a mother had spent very little time in Kettleman City, that would be taken into account in the review of the information.

Appendix 3: Kettleman City Birth Defects - Screening and Interviews



[1] Births to a mother living in Kettleman City at the time of birth of a baby with a major structural birth defect in CBDMP Registry between 2007 and March 31, 2010.
[2] Eligible births were expanded to include children born to mothers who wanted to be interviewed who had lived in Kettleman City for at least seven days during the three months before pregnancy through the first trimester.

Appendix 4: List of some medications known or suspected to be associated with an increased risk of birth defects

Medication type	Medical use
ACE inhibitors (Captopril, Enalapril and Lisinopril)	High blood pressure treatment
Seizure medications (Carbamazepine and Valproate)	Treatment of epilepsy
Anticoagulants (Coumadin and Heparin)	Blood thinners
Folic acid antagonists (Aminopterin and Methotrexate)	Cancer and autoimmune diseases treatment
Diethylstilbestrol (DES)	Miscarriage prevention (no longer prescribed)
Accutane (Isotretinoin)	Acne treatment
Misoprostol	Treatment of ulcers (rarely used)
Thalidomide	Originally prescribed for morning sickness. Now approved under restricted conditions for one skin condition and a cancer treatment.[68]

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An Evaluation of the Pattern of Cancer Occurrence in the Vicinity of Kettleman City, California

Public Review Draft
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Executive Summary

The California Cancer Registry (CCR) is a population-based cancer registry which has monitored the occurrence of cancer and cancer related deaths among residents of California since 1988. The CCR has completed an evaluation of cancer in the vicinity of Kettleman City, CA for the years 1996-2008. The area included census tract 16.01 in Kings County, CA which had a population of 4554 in the 2000 U.S. Census.

- During this time period, there were 113 cancers diagnosed in the residents of this area. 143 cancers would be expected to occur if the area experienced the same rate of cancer as the rest of the state of California.

- Most of the cancers diagnosed were prostate cancer, lung cancer, and breast cancer.

- Among children less than 15 years of age, there were five cancers diagnosed during this time period, while 2.8 childhood cancers would be anticipated.

- Among Hispanics, who comprise a majority of the population, there were 44 cancers observed and 61.1 cancers expected.

- Overall, this census tract experiences the same types of cancer as found elsewhere and somewhat less cancer than would be anticipated.

Abstract

Background: Kettleman City is a small community in Kings County, CA with a population of approximately 1620, the majority of whom are Hispanic. The community is located in southern Kings County, adjacent to the Interstate 5 freeway and surrounded by agricultural fields, and formerly, oil and natural gas extraction operations. A chemical waste site operated by Waste Management, Inc. is located in the Kettleman Hills about 3.5 miles southwest of the city. Although there is currently no scientific evidence for an exposure pathway linking the waste site with the community, the California Cancer Registry (CCR) was asked to evaluate cancer in the Kettleman City community due to environmental concerns and reports of numerous birth defects occurring in the community in the last few years.

Methods: The standard methodology of the CCR involves conducting both a quantitative and qualitative analysis of cancer occurring in the census tract within which the community lies. The census tract is used because the U.S. Census Bureau provides the best estimate of the population characteristics such as age, sex and race/ethnicity, which are critically necessary for an epidemiologic analysis. In this analysis, census tract (CT) 16.01 in Kings County was evaluated (2000 population = 4,554). This census tract covers a large geographic area and, in addition to Kettelman City, includes portions of Stratford, the Santa Rosa Rancheria and Avenal. An analysis was conducted which included the occurrence of 30 of the most common different forms of cancer, cancer among all racial groups, Hispanics, all age groups and among children less than 15 years of age. The analysis covered the years 1996-2008, the latest year for which CCR data are accurate and complete. The observed number of cancer cases diagnosed among residents of this census tract were obtained from the CCR, the population-based cancer registry which has monitored the occurrence of cancer throughout the State since 1988. The expected numbers of cancers were derived by applying (on an age, sex, race and calendar years specific basis) the rates of cancer in California to the population at risk in the census tract. The result is expressed as the ratio of observed to expected cases, and a value of one (1.0) would indicate neither an excess nor a deficit of cancer in the area of interest.

Results: Between 1996 and 2008, a total of 113 residents of the census tract surrounding Kettleman City were diagnosed with cancer. Cancer of the prostate, lung, and breast are the three major types of cancer found in the census tract. The patterns of breast, lung, and prostate cancers detected in CT 16.01, as anticipated, followed the general pattern of cancer occurrence in the general population. If the census tract experienced the same rate of cancer as the state of California as a whole, a total of 143.2 cancers would be expected in the same time period (standardized incidence ratio or SIR=0.8; 99% CI = 0.6 - 1.0). The SIR for acute lymphocytic leukemia (ALL) was the highest (3.5) although not statistically significant. Somewhat elevated SIRs were also noted for kidney (1.7) and pancreas cancers (1.6). Again, they were not statistically significant.

Since concerns have been raised about local water supply being potentially contaminated with arsenic and polychlorinated biphenyls (PCBs), both of which are known carcinogens and which are being stored at the local chemical waste site, the number of observed and expected cancers and SIRs were calculated for those cancer sites thought to be associated with these toxins, including urinary bladder (SIR = 0.9; 99% CI = 0.2 – 2.6), liver (SIR = 1.2; 99% CI = 0.1 – 4.2) and lung cancers (SIR = 0.9; 99% CI = 0.4 – 1.8). Among Hispanics in the census tract, there were 44 cancers diagnosed and 61.1 expected in the time period of interest (SIR = 0.7; 99% CI = 0.5 - 1.0). None of these findings were statistically significant.

Among children in the census tract, there were five cancers diagnosed and 2.8 expected (SIR = 1.8; 99% CI = 0.4 - 5.1). As is usual, ALL comprised the majority of these childhood cancers, and there were fewer than five observed (SIR = 4.6; 99% CI = 0.8 - 14.4). The children with ALL actually resided in other areas of CT 16.01 and outside of Kettleman City.

Since Kings County has an overall high incidence rate of ALL and there is heightened interest in childhood ALL, the CCR also conducted an analysis of childhood cancer in another census tract in Kings County (CT 12.00). This census tract is adjacent to the northeast side of CT 16.01, and is similar to CT 16.01 as far as land use patterns and population demographics. Again, there was an elevated SIR = 3.1 (99% CI = 0.02 – 23.4), though not statistically significant.

The census tract which actually contains the waste management site (CT 17.01) was also evaluated. The overall SIR for census tract 17.01 was 0.7 (99% CI = 0.6 - 0.8), and the SIR for childhood ALL was 1.1 (99% CI = 0.1 - 5.3). No alterations in cancer were detected.

Conclusions: The results from this study reveal no unusual patterns of cancer occurrence in CT 16.01. When examining cancer of the liver, lung, and urinary bladder, which may be associated with arsenic and PCBs, no significant alterations in risk were noted. The SIRs for all childhood cancers and ALL were somewhat elevated, however, none of the SIRs were statistically significant, and they were within the range of what would be considered normal when compared to the experience of other communities with similar population size and racial/ethnic composition.

An Evaluation of Pattern of Cancer Occurrence in the Vicinity of Kettleman City, California

Background

Kettleman City is a small community in Kings County, CA with a population of approximately 1620 (Kings County, 2010), the majority of whom are Hispanic. The community is located in southern Kings County, adjacent to the Interstate 5 freeway and surrounded by agricultural fields, and formerly, oil and natural gas extraction operations. A chemical waste site operated by Waste Management Inc. is located in the Kettleman Hills about 3.5 miles southwest of the city. In the last few years, community members have expressed concern about of the number of birth defects, which they perceived to be attributed to environmental concerns.

The California Cancer Registry (CCR) is the population-based cancer registry which has monitored cancer diagnoses and cancer-related death among residents of California since 1988. The CCR was asked to evaluate the pattern of cancer occurrence in the Kettleman City area amid reports of numerous birth defects and environmental concerns. Currently, the CCR database is complete from 1988-2008.

In conducting cancer evaluations, it is the policy of the CCR to examine cancer occurrence for a particular area at the census tract level. This is done for two reasons, the first being to avoid the publication of small numbers and thus ensure the privacy and confidentiality of cancer patients in the area, and second, to use the official census population estimates that are available on an age, race and sex specific level. Thus, for the purpose of this report, the term “Kettleman City area” will, henceforth, include and be referred to as census tract (CT) 16.01, since the town of Kettleman City is enclosed within CT 16.01. The population of CT 16.01 in 2000 was enumerated at 4,554 (U.S. Census Bureau, 2000a). It was estimated to be 5,134 at the end of 2008. This estimation was done by CCR staff by employing a method utilized by the U.S. Census, which imputes and applies the growth rates of nearby cities (Avenal and Hanford) to the population base of CT 16.01 (U.S. Census Bureau, 2008). Similar to many communities in the San Joaquin Valley, the population is growing. Hispanics comprised about 72% of the census tract population and the median age was relatively young at 24.6 years (U.S. Census Bureau, 2000b). These figures are quite important in studying the occurrence of cancer, since cancer is a function of age, race/ethnicity, and gender as well as other important factors such as smoking, diet, and family history. In addition, screening for cancers, especially for breast, prostate and cervical cancers will influence how many cancers are diagnosed in a specific area.

Methods

Standardized procedures developed by the CCR were utilized for examining cancer occurrence in CT 16.01. The approach involves both a quantitative evaluation and a qualitative evaluation of cancer occurrence in the area. Qualitatively, the types of the most frequently occurring cancers were examined in CT 16.01 and compared to the types of cancers that usually occur in communities throughout California. In addition, the age breakdown and gender distribution were also examined. The quantitative approach involves calculating the number of cancers that might be expected to occur in CT 16.01 if the population in the census tract experienced the same rate of cancer that is found in the population living elsewhere in California with the same size, age, and racial/ethnic structure. Specifically, the age, sex, race/ethnicity and calendar year specific rates of cancer in California are applied to the corresponding person years at risk in the census tract to derive the expected numbers of cancers. The database of the CCR was then examined to determine the number of cancer cases that were actually observed in CT 16.01.

Based on the number of expected and observed cases, a standard incidence ratio (SIR) was calculated in which the observed number of cases is divided by the expected number of cases. The result is expressed as a ratio, which would take the value one (1.0) if the number of cases observed is equal to the number of expected. Thus, SIR describes in a quantitative fashion the pattern of cancer occurrence (both in terms of elevations and depressions).

For this evaluation, the patterns of cancer occurrence in the population of CT 16.01 were compared to statewide population in California. Other nearby census tracts, namely tracts 12.00 and 17.01, were also examined (Appendix A). CT 17.01 is the adjacent geographic area that encompasses the location of chemical waste site, operated by Waste Management, Inc. At each of these evaluations, a 99% confidence interval (CI) was also calculated. The CI is simply a measure of the stability or precision of the SIR, and if it includes the value of 1.0, then the result is not considered statistically significant (i.e., the rate is within a range of what might be expected by chance alone). The CCR uses the 99% CI to minimize the number of false positive results which might occur when calculating a large number of SIRs.

Furthermore, the SIRs and 99% CI were calculated for 30 of the most common cancer sites and for childhood cancers occurring in children younger than 15 years of age at the time of diagnosis. Because CT 16.01 is primarily Hispanic in nature, the evaluation was also conducted by focusing on Hispanics only.

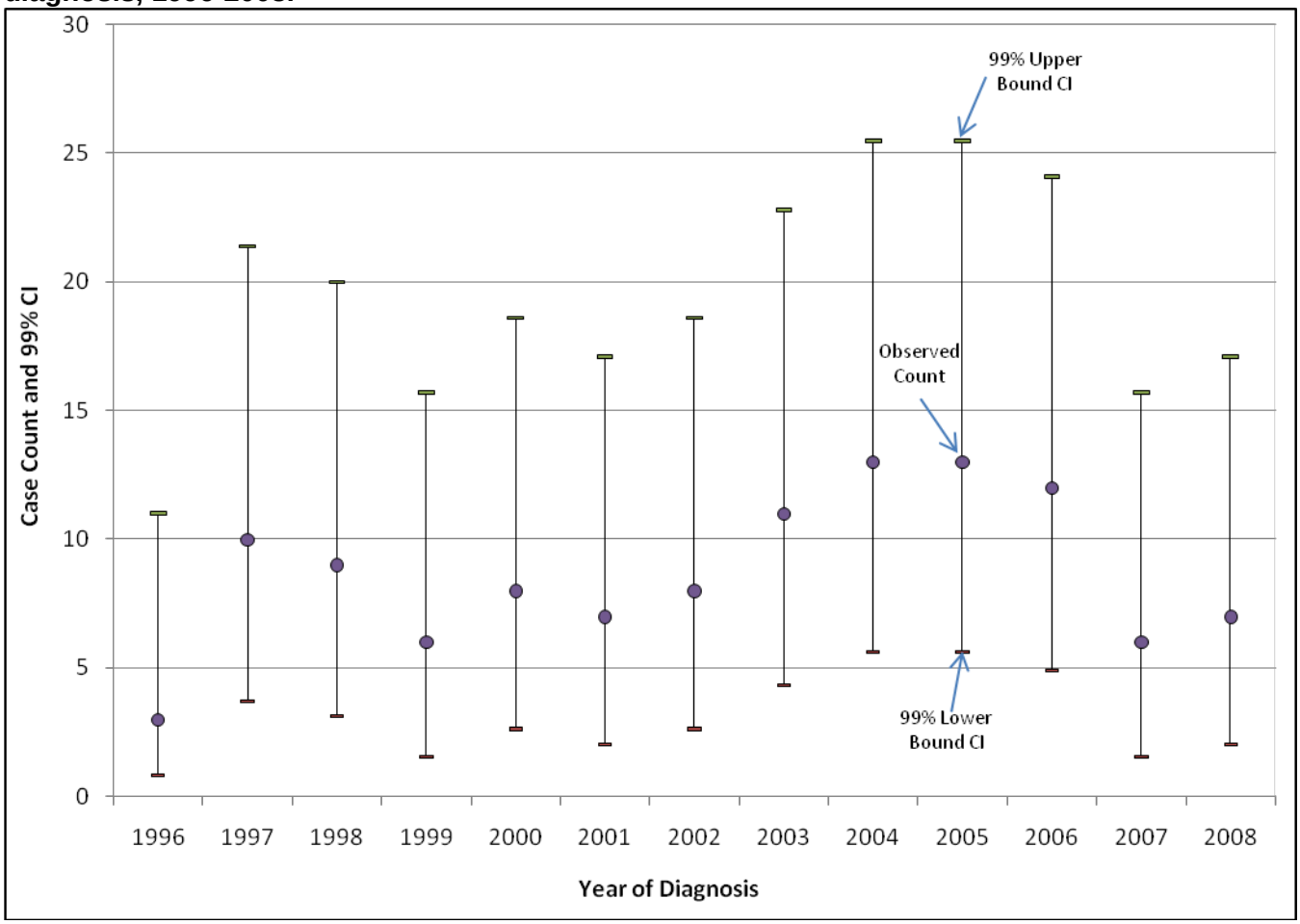
The analysis included the time period 1996 through 2008, the latest year for which the CCR data are considered complete. This 13-year time period of observation was chosen because the geocoding of cancer cases (i.e., the process of accurately assigning the geographic location of residence to each cancer case) was considered reliable during this time period and unreliable prior to 1996. In addition, the U.S. Census Bureau changes the definition of census tracts with each decennial census.

California law (Health and Safety Code Section 103885) requires that reports that contain CCR data not identify any individual cases. CCR guidelines require that small numbers of incident cases not be reported for a limited geographic area with a small population in order to limit the possibility that the identity of an individual cancer patient could be ascertained. Therefore, in this report, any cancer case counts of 1, 2, or 3 shall be reported only as a count of < 4.

Results

Qualitative Evaluation: In the 13-year period between 1996 and 2008, a total of 113 residents living CT 16.01 were diagnosed with one type of cancer or another, for an average of about 9 cases diagnosed each year. Among these, only 28 cases were actually from Kettleman City; the rest were from other areas within the census tract. The annual distribution of cancer cases in CT 16.01 varies from year to year due to the small population size (Figure 1). The figure demonstrates the actual observed number of cancers cases per year, plus the expected variation around each count. As far as the gender distribution of cancer in this area is concerned, between 1996 and 2008, more males were diagnosed with cancer (59%) than females (41%) and this is the pattern commonly found for cancer (data not shown). Within the census tract, males account for 53.8% of the population, females for 46.2% (U.S. Census Bureau, 2000b). Males tend to have higher risk of developing cancer because they traditionally smoke more often than females, and may be more often exposed to potentially carcinogenic agents in the work environment (Ries, DeVesa, 2006). In addition, the major occupational pursuit in this area of the San Joaquin Valley is agriculture. With higher percentage of men living in the area, there may be many more men than women working in the fields adjacent to Kettleman City.

Figure 1. Distribution of cancer counts in CT 16.01, Kings County California by year of diagnosis, 1996-2008.



The breakdown of cancer by racial groups in the Kettleman City area shows that most cancers were diagnosed in non-Hispanic white (NHW) population, followed by the Hispanic population of this area. No cancers were observed in the Asian/Pacific Islander (API) group, and very few were found in African Americans and American Indians (AI). The combination of these three racial groups comprised only 13% of all the cancer diagnosed in CT 16.01 (Table 1). This pattern reflects the racial distribution of the census tract area population, which is predominately Hispanic in nature. In general, the burden of cancer is twice as high in NHW than in Hispanics, and the NHW population tends to be much older than the Hispanic population, which is why non-Hispanic white have the highest numbers of cancers in the census tract, despite the large number of Hispanics in the population in the Kettleman City area.

Table 1. Distribution of cancer in CT 16.01 for all ages, by racial groups, 1996-2008.

Racial Group	Percent	Observed Count	99% Confidence Interval
NHW	47.8	54	36.9 – 76.0
Hispanic	38.9	44	28.8 – 64.1
Other*	13.3	15	6.9 – 28.2

Note: * includes API, African Americans, and AI

Cancer is not one disease but represents, perhaps, hundreds of different diseases, all of which are characterized by uncontrolled cellular growth and proliferation. The occurrence of the leading forms of

cancer in the Kettleman City area included breast cancer, prostate cancer, and lung cancer (Appendix B). Cancer of the breast, prostate, lung, colon and rectum are generally considered as the four major types of cancer that often account for about half of all cancers diagnosed each year throughout the United States, as they do in the Kettleman City area.

The greatest single risk factor for cancer is advancing age. The age distribution of new cases of cancer in the Kettleman City area shows that as age increases, the number of cancers increases dramatically, such that 71% of all cancers diagnosed are in people 55 years of age or older. This pattern may be due to the loss of immune competence, which accompanies aging or the life-long accumulation of toxic substances at the cellular level.

Quantitative Evaluation: Between 1996 and 2008, a total of 113 residents of the census tract surrounding Kettleman City were diagnosed with cancer. If the census tract experienced the same rate of cancer as the state of California as a whole, a total of 143.2 cancers would be expected to occur in the same time period (SIR = 0.8; 99% CI=0.6 – 1.0). This indicates somewhat less cancer in the area than might be anticipated. The SIRs for 30 of the most common cancer sites for all races and all ages in CT 16.01, evaluated by the CCR, are found in Appendix B.

Of the 30 cancer sites examined, six of the SIRs were above 1.0 while the rest were below 1.0. The SIR for acute lymphocytic leukemia (ALL) was the highest (3.5) although not statistically significant. Somewhat elevated SIRs were also noted for kidney (1.7) and pancreas cancers (1.6). Again, they were not statistically significant.

The occurrence of cancer in Hispanics living in CT 16.01 was also evaluated and the overall SIR for Hispanics was 0.7 (99% CI = 0.5 – 1.0), indicating slightly less cancer than would be anticipated. Among the Hispanics in the census tract, there were 44 cancers diagnosed and 61.1 expected in the time period of interest.

Since concerns have been raised about local water supply being potentially contaminated with arsenic and polychlorinated biphenyls (PCBs), both of which are known carcinogens (ATSDR, 2001; Gehle et al, 2003; Chiou et al, 2001), and are being stored at the local chemical waste site, the number of observed and expected cancers and SIRs were calculated for those cancer sites (IARC, 1987) thought to be associated with these toxins. These include urinary bladder cancer, liver, and lung cancers. While the SIR for liver (SIR = 1.2; 99% CI = 0.1 – 4.2) is slightly elevated, as compared to those of lung (SIR = 0.9; 99% CI = 0.4 – 1.8) and urinary bladder (SIR = 0.9; 99% CI=0.2 – 2.6), none of these findings were statistically significant (Appendix B).

Childhood cancers: Due to the concern with birth defects in the Kettleman City area, a separate analysis of cancer occurring in children < 15 years of age at diagnosis was also completed (Table 2). Among children in the census tract, there were 5 cancers diagnosed and 2.8 expected (SIR = 1.8; 99% CI = 0.4 – 5.1). As is usual, ALL comprised the majority of these childhood cancers, and there were four observed (SIR = 4.6; 99% CI = 0.8 – 14.4). The children who were diagnosed with ALL actually resided in areas of CT 16.01 outside of Kettleman City.

Table 2: Standardized incidence ratios (SIR) and 99% confidence intervals for cancer in children <15 years of age at diagnosis in CT 16.01, 1996-2008, all race/ethnicities.

Cancer	Observed	SIR	99% CI
All cancer sites	5	1.8	0.4 – 5.1
Acute lymphocytic leukemia	4	4.6	0.8 - 14.4

Other Comparisons
The CCR maintains an interactive website (http://www.cancer-rates.info/ca/) by which incidence rates of cancers in each of the 58 counties in California can be calculated and displayed. A review of the website indicates that the counties in the central San Joaquin Valley (i.e., Fresno, Tulare, and Kings) experienced elevated rates of ALL during the last five year time period, 2003-2007. Since Kings County has an overall high incidence rate of ALL, and there is heightened interest in childhood ALL, the CCR also conducted an analysis of childhood cancer in another census tract in Kings County (CT 12.00). This census tract is adjacent to the northeast side of CT 16.01, and is similar to CT 16.01 as far as land use patterns and population demographics. Again, there was an elevated SIR = 3.1 (99% CI = 0.02 – 23.4) that was not statistically significant.

One of the major environmental concerns expressed by the public in the Kettleman City area is the presence of the chemical waste site managed by Waste Management, Inc. The location of the chemical waste site is about 3.5 miles southwest of Kettleman City proper along California State Route 41. The census tract which actually contains the waste site is CT 17.01 in Kings County. This census tract was also evaluated using the same methodology, as described above. The overall SIR for CT 17.01 was 0.7 (99% CI = 0.6 - 0.8), and the SIR for childhood ALL was 1.1 (99% CI = 0.1 - 5.3). No alterations in cancer patterns were detected.

Discussion and Conclusions
In recent years Kettleman City residents have expressed concerns over the number of children born with birth defects in the area and about potential environmental factors that may be associated with the development of those birth defects. CCR was asked to evaluate cancer occurrence in the Kettleman City area in response to questions raised by residents at community meetings concerning other health outcomes that might be related to environmental factors. The CCR examined cancer data for the census tract which contains Kettleman City (CT 16.01) from 1996-2008 and found no unusual patterns of cancer for the population overall in this census tract.

During the time period 1996-2008, 113 cancers were diagnosed in the residents of this area, while 143 cancers would be expected to occur if the area experienced the same rate of cancer as the rest of the state of California. Among Hispanics, who comprise a majority of the population in CT 16.01, there were 44 cancers observed and 61.1 cancers expected. The CCR examined the occurrence in CT 16.01 of the 30 most common cancers among the overall population and among Hispanics and found no elevations. This analysis included cancers that have been linked to the carcinogens arsenic and polychlorinated biphenyls (liver, lung, and urinary bladder cancers) which have been of concern to Kettleman City residents.

Due to the focus on children's health among residents, a separate analysis of cancers diagnosed among children age 0-14 years of age was also done. During the same time period 1996-2008, five children residing in CT 16.01 were diagnosed with a cancer, while 2.8 would be expected resulting in a SIR of 1.8. This elevation was not statistically significant. Four of the five cancers diagnosed among children in CT 16.01 were ALL, the most common childhood cancer. None of these four children resided in the town of Kettleman City at diagnosis. The SIR for ALL in CT 16.01 was elevated at 4.6, but did not reach statistical significance. The SIR for ALL in children 0-14 years of age in an adjacent census tract (CT 12.00) also showed an elevation that was not statistically significant. These SIRs, must be considered against the rates of ALL found in Kings County and other counties in the San Joaquin Valley. It has been documented by the CCR that rates of ALL in Kings County, and neighboring Tulare and Fresno counties are higher than elsewhere in the State. While CCR data can document the presence of elevated rates of a cancer in a region, they cannot determine any specific cause for an elevation. A large study of childhood leukemia in Northern California, including Kings,

Fresno, and Tulare counties, is underway and is designed to identify risk factors and the complex genetic and environmental causes of childhood leukemias.

There are limitations inherent in any such analysis as this. First, only a substantial increase in risk for cancers in a geographic area is likely to be detected using CCR data, because typically the small number of cases limits the power of the analysis to detect subtle increases in risk in a small geographic area. Second, CCR data include the address at diagnosis, but do not include the length of residence at that address. Because cancers may develop over many years, a person diagnosed with a cancer may no longer reside in the area where a potential carcinogenic exposure occurred. Third, there may be a delay of up to 18 months between the end of the calendar year of a cancer diagnosis and the inclusion of a case in the CCR database, which limits the inclusion of more recent cases in the analysis. The CCR will continue to monitor the occurrence of cancers in the Kettleman City area as new data become available.

In summary, the cancer experience of Kettleman City residents from 1996-2008 was similar to that experienced by California residents overall. Currently, nearly one out of every two California men and one out of three California women will be diagnosed with a cancer at some time in their lives. While much remains to be learned about the underlying causes of cancers, many risk factors are well-established. Kettleman City residents may wish to contact the American Cancer Society to learn more about cancer and cancer risk factors, and for questions regarding resources available to the community and to individual cancer patients.

As for the concern of childhood cancer, though the SIRs for all childhood cancers and ALL were elevated, none of these were statistically significant. They were within the range of what would be expected for the area. Because there is a longstanding concern that rates of childhood cancer are elevated in the central San Joaquin Valley, a study of cancer in these counties is underway (Ma, 2002.) This study of chldhood cancer is underway in an attempt to ascertain the risk factors for this unfortunate situation. A report such as the current one is designed to determine if there is an excessive amount of cancer occurring in the communty, not to identify the causes of cancer.

There are limitations inherent in any such analysis as this. The usual problems of small numbers, which are associated with unstable statistics, are typical of such an investigation. The cancer cases in this geographic area were not accurately geocoded prior to 1996, which precluded the period from 1988 to 1995 being part of the analysis.

In summary, although residents in the Kettleman City area are diagnosed with cancer, the frequency is not excessive nor are there any indications for an unusual pattern of cancer in the community. Currently, one out of three Americans will be diagnosed with cancer at some point in their life. Cancer is now the second leading cause of death in the United States and continued efforts to reduce smoking, obesity, and exposures to toxic agents which may contribute to higher cancer risk should be pursued. In Kings county, the American Cancer Society and other advocacy groups are instrumental in educating the public about the cancer issue confronting the community.

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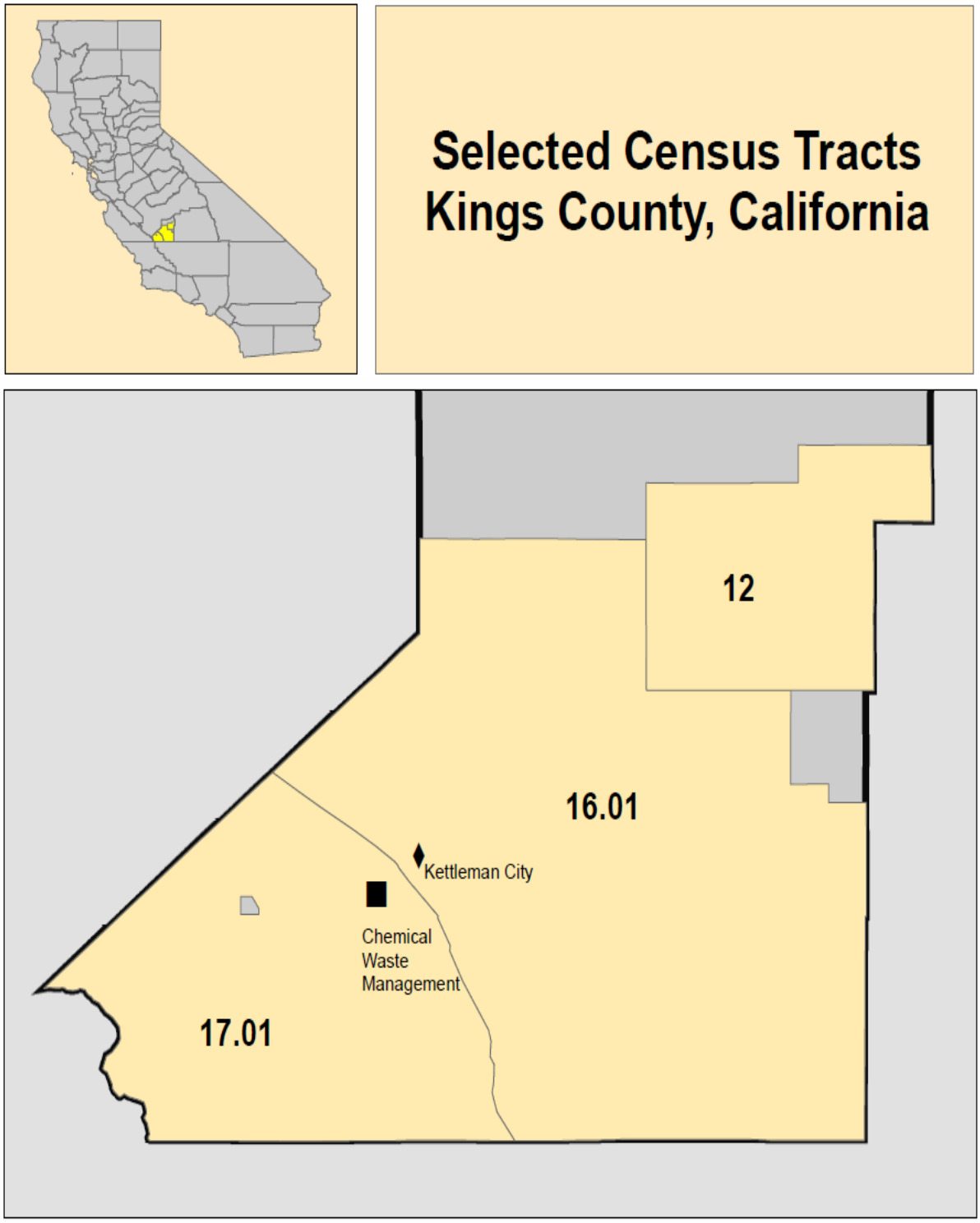
Appendix Materials

Appendix A

Map of census tract 16.01 in Kings County, California



Source: CCR, Cancer Surveillance Research Unit, July 13, 2010

Appendix B

Observed and expected case counts, standardized incidence ratios (SIR) and 99% confidence intervals for 30 major cancer sites in census tract 16.01, Kings County, California, 1996-2008, all ages and all races.

	Observed Counts, 99% Confidence Interval (CI)		SIR, 99% Confidence Interval (CI)	
Cancer Site	Observed	99% CI	SIR	99% CI
Brain	<4	--	^	^
Breast	12	4.9 - 24.1	0.6	0.2 - 1.2
Cervix uteri	<4	--	^	^
Colon	<4	--	^	^
Colon and rectum	<4	--	^	^
Corpus Uteri	<4	--	^	^
Esophagus	0	--	^	^
Hodgkin Lymphoma	0	--	^	^
Kaposi Sarcoma	0	--	^	^
Kidney and Renal Pelvis	7	2.0 - 17.1	1.7	0.5 - 4.2
Larynx	<4	--	^	^
Leukemia	7	2.0 - 17.1	1.5	0.4 - 3.6
Acute Lymphocytic Leukemia	5	1.1 - 14.2	3.5	0.8 - 10.0
Chronic Lymphocytic Leukemia	0	--	^	^
Acute Myeloid Leukemia	<4	--	^	^
Chronic Myeloid Leukemia	<4	--	^	^
Liver	<4	--	^	^
Lung and Bronchus	15	6.9 - 28.2	0.9	0.4 - 1.8
Melanoma of the Skin	4	0.7 – 12.6	0.9	0.1 - 2.7
Myeloma	0	--	^	^
Non-Hodgkin Lymphoma	5	1.1 - 14.2	0.8	0.2 - 2.3
Oral Cavity and Pharynx	<4	--	^	^

Ovary	0	--	^	^
Pancreas	5	1.1 - 14.2	1.6	0.3 - 4.4
Prostate	25	14.0 - 41.0	1.1	0.6 - 1.7
Rectum	<4	--	^	^
Stomach	<4	--	^	^
Testis	0	--	^	^
Thyroid	<4	--	^	^
Urinary Bladder	5	1.1 - 14.2	0.9	0.2 - 2.6
Total (All sites combined)	113	87.5 - 143.4	0.8	0.6 - 1.0

^ SIR not calculated.

Part 2

Kettleman City Community Exposure Assessment

by the California Environmental Protection Agency

California Environmental Protection Agency

Kettleman City Community Exposure Assessment

PUBLIC REVIEW DRAFT
November 2010

California Environmental Protection Agency
Air Resources Board
Department of Pesticide Regulation
Department of Toxic Substances Control
Office of Environmental Health Hazard Assessment
State Water Resources Control Board

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California Environmental Protection Agency

Kettleman City Community Exposure Assessment

PUBLIC REVIEW DRAFT
November 2010

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ARB Report
DPR Report
DTSC Report

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LIST OF ACRONYMS

ACR	Air cancer risk
ARB	Air Resources Board
Cal/EPA	California Environmental Protection Agency
CHHSL	California Human Health Screening Level
CDFA	California Department of Food and Agriculture
CIMIS	California Irrigation Management Information System
CDPH	California Department of Public Health
DEHP	Bis(2-ethylhexyl)phthalate
DnBP	Di-n-butyl phthalate
DPM	Diesel particulate matter
DPR	Department of Pesticide Regulation
DTSC	Department of Toxic Substances Control
HI	Hazard index
HQ	Hazard quotient
KCCSD	Kettleman City Community Services District
KHF	Kettleman Hills Facility
LOD	Limit of detection
MADL	Maximum allowable dose level
MCL	Maximum contaminant level
MITC	Methyl isothiocyanate
OCPs	Organochlorine pesticides
OEHHA	Office of Environmental Health Hazard Assessment
PCBs	Polychlorinated biphenyls
PSL	Preliminary screening level
PHG	Public Health Goal
PM	Particulate matter
PM2.5	Particulate matter less than 2.5 microns in size
REL	Reference exposure level

RSL	Regional screening level
SVOCs	Semivolatile organic compounds
SWRCB	State Water Resources Control Board
TEF	Toxicity equivalent factor
TEQ	Toxicity equivalence
TPH	Total petroleum hydrocarbons
U.S. EPA	United States Environmental Protection Agency
UST	Underground storage tank
VOCs	Volatile organic compounds
WBZ	Water-bearing zones

INTRODUCTION

In January 2010, Governor Arnold Schwarzenegger directed the California Department of Public Health (CDPH) and the California Environmental Protection Agency (Cal/EPA) to investigate potential causes of increased birth defects in the small farming town of Kettleman City in Kings County. Cal/EPA was directed to assess possible environmental contaminants in the air, groundwater and soil (the Kettleman Community Exposure Assessment) that could cause birth defects. and CDPH was directed to conduct a health investigation of the families whose children were born with birth defects.

This report is the product of the Cal/EPA including its boards, departments, and office and the Kettleman City Technical Work Group, which is comprised of technical experts and managers representing Cal/EPA, the Air Resources Board (ARB), the Department of Pesticide Regulation (DPR), the Department of Toxic Substances Control (DTSC), the State Water Resources Control Board (SWRCB), and the Office of Environmental Health Hazard Assessment (OEHHA). OEHHA is the lead entity for the assessment. Technical assistance was provided by CDPH and the U.S. Environmental Protection Agency (U.S. EPA).

Cal/EPA was directed to determine whether unsafe levels of chemicals in the environment may have contributed to the increase in birth defects in the Kettleman City community since 2007. Samples of air, water and soil were analyzed for chemicals that could cause birth defects as well as cancer and other health effects. Potential health risks from pesticides were evaluated using records of pesticide use and computer modeling, in addition to environmental monitoring. Historical records were also reviewed to identify past and present activities and chemicals that may have been present in the environment during the time of the reported birth defects.

Public participation

Cal/EPA and CDPH worked to maximize public participation and community input throughout the planning and implementation of the Kettleman Community Exposure Assessment. Cal/EPA and CDPH led or participated in well-attended public meetings in Kettleman City in February, March, April, and June 2010 to discuss the investigation and address health concerns in the area. Cal/EPA released this report in November 2010 for public review and is allowing a 30-day written comment period ending in December. Cal/EPA also will host a workshop in Kettleman City in November to discuss and receive public comments about this draft report.

Each of the meetings drew extensive television, radio, and newspaper coverage, and Cal/EPA published an advertisement in the Hanford Sentinel newspaper to notify the community of the investigation and the sampling conducted in Kettleman City.

Cal/EPA also prepared documents and informational materials about the investigation in both English and Spanish and distributed them as widely as possible in the community.

Copies of an informational flyer were distributed door-to-door, and copies of the Kettleman City Community Exposure Assessment Work Plan technical document were provided for community review at several locations.

On February 9, 2010, officials from OEHHA and DTSC joined CDPH officials at a community meeting at the Kettleman City Elementary School and a meeting of the Kings County Board of Supervisors in Hanford.

On March 25, 2010, Cal/EPA hosted a community meeting at the Kettleman City Community Center to discuss preliminary plans for the environmental health investigation and solicit public input for improving the plans. On April 15, 2010, officials from Cal/EPA and its five boards, departments, and office joined CDPH representatives at a public meeting and open house at the Kettleman City Elementary School to update the community on the investigations. Representatives from OEHHA, DTSC, ARB, DPR, and the SWRCB participated and met with residents to discuss their ideas, questions, and concerns. Earlier in the day, Cal/EPA officials visited several homes in the community to ask residents about their concerns and request suggestions with regard to the scope of the Cal/EPA exposure assessment.

Cal/EPA staff also worked closely with the Mexican Consulate in Fresno to ensure that the large Mexican-American community in Kettleman City was aware of the investigation and had extensive opportunities to ask questions and provide input. On June 3, 2010, a Cal/EPA representative delivered a presentation on the investigation at an open house event in Kettleman City hosted by the Mexican Consulate.

Finally, Cal/EPA and CDPH representatives participated in a June 17, 2010, hearing conducted by the California Latino Legislative Caucus at the Kettleman City Elementary School. They answered questions from legislators at the hearing and met with members of the Kettleman City community.

Background

Kettleman City is a rural community of approximately 1,620 residents in southwestern Kings County (see Figure 1). It is located along the State Highway 41 (SR-41) corridor just north of Interstate 5 (I-5). The community covers approximately 118 acres and consists of two separate areas—a highway commercial area along SR-41 immediately north of I-5, and a residential area north of the commercial area (see Figure 2).

Since 2007, 10 infants have been born with birth defects in Kettleman City. Some of these infants have died. The community is concerned about the birth defects and the possibility that they may have been caused by environmental exposures to chemicals in the community.

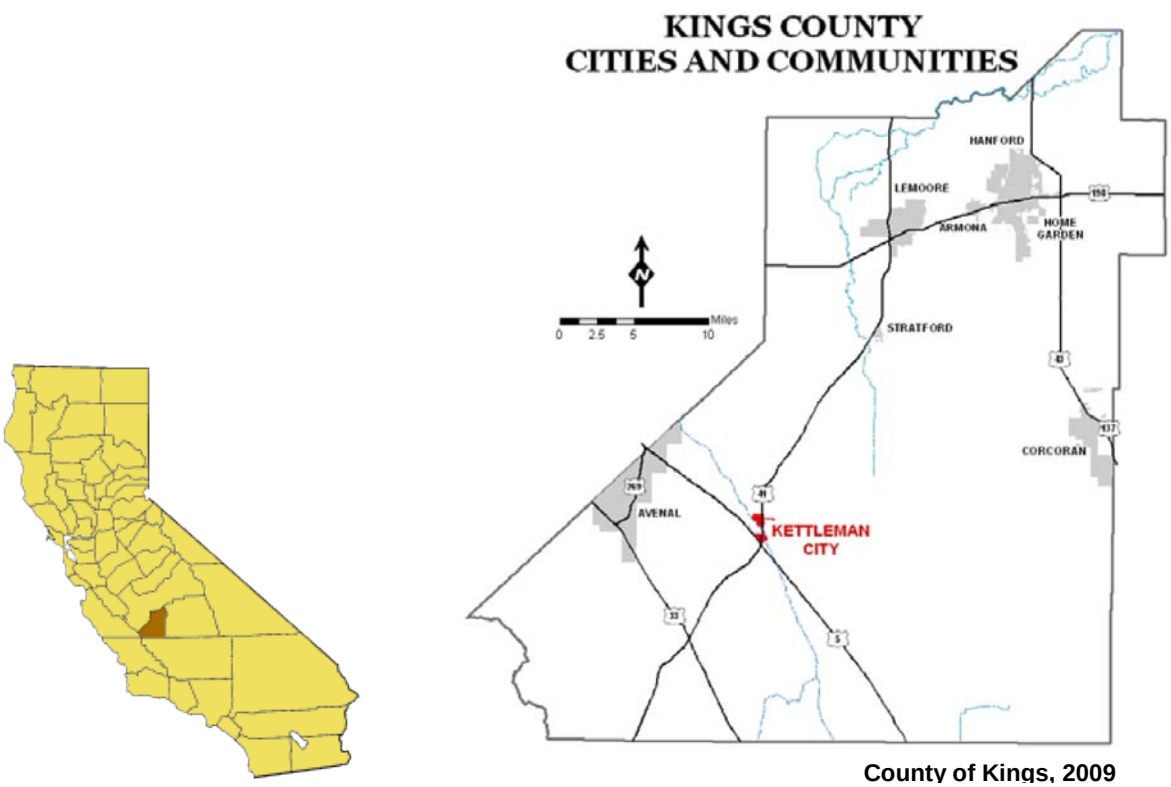

Figure 1. Location of Kings County and Kettleman City

Community history

Kettleman City was founded in 1929, a year after the discovery of oil in nearby Kettleman Hills. The community originally provided housing for the oil workers. The population rapidly increased as oil production operations reached their peak. By 1940, the community had hotels, libraries, an elementary school, and a population of 600. In 1945, oil production began to decline and the community's economy and population growth began to slow. The community is an unincorporated area of Kings County.

The I-5 freeway, California Aqueduct, and Chemical Waste Management, Inc.'s Kettleman Hills Facility (KHF) began operation in the 1970s. Today, the community has a population of about 1,620 (Kings County, 2010). Its economy is mostly based on agriculture, with some commercial business near the intersection of I-5 and SR-41 and along SR-41 (see discussion in the following section).

Description of the area

Figure 2 shows the location of the residential and commercial areas of Kettleman City. The commercial area, located in the southern portion of Kettleman City along both sides of SR-41 immediately north of I-5, consists of motels, restaurants, and fuel stations. This area is bounded to the north by the California Aqueduct, which acts as a permanent buffer separating the commercial and residential areas. North of the aqueduct is an area less than a mile long, consisting mostly of open space land with

some industrial and commercial uses, including a Chevron mixing and storage facility to the west and a Con-Way Freight Transfer Station to the east.

Figure 2. Satellite view of Kettleman Hills showing residential [R] and commercial [C] areas

The residential area is at the north end of the community, about 1.7 miles north of I-5. Homes are located on both sides of SR-41, also known as Brown Street. Approximately 300 residential units are located west of Brown Street, and 46 units to the east. The residential area is made up largely of single-family homes averaging 1,100 square feet in size. Most of the homes were built before 1975. A large proportion of the residential units—about 14 percent—are mobile homes.

A few commercial businesses are located along Brown Street, including a gas station, two small convenience stores, an auto parts dealer, and two towing companies. Community facilities such as the Kettleman City Community Services District (KCCSD) Office, KCCSD Park, Kettleman Elementary School, County Fire Station No. 9, County Library, and medical clinic are all located west of SR-41.

KCCSD supplies municipal water from two local wells to the residents of the community. The Kettleman City Elementary School receives water from a third well located at the school.

Surrounding land uses

Agricultural land surrounds the residential area of Kettleman City to the north and east and portions of the west. Major crops grown within five miles of Kettleman City include alfalfa, carrots, nuts (almonds and pistachios), onions, tomatoes, and stone fruit (apricots, nectarines, peaches, and plums). Pistachio and almond orchards were planted in the past year (orchards to the northeast and east were planted about a year ago; those to the northwest were planted in the last few months). The orchards are separated from the closest homes only by streets—Edward Street to the north and Carter Street to the east—or by a driveway (to the west of First Street). The rest of the surrounding agricultural lands are planted with rotating crops.

The Kettleman Hills Hazardous Waste Facility, operated by Chemical Waste Management, Inc., is located 3.5 miles southwest of the community (see Figure 3). The facility has a permit to accept commercial hazardous waste for treatment, storage and landfill disposal. It also accepts municipal garbage for landfill disposal in a separate area.

The Kettleman City community is located between the Kettleman City oil field and the Kettleman North Dome oil field. Several abandoned or idle oil wells are located outside the community. There are also naturally occurring petroleum deposits as well as oil pipelines, wells, pump stations, and a bulk storage facility in the area. Three aboveground oil pipelines currently run outside the south boundary of the residential area.

Finally, the California Aqueduct and local canals are located close to the community. The Aqueduct is not a source of drinking water for the area. It is a source of drinking water for southern California. The canals are used to convey water for crop irrigation in the valley. Some residents catch and consume fish from these water bodies.

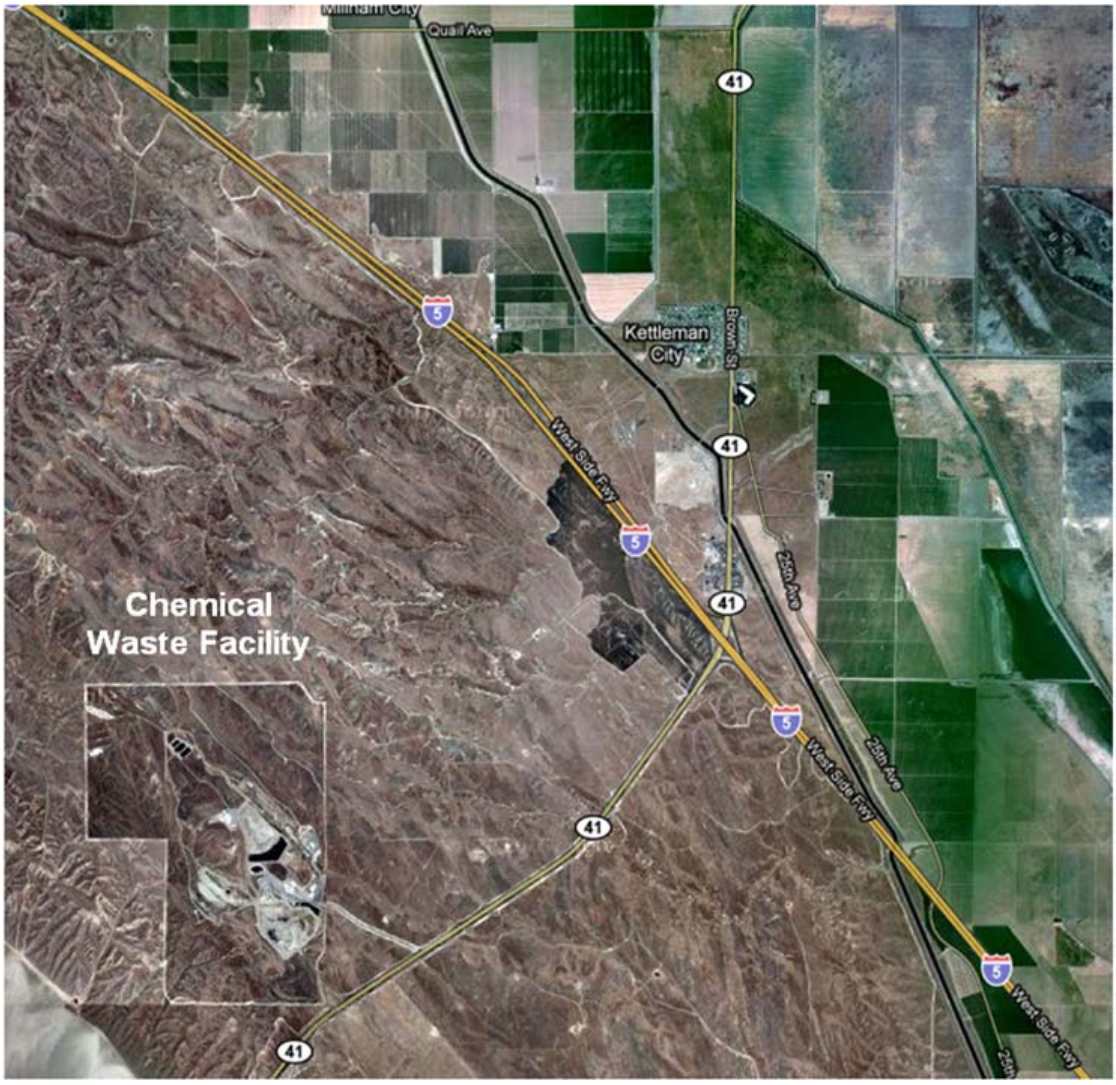

Figure 3. Location of Chemical Waste Facility relative to Kettleman Hills

Demographics

Most of the residents are employed by local farming operations or other related industries. The 2000 census reported about 1,500 people in the community, which had 320 households and 289 families. The median age is about 24 and about 63 percent of households include children under 18 years old. The community is about 93 percent Hispanic or Latino and 5 percent white, with a small percentage of American Indians, African Americans, and Asians. In 2000, about 6 percent of adults over 25 years old were high school graduates. About 39 percent of families were reported at poverty status in 1999, compared with about 11 percent of families statewide. The median household income was $22,409, compared with a statewide median of $47,493.

Climate

The climate in Kettleman City is characteristic of the southern San Joaquin Valley: hot summers, mild winters, and low annual rainfall. Summer temperatures in the San Joaquin Valley commonly exceed 100°F. The Coastal Ranges block much of the

moisture from the Pacific Ocean from reaching the interior valley. As a result, the average annual precipitation for Kettleman City is approximately 7 inches. Most of the rain is absorbed by the dry soils.

Meteorological data from nearby Lemoore and Hanford show that the wind in this portion of the San Joaquin Valley generally comes from the northwest and moves toward the southeast. The average wind speed is 5.6 miles per hour. During the winter months, wind will often travel from the southeast and move toward the northwest. (See Figure 4.)

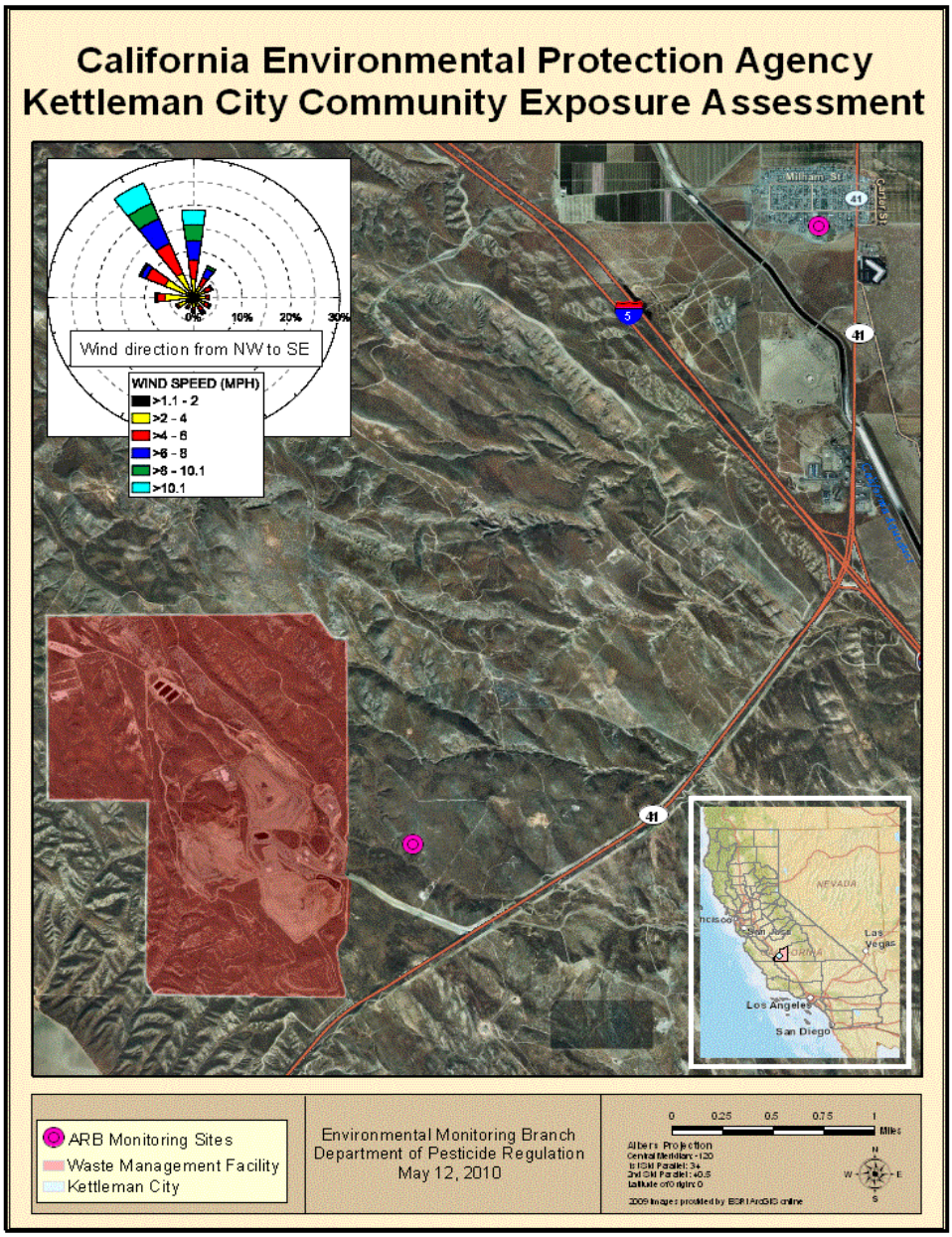

Figure 4. Wind rose

Area geology and groundwater

Kettleman City is part of the Tulare Lake Basin. Groundwater is found approximately 170 feet below-ground surface (bgs)[1] in saturated sandstone beds or water-bearing zones (WBZs). These zones are isolated hydraulically from one another by intervening siltstone and claystone intervals. Of the two municipal wells that serve Kettleman City, one well was drilled to 660 feet deep and draws water at two depths: from 210 to 390 feet bgs and from 420 to 545 feet bgs. The other well is drilled to 700 feet deep and draws water from 400 to 630 feet bgs. The third well, which serves the elementary school, was drilled to 410 feet deep and draws water between 219 and 410 feet.

Arsenic and benzene have historically been detected in the water supplied by the wells. Prior to this investigation, arsenic in well water had been measured at levels up to 16.3 micrograms per liter (µg/L). This is above the state arsenic drinking water standard of 10 µg/L, which was reduced from 50 µg/L in 2008. Also prior to this investigation, benzene had been detected at levels ranging from 6.9 to 120 µg/L — above the state drinking water standard of 1 ug/L. In 1998, both municipal wells were equipped with an aeration treatment system to reduce the level of benzene to less than 0.5 µg/L. Arsenic, however, cannot be removed by the same water treatment process. The water is also disinfected with chlorine.

[1] This measurement was taken in 1985 and was recorded on the United States Geological Survey's database for groundwater sites.

CHEMICALS OF INTEREST

Developmental toxicants

In the first step of the assessment, OEHHA scientists prepared a comprehensive list of chemicals that are known to cause birth defects and other developmental effects – especially facial cleft lip and cleft palate.

This list of developmental toxicants was developed from chemical assessments conducted by OEHHA, as follows:

- The Proposition 65 list of chemicals known to the State of California to cause birth defects and other reproductive harm.
- Chemicals under consideration for listing under Proposition 65
- Public Health Goals for drinking water contaminants developed under the California Safe Drinking Water Act of 1996
- Reference Exposure Levels for air toxics developed for California's Air Toxics "Hot Spots" program.

The chemicals were evaluated for the types of developmental effects reported in humans and laboratory animals. This evaluation was conducted to identify the chemicals from the above-mentioned sources that are most likely to cause birth defects. Most of the information comes from studies on laboratory animals, but some comes from studies on human populations exposed to chemicals in the workplace and in the environment.

The Cal/EPA Kettleman City Technical Work Group evaluated these chemicals to determine which should be included in the assessment. The following factors were considered for each chemical:

- Location
  - Is the chemical likely to be in the Kettleman City environment?
  - Is the chemical known to be used in or near Kettleman City?
  - Was the chemical used in the past in Kettleman City?
  - In what media (such as air, water, or soil) is the chemical found?

- Ease of detection
  - Is there a current method for laboratories to analyze the chemical?
  - Is it part of a standard analytical method?
  - Is there a Cal/EPA laboratory that can do the analysis?
  - Is there a private or other government laboratory that can do the analysis?

- Likely presence
  - Is the chemical used seasonally?
  - Is the chemical likely to stay in the local environment when released?

- Could the chemical enter the local environment from another point of release?

In addition to the chemicals identified through this process, DPR identified pesticides that could potentially cause birth defects and whose use was reported within five miles of Kettleman City during 2007 or 2008. (Pesticide use data for Kettleman City in 2009 were not available when the list of pesticides was developed.)

Cal/EPA then released a list of chemicals (including the pesticides identified by DPR) for public review and comment. The comments were used to compile a final list of chemicals (see Table 1).

Table 1. Chemicals investigated at Kettleman City

Chemical	Monitored Media			Air Model[1]	Use(s)
	Soil	Air	Water		
Abamectin				X	Pesticide
Arsenic	X	X	X		Industrial/NO[2]
Azoxystrobin				X	Pesticide
Benzene	X	X	X		Industrial
Boscalid				X	Pesticide
Bromoxynil				X	Pesticide
Cadmium	X	X	X		Industrial/NO
Carbaryl				X	Pesticide
Carbon Disulfide		X			Industrial & Pesticide
Chlorpyrifos		X		X	Pesticide
Chlorinated dibenzodioxin and dibenzofuran congeners	X	X			Industrial Contaminant
Chromium	X				Industrial/NO
Chromium VI		X	X		Industrial/NO
Clethodim				X	Pesticide
Diazinon		X		X	Pesticide
DDT (Dichlorodiphenyl-trichloroethane), DDE	X				Pesticide
Diflubenzuron				X	Pesticide
2,4-D				X	Pesticide
Endrin	X				Pesticide
Ethyl benzene	X	X	X		Industrial
Fenoxaprop-p-ethyl				X	Pesticide
Flumioxazin				X	Pesticide
Lead	X	X	X		Industrial/NO

Chemical	Monitored Media			Air Model[1]	Use(s)
	Soil	Air	Water		
Maneb				X	Pesticide
MCPA ((4-chloro-2-methylphenoxy)acetic acid)				X	Pesticide
Mercury and mercury compounds	X				Industrial/NO
MITC (methyl isothiocyanate)		X		X	Pesticide
Myclobutanil (Laredo)				X	Pesticide
Nickel	X	X	X		Industrial/NO
Oxyfluorfen		X		X	Pesticide
Polychlorinated biphenyl congeners	X	X	X		Industrial
Propiconazole				X	Pesticide
Pyraclostrobin				X	Pesticide
Sulfur dioxide		X			Pollutant/NO
Toluene	X	X	X		Industrial

[1] Amounts of pesticides in the air were estimated by DPR using computer models. This allowed DPR to estimate public exposure in Kettleman City from pesticide applications on nearby fields. DPR monitored for four pesticides: chlorpyrifos, diazinon, MITC (methyl isothiocyanate), and oxyfluorfen.

[2] NO-Naturally occurring in the environment as well as a contaminant from human activity.

During the public meetings and comment period, community members and others requested that Cal/EPA evaluate other potential health risks in addition to developmental effects. Several of the chemicals in Table 1 have been linked to cancer and other serious health effects. The Work Group responded to the community requests and evaluated the cancer risks of these chemicals as well as their risks of causing developmental effects (see next section).

Other chemicals analyzed

Community members requested that the assessment evaluate other environmental contaminants that may be present in Kettleman City in addition to the chemicals inTable 1. While the primary purpose of the assessment is to determine whether contaminants may be responsible for birth defects, the analytic methods used to measure the chemicals in Table 1 also can measure levels of many other chemicals. Cal/EPA was able to evaluate these additional chemicals to determine if they might pose potential health risks to the community. These chemicals are listed in Table 2 and include those routinely collected. and analyzed as part of the monitoring process.

Table 2. Other chemicals routinely collected and analyzed as part of the monitoring process (industrial and banned and currently registered pesticides)

Chemical	Chemical
Acenaphthene	Dinitrophenol, 2,4-
Acenaphthylene	Dinitrotoluene, 2,4-
Acetone	Dinitrotoluene, 2,6-
Aldrin*	Di-n-octyl phthalate
alpha-BHC*	Dioxane, 1,4-
alpha-Chlordane*	Diphenyl amine
Aluminum	Endosulfan I**
Anthracene	Endosulfan II**
Antimony	Endosulfan sulfate**
PCB, Aroclor 1016	Fluoranthene
PCB, Aroclor 1221	Fluorene
PCB, Aroclor 1232	Fluorobiphenyl, 2-
PCB, Aroclor 1242	Fluorophenol, 2-
PCB, Aroclor 1248	Freon 113
PCB, Aroclor 1254	gamma-BHC (Lindane)*
PCB, Aroclor 1260	gamma-Chlordane*
PCB, Aroclor 1262	Hardness, as $CaCO_3$ (Calculated)
PCB, Aroclor 1268	Heptachlor*
Barium	Heptachlor epoxide*
Benzo(a)anthracene	Hexachlorobenzene*
Benzo(a)pyrene	Hexachlorobutadiene
Benzo(b)fluoranthene	Hexachlorocyclopentadiene
Benzo(g,h,i)perylene	Hexachloroethane
Benzo(k)fluoranthene	Indeno(1,2,3-cd)pyrene
Benzyl alcohol	Iron
Beryllium	Isophorone
beta-BHC*	Isopropylbenzene
Bis(2-chloro-1-methylethyl) ether	m&p-Xylene
Bis(2-chloroethoxy)methane	m/p-Xylene
Bis(2-chloroethyl)ether	Magnesium
Bis(2-ethylhexyl) phthalate	Manganese
Boron	Methoxychlor*
Bromobenzene	Methyl-2-Pentanone, 4-
Bromochloromethane	Methylene Chloride
Bromodichloromethane	Methylnaphthalene, 2-

Chemical	Chemical
Bromoform	Methylphenol, 2-
Bromomethane**	Methylphenol, 3&4-
Bromophenyl phenyl ether, 4-	Methyl-Tert-Butyl-Ether (MTBE)
Butanone, 2- (MEK)	Molybdenum
Butyl benzyl phthalate	Naphthalene
Butylbenzene	Nitroaniline, 2-
Calcium	Nitroaniline, 3-
Carbazole	Nitroaniline, 4-
Carbon Tetrachloride	Nitrobenzene
Chlordane (technical)	Nitrophenol, 2-
Chloro-3-methylphenol, 4-	Nitrophenol, 4-
Chloroaniline, 4-	N-Nitrosodipropylamine
Chlorobenzene	o-Xylene
Chlorodibromomethane	Pentachlorophenol
Chloroethane	Phenanthrene
Chloroform	Phenol
Chloromethane	p-Isopropyltoluene
Chloronaphthalene, 2-	Potassium
Chlorophenol, 2-	Propylbenzene
Chlorophenyl phenyl ether, 4-	Pyrene
Chlorotoluene, 2-	sec-Butylbenzene
Chlorotoluene, 4-	Selenium
Chrysene	Silver
cis-1,2-Dichloroethene	Sodium
cis-1,3-Dichloropropene**	Styrene
Cobalt	Tert-Amyl-Methyl-Ether
Copper**	Tert-Butyl-Alcohol
Cyclohexane	Tert-Butylbenzene
Decachlorobiphenyl	Tetrachloroethane, 1,1,1,2-
delta-BHC*	Tetrachloroethane, 1,1,2,2-
Dibenz(a,h)anthracene	Tetrachloroethene
Dibenzofuran	Tetrachloroethene (PCE)
Dibromo-3-chloropropane, 1,2-	Tetrachloro-m-xylene
Dibromoethane, 1,2- (EDB)	Thallium
Dibromomethane	Toxaphene*
Dichlorobenzene, 1,2-	TPH as Diesel
Dichlorobenzene, 1,3-	TPH as Gasoline
Dichlorobenzene, 1,4-	TPH as Motor Oil

Chemical	Chemical
Dichlorobenzidine, 3,3'-	trans-1,2-Dichloroethene
Dichlorodifluoromethane	trans-1,3-Dichloropropene**
Dichloroethane, 1,1-	Tribromophenol, 2,4,6-
Dichloroethane, 1,2-	Trichloro-1,2,2-trifluoroethane, 1,1,2-
Dichloroethene, 1,1-	Trichlorobenzene, 1,2,3-
Dichloromethane	Trichlorobenzene, 1,2,4-
Dichlorophenol, 2,4-	Trichloroethane, 1,1,1-
Dichloropropane, 1,2-	Trichloroethane, 1,1,2-
Dichloropropane, 1,3-	Trichloroethene
Dichloropropane, 2,2-	Trichloroethene (TCE)
Dichloropropene, 1,1-	Trichlorofluoromethane
Dieldrin*	Trichlorophenol, 2,4,5-
Diethyl phthalate	Trichloropropane, 1,2,3-
Diisopropylether	Trimethylbenzene, 1,2,4-
Dimethyl phthalate	Trimethylbenzene, 1,3,5-
Dimethylphenol, 2,4-	Vanadium
Di-n-butyl phthalate	Vinyl Chloride
Dinitro-2-methylphenol, 4,6-	Zinc

* -- Banned pesticides
**-- Currently registered pesticides

Currently used pesticides

Pesticide	Common Trade Names	Type of Use
Azinphos-methyl	Guthion	Insecticide
Chlorothalonil	Bravo, Daconil	Fungicide
Chlorpyrifos	Dursban, Lorsban	Insecticide
Cypermethrin	Demon	Insecticide
Diazinon	Various brands	Insecticide
Dichlorvos	Vapona, DDVP	Insecticide
Dicofol	Kelthane	Insecticide
Dimethoate	Cygon	Insecticide
Diuron	Karmex	Herbicide
Endosulfan	Thiodan	Insecticide
EPTC	Eptam	Herbicide
Malathion	Various brands	Insecticide
MITC	Vapam, K-pam	Fumigant
Metolachlor	Dual	Herbicide
Molinate	Ordram	Herbicide
Naled (dichlorvos)	Dibrom	Insecticide
Norflurazon	Solicam	Herbicide
Oryzalin	Surflan	Herbicide
Oxyfluorfen	Goal	Herbicide
Permethrin	Ambush, Pounce	Insecticide
Phosmet	Imidan	Insecticide
Propanil	Duet, Wham	Herbicide
Propargite	Omite, Comite	Insecticide
Simazine	Princep	Herbicide
SSS-tributylphosphorotrithioate	DEF, Folex, Tribufos	Defoliant
Thiobencarb	Bolero, Abolish	Herbicide
Trifluralin	Treflan	Herbicide

POTENTIAL SOURCES OF ENVIRONMENTAL CONTAMINATION

The Cal/EPA investigation focused on identifying possible exposures to environmental contaminants in Kettleman City. Cal/EPA used the following three-step approach:

- Identifying the primary sources of contamination in the environment (for example, releases from a leaking chemical storage tank).
- Describing how chemicals might move in the environment (for example, a chemical in soil might penetrate down into groundwater or evaporate into air).
- Examining potential exposure pathways (for example, drinking contaminated water, inhaling chemicals in air, or contaminated soil contacting skin).

As a first step, the Cal/EPA team considered possible sources of chemicals of interest in the Kettleman City area from past or current activities. This included a review of potential sources of chemicals that are discussed below.

Agricultural operations

Kettleman City is surrounded by agricultural fields to the west, north and east, with minimal distance separating them from homes. Pesticides commonly associated with agricultural operations may migrate to the community because of winds or improper application.

Exposure to pesticides can occur in several ways. Pesticides applied in nearby fields may enter the community as airborne particles or gases when pesticides drift into the community or evaporate after application. Residents may be exposed primarily from inhalation of contaminated air. Other potential sources of agricultural pesticide exposure include food, water, soil, dust, and workplaces.

DPR, the U.S. Department of Agriculture, and U.S. Food and Drug Administration routinely monitor for pesticide residues in food. There is good compliance with pesticide residue regulations, making it unlikely that Kettleman City residents have been exposed to levels of pesticides in their food high enough to cause birth defects.

Similarly, it is unlikely that the community has been exposed to pesticides in water at levels high enough to cause birth defects. This is because the nearest groundwater source that is shallow enough to be vulnerable to pesticide contamination is 27 miles north of Kettleman City.

Surface water in the area is located in the California Aqueduct and agricultural canals. Pesticides can enter the water through soil and from air. While these sources are not used for the community's drinking water, exposures can occur from eating fish caught from these waters.

Pesticides can also be deposited onto soil because of agricultural activities. Pesticides in soil and airborne dust also can enter homes. Because of this, residents may be exposed by inhaling or ingesting dust from surfaces inside their homes.

Throughout this assessment, pesticide applications within five miles of Kettleman City were considered for evaluation. Of the approximately 1,000 pesticides currently approved for sale in California, approximately 236 pesticides totaling 650,000 pounds were reported to have been used within five miles of Kettleman City each year from 2007 through 2009. Although this is a significant amount of pesticides, many other San Joaquin Valley agricultural communities had higher levels of pesticide use within five miles of those other communities.

Kettleman Hills hazardous waste storage, treatment and disposal facility

Another possible source of environmental contamination for Kettleman City is the Chemical Waste Management Kettleman Hills Facility (KHF), which is located approximately 3.5 miles southwest of the community (see Figure 3). The KHF is a permitted commercial hazardous waste treatment, storage and disposal facility that accepts of hazardous waste and municipal solid waste. It conducts regular air and groundwater monitoring as part of its permit requirements.

The residential community is separated from the KHF by rolling hills and valleys. Based on the prevailing wind pattern (see Figure 4), winds from the facility generally do not pass over the community. Nevertheless, in conducting this assessment, Cal/EPA viewed the facility as a possible source of airborne contaminants in Kettleman City.

Studies show that groundwater beneath the KHF is not connected to the groundwater beneath Kettleman City (RWQCB, 2006). The KHF is on top of geological formations that tilt to the west away from the Kettleman City area, thus preventing any possibility for groundwater flow from the KHF towards Kettleman City. Disposal and treatment operations at the KHF cannot affect groundwater wells in the community because of these geologic conditions.

Former and current commercial operations

Almost all of the commercial businesses in Kettleman City are located along Brown Street (SR-41) (see Figure 2). There are six locations of interest because of underground storage tanks (USTs): five former gas stations and one currently operating gas station. These operations are potential sources of surface and subsurface soil contamination by petroleum products. Subsurface soil contaminants can enter groundwater and volatile compounds (such as benzene and other hydrocarbons) may be transported to the surface as soil gas.

Operations at the existing gas station can release contaminants directly into air when gasoline is pumped into storage tanks or vehicles. Exposure may occur from inhaling the airborne contaminants.

Gas station activities could also result in spills or leaks onto surface soil. Exposure to surface soil contamination can occur from direct contact. Contaminated soil can also be inhaled as dust.

If petroleum products contaminate groundwater, residents could be exposed to pollutants by drinking, cooking, or bathing. Volatile chemicals can travel in groundwater to distant locations where chemicals are released as soil gas and may be inhaled.

DTSC staff followed its methodology used for environmental assessments of potential school sites to identify potential sources. The DTSC review did not identify any historical spills or other contamination from former or current operations that could affect the community. However, this review did identify areas for sampling of soil and soil gas.

Municipal and school water wells

Kettleman City's drinking water comes from two municipal wells, plus a third well that serves the Kettleman City Elementary School. Water from the two municipal wells contains arsenic and benzene levels that have exceeded the state's drinking water standards, officially called maximum contaminant levels or MCLs. The arsenic is not removed when the water is treated for public consumption. Currently, each of the municipal wells has an aeration treatment system that removes benzene before the water is provided to the public.

A groundwater monitoring program required by the CDPH Drinking Water Program found the elementary school well had arsenic levels that were recently slightly higher than the MCL, but benzene has not been a problem.

People can be exposed to arsenic when they drink water or use it for cooking. Many community residents are aware that the groundwater is contaminated and avoid using it for drinking and cooking. However, individuals can also be exposed through skin contact to the water during washing and bathing.

Volatile contaminants in groundwater such as benzene may evaporate. People can be exposed to these contaminants as they leave the soil or as they seep into residences or other buildings.

The arsenic is naturally occurring and found in other locations in groundwater of the San Joaquin Valley. The source of benzene is unknown. The Central Valley Regional Water Quality Control Board in Fresno investigated the benzene found in the groundwater at the community's wells but was not able to conclusively identify the source. The benzene is most likely either natural or has entered the groundwater from past oil field-related activities (Issinghoff, 2010). Additional tests, such as groundwater

age-dating or isotopic analysis, may help to identify the source of the benzene. However, these tests are beyond the scope of this assessment.

Petroleum operations

Kettleman City is located between the Kettleman City Oil Field and Kettleman North Dome Oil Field (see Figure 5). Several abandoned or idle oil wells from previous operations are located outside of the community. Three oil pipelines currently run outside the south boundary of the residential area and oil and gas fields or oil processing facilities are within one-quarter mile of the community. Oil from previous operations and gasoline spills may have affected groundwater or soils beneath the community, potentially contaminating groundwater or air due to movement of soil gases.

Illegal dumps

Illegal dumping of household waste and hazardous waste could be a source of local environmental contamination. Residents have provided information on potential illegal dumping around the community. Household trash was observed on the western edge of the developed area. However, there is no evidence that paints, solvents or other hazardous chemicals were disposed of in the area.

Figure 5. Oil fields around Kettleman City

Age and construction of homes

Most homes in Kettleman City were built before 1975. Lead in paint, organochlorine pesticides (OCPs) used for termite control and polychlorinated biphenyls (PCBs) from electrical transformers are some of the potential sources of soil contamination next to these homes.

Residents may be exposed to these and other building-related contaminants in surface soil. The exposure can be direct when a person inadvertently transfers soil on their hands to their mouth or to food. . A person may also inhale airborne soil particles. People can also be exposed through skin contact, but for most contaminants only extremely small amounts can be absorbed through skin.

Water pipes in older homes may contain lead solder. Lead can leach or migrate into water used for drinking, cooking and bathing. In this case, exposure to lead would occur mainly by ingestion.

Outside soil and dust entering the home as well as dust generated indoors may result in exposures to contaminants inside the home. Examples of potential sources of chemicals in indoor dust and air include lead in dust and paint chips (before 1978, indoor paint often contained large amounts of lead); household products, cleaners, pesticides, and wear and tear on furniture. Residents can inhale or ingest household dust during day-to-day activities.

Improper disposal of household products, such as paint thinners, other solvents and motor oils, can lead to subsurface soil contamination. Soil gas that contains volatile pollutants can travel beneath homes and contaminate indoor air by entering through gaps in the foundation and flooring.

Other sources under consideration

Indoor dust and air

Indoor air can contain pollutants that travel inside a building. It can also contain hazardous chemicals such as cleaning products. Some contaminants such as pesticides may be found indoors because they do not break down easily. Pesticides and metals such as lead can accumulate as dust on surfaces inside homes. Volatile chemicals such as petroleum hydrocarbons can be present in indoor air, either as a result of indoor activities or after having entered the house from outside. The sampling for this assessment was conducted outdoors and did not provide information on indoor exposures.

Cal/EPA considered conducting air and dust sampling in the homes of the mothers who had children with birth defects, but then determined that this indoor sampling would not provide useful information because the chemicals in indoor air would mostly reflect current activities and chemical uses inside the home. Monitoring this year in the mothers' current or former residences would not produce accurate information on chemical exposures at the time the birth defects occurred.

U.S. EPA is planning in the near future to conduct indoor sampling for pesticides in a limited number of Kettleman City homes. While this sampling will not produce specific information on chemical exposures that the mothers may have incurred prior to or during their pregnancies, it will provide an indication of whether pesticides are in homes in Kettleman City. DPR, OEHHA and DPH are available to work with U.S. EPA on evaluating any data collected on pesticides in house dust.

Traffic-related diesel exhaust

The Kettleman Hills community is adjacent to SR-41 and I-5, which are potential sources of diesel emissions. Diesel exhaust contributes to airborne pollution as particulate matter (PM) and consists of many toxic chemical compounds. Diesel PM could be inhaled, primarily outdoors but possibly also indoors. Although a definitive link between diesel exhaust and birth defects has not been established, it was included in the exposure assessment at the request of community members.

California Aqueduct and irrigation canals

The California Aqueduct and irrigation canals flow across farm fields in the region and along SR-41. Pesticides used in farm operations and vehicular emissions may be transported by air or in runoff from soil and enter these waterways. These chemicals can deposit onto water and sediment. Pesticides and other pollutants could be ingested and stored in the edible parts of fish. Some community members told Cal/EPA staff that they eat fish from the aqueduct and irrigation canals. The water from the Aqueduct and water and sediment from one of the irrigation canals were sampled and analyzed for this assessment.

METHODS

This chapter provides an overview of the methods that the Air Resources Board (ARB), Department of Pesticide Regulation (DPR) and Department of Toxic Substances Control (DTSC) used for monitoring and modeling of chemicals in Kettleman City.

Air

ARB's methods to monitor and evaluate exposure to contaminants in air at Kettleman City are summarized in this section.

Chemicals monitored

ARB conducted air monitoring to measure levels of "target analytes", see Table 3 (these are the industrial chemicals listed inTable 1, but Table 3 also lists the specific PCB, chlorinated dioxin and chlorinated furan congeners that were monitored). ARB also measured "non-target analytes" (which include some of chemicals listed in Table 2 that have not been associated with birth defects but are routinely collected and analyzed as part of the process of monitoring for the target analytes).

The analytes are classified by ARB as either toxic chemicals—such as specific metals and volatile organic compounds (VOCs)—or as criteria air pollutants, which are common air pollutants with established ambient air quality standards—such as sulfur dioxide (SO_2), particulate matter less than 2.5 microns (PM2.5), and nitrogen dioxide (NO_2). Air monitoring was conducted at the Kettleman City Elementary School and at two locations near the KHF facility. Monitoring for toxic chemicals was carried out from June 16 to August 26, 2010. Monitoring for criteria air pollutants, PCBs, and dioxin and furan congeners took place from June 16 to September 6, 2010.

Monitoring sites

The ARB conducted ambient air monitoring at three monitoring sites (see Appendix A of the appended ARB report for locations and photographs of the monitoring sites):

- **Kettleman City Elementary School**, located at 701 General Petroleum Avenue, Kettleman City. ARB installed an ambient air monitoring trailer on the tennis courts on the school grounds near the corner of General Petroleum Avenue and 6th Street. The trailer was outfitted with ambient air monitoring instruments. (Note: trailers are commonly used as air monitoring instrument shelters for temperature-sensitive instruments.)

- **Chemical Waste Management's Kettleman Hills Facility**, located approximately 3.5 miles to the southwest of Kettleman City. ARB conducted ambient air monitoring at two locations:
    - Downwind Monitoring Station 2, located southeast of KHF, collocated (situated side-by-side) with the Facility's existing downwind monitoring site #2.

- Upwind Monitoring Station, located northwest of KHF, also collocated with the Facility's existing upwind monitoring site.

Table 3. Target analytes monitored by ARB

Metals	VOCs	PCB Congeners[a] Congener Number in ()	Dioxin/ Furan Congeners
Arsenic	Benzene	3,3',4,4'-TeCB (77)	**Dioxins[b]**
Cadmium	Toluene	3,4,4',5-TeCB (81)	2,3,7,8-TCDD
Lead	Ethyl Benzene	2,3,3',4,4'-PeCB (105)	1,2,3,7,8-PeCDD
Nickel	Carbon Disulfide	2,3,4,4',5-PeCB (114)	1,2,3,4,7,8-HxCDD
Hexavalent Chromium		2,3',4,4',5-PeCB (118)	1,2,3,6,7,8-HxCDD
		2',3,4,4',5-PeCB (123)	1,2,3,7,8,9-HxCDD
		3,3',4,4',5-PeCB (126)	1,2,3,4,6,7,8-HpCDD
Other		2,3,3',4,4',5-HxCB (156)	OCDD
Sulfur Dioxide		2,3,3',4,4',5'-HxCB (157)	**Furans[c]**
		2,3',4,4',5,5'-HxCB (167)	2,3,7,8-TCDF
		3,3',4,4',5,5'-HxCB (169)	1,2,3,7,8-PeCDF
		2,3,3',4,4',5,5'-HpCB (189)	2,3,4,7,8-PeCDF
			1,2,3,4,7,8-HxCDF
			1,2,3,6,7,8-HxCDF
			1,2,3,7,8,9-HxCDF
			2,3,4,6,7,8-HxCDF
			1,2,3,4,6,7,8-HpCDF
			1,2,3,4,7,8,9-HpCDF
			OCDF

[a] TeCB-tetrachlorinate biphenyl, PeCB-pentachlorinated biphenyl, HxCB-hexachlorinated biphenyl, HpCB-heptachlorinated biphenyl.

[b] TCDD-tetrachlorinated dbenzo-p-dioxin, PeCDD-pentachlorinated dbenzo-p-dioxin, HxCDD-hexachlorinated dbenzo-p-dioxin, HxCDD-hexachlorinated dbenzo-p-dioxin, HpCDD-heptachlorinated dbenzo-p-dioxin, OCDD-octachlorinated dbenzo-p-dioxin.

[c] TCDF-tetrachlorinated dbenzofuran, PeCDF-pentachlorinated dbenzofuran, HxCDF-hexachlorinated dbenzofuran, HxCDF-hexachlorinated dbenzofuran, HpCDF-heptachlorinated dbenzofuran, OCDF-octachlorinated dbenzofuran.

Samples of 24 hours in duration were collected for VOCs and metals. Sampling for SO_2, PM2.5 and NO_2 was conducted using continuous analyzers, which provide hourly average air concentrations. The sampling duration for PCB, dioxin and furan congeners was 28 days in length, resulting in three sampling periods between mid-June and early September 2010. (The extended sampling duration for PCB, dioxin and furan congeners was necessary to achieve more sensitive detection limits.) ARB equipment was used to collect air samples, which were all analyzed by ARB's laboratory with the exception of the PCB, dioxin and furan congeners, which were analyzed by a U.S. EPA

laboratory. For a complete discussion of the air monitoring equipment and analytical methods used to measure these contaminants, see Appendix V.1 of the appended ARB report.

Monitoring at Kettleman City Elementary School:
Sampling for toxic compounds was carried out twice per week (about once every third day) at this site. All sample inlet heights were approximately six feet above the sampling platforms. Data from ARB's routine toxics monitoring sites at Bakersfield and Fresno were used to compare to data collected at Kettleman City. Air sampling for SO_2, PM2.5 and NO_2 was conducted only at the Kettleman Hills Elementary School. Data from the routine monitoring network sites of Corcoran, Bakersfield, Fresno, Hanford, and Visalia were used for comparison.

Monitoring near Chemical Waste Management Facility:
Air samples were collected at two of the KHF air monitoring stations, as described above: the upwind station and the downwind station. From mid-June through late August 2010, six 24-hour sampling periods coincided with KHF's 24-hour air sampling periods, which occur every 12 days.

ARB used two types of samplers (Xonteck and Tisch) at the school for collecting samples of VOCs; the Tisch sampler was used at the KHF stations. The Xonteck sampler provided a means to relate measurements at the school to the ARB's statewide toxics monitoring network (see next paragraph). The Tisch sampler at the school provided a means to compare results from the Xonteck sampler.

Air monitoring data collected from around the state were compared to data obtained at Kettleman City. The current ARB statewide toxics monitoring consists of 17 sites that measure ambient concentrations of about 42 substances. Collection of 24-hour samples at the routine sites is conducted once every 12 days.

Meteorological methods
In addition to air sampling, meteorological data— wind speed and direction and temperature—were measured continuously at the monitoring sites in Kettleman City and near KHF. For more information on meteorological methods, see Appendix V.1 of the appended ARB report.

Quality control procedures
ARB conducted performance audits on the ambient air samplers and meteorological sensors located at the three sites. Audits were conducted at the beginning and the end of the field study. In addition, ARB conducted an in-depth site evaluation to determine compliance with federal regulations with regard to siting criteria of the air samplers. For more information concerning quality control procedures, see Appendix V.1 of the appended ARB report. Overall, the audits found that the instruments were operating consistent with the monitoring data quality objectives and all samplers met U.S. EPA ambient air monitoring siting criteria.

Differences were seen in the monitoring results collected by the two different samplers that were collocated at the school monitoring site. ARB staff conducted an evaluation of these differences. The results of this evaluation are described in Appendix B of the appended ARB report. ARB suggested that OEHHA use the higher of two measurements whenever ARB reported collocated monitoring results.

Additional air monitoring assessment

In response to community concerns, ARB conducted two additional types of air monitoring:

- Treatment units (referred to as air stripping treatment units) are connected to the well heads of two drinking water wells in Kettleman City. These treatment units remove benzene from the drinking water prior to distribution. Air samples were collected downwind and adjacent to these units to assess potential public exposure from benzene emitted into the air by the treatment units. One air sample was collected near each air stripping unit in mid-July, early August, and late August 2010.

- ARB assessed the public's exposure to diesel exhaust in Kettleman City. Diesel exhaust contributes to airborne PM2.5 and consists of a mixture of many chemical compounds. Due to the complexity of the mixture, there is no method to directly sample the air for diesel exhaust. Therefore, ARB used two approaches previously used by ARB in other parts of the state. To estimate exposure to diesel particulate matter (DPM) from local sources, ARB used modeling of emissions from trucks and other diesel sources. ARB has used this method to estimate local exposure to diesel exhaust at ports, rail yards, freeways, and warehouse distribution centers. To estimate the regional exposure to DPM, the population-weighted average concentration of DPM was estimated using the population-weighted average air concentration of nitrogen oxides (NO_x) in Kings County over a three-year period (2006-2008), scaled based on the average ratio of DPM to NO_x emissions.

Pesticide Assessment

DPR's methods to monitor and evaluate pesticide exposure for Kettleman City are summarized in this section. For a complete discussion of the methods, see Appendices A and B of the appended DPR report. The pesticides investigated are listed in Table 4.

Table 4. Pesticides of interest investigated by DPR

Pesticides	
2,4-D	Fenoxaprop-p-ethyl
Abamectin	Flumioxazin
Azoxystrobin	Maneb
Boscalid	MCPA
Bromoxynil	MITC pesticides
Carbaryl	Myclobutanil
Chlorpyrifos	Oxyfluorfen
Clethodim	Propiconazole

Pesticides	
Diazinon	Pyraclostrobin
Diflubenzuron	

DPR normally uses a combination of monitoring and computer modeling to estimate air concentrations of pesticides. Monitoring is typically conducted for individual pesticides in a region during a period of high use. Hence, monitoring provides a snapshot of air concentrations at a specific location and a specific time. DPR supplements the air monitoring with computer modeling to estimate concentrations for other locations, time periods, and circumstances. Due to the time constraints of this assessment and the changes in pesticide use during recent years, DPR relied primarily on computer modeling instead of air monitoring to estimate pesticide air concentrations in Kettleman City. The computer modeling methods are described in the Risk Assessment Methods section (see pg. 41).

Monitoring pesticides in air

DPR estimated air concentrations of pesticides using air dispersion computer modeling. There are two primary reasons for this approach:

- Air monitoring conducted in 2010 may not reflect potential exposures to pesticides applied in earlier years when reported birth defects occurred. This is particularly true for the Kettleman City area because pesticide use patterns have changed in recent years as orchards and other crops have replaced cotton fields. Different pesticides are used now than just a few years ago. DPR can model air concentrations for earlier years using information from pesticide use reports and data from nearby weather stations.

- Comprehensive air monitoring would take several months to more than one year for many of the pesticides assessed. Some of those pesticides have not been monitored in air previously, and no methods exist to analyze air for these pesticides. Developing analytical methods for a single pesticide normally takes several months.

Despite the limitations, DPR conducted air monitoring for several pesticides during June-July 2010. The specific objective of the monitoring was to estimate the daily and monthly (seasonal) average air concentrations in Kettleman City for certain pesticides for this time period. It provided measured data to compare with the air dispersion computer modeling estimates.

DPR collected pesticide air samples at Kettleman City Elementary School, the same location where ARB collected samples to be analyzed for other chemicals of interest. Ambient air monitoring began on June 8, 2010 and ended on July 29, 2010. Individual air samples were collected for 24-hour periods, twice weekly for 8 weeks, for a total of 16 discrete sampling periods. Two air samples were collected for each sampling period, one for methyl isothiocyanate (MITC) and one for 26 other pesticides. (ARB's

monitoring analyzed for several other chemicals with pesticidal uses including 1,3-dichloropropene and methyl bromide. ARB's data were provided to DPR.)

Collected samples were immediately placed on dry ice and kept frozen until they were delivered to the California Department of Food and Agriculture's (CDFA's) Center for Analytical Chemistry in Sacramento. The CDFA laboratory analyzed the samples using validated methods and standard quality control procedures.

Methods for compiling pesticide use data

Pesticide use reports served as a key source of information for two purposes: (1) to conduct air dispersion computer modeling to estimate concentrations of pesticides in air; and (2) to identify unusual use patterns from 2007 to 2009.

Under California law, all agricultural pesticide use must be reported. DPR maintains a database of all reported agricultural pesticide applications and some non-agricultural use in California. The database includes information on the pesticide product used, the application date, the application amount, crop/site treated, and application location to a square-mile section.

To aid in providing representative air dispersion computer modeling for Kettleman City, the Kings County Agricultural Commissioner's office provided data showing the locations of agricultural fields identified in pesticide use reports. This enabled DPR to estimate air concentrations associated with specific pesticide applications.

DPR also evaluated pesticide use reports of the 19 pesticides of interest to determine if the applications in the Kettleman City area during 2007-2009 were unusual. They compared Kettleman City to other communities in the San Joaquin Valley and evaluated trends over time for the pesticides of interest.

Methods for compiling weather data

The meteorological station selected for modeling is operated by the Department of Water Resources as part of the California Irrigation Management Information System (CIMIS). CIMIS consists of a network of weather stations in agricultural areas that records a variety of weather data.

DPR used data from station #15 Stratford. This station is roughly 12 miles northeast of Kettleman City at an elevation of 193 feet. The surrounding terrain is flat. This station was chosen because it reflected meteorology in the agricultural area of the San Joaquin Valley. Also, it provided needed elements for computer simulation modeling: wind speed, wind direction, temperature, standard deviation of horizontal wind direction, and amount of sun light. The Kettleman CIMIS station (#21) is roughly 10 miles to the south southeast. Although it is closer to Kettleman City, it is located in the hills and may not reflect the meteorology in the agricultural areas because of the influence of local topography. In addition, using weather data from a station closer to the sources of pesticides (fields to the north and upwind from Kettleman City) was preferred for modeling purposes. The KHF records meteorological information. However, this

information may not be reflective of the relatively flat agricultural areas in the San Joaquin Valley. DPR considered using data from other weather stations, such as the one at Lemoore, but the other stations were further from Kettleman City and the agricultural fields north of the city.

Water, soil and sediment, and soil gas

The sampling of water, soil and sediment, and soil gas was planned and carried out by DTSC with the assistance of U.S. EPA Region 9. The analyses of the samples were done primarily by the U.S. EPA Region 9 Richmond Laboratory. A few samples were also analyzed by Chemical & Environmental Laboratories, Inc., an Environmental Laboratory Accreditation Program-certified laboratory.

The samples were taken primarily within the Kettleman City residential community, although surface water samples were taken just outside the community's boundary and the agricultural soil samples on the boundary of the community. Residences, commercial property, public property and agricultural property (more specifically, the road ways next to agricultural fields) were sampled. The table below indicates the number of sites for each type of property from which water, soil, or soil gas samples were collected.

Area	Tap Water	Well Water	Surface Water	Surface Soil	Sediment	Soil Gas
Residential	11			9		9
Commercial	1					6
Public		3	1			2
Agricultural			1	3[a]	1	
Community wide				8[b]		

[a] 3 boundary streets @ 6 samples per street
[b] 4 samples at the base of utility poles, 4 samples 5 feet below the surface for background

Soil samples

With the exception of background metal samples, all other soil samples were taken from surface soil, zero to six inches below the surface. Thirty-seven soil samples were taken from nine residences, four at each residence from the four sides of each home except for one where five samples were taken. Eighteen soil samples were also taken from the boundary streets adjacent to agricultural fields to the west, east and north of the community. All samples were analyzed individually and not composited or combined.

Soil samples were analyzed for metals and organochlorine pesticides. One randomly selected sample from each residence was also tested for PCBs.

Four additional surface soil samples were taken from around the community. These were taken at the base of utility poles that have transformers attached to them. These soil samples were analyzed for PCBs.

Background samples were taken from four areas around the community. The subsurface background samples were taken from five feet below the surface to avoid any potential impacts by human activities or air deposition.

Twenty-four points across the entire community were screened with a hand-held instrument for gamma radiation.

Soil gas samples

Soil gas samples were taken by pushing a small diameter rod into the ground to the depths of 5-, 10- or 15-feet below ground surface. Nine residences were sampled for soil gas. The soil gas was collected at a depth of five feet for each residence. At one residence, an additional soil sample was collected from a depth of 15 feet.

Two separate soil gas samples were taken from the Kettleman Elementary School at a depth of 10 feet. The Kettleman City County Fire Station also had samples taken from two bore holes made to a depth of 10 feet.

Six commercial properties were sampled for soil gas. Most of these properties were former gas stations; one is an active gas station. The other property is where aboveground crude-oil pipelines run. Because some of these properties are active businesses, some samples were taken on the public right of way next to the property. Two separate bore holes 10 feet deep were sampled at most of these properties. Only one bore hole was made and sampled at the one active gas station property and one towing company had a bore hole sampled at two depths, five and 15 feet.

All soil gas samples were analyzed for volatile organic chemicals, methane and hydrogen sulfide.

Sediment samples

One sediment sample was taken from the bottom of the agricultural drainage canal located at Quebec Avenue and SR-41. This sample was analyzed for metals, organochlorine pesticides, PCBs and total petroleum hydrocarbons for diesel fuel and motor oil.

Water samples

Four types of water samples were taken: (1) tap water samples from 11 residences, (2) a vending machine water sample from the machine in front of Kettleman City Market (located at 216 Becky Pease Street), (3) groundwater samples taken before any treatment from the two municipal wells and the Kettleman City Elementary School well, and (4) two surface water samples from the California Aqueduct and an agricultural drainage canal.

The 11 residential water samples were taken from the kitchen faucet. Water was collected in containers for each type of analysis the sample was to undergo. The water samples were analyzed for metals, volatile organic compounds, and for total coliform

bacteria and E. coli bacteria. Three randomly selected tap water samples were also tested for semi-volatile organic compounds, organochlorine pesticides, PCBs, chromium VI, and total petroleum hydrocarbons for gasoline, diesel fuel and motor oil.

Groundwater was collected from the wells before the water was treated for domestic use. The groundwater samples were collected and analyzed in a similar manner as residential water samples. All ground water well samples were tested for metals, volatile organic compounds, semi-volatile organic compounds, organochlorine pesticides, PCBs, chromium VI, total petroleum hydrocarbons for gasoline, diesel fuel and motor oil, total coliform bacteria, and E. coli bacteria.

Surface water samples were also collected in containers specific for each analysis. The surface water samples were analyzed for the same chemicals and bacteria as was done for the groundwater samples.

Risk Assessment Methods

OEHHA evaluation of health risks

OEHHA evaluated possible health risks from exposure to environmental contaminants at or nearby Kettleman City. The purpose of the evaluation was to identify any chemical in the environment that is present at a level of a health concern.

Table 5 lists chemicals, other than pesticides, that were investigated because of their potential to cause birth defects. (DPR's evaluation of pesticides is discussed below.)

Table 5. Developmental toxicants evaluated by OEHHA

Chemical	Chemical
Arsenic	Ethylbenzene
Benzene	Lead
Cadmium	Mercury and mercury compounds
Carbon Disulfide	Nickel and Nickel compounds
Chromium VI	Polychlorinated biphenyl congeners
DDT (Dichlorodiphenyl-trichloroethane)	Sulfur Dioxide
Dioxin/Furan congeners	Toluene
Endrin	

OEHHA and U.S. EPA over the years have developed and updated "health-based criteria" for chemicals in air, water and soil. Exposure to chemicals at levels below or equal to their health criteria are unlikely to cause health effects. In conducting its evaluation, OEHHA compared measured levels of chemicals in air, water and soil with the health-based criteria.

The following are health-based criteria for environmental contaminants that OEHHA considered when evaluating levels of chemicals measured at Kettleman City:

Action Level is a regulatory requirement for lead in drinking water. It is used instead of a Maximum Contaminant Level standard. The action level for lead (15 µg/L) is used to determine the treatment requirements that a water system must complete. The action level for lead is exceeded if the concentration of lead in more than 10 percent of the tap water samples collected during any monitoring period is greater than 15 µg/L.

Air Cancer Risks (ACRs) are calculated based on assessments of cancer-causing air contaminants developed by OEHHA as part of ARB's Toxic Air Contaminants program, and by U.S. EPA. ACRs identify a level of a cancer-causing air contaminant that poses no significant risk from lifetime exposure to the chemical.

California Human Health Screening Levels (CHHSLs) are developed by OEHHA. CHHSLs identify levels of contaminants in soil and soil gas that do not pose a significant risk to public health and safety. They are based on evaluations of various soil contaminants conducted by OEHHA and the U.S. EPA. A CHHSL is an advisory number intended to assist with cleanups of soil contamination. It is not a legal requirement for property owners.

Integrated Risk Information System (IRIS) developed by U.S. EPA is a database of its evaluations of scientific information on health effects that may result from exposure to environmental contaminants. IRIS was initially developed for U.S. EPA staff in response to a growing demand for consistent information on substances for use in risk assessments, decision-making, and regulatory activities.

Maximum Allowable Dose Levels (MADLs) are developed by OEHHA and apply to individual chemicals on the state's Proposition 65 list of chemicals that cause reproductive and developmental toxicity. MADLs identify a level of exposure to an individual chemical that is 1,000 times less than the level that has been in shown in studies to cause no observable reproductive or developmental effects.

Maximum Contaminant Levels (MCLs), adopted as regulations by CDPH, are health-protective drinking water standards to be met by public water systems. MCLs take into account not only chemicals' health risks but also factors such as their detectability and treatability, as well as costs of treatment. CDPH is required by law to establish a contaminant's MCL at a level as close to its corresponding Public Health Goal (see below) as technically and economically feasible, placing primary emphasis on the protection of public health.

Public Health Goals (PHGs) are developed by OEHHA and provide estimates of the levels of contaminants in drinking water that would pose no significant health risk to individuals consuming the water on a daily basis over a lifetime. PHGs are not

regulatory requirements, but instead represent non-mandatory goals and are used by CDPH to develop MCLs.

Reference Exposure Levels (RELs) are developed by OEHHA. These are airborne concentrations that are not anticipated to present a significant risk of an adverse non-cancer health effect. RELs are developed for acute, 8-hour and chronic exposures. For this assessment, chronic RELs are used unless they are specifically identified as representing an acute or 8-hour exposure scenario.

Regional Screening Levels (RSLs), developed by U.S. EPA Region 9, identify concentrations of individual contaminants in air, drinking water and soil that may warrant further investigation or site cleanup.

Preliminary Screening Levels (PSLs) are levels referenced from existing health-based standards, such as the MCLs adopted by CDPH for drinking water, the California Human Health Screening Levels (CHHSLs) established by OEHHA for residential soil gas and soil, and the Regional Screening Levels (RSLs) established by U.S. EPA for various media.

If a measured level of a chemical in the environment is lower than established health-based criteria, then no health effects would be expected from the chemical exposures. If a chemical was found to exceed the health-based criteria, OEHHA would determine if the measured environmental levels are above or below normal environmental levels (also called background levels) elsewhere in the San Joaquin Valley.

For example, OEHHA compared the levels of contaminants found in the soil and air at Kettleman City to levels in other areas in the region, such as Fresno. If the environmental levels in Kettleman City were similar to the normal levels found in other regions, OEHHA would conclude that residents of Kettleman City are not exposed to levels of contaminants that could explain the birth defects. If the environmental levels of any of the chemicals in Kettleman City were to exceed those in similar areas, then OEHHA would recommend further action be taken to reduce exposures if the concentration were at a level of potential health concern.

In addition to evaluating the developmental toxicants inTable 5, OEHHA conducted a similar evaluation of other health effects (such as asthma and cancer) that might conceivably occur from exposures to chemicals in Kettleman City.

DPR evaluation of health risks – Currently used pesticides

For this evaluation, DPR developed “health screening levels” based on available toxicology data. Health-protective screening levels are necessary because there are no federal or state standards for pesticides in air, that is, there are no enforceable health-based limits on pesticide emissions allowed in air. Concentrations below the screening level for a given pesticide would not be considered to represent a significant health concern and generally would not undergo further evaluation. Concentrations above the

screening level do not necessarily signal a significant health concern but point out the need for the second step—a more refined evaluation.

To the extent possible, DPR's pesticide health screening levels are based on existing documents that have already been subject to scientific peer review and/or public comment. The primary sources are risk assessments conducted by DPR (presented in risk characterization documents); re-registration eligibility documents completed by U.S. EPA; risk assessments completed by U.S. EPA to ensure the safe use of pesticides; and reference exposure levels (explained on the previous page) established by OEHHA.

After determining the health screening levels, DPR used information from pesticide use reports to estimate the worst-case air concentrations in Kettleman City between September 2006 and December 2009, the period of time identified by CDPH as when the exposures that may have led to birth defects could have occurred. DPR estimated air concentrations with an air dispersion computer model (Industrial Source Complex-Short Term model; ISCST). U.S. EPA developed this model and has validated its performance. The model is used by many government agencies and others to estimate air concentrations of toxic chemicals.

DPR used a tiered approach to the air dispersion computer modeling. The first tier (Tier 1) modeled simple, hypothetical worst-case situations for each pesticide. This hypothetical situation assumed 100 percent emission of the pesticide off the field or orchard—not a real occurrence, but this is an appropriate approach as a screening tool. If these modeled air concentrations exceeded health screening levels, a second tier of modeling was conducted. The second tier (Tier 2) used information from pesticide use reports for specific applications during September 2006 through December 2009 and local weather data for this period to provide a more refined estimate of historical air concentrations in Kettleman City. DPR estimated air concentrations for individual pesticides as well as air concentrations for multiple pesticides combined to estimate cumulative exposure.

Both the first tier and second tier of air dispersion computer modeling relied on the following key information to estimate air concentrations:

- Agricultural field information – number, dimensions, locations
- Pesticide applications – product, dates, and amount applied
- Amount of applied pesticide released to the air (emission rate or flux)
- Weather – wind speed, wind direction, atmospheric stability
- Location of people (Kettleman City)

To evaluate exposures, DPR determined hazard quotients for individual pesticides and a hazard index for multiple pesticides. The hazard quotient (HQ) is the ratio of measured air concentration of a pesticide to a reference concentration or screening level for that pesticide. If the HQ is greater than 1, then the air concentration exceeds the screening level. The equation for the HQ is as follows:

$$\text{Hazard Quotient} = \frac{\text{Air Concentration } (ng/m^3)}{\text{Screening Level } (ng/m^3)}$$

The risk from multiple pesticides (cumulative risk) was evaluated using the hazard index (HI) approach. The HI is determined by adding the HQs for the pesticides that can be appropriately grouped according to mechanism or site of toxicity.

$HI = HQ_1$ (pesticide 1) + HQ_2 (pesticide 2) + HQ_3 (pesticide 3) + ... (and so forth)

As with the HQ, an HI greater than 1 indicates the need for further evaluation. If an HQ for one pesticide is greater than 1, the HI for the same period will be greater than 1, since the HQs are added together. The HI is most useful when individual HQs are less than 1. An HI greater than 1 indicates that the cumulative toxicity of the multiple pesticides should be further evaluated and that potential health impacts may have been missed by only considering the pesticides individually.

RESULTS

Records Review

In order to identify any potential contamination sources near Kettleman City, DTSC staff reviewed federal and state databases that list facilities and sites that may have released contaminants into the environment. There are five sites in the commercial area one mile south of the community where underground storage tank releases had been identified and remediated. Based on conversations with Central Valley Regional Water Quality Control Board staff, the releases were unlikely to have affected groundwater and, due to the distance of these sites from the community and the direction of groundwater flow, it is unlikely that they would contribute to contamination in the community.

DTSC staff also reviewed records of underground storage tanks in Kings County to identify any current or former tanks in Kettleman City. There is currently one business, Spirit Gas Station, located within the community that has underground storage tanks. Five other locations in the community had underground storage tanks that were closed during the late 1980s and 1990s: Kettleman City Elementary School, Kings County Fire Department, Beacon Station, Wades Union Services, and Marcias Services. In addition, information indicated remediation of a Chevron pipeline leak located at 30th and Quail Ave, and a hydraulic fluid release in the Kettleman City Well on General Petroleum St. DTSC used this information on potential contaminant releases near Kettleman City and the locations of underground storage tanks in the community to help identify locations for the soil gas monitoring.

The Central Valley Regional Water Quality Control Board provided information on groundwater and locations of former gasoline stations in Kettleman City. This was used to identify specific locations for soil gas monitoring near each former gasoline station. From review of California Department of Conservation maps, DTSC located 7 idle oil wells within a one-mile radius of Kettleman City. Information on municipal landfills from the California Department of Recycling, Resources and Recovery indicated that the nearest sanitary landfill, closed in 1978, is located about 0.7 miles south of Kettleman City. The information from these local and State agencies was used in the development of sampling plans.

Air

Industrial and commercial chemicals

ARB measured levels of toxic compounds (specifically volatile organic compounds (VOCs), metals, and PCB, dioxin and furan congeners) and criteria air pollutants (sulfur dioxide, particulate matter less than 2.5 microns (PM2.5), and nitrogen dioxide). Appendix C of the appended ARB report presents complete monitoring results, which includes an overview regarding air quality in the San Joaquin Valley and monitoring data on additional measured pollutants.

As discussed in the “Methods” chapter, air samples were taken at the Kettleman City Elementary School and at two sites upwind and downwind of the Kettleman Hills Facility (KHF). Data from these sites were compared with data from other monitoring stations in the San Joaquin Valley (Corcoran, Bakersfield, Hanford and Visalia) that are part of the statewide monitoring network operated by ARB and,the San Joaquin Valley Air Pollution Control District.

Toxics - VOCs

Out of 22 sampled days at Kettleman City, five were also routine sampling days in the statewide monitoring network. Table 6 summarizes the monitoring data on VOCs.

Table 6. Ambient air concentrations of volatile organic compounds

	Toluene[a]	Carbon Disulfide	Benzene	Ethylbenzene
	µg/m^3			
Site Name	**Average**	**Average**	**Average**	**Average**
Bakersfield	3.0	2.4	0.58	*ND*[f]
Fresno	1.1	0.78	0.34	*ND*
Kettleman City School (Type 1 Sampler[b])	0.75	*ND*	0.3	*ND*
Kettleman City School (Type 2 Sampler[c])	3.9	2.3	0.57	*ND*
Waste Mgt NW Upwind	6.5	6.0	0.64	*ND*
Waste Mgt SE Downwind	3.8	9.1	0.45	*ND*
Detection Limit	0.75	0.31	0.16	0.87
ACR[d] (cancer)	-	-	0.034	0.4
REL[e] (non-cancer)	300	800	60	2000

Xonteck Model 910PC toxic gaseous sampler for volatile organic chemicals
[c] The Tisch 323 sampler for volatile organic chemicals
[d] ACR**-**Air Cancer Risks were calculated using cancer unit risk values
[e] REL-Reference Exposure Levels are developed by OEHHA non-cancer health effect
[f] ND-ND-Not Detected, below the detection limit.

Toluene: Concentrations at the Kettleman City school were generally similar to those routinely measured at Bakersfield and Fresno. Concentrations at the school were similar to those measured at the downwind KHF monitoring site. Slightly higher concentrations were measured at the upwind KHF monitoring site.

Carbon Disulfide: Concentrations at the school were lower than those measured at both KHF monitoring sites. Higher concentrations were measured at the downwind KHF monitoring site than at the upwind monitoring site. Concentrations were lower at the school than at the Fresno and Bakersfield sites.

Benzene: Concentrations at the school were generally similar to those at Bakersfield and Fresno. Concentrations at the school were also similar to those measured at both the upwind and downwind KHF sites.

Ethyl Benzene: Concentrations at all sites were too low to be measurable, which is typical for summer months at surrounding sites in the San Joaquin Valley.

As can be seen in Table 6, benzene is the only chemical that was found in concentration in Kettleman City to be above one of the health screening concentrations. The ACR for benzene is about one-twentieth of the ambient air concentrations. However, this is not unique to Kettleman City. Benzene is a common air pollutant, and is found at similar concentrations in other areas, including Bakersfield and Fresno.

Toxics – Metals

Sampling was conducted on 22 days six of which were also sampling days for the statewide monitoring network. Results can be viewed in Table 7.

Table 7. Ambient air concentrations of metals

	Lead[a]	Nickel	Arsenic	Cadmium	Hexavalent Chromium	Manganese
	nanograms per cubic meter (ng/m^3)					
Site Name	**Average**	**Average**	**Average**	**Average**	**Aggregated Sample**	**Average**
Bakersfield	3.8	ND[d]	ND	ND	ND	31
Fresno	3.5	ND	ND	ND	ND	26
Kettleman City School	3.3	ND	ND	ND	ND[e]	36
Waste Mgt NW Upwind	2.2	ND	ND	ND	ND	19
Waste Mgt SE Downwind	2.6	ND	ND	ND	ND	19
Detection Limit	1.5	9	1.5	1.5	0.06	1.5
ACR[b] / (cancer)	83	3.8	0.3	0.24	0.007	-
REL[c] (non-cancer)	(Federal Std. 150)	50	15	20	2	90

[b] ACR-Air Cancer Risks were calculated using cancer unit risk values developed by OEHHA and set at one in a million lifetime risk.
[c] REL-Reference Exposure Levels are developed by OEHHA for non-cancer health effect
[d] ND means the measurement was below the limit of detection.
[e] One aggregated sample was slightly above the limit of detection. The average of the three aggregated samples was less than the limit of detection.

Lead: Concentrations at all sites were below the state and federal standards. Concentrations at the school were generally similar to those measured at the both KHF monitoring sites as well as to the routinely measured values at Bakersfield and Fresno.

Nickel: Concentrations at all sites were below the detection limit. Concentrations below the detection limit are typical for summer months at other sites in the San Joaquin Valley.

Arsenic: Concentrations at all sites were below the detection limit, which is typical for summer months at other sites in the San Joaquin Valley.

Cadmium: Concentrations at all sites were below the detection limit, which is typical for summer months at other sites in the San Joaquin Valley.

Hexavalent Chromium: Hexavalent chromium (Cr VI) samples at the school and both KHF monitoring sites were all below the detection limit of 0.06 nanograms per cubic meter (ng/m^3), except for the second sample at the school, which was slightly above the detection limit with a value of 0.09 ng/m^3. The average of the three composite samples at the school was below the detection limit. Since 2008, Cr VI measurements have been below the detection limit at other sites in the San Joaquin Valley. The sole detection of Cr VI is at a very low level and does not pose a significant hazard for cancer, birth defects or other health effects.

Manganese: The average concentration at the school was slightly higher than those measured at the other locations. Average concentrations at both KHF monitoring sites were about half that found at the school. Routine measurement values at Bakersfield and Fresno were about 70 to 85 percent of the level found at the school. None were high enough to be a health concern.

Criteria air pollutants

A summary of the monitoring results for criteria air pollutants is presented in Table 8**.**

Table 8. Ambient air concentrations of criteria air pollutants

	Sulfur Dioxide[a]	PM2.5	Nitrogen Dioxide
	µg/m^3		
Site Name	**1-Hr Average**	**24-Hr Average**	**1 Hr Average**
Bakersfield	-	13	28
Corcoran	-	19	-
Fresno	4	12	17
Hanford	-	14	13
Kettleman City School	3	14	14
Visalia	-	11	21
Detection Limit	1	1	0.75
Standard	196 (Federal: 1-hour)	35 (Federal 24-hour)	188 (Federal 1-hour)

Sulfur Dioxide: All sulfur dioxide measurements were below the state and federal air quality standards. Sulfur dioxide levels at the Kettleman City Elementary School were similar to those measured at Fresno, which is currently the only sulfur dioxide monitoring site in the San Joaquin Valley.

PM2.5 and Nitrogen Dioxide: All PM2.5 and nitrogen dioxide measurements were below California and federal standards. Nitrogen dioxide and PM2.5 levels at the

Kettleman City school were similar to those measured at other sites in the San Joaquin Valley.

PCB, chlorinated dioxin, and chlorinated furan congeners

PCBs, chlorinated dioxins, and chlorinated furans are separate groups of chemicals, each made up of a many similar chemicals called congeners. Congeners may produce the same toxic effects (such as developmental toxicity) but differ in how toxic they are. Each congener is given a specific Toxicity Equivalence Factor (TEF) – based on its toxicity relative to the most toxic congeners among the three groups. To assess the toxicity of a mixture of these chemicals, the TEFs for individual congeners present in the mixture are used to derive a single value, the "Toxic Equivalents" or TEQ value. The TEQ is calculated by multiplying the amount of each congener in the mixture by its corresponding TEF, and then adding up the results. The TEQ is then used to estimate health risks posed by exposure to the overall mixture.

Monitoring results for Kettleman City are compared with historical data from ARB's California Ambient Dioxin Air Monitoring Program (CADAMP) monitoring network. Data collected in 2005 from two Fresno County monitoring sites (First Street and Five Points) are used for this purpose:

All Kettleman sites had combined PCB/dioxin/furan TEQ of less than 10 femtogram per cubic meter of air (fg/$m^{3)}$. (A femtogram is one-billionth of a microgram.) By comparison, the annual average PCB/dioxin/furan TEQ at other California monitoring sites is 31 fg TEQ/m^3. The average PCB/dioxin/furan toxicity equivalence at other California monitoring sites for the same time of year as the sampling period (June - August) is 19 fg TEQ/m^3. Dioxins/furans contributed the most TEQ at all Kettleman sites.

The TEQ for PCB/dioxin/furan in Kettleman City are not significantly different than found at other areas of California, including KHF. As indicated below, concentrations of chlorinated dioxins and chlorinated furans were higher at the three Kettleman sites than in Frenso, but the combined toxicity of PCBs, dioxins and furans found at the Kettleman sites is comparable at one of the two Fresno sites and lower than the other.

<u>PCBs</u> – The PCB congener patterns were alike at all three monitoring sites (Kettleman City Elemantary School and the upwind and downwihd KHF sites) and similar to the Fresno First Street site. Two PCB congeners were the predominant PCBs at all these sites. At all sites, one of the predominant congeners was 2-3 times higher than the other main congener, which is a typical pattern for ambient air. At the school site, the main congeners were approximately twice as high as at the two KHF sites. All three Kettleman monitoring sites were lower than the urban Fresno First Street site and higher than the rural Fresno Five Points site for both main congeners.

<u>Chlorinated Dioxins</u> – The dioxin congener patterns were similar at all three Kettleman monitoring sites. All dioxin congeners, except for the two highest chlorinated ones, had average concentrations below 20 fg/m^3.

The two chlorinated congeners that had the highest levels were the main dioxins at all three monitoring sites. The highest chlorinated congener was approximately 4 times higher than the second-highest one at all three monitoring sites. The concentrations for all dioxins at the three Kettleman monitoring sites were higher than at the Fresno sites.

Chlorinated Furans – The furan congener patterns were similar at all three Kettleman monitoring sites. All furan congeners, except for the two highest chlorinated ones had average concentrations below 20 fg/m^3. The two highest chlorinated congeners were the predominant furans at all three monitoring sites. The concentrations for all furans at the three Kettleman monitoring sites were higher than at the Fresno sites.

Air sample results near drinking water well air treatment units

Treatment units are connected to the well heads of two drinking water wells in the southeast and southwest corners of Kettleman City. The treatment units, also referred to as air stripping units, were installed in 1998 to remove benzene from the drinking water before the water is delivered to the public.

To assess potential public exposure from benzene near the air stripping units, air samples were collected immediately downwind of the units on three separate days. The air samples were brief (several seconds) and are referred to as "grab samples". Table 9 presents the results of the air monitoring near the air treatment units and, for comparison, at the elementary school.

Table 9. Benzene air concentrations at the well treatment units

Sample Date	Southeast Unit	Southwest Unit	School (Tisch Sampler)	School (Xontech Sampler)
	Results in µg/m^3			
July 14	0.39	4.9		
August 11	0.48	0.11		
August 25	0.35	26		
June-August (range)			0.36 – 0.94	0.21 – 0.49
Limit of Detection	0.23	0.23	0.16	0.16

Three samples were collected near each of the units. The benzene measurements from the grab samples were all above the limit of detection (LOD). The methodology and instrumentation used to capture these grab samples were different than those used for continuous sampling at the elementary school. This difference in sampling methodology results in measurements that are not directly comparable because one is a brief snapshot of the benzene level and the other is an average benzene level over the whole day. Nonetheless, the results (see Table 9) near the southeast unit were similar to the average concentrations measured at the school. The results near the southwest unit were much higher on two of the three days.

Benzene emissions from the air stripping units do not appear to be affecting average air concentrations in Kettleman City, because average levels at the school were similar to those in Fresno and Bakersfield.

To further evaluate potential public exposure to benzene in the air near the southwest air stripping unit, ARB used air dispersion computer modeling to estimate air concentrations of benzene downwind of the unit. The 2010 average benzene concentration in the water entering the air stripping unit and the average flow of water through the unit were used in the modeling. Exposure of potential concern is limited to an area within close proximity (about 50 meters) of the air stripping unit. Beyond that distance, estimated air concentrations are similar to those measured at the school or in Fresno. Concentrations of benzene in the water at the southeast treatment unit were much lower. Estimated air concentrations downwind of the southeast unit are less than those measured at the school.

Interpretation of results with meteorological data

No clear difference was seen when comparing data collected upwind and downwind of KHF. Concentrations of the target chemicals measured upwind and downwind of KHF were similar to those measured in Kettleman City at the school. However, prevailing winds during the monitoring period were from the northwest. This is typical for the entire year for this region. Occasional winds that blow from the southwest have the potential to transport KHF emissions in the direction of Kettleman City.

Historical wind data collected in Lemoore, approximately 22 miles north of Kettleman City, were deemed to be representative of the frequency of wind directions in Kettleman City. These data were compared with the data collected in Kettleman City during the June - August 2010 monitoring period. The wind patterns at Lemoore for the past three years and during 2010 indicate that winds blow from the southwest about 4 percent of the year. Similarly, during the monitoring period, winds in Kettleman City were measured to blow from the southwest about five percent of the time (see Figure 4).

Diesel exhaust exposure assessment

ARB estimated regional and local contributions to diesel particulate matter (DPM) using approaches previously utilized by ARB in other communities. Two different methodologies were used: a population-weighted method for a regional scale assessment and air dispersion modeling for a local scale assessment.

The estimated population-weighted average concentration of DPM for Kings County was 0.9 $\mu g/m^3$. This concentration can be compared to the population-weighted average DPM concentration for another county in the San Joaquin Valley, Kern County, which was estimated to be 1.3 $\mu g/m^3$. More details on the regional assessment are included in Appendix D of the appended ARB report.

At the local scale, an air dispersion model was used to estimate the DPM concentration in Kettleman City from local emission sources. The estimated annual average DPM concentration from local sources in the immediate vicinity of Kettleman City, including vehicles on Interstate 5 and Highway 41, was approximately 0.09 $\mu g/m^3$. The local sources are a subset of county DPM emission sources and a contributor to the county-

wide DPM concentration. More details on the local assessment are included in Appendix E of the appended ARB report.

Historical monitoring results at Kettleman Hills Facility (KHF)

For many years, DTSC has required that KHF conduct perimeter air monitoring as a condition of its hazardous waste facility permit. KHF contracts with an environmental consulting firm for collection and analysis of air samples. Air monitoring is conducted at one location upwind based on the prevailing wind direction (northwest of the facility) and at two downwind locations (south and southeast of the facility). Two of the organic compounds (benzene and toluene) and three of the metals (arsenic, lead, and nickel) measured by KHF are also monitored in this Kettleman City assessment.

KHF's quarterly monitoring results for 2007 to 2010 are summarized in Appendix F of ARB's report. The maximum and mean concentrations measured in ARB's statewide monitoring network during 2007 are included for comparison against KHF's 2007 and 2008 data; statewide data from 2009 are included for comparison against KHF's 2009 and 2010 data.

KHF's monitoring data became relevant to the Cal/EPA assessment after KHF in mid-2010 substantially reduced the volume of hazardous waste it was accepting. This raised the question of whether emissions monitored by ARB at the facility in 2010 were representative of emissions occurring in 2007 to 2009. To answer the question, ARB did the following:

- ARB compared its 2010 monitoring results upwind and downwind of the facility with KHF's monitoring data for the same period (see Appendix G of ARB's report). In a few cases, the ARB and KHF data showed comparable results. In some cases, ARB found measurable air levels of a contaminant and KHF did not. In other cases, KHF found higher air concentrations than ARB. It is not surprising that some differences were found because two different laboratories were involved in analyzing samples which had relatively low air concentrations. Because there was no consistent bias in the Facility's data, these differences do not put into question the validity of the monitoring data collected by the Facility from 2007 to 2009.

- ARB analyzed KHF's upwind and downwind monitoring data from the facility for 2007 to 2009. Overall, upwind and downwind levels of measured chemicals are similar to levels measured statewide and in Fresno. Similarly, there does not appear to be a substantial difference in levels from 2007, when KHF was operating much as it has for many years, and from 2010.

It is important to recognize that pollutant levels measured at KHF do not typically reach Kettleman City, because, as discussed earlier, the prevailing winds are usually from the north or northwest. During the approximately five percent of the time when the wind comes from the southwest, KHF emissions may reach Kettleman City, but computer models estimate that pollutant levels reaching Kettleman City would be, at most, one-tenth of the levels originating from KHF, due to atmospheric dispersion and dilution.

Pesticides

Information from Pesticide Use Reports

DPR compiled pesticide use information on the 19 pesticides of interest for 2007-2009 (when most of the reported birth defects occurred) applied within five miles of Kettleman City. For comparison, information on pesticide applications within five miles of the other 160 communities within the San Joaquin Valley for 2007-2008 were evaluated. Statewide use information for the other 160 communities was not yet available for 2009.

Table 10 shows use of the 19 pesticides for three years prior to the occurrence of the birth defects that are being investigated (2003-2005) and use during the three years that are being investigated for birth defects (2007-2009).

Table 10. Reported use of the 19 pesticides of interest within five miles of Kettleman City during 2003-2005 and 2007-2009.

Pesticide	2003-2005 (total pounds)	2007-2009 (total pounds)
2,4-D	548	635
Abamectin	56	109
Azoxystrobin	1,089	779
Boscalid	128	869
Bromoxynil	1,352	1,156
Carbaryl	1,804	4,903
Chlorpyrifos	11,251	6,635
Clethodim	325	1,214
Diazinon	3,002	222
Diflubenzuron	0	559
Fenoxaprop-p-ethyl	236	110
Flumioxazin	0	409
Maneb	1,270	1,544
MCPA	9,246	4,459
MITC pesticides	124,766	774,088
Myclobutanil	43	735
Oxyfluorfen	3,570	4,964
Propiconazole	379	587
Pyraclostrobin	358	1,230
Total	159,423	805,208

Most of the pesticides (13 of 19) had greater use during 2007-2009 than during 2003-2005. However, two of the higher risk pesticides, chlorpyrifos and diazinon, had lower use during 2007-2009. Use of MITC pesticides increased approximately 6 times between 2003-2005 and 2007-2009 due to greater use treating the soil prior to planting onions and tomatoes.

Table 11 compares the largest single applications in the Kettleman City area to the largest applications statewide for the 19 pesticides of interest during 2007-2008. Table 11 also shows the rank of the Kettleman City area among the 161 communities in the San Joaquin Valley for total use of each pesticide of interest during 2007-2008, with rank 1 assigned to the community with highest use and rank 161 assigned to the community with lowest use. (Statewide data is not yet available for 2009, so that year could not be included.) In general, lower amounts were applied in Kettleman City than in the other San Joaquin Valley communities. For most of the pesticides (12 out of the 19), the largest individual applications in the Kettleman City area involved amounts that were one-half or less the amounts used in the largest individual applications statewide. The table also shows that among the 161 San Joaquin Valley communities, Kettleman City ranked among the top quarter for 7 of the 19 in the amount of pesticides of interest used. For chlorpyrifos, diazinon, and MITC (the three pesticides with higher risk as discussed below), Kettleman City ranked 120th, 101st, and 8th of the 161 communities, respectively.

Table 11. Reported maximum amounts of pesticides applied , 2007-2008

Pesticide	2007-8 KC Max Application[a] (pounds)	2007-8 Statewide Max Application (pounds)	2007-8 KC Use Rank Among 161 SJV Communities[b]
2,4-D	73	1,097	80
Abamectin	6	13	81
Azoxystrobin	78	172	36
Boscalid	44	183	103
Bromoxynil	113	139	21
Carbaryl	320	1,592	30
Chlorpyrifos	652	1,306	120
Clethodim	36	90	15
Diazinon	160	1,778	101
Diflubenzuron	71	534	59
Fenoxaprop-p-ethyl	25	50	15
Flumioxazin	38	239	104
Maneb	203	3,177	91
MCPA	181	625	39
MITC pesticides	22,308	51,849	8
Myclobutanil	63	126	60
Oxyfluorfen	270	1,313	103
Propiconazole	95	144	48
Pyraclostrobin	62	88	65

[a] *Max Application* is the greatest amount of pesticide applied for any single application, within five miles of Kettleman City (first column of data) to the largest application statewide (second column of data).

[b] *KC Use Rank* is the rank of Kettleman City among 161 communities in the San Joaquin Valley, for use (within five miles) of the 19 pesticides of interest.

More detailed information on use of the individual pesticides is given in Appendix A of the appended DPR report.

Modeling results of pesticides in air

Pesticide use in the Kettleman City area changed considerably between 2007 and 2010. As a result, air monitoring for pesticides in 2010 would provide little information about airborne concentrations that may have reached the community during 2007 to 2009. Therefore, DPR used air dispersion computer modeling and data from pesticide use reports to estimate air concentrations of the 19 pesticides of interest that were used within five miles of Kettleman City during 2007 to 2009.

DPR first conducted Tier 1 modeling to estimate the hypothetical "worst-case" air concentration for screening purposes. For each pesticide, Tier 1 modeling used the following key assumptions:

- Application size was equal to the largest application that actually occurred within 5 miles of Kettleman City during September 2006 – December 2009 (the period when the birth defects occurred)
- All of the pesticide amount applied was released to the air in 24 hours (this is a hypothetical scenario – not a real occurrence)
- Kettleman City was 25 feet downwind from the application
- Reasonable worst-case weather conditions existing during the application, including wind blowing directly toward Kettleman City at approximately 3 miles per hour.

The Tier 1 modeling results were higher than the maximum air concentration measured during monitoring studies for all pesticides monitored, as discussed below. These results verified that the Tier 1 computer modeling procedures overestimated air concentrations.

Of the 19 pesticides evaluated, four (carbaryl, chlorpyrifos, diazinon, and MITC) exceeded the health screening level, indicating the need for additional evaluation using Tier 2 modeling. For these four pesticides, Tier 2 modeling used the following key model inputs:

- Exact application sizes as recorded in pesticide use reports during September 2006 – December 2009
- The amount of pesticide released to the air was based on worst-case estimates of drift and volatilization data for each pesticide
- The exact location of the applications as recorded in pesticide use reports
- Weather conditions as recorded by a local weather station

Tier 2 modeling for the days with the highest applications showed at least one day above the screening levels for three pesticides (chlorpyrifos, diazinon, and MITC). DPR staff then conducted a more-detailed modeling and health evaluation for these three pesticides by conducting additional Tier 2 modeling for all applications (not just the highest applications) of chlorpyrifos, diazinon, and MITC from September 2006 through December 2009.

DPR's more in-depth health evaluation included a consideration of a variety of possible adverse health effects and the air concentrations at which these different effects might occur. For chlorpyrifos, diazinon, and MITC, the air concentrations that might cause other health effects, such as nervous-system effects, are lower than the concentrations that might cause birth defects. DPR set its screening levels for these pesticides at levels that account for uncertainties in how they may affect human health. These are standard, widely accepted assumptions that scientists use in evaluating health effects of chemicals. For example, a screening level assumes that human adults would be ten times more sensitive than the lab animals. It also assumes that some people are as much as ten times more sensitive than other people. For some chemicals, an additional factor may also be included to account for increased sensitivity of infants and children.

The estimated air concentrations based on the Tier 2 modeling are presented in Table 12, along with "minimum" health screening levels (based on the most sensitive adverse health effect and the highest uncertainty factors) and "maximum" screening levels (based on developmental effects and the lowest uncertainty factors). MITC air concentrations exceeded the screening level for developmental effects on one day, and exceeded the screening level for lung irritation (the most sensitive health effect) on two days. Chlorpyrifos air concentrations did not exceed the screening level for developmental effects, but exceeded the screening level for toxic effects to the nervous system (cholinesterase inhibition) on three to nine days. Similarly, diazinon air concentrations did not exceed the screening level for developmental effects, but exceeded the screening level for cholinesterase inhibition on three to six days. The steps DPR is taking to address the potential risk from chlorpyrifos, diazinon, and MITC are described in the Findings and Recommendations sections.

Table 12. In-depth evaluation of chlorpyrifos, diazinon, and MITC air concentrations that may have exceeded the health screening levels

Pesticide and Application Date	**Estimated Air Concentrations (ng/m^3)[a]**		**Health Screening Levels (ng/m^3)[b]**	
	Minimum	**Maximum**	**Minimum[c]**	**Maximum[d]**
Chlorpyrifos			334	47,000
09/06/06	200	1,010		
03/12/07	75	380		
05/04/07	160	800		
05/07/07	430	2,190		
04/17/08	3,820	19,400		
07/22/08	96	490		
08/15/08	83	420		
09/06/08	1,890	9,600		
10/28/08	240	1,200		
Diazinon			376	940,000
03/05/07	1,510	7,680		
03/28/07	380	1,920		
05/10/07	150	780		
04/05/08	400	2,050		

Pesticide and Application Date	Estimated Air Concentrations (ng/m^3)[a]		Health Screening Levels (ng/m^3)[b]	
	Minimum	Maximum	Minimum[c]	Maximum[d]
04/21/08	120	620		
05/14/09	160	830		
MITC[e]			66,000	141,000
11/14/08	110,300	110,300		
12/03/08	176,500	176,500		

[a] Air concentrations are the highest and lowest estimated 24-hour average concentrations at the border of Kettleman City using Tier 2 modeling procedures. The range of values for the air concentrations is based on the uncertainty in the percentage of the applied pesticides that is released to the air.
[b] The range of values for the screening levels is based on different adverse health effects, and uncertainties in the toxicological data. See Appendix A of the appended DPR report for descriptions of the data used to determine the screening levels.
[c] Screening level for most sensitive adverse health effect and highest uncertainty factors.
[d] Screening level for developmental effect and lowest uncertainty factors.
[e] The flux for MITC is based on a single field study, hence the variability in amount released is not known, and the minimum and maximum air concentrations are the same.

Further, DPR evaluated cumulative exposure to multiple pesticides by examining the five days with the highest air concentrations for chlorpyrifos, diazinon and MITC: 4/17/08 and 09/06/08 for chlorpyrifos, 3/05/07 for diazinon, and 11/14/08 and 12/03/08 for MITC. Of these dates, 4/17/08, was the only day when another pesticide of interest was applied: a single application of azoxystrobin, along with several chlorpyrifos applications. Because azoxystrobin and chlorpyrifos have different toxic effects, it is not appropriate to evaluate their cumulative exposure. However, had they had the same toxic effect, combining the estimated concentration of azoxystrobin (from Tier 1 modeling results) with the maximum estimated concentration of chlorpyrifos (from Tier 2 modeling results) shows that the azoxystrobin would have had a negligible contribution to the cumulative toxic effect.

Detailed descriptions of the inputs for the air dispersion computer modeling, results, and health evaluation are given in Appendix A of the appended DPR report.

Monitoring results of pesticides in air

DPR conducted air monitoring at the Kettleman City Elementary School for 27 pesticides, four of which, chlorpyrifos, diazinon, MITC, oxyfluorfen, could possibly cause birth defects. DPR collected two samples each week, for eight weeks, beginning on June 8, 2010 and ending on July 29, 2010. Sample analysis also included four breakdown products, that is, chemicals that are formed when a pesticide “breaks down” into another after its release. ARB’s monitoring included two additional pesticides: 1,3-dichloropropene and methyl bromide (ARB provided these data to DPR.). DPR collected 16 sets of samples.

DPR detected four pesticides (chlorpyrifos, endosulfan, MITC, trifluralin) and one breakdown product (chlorpyrifos oxygen analog). Additionally, ARB detected methyl

bromide (bromomethane). Four pesticides were detected at quantifiable concentrations (chlorpyrifos oxygen analog, endosulfan, methyl bromide, and MITC); the other two were detected at trace levels. These results are presented in Table 13, along with detection limits, maximum concentrations from historical monitoring ("other studies") and the minimum screening levels for each pesticide.

None of the detected concentrations exceed the minimum screening levels. All concentrations were less than those detected in other pesticide-monitoring studies of agricultural areas. Chlorpyrifos oxygen analog had a measured concentration that was less than 5 percent of the chemical's minimum screening level. Measured concentrations of the other pesticides were even lower relative to their minimum screening levels.

Table 13. Highest monitored 24-hour pesticide air concentrations in Kettleman City (June and July 2010) and comparison to historical monitoring and minimum screening levels

Pesticide	Max Conc (ng/m^3)	Detection Limit (ng/m^3)	Max Conc in Other Studies (ng/m^3)	Min Screening Level (ng/m^3)
1,3-Dichloropropene (ARB)	ND	450.0	135,000	160,000
Azinphos-methyl	ND	7.6	ND	101,000
Chlorothalonil	ND	13.7	14	34,000
Chlorpyrifos (possible birth defects)	Trace	5.1	1,340	334
Chlorpyrifos oxygen analog	15	2.9	230	334
Cypermethrin	ND	4.7	ND	40,000
Diazinon (possible birth defects)	ND	1.2	290	376
Diazinon oxygen analog	ND	2.1	71	376
Dichlorvos	ND	3.2	65	11,000
Dicofol	ND	2.1	ND	68,000
Dimethoate	ND	2.3	ND	34,000
Dimethoate oxygen analog	ND	1.9	ND	34,000
Diuron	ND	5.1	ND	170,000
Endosulfan	27	3.2	166	4,000
EPTC	ND	1.7	240	230,000
Malathion	ND	2.2	90	40,000
Malathion oxygen analog	ND	1.3	28	40,000
Methyl bromide (ARB)	160	130.0	142,000	820,000
Metolachlor	ND	2.7	ND	85,000
MITC (possible birth defects)	387	5.6	18,000	66,000
Molinate	ND	1.8	1.2	200,000
Naled (dichlorvos)	ND	3.2	ND	920
Norflurazon	ND	3.8	ND	170,000
Oryzalin	ND	1.4	ND	420,000
Oxyfluorfen (possible birth defects)	ND	6.4	ND	1,410,000
Permethrin	ND	7.2	Trace	168,000
Phosmet	ND	7.8	ND	77,000
Propanil	ND	2.3	149	51,000
Propargite	ND	3.8	1,300	14,000
Simazine	ND	1.2	18	110,000
SSS-tributylphosphorotrithioate	ND	1.8	330	8,800
Thiobencarb	ND	5.6	ND	425,000

Pesticide	Max Conc (ng/m^3)	Detection Limit (ng/m^3)	Max Conc in Other Studies (ng/m^3)	Min Screening Level (ng/m^3)
Trifluralin	Trace	1.7	Trace	1,200,000

Water

DTSC took water samples from 11 home kitchen sink faucets, 3 water wells, the California Aqueduct, and an agricultural drainage canal. One additional sample was taken from the water vending machine at the Kettleman City Market (located at 216 Becky Pease Street). The samples were analyzed for metals, volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), organochlorine pesticides, and total petroleum hydrocarbons (TPH).

Residential water

Home drinking water (i.e., tap water) in Kettleman City is pumped from two municipal wells, treated, and then distributed throughout Kettleman City through a network of water supply pipes. Water treatment consists of air stripping to remove benzene, and chlorination to remove bacteria and other pathogens.

Once the water enters the network of water supply pipes it may be contaminated by chemicals present in or around the distribution system. A final point of possible contamination to residential water is in the home itself. Older plumbing may have been connected with lead solder and lead from the solder can leach into the water.

Metals – Arsenic was the only metal found at a level of concern in residential drinking water. This was not surprising because historically arsenic is a known natural contaminant found in San Joaquin Valley groundwater. The levels found in the residential water samples, 9.8 to 19 micrograms per liter (µg/L), were consistently above the maximum contaminant level (MCL) of 10 µg/L in all homes tested except for one where it was just below the MCL. The MCL for arsenic was lowered from 50 µg/L to 10 µg/L in 2008. The public health goal (PHG) for arsenic in drinking water, 0.004 µg/L, is substantially lower than the MCL and is often below the laboratory reporting limits. Hence, the level of arsenic in the residential water is a concern. CDPH did find that most of the mothers who they interviewed reported that they drank and cooked with bottled water.

Lead was detected in the water of only one home. Its amount cannot be measured precisely because it was lower than the reporting limit (the lowest level of a contaminant that be accurately measured) of 2 µg/L. The estimated concentration was well below the regulatory action level (a level that triggers certain regulatory requirements for water systems if it is exceeded) for lead of 15 µg/L.

Other naturally occurring metals were found such as barium, copper, nickel and zinc, but this would be expected in normal groundwater. The levels that were found are not expected to pose any health concerns.

Volatile Organic Compounds – Few VOCs were found in the home drinking water. This was expected because the groundwater is treated to remove volatile compounds before it is distributed to homes.

The only two volatile compounds that were found in the residential water were bromoform and chlorodibromomethane. These chemicals do not occur naturally but are commonly formed by the chlorination process used to disinfect drinking water. The highest combined amount of bromoform and chlorodibromomethane found in any residential drinking water was well below the applicable MCL and is not a health concern.

Only one other chemical was found in the water from one home. Acetone was found at a very low level that could only be estimated and is likely a laboratory contaminant.. There is no MCL for acetone, but it is not considered to be toxic at such a low concentration.

Semi-Volatile Organic Compounds – The residential drinking water of three homes was analyzed for SVOCs. The analytical procedure looked for 66 chemicals and the only one that was detected was di-n-butyl phthalate (DnBP). DnBP and another chemical found in non-residential samples, bis(2-ethylhexyl) phthalate (DEHP), are used to make plastics flexible. While both chemicals may potentially cause birth defects, they are so widely used that they show up frequently in low concentrations in environmental samples, including drinking water, because they are present in the sample or they are a laboratory contaminant. In this case, it is likely the chemicals are laboratory contaminants since it is unlikely these chemicals would have contaminated the deep groundwater. The DnBP detected in the one home water sample was too low to be quantified and was below the level of a health concern for developmental effects.

Organochlorine Pesticides – No organochlorine pesticides were detected in the water of the three homes that were part of this analysis.

Polychlorinated Biphenyls - No polychlorinated biphenyls were detected in the water of the three homes that were part of this analysis.

Total Petroleum Hydrocarbons (TPH) - No TPH associated with gasoline, diesel fuel or motor oil were detected in the water of the three homes that were part of this analysis.

Bacterial Contamination – Coliform bacteria are organisms that live in the general environment and some types live in the intestines of warm-blooded animals . They should not be present in drinking water.

Coliforms were reported in water samples from two residences. Because *E.coli* (the coliform bacteria of greatest concern) was not present, the findings were of moderate concern. Because only two of the 11 residences had bacteria in their water, it was concluded that this was not a distribution-wide problem, but rather limited to the individual residences.

DTSC followed up with the residents of the two homes and replaced the aerators in their kitchen sink faucets. Subsequent testing showed that replacement of the aerators eliminated the coliform problem.

Well water

There are three water wells in Kettleman City. Two municipal wells supply drinking water to the city. The third well is at the Kettleman City Elementary School and is used only for the school. The groundwater from these wells was analyzed for the same contaminants as the residential tap water. The water analyzed from the wells was tested before it was treated and chlorinated so that any VOCs in the well would be detected during the analysis.

Metals – The metal levels found in the water of the three wells were similar to those found in the home water samples. The most notable is arsenic. The arsenic levels in all wells, 12 to 19 µg/L, were above the MCL of 10 µg/L.

Lead was detected in one of two samples taken at one municipal well at a level of 2.3 µg/L. Lead was also found in the water sample taken from the school well at a concentration of 5.1 µg/L. These levels are below the regulatory action level of 15 µg/L but above the PHG of 0.2 µg/L. Finding of detectable lead in the water from the school well differs from the reported level in the 2008 Consumer Confidence Report for the Kettleman City Elementary School, which reported that lead was not detectable. Furthermore, a July 2010 test of the school's well unrelated to the Cal/EPA investigation did not detect lead, according to the Kings County Department of Public Health, Finding a discrepancy in the duplicate samples taken at the municipal well also raises the question whether there was a laboratory error. Further sampling should be undertaken to determine if Cal/EPA's detections of lead can be verified.

Antimony was also detected in the school well water at a level below the reporting limit and the estimated concentration was below the levels of concern. Vanadium was found in the school well at a much higher level than in the other water samples. The vanadium level is about the median level reported in one study of groundwater in California (Hunter *et al.*, 2005) but below a level of health concern.

Volatile Organic Compounds – Benzene was the primary VOC found in the well water. It was found at 72 µg/L in water from one municipal well and at 7.7 µg/L in the water of the other municipal well. Benzene was not detected in the water sample from the school well. The benzene levels in the municipal wells were well above the MCL of 1 µg/L. The treatment system to remove volatile contaminants from the municipal well water appears to work properly because benzene was not found in water from kitchen faucets.

A small amount of ethyl benzene was found in the municipal well with the highest benzene level. The level of ethyl benzene, 0.7 µg/L, is much lower than the MCL at

300 µg/L. It is also removed by the process to remove volatile contaminants from the drinking water.

Semi-Volatile Organic Compounds – The only SVOC on the list of contaminants found in the municipal wells was bis-(2-ethylhexyl)-phthalate (also known as DEHP). This chemical is commonly found in the environment because of its widespread use in plastics. In one well water sample it was found at 4.3 µg/L. However, this measurement may not be accurate because of concerns that arose with the analytical method. DEHP was found at 2 µg/L in the other municipal well water sample. These levels are at or below the MCL for bis-(2-ethylhexyl)-phthalate of 4 µg/L. The school well water sample had an estimated concentration of di-n-butyl-phthalate (DnBP) of 0.6 µg/L, which is below the level of health concern. As discussed earlier, these findings may be due to laboratory contamination.

Organochlorine Pesticides -- No organochlorine pesticides that were part of this analysis were detected in the wells.

Polychlorinated Biphenyls - No polychlorinated biphenyls that were part of this analysis were detected in the wells.

Total Petroleum Hydrocarbons (TPH) – The municipal well water sample that had the highest level of benzene also reported TPH associated with gasoline. However, the laboratory results indicated it is likely that the TPH finding is actually only due to the benzene rather than gasoline. No TPHs associated with diesel fuel or motor oil were detected in any of the well water sample.

Bacterial Contamination - No bacterial contamination was detected in the analyses of water samples taken from the three wells. This finding is further evidence that the bacteria found in the water from the two homes were not due to a system-wide contamination problem.

Surface water

Surface water was sampled from the California Aqueduct and an agricultural drainage canal. The California Aqueduct sample was taken just west of the city and the drainage canal sample was taken at Quebec Avenue and SR-41.

Because these samples are exposed to the whole environment, it is expected that this water will have many more contaminants than water from a faucet or wells. Most residents of Kettleman City are not directly exposed to surface waters unless they swim or fish in these waters. In the future, the community may obtain its drinking water from the California Aqueduct. That water would be treated to remove unacceptable levels of contaminants before it is provided to the public.

Metals – Both the aqueduct and drainage canal had arsenic in the water at 2.5 µg/L and 4.8 µg/L, respectively. These levels are below the drinking water MCL of 10 µg/L. The only other metal of potential concern is lead, which was found in the drainage canal

water at 3.3 µg/L. Other metals were found at concentrations below the levels of concern.

Volatile Organic Compounds – As expected, because this is surface water, no VOCs were found in the water from the aqueduct and drainage canal.

Semi-Volatile Organic Compounds – Only one SVOC was detected in the in the water samples collected from the aqueduct and drainage canal: bis-(2-ethylhexyl)-phthalate (DEHP) at 4.8 µg/L and 0.5µg/L, respectively. These low concentrations for this chemical are below the level of a health concern.

Organochlorine Pesticides - No organochlorine pesticides were detected in the water from the aqueduct and drainage canal.

Polychlorinated Biphenyls - No polychlorinated biphenyls were detected in the water from the aqueduct and drainage canal.

Total Petroleum Hydrocarbons - No TPH associated with gasoline, diesel fuel or motor oil were detected in water from the aqueduct and drainage.

Bacterial Contamination – Water from both the aqueduct and the drainage canal had high levels of total coliforms. This is not surprising because coliforms are naturally present in the surface environment. Both water samples also had small amounts of E. coli. Again this is not surprising because both water bodies receive surface runoff where animal fecal matter (the principal source of E. coli) is present. Treatment can reduce coliforms to levels that are safe for drinking water.

Vending Machine

A water vending machine is located at the Kettleman City Market. Water dispensed from this machine goes through a carbon filter, a micron filter, reverse osmosis, a post-carbon filter, and finally UV treatment. One water sample was taken from the machine.

This water sample was tested for metals, VOCs, and coliform bacteria. The water had no detectable levels of arsenic, lead, VOCs or coliform bacteria.

Soil

Soil contamination can happen in several ways. Around older homes, lead from paint can come off walls as dust or chips and contaminate the soil near the house. Activities around the house such as mechanical work on cars can also leave contaminants in the soil. The use of older chlorinated pesticides can also leave contamination. More generalized contamination can occur from industrial or farm sites elsewhere in the San Joaquin Valley that emit particulates in the air that are then carried by wind and deposited on soil at distant locations.

Soil samples were taken from nine residences. Four surface samples were taken from each residence, except for one where five samples were taken. Samples were also

taken from farm fields west, north, and east of the community. Six samples were taken from each farm area. These samples were taken next to the fields along roads bordering the community. The same analyses were conducted for the home and farm soils.

The surface soil samples were analyzed for metals, organochlorine pesticides, and PCBs. The average concentration of each chemical from the multiple samples taken at each site was used. If a chemical was not detected in one sample, it was not included in this average.

Residential

Metals – Many of the metals were found in the residential soil samples. However, only arsenic was above the California Human Health Screening Levels (CHHSLs) established for metals in soil. The range of arsenic concentrations in surface soil for each residence was 3.8 to 6.2 milligrams of arsenic per kilogram of soil (mg/kg soil).

Samples used for background comparison with the surface soil metals were taken from four sites around the area at five feet below the surface. Arsenic was not detected. This was somewhat surprising, since arsenic occurs naturally in the area and would generally be expected to be detectable five feet below the surface, although at that depth the soil may represent a different geological environment.. Further evaluation of this is discussed in the next chapter.

Lead is a metal of concern around older homes because it was historically used in high concentrations in household paint. Lead can be found in the soil around the homes because weathered paint tends to rub off walls as dust or peel off as flakes. As expected, lead was found in residential surface soil at higher concentrations than those found in background soil samples. The highest average concentration in soil samples taken at a residence was 27 mg/kg soil. However, the CHHSL for lead is 80 mg/kg soil in soil, so these lead levels are not a significant health hazard.

Organochlorine Pesticides – The most well known pesticide in this group of chemicals is DDT, which was banned in the United States in 1972. It is a persistent chemical that breaks down slowly and forms other equally toxic chemicals, DDE and DDD. As expected, DDT and DDE were detected in the soil at all but one of the nine residences sampled. However, the concentrations were very low. The highest combined concentration of DDT and DDE found at any residence was 58.2 ppb. The CHHSLs for DDT and DDE are both 1,600 ppb, so the concentrations of these chemicals are below the level of health concern.

Chlordane, formerly used to control termites but now a banned pesticide, was found in high concentrations in some of the soil samples at one residence. Chlordane is composed of two chemicals: gamma-chlordane and alpha-chlordane. One soil sample had a high concentration of gamma-chlordane (1,100 µg/kg soil). The other three samples taken at the same residence had low concentrations of gamma-chlordane. The same soil sample that had high gamma-chlordane also had a high level of alpha-

chlordane (980 µg/kg soil). Because the CHHSL for chlordane is 430 µg/kg soil, at least one area of this property has excessive levels of chlordane in the soil.

Because significant levels of chlordane were not found anywhere else in Kettleman City, it should not be considered a health threat to the community. Further investigation is needed to determine the source of the chlordane contamination at the residence in question, although it is likely from a past application to prevent termite infestation. We recommend that DTSC follow up to identify the source of the chlordane and determine whether remedial action is needed.

The other organochlorine pesticides detected in residential soil were at low concentrations and below the levels of health concern.

Polychlorinated Biphenyls - No polychlorinated biphenyls were detected in the residential soil samples.

Agricultural

As mentioned before, samples were taken in farm fields bordering the community on the west, north, and east. The samples were subjected to the same analyses as the home soil samples. Six samples were taken from each area.

Metals – The soil concentrations of metals in the farm areas did not differ from those found on residential properties. The average arsenic concentrations from the three areas were within the same range as the averages found in the soil taken from the homes. Exposure to the farm soil would not be continuous as it would be with residential soil, but exposures can occur especially under dusty conditions in the fields.

Lead concentrations found in agricultural soils are below the levels of health concern.

Organochlorine Pesticides – Organochlorine pesticides were found in the farm fields, but the concentrations found were low and below the level of health concern.

Sediment

One sediment sample was taken from the bottom of an agricultural drainage canal. While it is unlikely many residents of Kettleman City would be exposed to the sediment, it can be used as a potential indicator of general contamination.

Metals – The sediment sample had somewhat higher concentrations of metals than some of the home soil samples. Except for arsenic, these concentrations were far below levels of health concern. The sediment concentration of arsenic was in the same range as found in home soil samples, so these levels are not of concern.

Organochlorine Pesticides – No organochlorine pesticides were detected in the sediment. This is surprising because these chemicals tended to adhere to soil particles rather tightly and some of these pesticides are found in the farm soil.

Polychlorinated Biphenyls – No polychlorinated biphenyls were detected in the drainage canal sediment sample.

Total Petroleum Hydrocarbons – No TPH associated with diesel fuel or motor oil were detected in the drainage canal sediment sample.

Soil gas

Soil gas sampling is much more useful than direct soil sampling for finding VOCs and SVOCs in soil. It can detect these chemicals at lower concentrations in the gas than in soil. Soil gas samples were taken at nine residences, the Kettleman Elementary School, the Kings County Fire Station, a location along one of the pipelines running through the city, and at several current and former gas stations and automotive repair facilities. Most residential soil gas samples were taken at five feet below the surface. Samples in other areas of the city were taken at five, ten and 15 feet below the surface.

Very few chemicals were detected in the samples taken. At one residence chloroform was found at a concentration of about 0.40 µg/L in soil gas. This is the only chemical found in the soil gas at any home. The level of chloroform is about double a preliminary CHHSL calculated for chloroform (0.2 µg/L air). (Chloroform does not have an official CHHSL, so OEHHA calculated one using the standard methodology used to develop CHHSLs.) It is not clear why chloroform would be in the soil at one home, because no other VOCs were detected and it is not a common chemical used in a residential setting. This one chemical, at the concentration found, may represent is a health concern for the residents of the house. Because chloroform was not found anywhere else in Kettleman City, it should not be considered a health threat to the community.

The only other place soil gas VOCs were detected was at a repair facility. Ethyl benzene and xylenes were detected at levels below the established CHHSLs. Both these chemicals are associated with gasoline and it is not surprising that they were found in the soil gas at an auto repair facility. A small gasoline spill could be the cause of this finding. Further investigation may be required but the levels found do not pose a health risk.

At the time the soil gas samples were collected for laboratory analysis, handheld instruments were used to measure hydrogen sulfide and methane at the holes. Hydrogen sulfide was never detected, while methane was detected once in a duplicate sample where the other sample was below the detection limit.

When obtaining the soil gas measurements, the ambient radiation level was measured with a handheld detector. Additional measurements were taken at the well houses and at one place where a soil sample was taken near the northern farm fields. The levels ranged from 5 to 18 microREMS per hour (µREM/hour, a measure of radiation dose) and were well below the DTSC Preliminary Screening Level (PSL) of 200 µREM/hour.

RISK EVALUATION

Air

Risk evaluation of non-pesticide ambient air exposure

ARB conducted extensive air monitoring of Kettleman City for 2-1/2 months in the summer of 2010. Volatile organic compounds, metals, PCBs, chlorinated dioxins, chlorinated furans, and some criteria air pollutants were measured.

The chemicals of primary concern are the developmental toxicants listed in Table 1. These chemicals were measured at concentrations similar to those found in Fresno, Bakersfield, and other cities in the San Joaquin Valley. Therefore, the risk of birth defects and other developmental harm posed by these air contaminants is not likely to be any greater in Kettleman City than at other locations in the San Joaquin Valley.

The low concentrations of benzene found in Kettleman City, Fresno and Bakersfield are higher than the air cancer risk screening level for benzene. However, this is the case throughout much of California because of the presence of benzene in gasoline, diesel fuel and motor vehicle exhaust. For other health effects, the measured concentrations were below levels of concern. .

PCB, chlorinated dioxin and chlorinated furan congeners were found in the ambient air in concentrations similar to other parts of California. The concentration found at the Kettleman City Elementary School monitoring site was a little higher than found upwind and downwind of the KHF. The concentration at these three sites was in between the concentrations found at two comparison sites in Fresno County (First Street and Five Points). The ambient concentrations of PCB, chlorinated dioxins and chlorinated furans congeners found at all these sites were well below the level of health concern.

The air monitoring indicated that the KHF did not affect the ambient concentrations of the chemicals found in the air of Kettleman City. It is not likely that airborne contaminants measured in this study at KHF pose health risks to the residents of Kettleman City.

ARB collected air samples downwind of the two air-stripping units at the municipal wells. Benzene levels near the southeast unit were similar to the 24-hour average concentrations measured at the elementary school. However, benzene levels near the southwest unit were much higher than near the southeast unit on two of the three sampling days. Benzene emissions from the treatment units do not appear to be affecting the ambient air concentrations in Kettleman City as measured at the school. The modeled air concentration of benzene within close proximity (within about 50 meters) of the southwest air stripping unit is of potential health concern and should be further investigated.

Risk evaluation of pesticide ambient air exposure

DPR's air monitoring and evaluation of pesticide air concentrations using computer modeling indicated most levels of pesticides in Kettleman City during the September 2006 – December 2009 period, as well as in 2010, were below levels of health concern. Pesticide air concentrations estimated by modeling on one day – December 3, 2008 – exceeded the screening level for birth defects during the 40-month period evaluated, indicating a low probability of developmental effects from pesticides. The day with the highest estimated cumulative risk from multiple pesticides was negligibly higher than for a single pesticide. Additionally, other communities in the San Joaquin Valley have higher use and likely higher risk for the 19 pesticides that were evaluated. Kettleman City ranks among the top quarter of the San Joaquin Valley communities for 7 of the 19 evaluated for pesticide use.

The risk in Kettleman City for other health effects, such as lung irritation and cholinesterase inhibition, is uncertain. However, the computer modeling indicated that the screening levels for other acute toxic effects were likely exceeded on three to nine days for chlorpyrifos, on three to six days for diazinon, and two days for MITC. The uncertainty in the exceedences is due to the uncertainty in the amount of pesticides actually emitted to the air.

While the risk of other toxic effects is uncertain, the risk in Kettleman City is expected to be lower than in other communities. All of the detected air concentrations in Kettleman City were lower than previously measured in other communities, although the Kettleman City monitoring captured the peak use for only a few pesticides. Other communities have higher use for most if not all of the 27 pesticides monitored. DPR did not estimate long-term pesticide air concentrations or chronic risk for Kettleman City because it was beyond the scope of this assessment. In addition, the methods to model long-term pesticide exposure are uncertain and the high number of samples with no detectable amount makes the estimates using monitoring data uncertain.

Water

Tap water from the 11 homes sampled contained arsenic levels ranging from 9.8 to 19 micrograms per liter. While these levels of arsenic exceed the state's drinking water standard, it is highly unlikely that the birth defects in the community were caused by arsenic in the drinking water. CDPH's interviews with mothers of the children with birth defects found that most used bottled water at home, instead of tap water. Most did not cook with tap water, either.

Although arsenic levels in Kettleman City's water are elevated, they are not unique. Similar levels of arsenic are found in drinking water in Hanford and Lemoore. In addition, arsenic levels in Kettleman City's drinking water are not new. Monitoring records indicate the drinking water has had comparable levels of arsenic for many years, while the increase in the rate of birth defects in the community began in 2007. CDPH's review found no unusual incidence of birth defects between 1986 and 2006.

High levels of exposure to arsenic have been found to cause birth defects in laboratory animals. It has also been linked to fetal death and growth retardation in animals at high levels of exposure. In its 2004 risk assessment of arsenic in drinking water, OEHHA identified 17 micrograms per liter as a level of arsenic in drinking water that would protect against developmental effects. This means that people who drink water with 17 micrograms or less of arsenic per liter are not expected to have an increased risk for birth defects. Most of the measured water samples detected arsenic at or below this level, indicating that arsenic in the drinking water does not pose a high risk of birth defects.

Nevertheless, these levels of arsenic are a health concern. Elevated levels of arsenic in drinking water can increase risks for a variety of other health ailments, including heart disease, stroke and cancer. Reducing arsenic levels – either through improved treatment of the existing water supply or identifying an alternative source of water -- will reduce these risks. Kettleman City residents should be able to drink tap water with confidence that it will not harm their health.

While benzene was found in the groundwater from the two municipal wells at levels potentially harmful to human health, it is removed before the water is provided to the public. Since there is no exposure to benzene it does not present a health risk to the community.

Lead was found in the water sample taken from the school well at a concentration of 5.1 µg/L. This is below the regulatory action level of 15 µg/L but above the PHG of 0.2 µg/L. Because the PHG is based on lead's ability to affect the intelligence of children, further investigation of this result is needed. Previous testing of the water at the school did not detect the presence of lead.

Soil

Metals are naturally present in soil. Various metals were detected in the residential soil samples taken by DTSC. However, only arsenic was above the California Human Health Screening Levels (CHHSLs) established for metals in soil. The average arsenic concentrations in surface soil for each residence ranged from 3.8 to 6.2 milligrams of arsenic per kilogram of soil. This is consistent with naturally occurring arsenic in surface soil elsewhere in the San Joaquin Valley and other regions of California.

For example, in carrying out its responsibilities to evaluate the safety of proposed new school sites, DTSC measured 3 to 6 milligrams of arsenic per kilogram of soil at a proposed school site in Visalia. In Bakersfield, DTSC measured arsenic levels ranging from 4.7 to 9.9 milligrams of arsenic per kilogram of soil at one site and 8.6 to 14.4 milligrams per kilograms of soil at a second school site.

One study of nine Air Force installations around the state found the median background level of soil arsenic at less than 2.5 feet below the surface to be 2.1 milligrams of arsenic per kilogram of soil, with some samples as high as 11.1 milligrams of arsenic per kilogram of soil (Hunter *et al.*, 2005).

In the Kettleman City investigation, DTSC also took soil samples from four sites around the area at five feet below the surface. In those “background” samples, arsenic was not detected. It is not clear why the results from these deeper soil samples were different from the surface samples. However, it is likely the samples taken at a depth of five feet do not represent surface soil levels. The arsenic levels in the surface soil samples are consistent with the naturally occurring arsenic that is prevalent in the San Joaquin Valley.

This is important because OEHHA’s CHSSL for arsenic (0.07 milligrams of arsenic per kilogram of soil) is only to be used for areas that are known to have arsenic contamination from human activity. It should not be used to evaluate property with naturally occurring arsenic, which is not as easily absorbed by the body as forms of arsenic used in human industrial activities and therefore does not present the same risk. In the remediation of contaminated sites, DTSC does not consider a site contaminated if naturally occurring arsenic is below 12 milligrams of arsenic per kilogram of soil. Because there is no reason to believe the arsenic in Kettleman City is the result of human activity, the presence of arsenic in surface soil at measured levels does not pose a health risk.

Chlordane, a now-banned pesticide formerly used near the foundation of homes to treat termites, was found in the soil at one residence at a concentration that was five times higher than the CHSSL of 430 micrograms of chlordane per kilogram of soil. Chlordane is not a chemical of concern for developmental toxicity; the CHHSL was based on the chemical’s potential to cause cancer. This high level of chlordane was only found in one sample, although two other samples from that residence also had lower levels of chlordane. It is evident that the soil at that property is contaminated with chlordane, but not evenly. The samples were taken next to the home where chlordane would have been used in the past to treat for termites. Chlordane is unlikely to be spread over the entire lot.

Chlordane was found in some samples from three other residences, but the concentrations were below the CHHSL. This finding is not surprising because, as mentioned before, chlordane was a common pesticide used near the foundation of homes to prevent termite infestations. Because it was only found at one home at a level of concern, chlordane does not appear to pose risks to the community.

Sediment

Sediment taken from the bottom of an agricultural drainage canal was found to have no contaminants at levels of concern except for arsenic, which was found to be at a concentration similar to surface soil. The sediment was sampled, as well as the surface water, to determine if fish caught in the agricultural drainage canals and California Aqueduct may be contaminated and unsafe to eat. Because these samples did not find significant contamination, there is no evidence to suggest that fish from these waters have unusual levels in their tissues of contaminants measured in this study.

Despite these findings, OEHHA does not recommend eating fish from drainage canals, as these fish at any time may be exposed to potentially harmful levels of pesticides and other contaminants in agricultural runoff.

Soil gas

Only one sample had a soil gas concentration above a screening level. That was a residence with a detection of chloroform. Chloroform was detected at about 0.41 micrograms per liter, about twice the CHHSL of 0.2 micrograms per liter. The CHHSL is based on risks of cancer, and the levels detected in the one sample pose a very small risk. Also no other volatile chemical was detected at the residence so there is no additional risk from other measured chemicals.

Finding chloroform at such a low level and in only one sample indicates there is no significant contamination problem with volatile organic chemicals at the residence and that there is no reason to be concerned with the level found since it does not represent a significant health risk.

FINDINGS

Comprehensive testing of air, water, soil, and soil gas did not find any exposures to hazardous chemicals that could likely be associated with the birth defects. Similarly, historical records of facilities that operated in the area and investigations of possible illegal dumping of hazardous materials did not find evidence of chemical releases into the community that could pose risks of birth defects.

Cal/EPA's overall investigation found levels of environmental pollutants in the air, water and soil of Kettleman City to be comparable to those found in other San Joaquin Valley communities. Based on these findings, Cal/EPA does not believe there is anything unique about environmental conditions in Kettleman City that poses special health risks to residents.

The findings of our assessment are summarized below:

Agricultural operations

1. The risk of birth defects from pesticides is very low, both during the September 2006 to December 2009 period, and in 2010. Computer modeling and monitoring to evaluate 19 pesticides showed only a single day when the estimated air concentration of one pesticide, MITC, exceeded the screening level for birth defects.
2. The risk of other health effects from pesticides is uncertain, but likely lower than in other agricultural communities. Air monitoring in Kettleman City measured chlorpyrifos, endosulfan, methyl bromide, MITC, and trifluralin at concentrations below the lowest acute screening levels for all health effects. Estimated air concentrations for 2006-2009 using computer modeling exceeded the lowest acute screening levels for chlorpyrifos, diazinon, and MITC on several days. Historical air monitoring in other agricultural communities showed higher concentrations than detected in Kettleman City. This is consistent with the higher use of most pesticides near other communities.
3. DPR is already taking statewide action to address the risks that chlorpyrifos, diazinon, and MITC pose to agricultural communities. These activities (which involve risk assessments and development of appropriate mitigation measures) will reduce exposures in Kettleman City as well as other agricultural areas throughout the state. DPR beginning in 2011 will implement MITC mitigation measures statewide.

Kettleman Hills hazardous waste facility

1. Review of 2010 air monitoring data upwind and downwind of the facility, as well as at Kettleman City Elementary School, showed normal variability of air contaminants around the facility and in Kettleman City Levels of air contaminants did not differ markedly from contaminants measured in Fresno and

Bakersfield. Emissions originating from KHF as measured using fence-line monitoring were found not to affect the level of measured contaminants in the city.

2. A review of KHF air-monitoring data collected by the facility's contractor in 2007 to 2009 found that, overall, upwind and downwind levels of measured chemicals were similar to levels measured in Fresno. Similarly, there did not appear to be a substantial difference in air-monitoring data from 2007, when KHF was operating much as it has for many years, and 2010, when the facility reduced its operations.
3. The KHF is on top of geological formations that tilt to the west away from the Kettleman City area, thus preventing any possibility for groundwater flow from the KHF towards Kettleman City. Disposal and treatment operations at the KHF cannot affect groundwater wells in the community because of these geologic conditions.

- **Former industrial/commercial operations**

1. A review of historical records for former industrial or commercial operations in or near Kettleman City did not reveal information on contamination that may pose a threat to the community.
2. Soil-gas samples from commercial properties did not find evidence of contaminants that could migrate into the community through groundwater or air.

Municipal and school water wells

1. The community's publicly supplied drinking water contains elevated levels of arsenic. It is unlikely that arsenic in drinking water could have been a factor in the recent birth defects based on the concentrations measured and CDPH's findings that most mothers of children with birth defects who were interviewed did not use tap water for drinking water. There is still a need to reduce arsenic levels in the drinking water, either through an alternative drinking water source or improved treatment. Reduced levels of arsenic in drinking water would also lower risks of other health effects associated with arsenic.
2. Lead was detected in the well serving the Kettleman City Elementary School and in one duplicate sample taken from one of the municipal well at concentrations below the action level, and at levels common in California. However, previous monitoring at the school did not detect lead and only one duplicate sample had detectable lead.
3. The measurements of airborne benzene from the wellhead treatment unit at the southeast municipal water well were similar to average concentrations measured at the school. The results near the southwest unit were much higher on two of the three days when sampling occurred. Benzene emissions from the air stripping units do not appear to be affecting average air concentrations in Kettleman City. However, local concentrations near the southwest unit should be further investigated

Petroleum sources.

1. There is no indication that petroleum pipeline, former natural-gas wells in the vicinity of the town, gas stations, the oil-storage facility, or sporadic dumping or releases of oil wastes affected the town based on the lack of findings from the soil and water total petroleum hydrocarbon analyses and the lack of findings from the soil gas sampling.
2. All heavy metals from the soil samples (which may be naturally occurring but also may be a sign of contamination by petroleum-related chemicals) were consistent with background levels commonly found in the environment.

Illegal dumping

1. No evidence was found to corroborate rumors that illegal dumping of automobiles or household trash might have provided a source of exposure to contaminants. While household trash was observed on the western edge of the community, there was no evidence of a chemical release to the environment, nor did soil gas sampling in the vicinity indicate contamination.

Age and Condition of Homes

1. Soil and soil gas samples from residences did not find significant levels of contaminants, with the exception of one home with elevated soil levels of the pesticide chlordane. Arsenic levels in surface soil were consistent with levels measured elsewhere in the San Joaquin Valley and California where arsenic is naturally occurring. .
2. The one residence with elevated chlordane levels in the soil does not pose a threat to the community. However, DTSC should further investigate to determine if any remedial work is warranted.

Indoor dust and air

1. Cal/EPA determined that sampling of indoor dust and air was not warranted in the current and former homes of mothers who had children with birth defects. This sampling would not have provided useful information on indoor conditions during critical periods before and during the mothers' pregnancies.

Traffic-Related Diesel Exhaust

1. ARB's assessment of diesel exhaust found that estimated average concentrations of diesel exhaust particles in Kings County are less than neighboring Kern County and that the contribution to these air concentrations in Kettleman City from local sources was relatively small.

California Aqueduct, irrigation canals and agricultural soils

1. Water in the California Aqueduct and a local drainage canal had detectable levels of arsenic, and lead was detected in the canal water. These were below levels of health concern.
2. The one sediment sample taken from the drainage canal detected arsenic at levels comparable to those found in residential soils in the community.

3. The sampling found no evidence that contamination from the potential sources investigated in this assessment have contaminated fish that residents may catch and eat.
4. Samples of agricultural soil were similar to residential soil. No health concerns were found.

RECOMMENDATIONS

Although testing of air, water, soil, and soil gas did not identify a cause of the birth defects that occurred in Kettleman City from 2007 to 2009, the tests identified several environmental health issues that should be addressed.

Based on the test results, Cal/EPA recommends the following actions:

1) Continue to pursue a new source of drinking water for Kettleman City
2) Further review the possible lead contamination in the well that supplies water to the Kettleman City Elementary School
3) Continue assessment, and if needed, mitigation measures for applications of the pesticides methyl isothiocyanate (MITC), diazinon and chlorpyrifos
4) ARB work with the San Joaquin Air Pollution Control District to evaluate of the benzene emissions from the air stripping units at the southwest municipal water wells, particularly the southwest well
5) Further investigate the chlordane contamination in the soil at one home

Each recommendation is explained in greater detail below:

1. Reduce arsenic levels in Kettleman City's drinking water

Arsenic was the only metal found at a level of concern in home drinking water. The arsenic levels found in the home faucet water samples ranged from 9.8 to 19 micrograms per liter (µg/L). The arsenic concentrations were higher than the regulatory maximum contaminant level (MCL) of 10 µg/L in all but one of the tested homes. The public health goal (PHG), which is not a regulatory standard, for arsenic of 0.004 µg/L is substantially lower.

Although it is highly unlikely that the birth defects in the community were caused by arsenic in the water, these latest test results reinforce the importance of improving the quality of the drinking water in Kettleman City. Elevated levels of arsenic in drinking water can increase risks for a variety of other health ailments, including heart disease, stroke and cancer. Reducing arsenic levels – either through improved treatment of the existing water supply or identifying an alternative source of water -- will reduce these risks. The local water district is analyzing treatment options to ensure a sustainable solution to achieve compliance with the standard.

2. Investigate lead levels in well that supplies school's water

Elevated lead levels were detected in the well that supplies drinking water for the Kettleman City Elementary School and in one of the duplicate samples from one of the municipal wells. The lead concentration in water samples from the school's well and the municipal well were 5.1 µg/L and 2.3 µg/L, respectively. These lead levels are below the state's action level of 15 µg/L, but above the PHG of 0.2 µg/L. The significance of this finding is not clear, because in a previous test of the school's well water, in 2007, the lead was below the detection limit. Similarly, the lead level in the other duplicate sample from the municipal well was below the detection limit.

DTSC's findings of detectable lead in the water are not conclusive and may be the result of laboratory error. While lead was detected in the school and municipal wells, the findings were not consistent with previous tests of the well water. Furthermore, the lead levels detected by DTSC are commonly found in water throughout California. DTSC will conduct follow-up sampling to verify if there are detectable lead levels in the water.

3. Continue the assessment, and any necessary implementation of mitigation measures for MITC, chlorpyrifos and diazinon

While the Cal/EPA investigation did not find pesticide exposure to be a likely cause of the birth defects, the modeling analysis estimated that airborne levels of three pesticides – MITC, chlorpyrifos and diazinon – exceeded the screening levels. Kettleman City's volume of MITC use ranked 8th among 161 Central Valley communities studied for those three years.

Previous air monitoring for these three pesticides in the high use areas of California and at application sites also indicated concentrations of possible concern. Moreover, misapplications or unusual applications of MITC pesticides have caused several neighborhood evacuations elsewhere in California. This information led DPR to start comprehensive risk assessments for all three pesticides. DPR's comprehensive risk assessments include the evaluation of all exposures, including acute and chronic exposure, possible birth defects, and cancer risk. These risk assessments are in progress for chlorpyrifos and diazinon. The risk assessment for MITC is complete and it prompted DPR to develop measures to reduce exposures. DPR will implement the MITC exposure mitigation measures beginning in 2011 that include application method restrictions and buffer zones. In addition, U.S. EPA is phasing in mitigation measures nationwide for MITC pesticides beginning in December 2010.

The timely implementation of assessments and mitigation measures for these three pesticides will benefit the residents of Kettleman City, as well as residents of other California agricultural communities.

4. Evaluation of the benzene emissions from the air stripping units at the municipal water wells

Benzene found in the municipal water well necessitates the use of treatment units at each of the two wells to remove the benzene before the water enters the distribution system. Two of the three samples at the southwest treatment unit found elevated levels of benzene.

The measured benzene emissions are too low in volume to pose a general health risk to the community. However, there may be unnecessary exposures to benzene in the immediate surrounding area.

For this reason, we recommend that ARB should work with the San Joaquin Air Pollution Control District to further evaluate these units and determine if they need to be permitted and be subject to control measures.

5. Additional Review of Chlordane Contamination

High levels of chlordane, a banned pesticide that was formerly used to control termites, were found in some of the soil samples from one Kettleman City residence. These levels do not pose health concerns for the community as a whole. However, some of the measured levels are two to three times higher than OEHHA's California Human Health Screening Level (CHHSL) for chlordane. These screening levels are intended to help gauge the level of contamination on a specific site. The level of hazard, if any, on this property is not clear, as three other soil samples from the same residence had much lower concentrations of chlordane. None of the other residences where soil was sampled had high levels of chlordane.

The most likely source of the chlordane is a past application to prevent a termite infestation, However, DTSC will further investigate to identify the source of the chlordane contamination at this residence and determine whether remedial action is needed.

GLOSSARY OF TERMS

Air stripping treatment unit: Equipment that passes large amounts of air through water and then vents dissolved gases or volatile compounds into the air. The goal is to remove volatile contaminants from water.

Air Cancer Risk (ACR): A level of a cancer-causing air contaminant that poses no significant risk from lifetime exposure to the chemical. They are calculated by OEHHA as part of ARB's Toxic Contaminants Program and by U.S. EPA.

Birth defects: Physical abnormalities that are present at birth; they are also called congenital abnormalities. A birth defect is a type of developmental effect (see below).

California Human Health Screening Levels (CHHSLs): Levels of contaminants in soil and soil gas that do not pose a significant risk to public health and safety. They are based on evaluations of various soil contaminants conducted by OEHHA and U.S. EPA. A CHHSL is an advisory number intended to assist with the cleanups of soil contamination.

Cholinesterase Inhibition: Cholinesterase is one of many important enzymes needed for the proper functioning of the nervous systems of humans and insects. Certain chemical classes of pesticides, such as organophosphates (OPs) and carbamates (CMs) work against undesirable insects by interfering with, or 'inhibiting' cholinesterase's function. While the effects of cholinesterase inhibiting products are intended for insect pests, these chemicals can also be toxic to humans in some situations.

Criteria air pollutant: An air pollutant for which an ambient air quality standard has been set. Examples include: ozone, carbon monoxide, nitrogen dioxide, sulfur dioxide and PM2.5.

Developmental effects: Effects in the developing child which include birth defects, low birth weight, biological dysfunctions, or psychological or behavioral deficits that develop as the child grows.

Diesel emissions: Diesel engines emit a complex mix of pollutants, the most visible being very small carbon particles or "soot", known as diesel PM. Diesel exhaust also contains over 40 cancer-causing substances, most of which are readily adsorbed on the soot particles. In 1998, California identified diesel PM as a "toxic air contaminant" based on its potential to cause cancer, premature death, and other health problems.

Health screening level: An air concentration for a chemical that is used by DPR to evaluate monitoring results. Although not a regulatory standard, a measured air concentration that is below the health screening level for a given pesticide would not be considered to represent a significant health concern.

Maximum Allowable Dose Levels (MADLs): Levels developed by OEHHA that apply to individual chemicals on the state's Proposition 65 list of chemicals that cause reproductive and developmental toxicity. MADLs identify a level of exposure to a chemical that is 1,000 times less than the level that has been shown in studies to cause no observable reproductive or developmental effects.

Maximum Contaminant Levels (MCLs): Health-protective drinking water standards adopted by CDPH to be met by public water systems. MCLs take into account not only chemicals' health risks but also factors such as their detectability and treatability, as well as costs of treatment. California law requires CDPH to establish a contaminant's MCL at a level as close to its PHG as is technically and economically feasible, placing primary emphasis on the protection of public health.

Media: One of the major categories of material found in the physical environment that surrounds or contacts organisms, e.g., surface water, ground water, soil, or air, and through which chemicals or pollutants can move and reach the organisms.

MITC pesticides: MITC is a breakdown product of metam-sodium and metam-potassium, two pesticides used to fumigate soil before planting crops (for example, carrots, peppers, potatoes, and tomatoes. The pesticides are applied through sprinkler, drip, or flood irrigation systems, injected into the soil, or sprayed on the soil surface. When they contact warm, moist soil, they break down quickly to MITC and other volatile gases.

Organochlorine pesticides (OCPs): A large class of multipurpose chlorinated hydrocarbon chemicals, some of which are highly toxic. Due to their toxicity, most have been banned in the U.S. (e.g., chlordane and DDT). OCPs are extremely persistent in the environment and can accumulate in the fatty tissues of humans and animals.

Particulate matter (PM): A complex mixture of extremely small particles and liquid droplets made up of a number of components, including acids (such as nitrates and sulfates), organic chemicals, metals, and soil or dust particles. California and federal ambient air quality standards are established for respirable PM (particles with a diameter of 10 microns and smaller, referred to as PM10) and fine particulate matter (particles with a diameter of 2.5 microns and smaller, referred to as PM2.5). Diesel exhaust contributes to airborne PM2.5.

Petroleum product –A material derived from crude oil (petroleum) as it is processed in oil refineries (e.g., gasoline, home heating oil, lubricants).

Polychlorinated biphenyls (PCBs): PCBs belong to a broad family of man-made organic chemicals known as chlorinated hydrocarbons. Before banned in 1979, PCBs were used as coolants and lubricants in transformers, capacitors, and other electrical equipment. PCBs bind strongly to soil and may persist in the environment for long

periods of time. Some studies of workers indicate that PCBs are associated with certain kinds of cancer in humans, such as cancer of the liver.

Public Health Goals (PHGs): Estimates of contaminant levels in drinking water that would pose no significant health risk to individuals consuming the water on a daily basis over a lifetime. PHGs are non-mandatory goals developed by OEHHA and are used by CDPH to develop MCLs.

Reference Exposure Levels (RELs): Airborne concentrations that are not anticipated to present a significant risk of an adverse non-cancer health effect. RELs are developed by OEHHA for acute, 8-hour, and chronic exposures.

Soil gas: Gaseous elements and compounds in the small spaces between particles of the earth and soil. Such gases can be moved or driven out under pressure.

Total petroleum hydrocarbons (TPH): A family of several hundred chemicals that originally come from crude oil and are present in petroleum products. Because there are so many hydrocarbons in petroleum products, it is not practical to measure each one separately. Examples of chemicals found in TPH are benzene, ethyl benzene, and naphthalene.

Underground storage tanks (USTs): Large containers used to hold and prevent the release of petroleum products into the surrounding environment. They are used throughout North America at gas stations, and many have leaked, allowing petroleum to contaminate the soil and groundwater.

Volatile organic compounds (VOCs): A wide range of chemicals that evaporate readily into vapor form (gases) at room temperature, some of which may cause short- and long-term adverse health effects. VOCs are emitted by a wide array of products, including paints, pesticides, building materials, and cleaning supplies.

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