Health Consultation

Red Butte Creek Oil Spill: Soil and Sediment. Analysis of Polycyclic Aromatic Hydrocarbons

Salt Lake City, Salt Lake County, Utah

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Office of Epidemiology
Utah Department of Health
Under a Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry

TABLE OF CONTENTS

SUMMARY

INTRODUCTION

On Saturday, June 12, 2010, a high-voltage electrical arc, from a parallel above-ground power line followed a fence pole into the ground to a Chevron crude oil transfer pipeline, creating a small hole approximately one-half inch in diameter in the pipeline. This break resulted in a crude oil leak that spilled directly into Red Butte Creek in Salt Lake City, Utah. The leak was not detected until mid-morning Saturday, June 12. The pipeline was shut down once the leak was detected. It is estimated that approximately 33,600 gallons of crude oil spilled into Red Butte Creek. The creek travels through both residential and business properties in Salt Lake City. These include neighborhoods from the University of Utah southwest through Liberty Park. One neighborhood, Yalecrest, contains several properties bordered or traversed by Red Butte Creek. Yalecrest has been registered as a historic community due to its architectural home design and small business districts.

Although remediation of the oil and restoration of the creek has occurred, many area residents are concerned about chronic health effects resulting from exposure to crude oil. In October, 2011, the EEP released a Public Health Assessment (PHA) addressing acute health concerns related to crude oil exposure, particularly volatile organic compounds (VOCs). This current document is an extension of that PHA and addresses community concerns regarding exposures to polycyclic aromatic hydrocarbons (PAHs) in the water and creek soil sediment. After addressing these concerns with the Salt Lake Valley Health Department (SLVHD), the health officer asked the Environmental Epidemiology Program (EEP) in the Utah Department of Health (UDOH) to evaluate the data and create this health consultation (HC).

This HC addresses the crude oil contaminants and the environmental compartments that were impacted during the spill, specifically focusing on water and soil. It also addresses the potential for long-term health impacts in the community from exposure to components of crude oil.

CONCLUSION 1	Based on review of the sampling data, the EEP concludes that exposure to PAHs from Red Butte Creek soil and sediment does not present a health hazard to the community.
BASIS FOR DECISION	Based on review of the sampling data, the EEP concludes that all PAHs except benzo[a]pyrene (B[a]P) and dibenz[*a,h*]anthracene (DBA) were less than comparison values (CVs). B[a]P and DBA were further evaluated by calculating exposure doses for cancer and non-cancer risks assuming recreational use of the creek. Calculated non-cancer doses were well below EPA RfD values. The calculated cancer risk posed by B[a]P and DBA contamination was below the EPA designated excess cancer risk of 1 in 1,000,000.
NEXT STEPS	The EEP will continue to provide residents with information regarding the health effects associated with exposures to PAHs. The EEP will review new information as it becomes available and revise this assessment if necessary. The EEP will continue to address residents' health concerns.
CONCLUSION 2	Based on review of the sampling data, the EEP concludes that Red Butte Creek surface waters do not pose a health hazard associated with exposure to PAHs.
BASIS FOR DECISION	The Red Butte Creek surface waters samples did not contain detectable levels of PAHs.
NEXT STEPS	The EEP will continue to provide residents with information about the contaminants of concern and health effects for acute and chronic exposures.
FOR MORE INFORMATION	You may call UDOH at (801) 538-6191 and ask for additional information about the Chevron Red Butte Creek Oil Spill Health Consultation.

PURPOSE AND HEALTH ISSUES

The Environmental Epidemiology Program (EEP) at the Utah Department of Health (UDOH) prepared this Health Consultation to evaluate the human health risks from potential exposure to crude oil during a pipeline release into Red Butte Creek. Residents and visitors to the area were concerned about the movement of contaminants into the water column, sediments and air, as well as any adverse health effects that can be correlated to exposure. The EEP evaluates the human health risks of exposure to environmental contaminants in Utah through a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR).

The mission of ATSDR is to serve the public by applying the best science, taking responsive public health actions, and providing trusted health information to prevent harmful exposures and disease(s) related to toxic substances. The health officer at Salt Lake Valley Health Department (SLVHD) has requested that the EEP conduct this assessment to identify public health hazards posed by the oil spill to the surrounding area. The assessment process serves as a mechanism to help ATSDR and state health departments determine where public health actions should be addressed and for whom. The primary objective of this assessment is to determine if the residents living in close proximity to Red Butte Creek in Salt Lake City, Utah, were exposed to crude oil contaminants through any environmental pathway resulting from the Chevron oil spill, and if so, to develop appropriate public health interventions.

The Chevron oil spill was brought to the attention of the EEP in June of 2010. Community residents concerned about the short and long-term health effects associated with living near an oil spill voiced their concerns to the SLVHD. The SLVHD in turn requested that the EEP examine data related to the spill and evaluate potential acute and chronic health effects following exposure. The EEP finalized a public health assessment (PHA) in September 2011 that analyzed the hazards of the crude oil spill in terms of volatile organic compound (VOC) exposures. This health consultation (HC) addresses community concerns regarding another group of hazardous substances found in crude oil termed polycyclic aromatic hydrocarbons (PAHs).

Red Butte Creek originates in the Wasatch Mountains and flows southwest into the Jordan River, which drains into the Great Salt Lake. There are several areas along this route where the creek flows underground in culverts. However, the majority of the spill was contained at the retention pond in Liberty Park. There are approximately 600 residences in this area and it is estimated that approximately 1,800 citizens may have been impacted by the oil spill.

BACKGROUND

Oil Spill

Evidence suggests that in the early morning hours of Saturday June 12, 2010, an electrical arc created a one-half inch hole in the top of a steel crude oil pipe. As a result, approximately 800 barrels (33,600 gallons) of crude oil were released, traveling down Red Butte Creek and collecting in Liberty Park Pond with some sheen escaping into the Jordan River. At approximately 6:55 a.m. on Saturday, June 12, 2010, Salt Lake City Police/Fire were dispatched on a complaint of petroleum odors on the grounds of the Veteran's Administration (VA) facility at 500 Foothill Drive. This led to the discovery of significant amounts of crude oil in Red Butte Creek, which runs through the VA property.

At approximately 7:45 a.m., Chevron was alerted to the problem by the Salt Lake City Fire Department (SLCFD). After reviewing the logs for the pipeline, Chevron noticed unusual changes in the pipe-flow monitoring data for about 10:00 p.m. on Friday, June 11, 2010.

Once the scope of the problem was assessed, the SLCFD called in its own Hazardous Materials (Hazmat) Team to assist in the early mitigation phase. A construction company with excavating equipment that was on scene at a nearby project was asked to assist. Construction workers used a large backhoe to dig several temporary containment ponds. Chevron sent a truck to the site of the spill to pump oil from the ponds and transport the crude to the local Chevron refinery just north of Salt Lake City.

By evening on June 12, the leak had been effectively stopped and the focus had turned to remediation efforts, including controlling shoreline residue and riverbed damage as well as wildlife assistance and treatment. Absorbent booms were placed at the outlets of two culverts to contain the oil leak and prevent its migration into the Great Salt Lake. Hogle Zoo became the receiving point for all distressed wildlife and waterfowl. The zoo staff, with assistance from volunteers, treated and cleaned over 200 waterfowl and held them for observation. Additional oil-covered birds were collected by Salt Lake City teams and brought to an offsite location to be cleaned.

SLVHD and the Utah Department of Environmental Quality (UDEQ) conducted ongoing surface and air sampling on and near Red Butte Creek and the Jordan River to quantify the extent of the spill as well as the expected concentrations of exposure for communities residing in close proximity to the spill.

The affected waterways were not part of Salt Lake City's domestic water supply. Salt Lake City utility officials determined after appropriate sampling and monitoring that the spill had not impacted municipal drinking water. Although the city did not expect drinking water to be affected, it was regularly monitored during remediation for crude oil contaminant encroachment.

Of the oil spilled into Red Butte Creek, Chevron officials confirmed that approximately 600 barrels of crude oil, roughly 25,200 gallons, were collected and taken back to the refinery during the initial remediation phase of the spill. An estimated 100 barrels (4,200 gallons) evaporated into the atmosphere from the water's surface, leaving approximately 85 barrels (3,570 gallons) for further remediation (UDEQ, 2012).

Red Butte Creek and Canyon

Red Butte Creek is a perennial third-order[1] stream that flows southwest into the Jordan River, which eventually drains into the Great Salt Lake. The basin sharing the same name is located in the middle Rocky Mountains in the western foothills of the Wasatch Mountain range. The creek is without upstream regulation (dams, flow control gates, etc.) or diversion until the flow is collected by a reservoir at the base of the canyon. The creek has created a narrow canyon with steep sides rising at an average slope of 35 degrees on the north side and 40 degrees on the south side (Ehleringer et al., 1992). Immediately upstream of the reservoir is a U.S. Geological Survey Hydrologic Bench Mark Station, which has monitored monthly flow rate and discharge since January 1942.

The average monthly discharge rate recorded between 1964 and 1988 was approximately 4.7 ft^3/sec as it entered the reservoir at an elevation of 5,400 feet (ReMillard et al., 1996). Stream flow exhibits a straightforward annual pattern characteristic of this region, with high flows in the spring during snowmelt followed by reduced flows in the summer and early fall.

The climate along Red Butte Creek is characterized by hot, dry summers, and long, cold winters. The majority of precipitation falls in the winter and spring, with the summer being less predictable due to monsoonal systems which sweep across northern Utah. Mean annual precipitation ranges from about 20 inches at the lower elevations to approximately 35 inches at the higher elevations (Hely et al., 1971).

Soils in the basin are classified as mollisols[2], consisting of well-drained soils that are formed from mixed sedimentary rocks (Woodward, 1974). There is not much diversity among soils in the basin; most consist of a layer of dark- to reddish-brown, cobbly, loamy sand on top of bedrock. The depths of soils vary from 50 to 150 cm depending on which way the slope faces (south or north, respectively). Soils are neutral to slightly alkaline, with a pH range between 6.1 and 8.4, and the more alkaline soils are coated with lime (Woodward, 1974).

Land Use and Demographics

Impacted Area

The residential area surrounding Red Butte Creek is part of metropolitan Salt Lake City; therefore, demographic information is based on data at the census block group level. The impacted area includes properties along Red Butte Creek from the spill site to Liberty Park. Census block groups[3] corresponding to this area are: 101400.1-2, 103000.1, 103500.1-3, 103600.1-2, 104100.1-2, and 104200.3. The 2000 Census data estimates the population of this area is 16,550. The following is a description of one of several neighborhoods that make up the area.

[1] Streams are categorized by order; a first-order stream has not intersected with any other streams. A second-order stream results from the intersection of two first-order streams. A perennial third-order stream is simply a stream that was created by the intersection of two second-order streams, and runs year-round.

[2] Mollisoils form in semi-arid to semi-humid environments, under a grassland cover usually in savannahs or mountain valleys. The defining characteristic of mollisoils is the deep layer of organic matter in the surface soil.

[3] A census block group is the smallest grouping of geographical data that is used by the U.S. Census Bureau. Census block groups usually contain 600-3,000 people. There are 211,267 census block groups in the United States.

Yalecrest neighborhood

Yalecrest is bordered by Sunnyside Avenue to the north, 1900 East and 1300 East to the east and west, respectively and 1300 South to the south in Salt Lake City. This area is comprised of older, historic homes and three large recreational parks. Yalecrest was listed on the National Register of Historic Places in 2007. Red Butte Creek runs through many properties in the Yalecrest community and the creek's health and continued success have been a priority in the community for many years.

The community contains residential, commercial and recreational areas, including a theater and a small shopping area. The majority of the area is residential with homes and yards. Yalecrest also has a well-established neighborhood council to provide input and information to all Salt Lake City departments. It is led by a board of five volunteer officers that serve a one year term.

With three large parks within the Yalecrest community, several types of outdoor recreational activities including hiking, biking, walking, jogging, football, tennis, baseball, soccer and picnicking are common in the surrounding areas. The community is on a public water system and does not receive its drinking water from Red Butte Creek, although children have been observed playing in the creek during the warm summer months.

Because the area affected by the spill is considered a community within Salt Lake City, there is no accurate or current census data for the community available. However, it was estimated that approximately 600 homes and 1,800 residents were impacted by the oil spill. These estimates include the areas outside of Yalecrest that also border Red Butte Creek's path.

Site History

Red Butte Creek water was first utilized by Utah pioneers who diverted its waters, along with those of Emigration Creek, to City Creek for use as the city's main water supply. This use ended in 1862 when the Army constructed two reservoirs east of Fort Douglas and diverted Red Butte Creek to fill them for their use. In 1890, Congress gave the creek protected status and prevented future development along the watershed in response to concerns about water quality resulting from quarrying of red sandstone. Red Butte Canyon is currently managed by the United States Forest Service and the watershed is considered one of the best of the Wasatch Front. The area has been considered a Research Natural Area since 1969 and was described as "a living museum and biological library of a size that exists nowhere else in the Great Basin…an invaluable benchmark in ecological time" (Ehleringer et al., 1992). As a result of this designation, the area is well studied and has a large diversity of plant and animal life.

Presently, Red Butte Creek flows west out of Red Butte Canyon and through several areas of Salt Lake City, including Red Butte Garden and Arboretum, the University of Utah and Liberty Park. The creek borders and/or runs through many properties along its course, but also runs underground in culverts in several areas before emptying into the Jordan River. The creek's underground path does not impact area aquifers.

Surface Water Sampling
Samples of water analyzed for PAHs were collected from various locations along Red Butte Creek from June 1, 2011 to October 27, 2011. These water samples were analyzed for inorganic and organic content by American West Analytical Laboratories. The locations of each sample and analytical results are found in Table 2 (Appendix B).

Soil and Sediment Sampling
Soil and sediment samples were taken from various locations along Red Butte Creek. The first samples were collected on December 1, 2010. Subsequent sampling batteries were taken in February, July, August and September of 2011. These samples were assayed for their organic and inorganic composition by American West Analytics Laboratories and ALS Environmental Services. The locations of sample collection, date, and analytical results for Poly Aromatic Hydrocarbons (PAHs) are found on Table 1 (Appendix B).

DISCUSSION

Nature and Extent of Contamination

Sampling data revealed that PAHs were present in Red Butte Creek (RBC) sediment following the oil spill. However PAHs are generated by many sources (see contaminant discussion below) and the levels currently found in the RBC are comparable to those found in similar creeks located in the Salt Lake City metropolitan area.

There have been seven oil spills that have been studied regarding health effects from exposure to crude oil components (Aguilera et al., 2010; Janjua et al., 2006; Lyons et al., 1999; Campbell et al., 1993). All studies focused on acute effects and only a few extended studies beyond one year. In addition, most epidemiological analyses of chronic effects from crude oil exposures are occupational studies where exposures have occurred for many years (Kirkeleit et al., 2008). As a result, chronic effects of acute exposures to crude oil are not well understood.

This PHA addresses the potential for health effects based on exposure to components of crude oil. In addition, recent exposure events in the United States, specifically future published reports on investigations involving the Gulf Oil Spill and the Enbridge Oil Spill in Michigan, may provide future insight into health effects following acute or intermediate exposures.

Exposure Pathways Analysis

To determine if nearby residents, visitors, and workers are exposed to contaminants related to a site, ATSDR evaluates the environmental and human components that lead to human exposure. An exposure pathway consists of five elements (ATSDR, 2005):

(1) A source of contamination;
(2) Transport through an environmental medium;
(3) A point of exposure;
(4) A route of human exposure; and
(5) A receptor population.

ATSDR categorizes an exposure pathway as either *completed, potential, or eliminated*. In a *completed* exposure pathway, all five elements exist and indicate that exposure to a contaminant has occurred in the past, is occurring, or will occur in the future. In a *potential* exposure pathway, at least one of the five elements has not been confirmed, but it may exist. Exposure to a contaminant may have occurred in the past, may be occurring, or may occur in the future. An exposure pathway can be *eliminated* if at least one of the five elements is missing and will never be present (ATSDR, 2005).

When an exposure pathway is identified, comparison values (CVs) for air, soil, or drinking water are used as guidelines for selecting contaminants that require further evaluation (ATSDR, 2005). To protect susceptible populations, the CVs for children are used when available.

The exposure routes identified in this HC are the water pathway (residential and non-residential) and the soil and sediment pathway. Analytical samples were collected in both of these environmental compartments in order to evaluate the potential health impacts on the community.

Creek soil sediment: completed exposure pathway
Red Butte Creek is accessible to those who reside near the creek as well as to those who were involved in remediation. In addition, there are several areas where public access is likely (i.e., parks). All five elements of exposure exist in the surrounding community and other neighborhoods directly adjacent to the creek.

Exposure element	Red Butte Creek oil spill
1) A source of contamination……………….....	Red Butte Creek oil spill
2) Transport through environmental medium...	leak directly into creek water
3) A point of exposure………………………..	contact with contaminated soil and sediment directly or indirectly (i.e., playing in the creek, remediating the creek)
4) A route of human exposure……………..….	ingestion of creek soils
5) A receptor population……………………...	residents in contaminated area

Creek water: completed exposure pathway

Exposure element	Red Butte Creek oil spill
1) A source of contamination……………….....	Red Butte Creek oil spill
2) Transport through environmental medium...	leak directly into creek water and carried to the sediment
3) A point of exposure………………………..	contact with contaminated water directly or indirectly (i.e., playing in the creek, remediating the creek)
4) A route of human exposure……………..….	ingestion of creek soils
5) A receptor population……………………...	residents in contaminated area

Water and soil samples were collected from the entire length of the creek between spill site and Liberty Park pond (Figs 1, 2, 3 Appendix A). These samples were evaluated as to the risks to residents living within close proximity to the spill and those utilizing it recreationally.

Estimated exposure doses and the health effects associated with exposure to crude oil contaminants will be discussed in the "Exposure Dose Estimates and Toxicological Evaluation" section of this document.

Public Health Implications

Levels of contaminants that exceed CV will not necessarily cause adverse health effects upon exposure. The potential for exposed persons to experience adverse health effects depends on many factors, including:

(1) The amount of each chemical to which a person is or has been exposed;
(2) The length of time that a person is exposed;
(3) The route by which a person is exposed (inhalation, ingestion, or dermal absorption);
(4) The health condition of the person;
(5) The nutritional status of the person; and
(6) Exposure to other chemicals (such as cigarette smoke or chemicals in the work place).

Evaluation Process

The EEP examined the types and concentrations of each chemical of concern for each media type (soil, groundwater, air, etc.) in which the chemical was measured. ATSDR and EPA comparison values (CVs) were then used to screen for chemicals of concern that would warrant further evaluation for a possible risk to human health. CVs are media-specific concentrations of contaminants that can be reasonably assumed to be harmless when assuming default conditions of exposure. These values are generally conservative concentrations used to ensure the protection of sensitive populations, most notably pregnant women and growing children. Values of contaminants that exceed the CVs do not indicate that a health risk exists; it merely indicates that further evaluation is required for these chemicals.

Exposure Dose Estimates and Toxicological Evaluation

For this Health Consultation, the primary chemicals of concern for the Red Butte Creek oil spill were PAHs. Exposure doses for children and adults were calculated and reported below.

For present and future exposure, accidental ingestion of creek water or soil are the most likely pathways of contaminant exposure for those utilizing Red Butte Creek.

Therefore, the exposure pathways described above were assessed using doses calculated from the highest contaminant levels found associated with each pathway. Exposure doses were then compared with health guidelines. These guidelines are conservative health-protective values that have been developed using human exposure data when it is available from scientific literature. When human data is not available, animal exposure data is used. Health guidelines used in this report include ATSDR's Minimal Risk Levels (MRLs) and EPA's Reference Doses (RfDs). Exposure doses that are lower than the MRL or RfD are considered to be without appreciable risk to human health. If a calculated exposure dose exceeds the health guidelines, the dose is then compared to values from individual studies documented in the scientific literature that have reported health effects. These values may be No Observable Adverse Effect Levels (NOAEL) or Lowest Observable Adverse Effect Levels (LOAEL). If a contaminant has been determined by the scientific literature to be cancer causing (carcinogenic), a cancer risk is also estimated (ATSDR, 2005). The calculations for determining exposure dose for oral ingestion and inhalation can be found in Appendix C.

Polycyclic Aromatic Hydrocarbons (PAHs)

PAHs are a group of chemicals that are formed during the incomplete burning of coal, oil, gas, wood, garbage, or other organic substances, such as tobacco and charbroiled meat. There are more than 100 different PAHs. PAHs generally occur as complex mixtures, not as single compounds. As pure chemicals, PAHs generally exist as colorless, white, or pale yellow-green solids. They have a faint, pleasant odor. A few PAHs are used in medicines and to make dyes, plastics, and pesticides. Others are contained in asphalt used in road construction. They can also be found in crude oil, coal, coal tar pitch, creosote, and roofing tar. They are found throughout the environment in the air, water, and soil. Additionally, they can occur in the air, either attached to dust particles or as solids in soil or sediment (ATSDR, 1995).

Although the health effects of individual PAHs are not exactly alike, the following PAHs are part of a group profiled together by ATDSR; table A lists the PAHs and their respective CVs.

Table A. PAH species and respective comparison values.

PAH Species	Comparison Values (ppm)	Type/Source
acenaphthene	1,000	RMEG/ ATSDR, 1995
anthracene	20,000	RMEG/ ATSDR, 1995
benzo[a]pyrene	0.1	CREG/ ATSDR, 1995
fluoranthene	800	RMEG/ ATSDR, 1995
fluorene	800	RMEG/ ATSDR, 1995
pyrene	2,000	RMEG/ ATSDR, 1995
benz[a]anthracene	1*	CREG*/ ATSDR, 1995; EPA, 2011b
benzo[e]pyrene	2,000*	RMEG*/ ATSDR, 1995
benzo[b]fluoranthene	1*	CREG*/ ATSDR, 1995; EPA, 2011b
benzo[j]fluoranthene	800*	RMEG*/ ATSDR, 1995
benzo[g,h,i]perylene	2,000*	RMEG*/ ATSDR, 1995
benzo[k]fluoranthene	10*	CREG*/ ATSDR, 1995; EPA, 2011b
chrysene	10*	CREG*/ ATSDR, 1995; EPA, 2011b
dibenz[a,h]anthracene	0.1*	CREG*/ ATSDR, 1995; EPA, 1995
indeno[l,2,3-c,d]pyrene	1*	CREG*/ ATSDR, 1995; EPA, 2011b
phenanthrene	20,000*	REMG*/ ATSDR, 1995

CREG- cancer risk evaluation guide
RMEG- non-cancer reference dose evaluation guide
* value estimated based on chemical similarity (RMEG), or carcinogen potency (CREG) relative to B[a]P (EPA, 2011b)
Note- CV values listed as ppm (parts per million); values in Appendix C listed as ppb (parts per billion), 1 ppm= 1000 ppb

The comparison value (CV) is the calculated concentration of the substance in air, water, food, or soil that is unlikely to cause harmful (adverse) health effects in exposed people. Substances found in amounts greater than their CVs are selected for further evaluation.

These PAHs were grouped into one profile by ATSDR because (1) more information is available on these than on others; (2) they are suspected to be more harmful than some of the others, and they exhibit harmful effects that are representative of the PAHs; (3) there is a greater chance of exposure to these PAHs than to others; and (4) of all the PAHs analyzed by ATSDR, these were identified at the highest concentrations at National Priorities List (NPL) hazardous waste sites. The samples from Red Butte Creek were analyzed for all PAHs.

PAHs enter the environment mostly as releases to air from volcanoes, forest fires, residential wood burning, and exhaust from automobiles and trucks. They can also enter surface water through discharges from industrial plants and waste water treatment plants, and they can be released to soils at hazardous waste sites if they escape from storage containers.

The movement of PAHs in the environment depends on properties such as how easily they dissolve in water, and how easily they evaporate into the air. PAHs in general do not easily dissolve in water. They are present in air as vapors or stuck to the surfaces of small solid particles. They can travel long distances before they return to earth in rainfall or particle settling. Some PAHs evaporate into the atmosphere from surface waters, but most stick to solid particles and settle to the bottoms of rivers or lakes. In soils, PAHs are most likely to stick tightly to particles. Some PAHs evaporate from surface soils to air. Certain PAHs in soils also contaminate underground water.

The PAH content of plants and animals living on the land or in water can be many times higher than the content of PAHs in soil or water. PAHs can break down to longer-lasting products by reacting with sunlight and other chemicals in the air, generally over a period of days to weeks. Breakdown in soil and water generally takes weeks to months and is caused primarily by the actions of microorganisms.

The primary sources of exposure to PAHs for most of the U.S. population are inhalation of the compounds in tobacco smoke, wood smoke, and ambient air, and consumption of PAHs in foods. Exposures to PAHs most commonly occur at home, outside, or at the workplace. In the home, PAHs are present in tobacco smoke, smoke from wood fires, creosote-treated wood products, cereals, grains, flour, bread, vegetables, fruits, meat, processed or pickled foods, and contaminated cow's milk or human breast milk. Food grown in contaminated soil or air may also contain PAHs. Cooking meat or other food at high temperatures (during grilling or charring) also increases the amount of PAHs in the food.

For some people, the primary exposure to PAHs occurs in the workplace. PAHs have been found in coal tar production plants, coking plants, bitumen and asphalt production plants, coal-gasification sites, smoke houses, aluminum production plants, coal tarring facilities, and municipal trash incinerators. Workers may be exposed to PAHs by inhaling engine exhaust and by using products that contain PAHs in a variety of industries such as mining, oil refining, metalworking, chemical production, transportation, and the electrical industry. PAHs have also been found in other facilities where petroleum, petroleum products, or coal are used or where wood, cellulose, corn, or oil are burned. People living near waste sites containing PAHs may be exposed through contact with contaminated air, water, and soil.

The rate at which PAHs enter the body by eating, drinking, or through the skin can be influenced by the presence of other compounds. PAHs can enter all tissues that contain fat. They tend to be stored mostly in the kidneys, liver, and fat. Smaller amounts are stored in the spleen, adrenal glands, and ovaries. PAHs are changed by all tissues in the body into many different substances. Some of these substances are more harmful than the original PAHs. Results from animal studies show that PAHs do not tend to be stored in the body for a long time. Most PAHs that enter the body leave within a few days, primarily in the feces and urine.

PAHs can be harmful to health under some circumstances. Several of the PAHs have caused tumors in laboratory animals when they breathed these substances in the air, when they ate them, or when they had long periods of skin contact with them. Human studies show that individuals exposed by breathing or skin contact for long periods to mixtures that contain PAHs and other compounds can also develop cancer (ATDSR, 1995).

Exposure to benzo[a]pyrene has shown to have harmful effects on the reproductive system and fetus of mice. ATSDR states similar effects could occur in people; however there is no information to show these effects do occur (ATDSR, 1995). Other studies in animals have shown that PAHs can cause harmful effects on skin, body fluids, and the body's system for fighting disease after both short and long-term exposure. These effects have not been reported in people.

The results of sampling data determined that levels of acenaphthene, anthracene, fluoranthene, fluorene, and pyrene were not above CV; therefore, exposure doses were not calculated and no adverse health effects are likely. Benzo[a]pyrene sampling data showed levels above its CV, therefore, exposure dose calculations for B[a]P were performed.

Benzo[a]pyrene

Benzo[a]pyrene (B[a]P) is formed when gasoline, garbage, or any animal or plant material burns and is usually found in smoke and soot. This chemical can combine with dust particles in the air and is carried into water and soil and onto crops. Benzo[a]pyrene is found in the coal tar pitch that industry uses to join electrical parts together. It is also found in creosote, a chemical used to preserve wood.

People may be exposed to B[a]P from environmental sources such as air, water, and soil and from cigarette smoke and cooked food. Workers who handle or are involved in the manufacture of PAR-containing materials may also be exposed to B[a]P. Typically, exposure for workers and the general population is not to B[a]P alone but to a mixture of similar chemicals.

The general population may be exposed to dust, soil, and other particles that contain B[a]P. The largest sources of B[a]P in the air are open burning and home heating with wood and coal. Factories that produce coal tar also contribute small amounts of B[a]P to the air. People may come in contact with B[a]P from soil on or near hazardous waste sites, such as former gas-manufacturing sites or abandoned wood-treatment plants that used creosote. At this time, B[a]P has been found at 110 out of 1,117 sites on the National Priorities List (NPL) of hazardous waste sites in the United States. As more sites are evaluated by the Environmental Protection Agency (EPA), this number may change (ATSDR, 1990).

The soil near areas where coal, wood, or other products have been burned is another source of exposure. Exposure to B[a]P and other PAHs may also occur through skin contact with products that contain PAHs such as creosote-treated wood, asphalt roads, or coal tar.

People may also be exposed to B[a]P by drinking water from the drinking water supplies in the United States that have been found to contain low levels of the chemical. Foods grown in contaminated soil or air may contain B[a]P. Cooking food at high temperatures, as occurs during charcoal grilling or charring, can increase the amount of B[a]P in the food. Benzo[a]pyrene has been found in cereals, vegetables, fruits, meats, beverages, chewing tobacco, and in cigarette smoke (ATSDR, 1990).

The most common way B[a]P enters the body is through the lungs when a person breathes in air or smoke containing it. It also enters the body through the digestive system when substances containing it are swallowed. Although B[a]P does not normally enter the body through the skin, small amounts could enter if contact occurs with soil that contains high levels of B[a]P (for example, near a hazardous waste site) or if contact is made with heavy oils containing B[a]P.

B[a]P causes cancer in laboratory animals when applied to their skin. This finding suggests that it is likely that people exposed in the same manner could also develop cancer. No information has been found about specific levels of B[a]P that have caused harmful effects in people after breathing, swallowing, or touching the substance.

Because studies of B[a]P are not complete, further studies are needed to determine if B[a]P that is breathed in or swallowed could cause cancer. Mice fed high levels of B[a]P during pregnancy had trouble reproducing, and so did their offspring. The newborn animals of pregnant mice fed B[a]P also had other harmful effects (for example, birth defects and lower-than-normal body weight). It is possible that similar effects could happen to people exposed to B[a]P. No information has been found about specific levels of B[a]P that have caused harmful effects in people after breathing, swallowing, or touching the substance (ATSDR, 1990).

EPA has not derived an oral non-cancer Reference Dose (RfD) or inhalation Reference Concentration (RfC) for B[a]P (U.S. EPA, 1995). For the purposes of risk assessment, RfD values from chemically similar contaminants may be adopted. For B[a]P, the RfD for pyrene ($3x10^{-2}$ mg/kg/day) was adopted (ATSDR, 1995).

Based on no human data and sufficient evidence for carcinogenicity in animals, EPA has assigned B[a]P a weight-of-evidence classification of B2, probable human carcinogen (U.S. EPA,1995).

Sampling results indicate that the highest concentration of B[a]P found in Red Butte Creek soil sediment was 311 ppb. This value is above the ATSDR CV for B[a]P at 100 ppb (ATSDR, 1995). This CV is based upon a cancer risk evaluation guideline (CREG). To determine if the exposure to B[a]P in Red Butte Creek, as it is utilized (as a recreational area), constitutes a health hazard to citizens using the creek, we performed an exposure dose calculation (Appendix C) followed by a calculation of cancer risk (Appendix C). Based upon recreational usage (estimated at 40 days/year), we expect that children will be exposed to 4.28×10^{-7} mg/kg/day of B[a]P. This is well below the EPA non-cancer reference dose (RfD) of 3×10^{-2} mg/kg/day. This exposure equates to a calculated excess cancer risk for children (over a 13 year period) of 5.8×10^{-7} or an excess risk of roughly 6 incidences of cancer in 10,000,000 exposures. For adults, utilizing the Red Butte Creek in the same manner, calculations indicate that an individual will be exposed to 4.89×10^{-8} mg/kg/day of B[a]P, again well below the EPA non-cancer RfD. This equates to a lifetime (70 year period) cancer risk of 3.57×10^{-7}, or an excess risk of roughly 4 incidences of cancer in 10,000,000 exposures.

Exposure to B[a]P can also occur through dermal contact. Taking the highest concentration of B[a]P in any samples, we calculated the dermal exposure dosage for a child in contact with the stream soils for 40 days of the year for 13 years (Appendix C). This calculation yielded a B[a]P dose of 1.99×10^{-7} mg/kg/day. This exposure equates to an excess cancer risk (over a 13 year period) of 2.7×10^{-7}, or an excess risk of roughly 3 incidences of cancer in 10,000,000 B[a]P exposures of this kind. For adults, the dermal exposure calculation yielded a dose of 6.68×10^{-8} mg/kg/day, which equates to a lifetime (70 year) excess cancer risk of 4.83×10^{-7}, or an excess risk of roughly 5 incidences of cancer in 10,000,000 B[a]P exposures of this kind.

Dibenz[a,h]anthracene

There is no commercial production or known use of dibenz[*a,h*]anthracene (DBA). It occurs as a component of coal tars, shale oils, and soots and has been detected in gasoline engine exhaust, coke oven emissions, cigarette smoke, charcoal broiled meats, vegetation near heavily travelled roads, surface water, and soils near hazardous waste sites (ATSDR, 1995).

DBA is poorly absorbed from the gastrointestinal tract and is primarily excreted via feces (ATSDR, 1995). Following absorption, DBA is distributed to various tissues, with highest accumulation in the liver and kidneys (ATSDR, 1995). No human studies were available to evaluate the toxicity of DBA. In animals, depressed immune responses were observed in mice following single or multiple subcutaneous (s.c.) injections of DBA (ATSDR, 1995).

EPA has not derived an oral Reference Dose (RfD) or inhalation Reference Concentration (RfC) for DBA (U.S. EPA, 1995). For the purposes of risk assessment, RfD values from chemically similar contaminants may be adopted. For DBA, the RfD for anthracene (3×10^{-1} mg/kg/day) was adopted (ATSDR, 1995).

No epidemiologic studies or case reports addressing the carcinogenicity of DBA in humans were available. In animals, DBA has produced tumors by different routes of administration, having both local and systemic carcinogenic effects. After oral administration, DBA produced tumors at several sites. Carcinogenic as well as tumor-initiating activity of DBA has been demonstrated in topical application studies with mice. Repeated dermal application of 0.001 to 0.01% solutions produced a high incidence of skin papillomas and carcinomas in mice (ATSDR, 1995).

Based on no human data and sufficient evidence for carcinogenicity in animals, EPA has assigned DBA a weight-of-evidence classification of B2, probable human carcinogen (U.S. EPA, 1995).

Sampling results indicate that the highest concentration of DBA found in Red Butte Creek soil sediment was 504 ppb. This value is above the estimated ATSDR CV for DBA of 100 ppb (ATSDR, 1995). This CV is based upon the CREG value for B[a]P, as DBA is estimated by the EPA to be of similar carcinogenic potency to B[a]P (EPA, 1995; 2011b). To determine if the exposure to DBA in Red Butte Creek, as it is utilized (as a recreational area), constitutes a health hazard to citizens using the creek, we performed an exposure dose calculation (Appendix C) followed by a calculation of cancer risk (Appendix C). Based upon recreational usage (estimated at 40 days/year), we expect that children will be exposed to 6.93 x 10^{-7} mg/kg/day of DBA. This is well below the EPA non-cancer RfD of 3x10^{-1} mg/kg/day. This exposure equates to a calculated excess cancer risk for children (over a 13 year period) of 9.4 x 10^{-7} or an excess risk of roughly 9 incidences of cancer in 10,000,000 exposures. For adults, utilizing the Red Butte Creek in the same manner, calculations indicate that an individual will be exposed to 7.92 x 10^{-8} mg/kg/day of DBA. This equates to a lifetime (70 year period) cancer risk of 5.78 x 10^{-7}, or an excess risk of roughly 6 incidences of cancer in 10,000,000 exposures.

Exposure to DBA can also occur through dermal contact. Taking the highest concentration of DBA in any samples, we calculated the dermal exposure dosage for a child in contact with the stream soils for 40 days of the year for 13 years (Appendix C). This calculation yielded a DBA dose of 3.22 x 10^{-7} mg/kg/day. This is well below the EPA non-cancer RfD of 3x10^{-1} mg/kg/day. This exposure equates to an excess cancer risk (over a 13 year period) of 4.37 x 10^{-7}, or an excess risk of roughly 4 incidences of cancer in 10,000,000 DBA exposures of this kind. For adults, the dermal exposure calculation yielded a dose of 1.07 x 10^{-7} mg/kg/day, which equates to a lifetime (70 year) excess cancer risk of 7.82 x 10^{-7}, or a risk of roughly 8 incidences of cancer in 10,000,000 DBA exposures of this kind.

Cancer Risk Conclusions

ATSDR has adopted the EPA-designated cancer risk levels. When risk calculations indicate a cancer occurrence greater than 1 in 10,000 further investigations and the institution of protective measures for the public are required. Cancer risks less than 1 x10^{-6} (one incidence in one million exposures), are so small as to be negligible (EPA, 2011). The combined cancer risk presented by the cancer driversBased upon this data, the EEP finds that although the concentrations of B[a]P and DBA exceed the ATSDR CV for the chemicals, the calculated exposure dose based upon the usage of Red Butte Creek indicates that the soil sediment contaminants do not pose an excess cancer hazard to the public.

Multiple Chemical Exposure Evaluation

The potential for the toxic effects from the chemical mixture interactions of the contaminants at Red Butte Creek were evaluated. Among all PAHs, only B[a]P and DAB exceeded the CVs for the contaminant. When considering the non-cancer effects of multiple substances, a Hazard Index (HI) is calculated. The HI is the calculated dosage of the contaminant divided by the relevant MRL or RfD. The HI values for all substances that exceed CV are added together to define the combined HI. If an HI value is greater than 1.0, that indicates that a potential health hazard could be presented by the presence of multiple contaminants. As shown in Table B, the combined HI for B[a]P and DAB are 2.40 x 10^{-5} for children and 4.62 x 10^{-6} for adults. Both values are well below 1.0, therefore we conclude that the non-cancer risk presented by these contaminants together does not pose an apparent health hazard.

As these compounds are carcinogens, ATSDR guidelines recommend that if two or more of the contaminants of concern convey an excess cancer risk greater than 1 x 10^{-6} (one in one million), then further evaluation is needed (ATSDR, 2004).

The greatest calculated cancer risk for B[a]P was 1.65 x 10^{-6}. The greatest cancer risk for DBA was 2.36 x 10^{-6}. Together, these two carcinogens represent an excess cancer risk of 4.0 x 10^{-6} (Table B). Therefore, the EEP finds that the cancer risk presented by these contaminants together does not pose an apparent health hazard.

Table B. Combined non-cancer and cancer health risks for dermal and ingestion exposures to B[a]P and DBA.

Non-Cancer	B[A]P (RfD: 3 x 10^{-2} mg/kg/day)	DBA (RfD: of 3x10^{-1} mg/kg/day)	Combined HI (<1.0)
Children	6.27 x 10^{-7} mg/kg/day	1.01 x 10^{-6} mg/kg/day	2.40 x 10^{-5}
Adults	1.20 x 10^{-7} mg/kg/day	1.86 x 10^{-7} mg/kg/day	4.62 x 10^{-6}
Cancer Risk	EPA IRIS (1 x 10^{-4} – 1 x 10^{-6})	EPA IRIS (1 x 10^{-4} – 1 x 10^{-6})	Combined Risk (1 x 10^{-4} – 1 x 10^{-6})
Children (13 years)	9.5 10 x 10^{-7}	1.26 x 10^{-6}	2.2 x 10^{-6}
Adults (57 years)	7.0 10 x 10^{-7}	1.10 x 10^{-6}	4.0 x 10^{-6} (70 years)

CHILD'S HEALTH CONSIDERATIONS

ATSDR recognizes that the unique vulnerabilities of infants and children demand special emphasis in communities faced with contamination of their water, soil, air, or food. Children are at a greater risk than adults from certain kinds of exposures to hazardous substances emitted from waste sites and emergency events. Children are more likely to be exposed because they play outdoors and because they often bring food into contaminated areas. They are more likely to come into contact with dust, soil, and heavy vapors close to the ground. Due to their larger surface area to body weight ratio, children are more vulnerable to toxicants absorbed through the skin. Furthermore, the developing body systems of children can sustain permanent damage if toxic exposures occur during critical growth stages.

In the communities surrounding Red Butte Creek, children were generally at higher risk of exposure to contaminants related to crude oil in both the waters of the creek, soil, and ambient air. Not only will children ingest, inhale and absorb a higher dosage of these contaminants from the environment as a result of their daily activities, but they are also more susceptible to the adverse health effects resulting from such exposure. Recommendations for action are therefore focused first on children and aimed at reducing overall chronic exposure to these contaminants.

COMMUNITY HEALTH CONCERNS

The EEP conducted a Community Needs Assessment in 2010 to evaluate the public health concern associated with potential exposures to components of crude oil that resulted from the June 12, 2010 spill into Red Butte Creek in Salt Lake City, Utah. As part of the process, the EEP staff conducted a site visit, attended town meetings, and distributed a survey. The goal of this needs assessment was to document and respond accordingly to community questions and concerns regarding the spill.

CONCLUSIONS

UDOH's purpose is to serve the public by using the best science, taking responsive public health actions and providing trusted health information to the public to prevent people from residing in close proximity to hazards and coming into contact with harmful toxic substances.

Surface Water Ingestion Pathway
The EEP concludes that the accidental ingestion of PAHs that occurs when playing and swimming in Red Butte Creek will not harm the public's health. Concentrations of PAHs in the surface water of the creek were below CVs; therefore no long-term effects are expected to result from this exposure.

Surface Water Dermal Contact Pathway
The EEP concludes that the dermal contact with PAHs that occurs when playing and swimming in Red Butte Creek will not harm the public's health. Concentrations of PAHs in the surface water of the creek were below CV; therefore no long-term effects are expected to result from this exposure.

Soil Sediment Ingestion Pathway

The EEP concludes that accidental ingestion of PAHs in Red Butte Creek soil sediment does not pose a health hazard to the public. Although one contaminant (B[a]P) was found in excess of the ATSDR designated CV, dose calculations revealed that the accidental ingestion of Red Butte Creek soil sediment during recreational usage does not pose an elevated cancer risk due to B[a]P exposure.

Soil Sediment Dermal Exposure Pathway

The EEP concludes that the dermal contact with PAHs that occurs when playing and swimming in Red Butte Creek will not harm the public's health. Though B[a]P concentrations in the soil sediment of the creek exceeded CV; the limited bioavailability of the contaminant through the skin (less than 1% vs. 100 % for ingestion) indicates that dermal contact PAHs in Red Butte Creek soil and sediment does not pose an elevated cancer risk.

RECOMMENDATIONS

Based upon the EEP's review of the Red Butte Creek surface water and soil sediment data and the concerns expressed by community members, the following recommendations are appropriate and protective of the health of residents in the community. Based on the conclusions of this report, the following general public health recommendations will be implemented by the EEP:

- The EEP recommends that the cancer incidence study specific for cancer types linked to crude oil exposure is re-evaluated every five years, as additional data becomes finalized.
- Coordinate with UDEQ to assess future sampling data to better guide further remediation if it is deemed necessary.

PUBLIC HEALTH ACTION PLAN

The public health action plan for the site contains a description of actions that have been or will be taken by the EEP and other government agencies at the site. The purpose of the public health action plan is to ensure that this public health assessment both identifies public health hazards and provides a plan of action designed to mitigate and prevent harmful human health effects resulting from breathing, drinking, or touching hazardous substances in the environment. Included is a commitment on the part of the EEP to follow up on this plan to ensure that it is implemented.

Public health actions that have been taken at the site include:

- A community health group has been established to work with state and local agencies to determine the adverse health impact to the community from the oil spill.
- Public meeting held with county, state and local authorities on action items to pursue regarding the spill and remediation activities.

- The EEP created and conducted a Needs Assessment survey in the community to determine resident concerns and create targeted health education strategies to address concerns.
- The EEP completed the ATSDR Public Health Assessment document, evaluating potential for acute adverse health effects from exposure to crude oil VOC contaminants in Red Butte Creek.
- The EEP completed the ATSDR Health Consultation document, evaluating the potential for adverse health effects from exposure to crude oil PAH contaminants in Red Butte Creek.

Public health actions that are ongoing or will be implemented at the site include:

- The EEP will participate in a public meeting with other stakeholders and the community to explain the results of this Health Consultation and address any community or individual resident health concerns.
- The EEP will make copies of the finalized HC available to both Salt Lake County and interested residents through various public buildings. Upon finalization, the document will also be able to be accessed electronically through both the EEP website at http://health.utah.gov/enviroepi/activities/hha/hhamain.htm and the Salt Lake County environmental health website at http://www.slvhealth.org/programs/environmentalHealth.
- The EEP will provide continued health education (in the form of fact sheets, flyers and pamphlets) to the community regarding acute and chronic health effects related to exposure to crude oil, including VOCs, BTEX, naphthalene, and petroleum hydrocarbons.
- The EEP will remain available to address any public health questions or concerns regarding this issue for residents, visitors and the general public following this report's final release.
- The EEP will conduct baseline health studies using standard cross sectional statistical review methodology to assess the adverse health outcomes related to crude oil exposure in the neighborhoods surrounding Red Butte. This will allow a historical baseline for cancer, ischemic heart disease, and COPD in the community. As new data become available, additional analyses will be conducted to determine if any increases in specific illnesses are occurring that could be correlated to exposure to contaminants related to the spill. These updated studies will be made available to the community upon peer review and finalization.
- The EEP will provide continued support to both city and county agencies on interpreting sampling data and adverse health outcomes, as well as participating in all community and public health meetings.

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CERTIFICATION

This Health Consultation, **Red Butte Creek Oil Spill: Soil and Sediment. Analysis of Polycyclic Aromatic Hydrocarbons, Salt Lake City, Utah** was prepared by the Utah Department of Health under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures for health consultations. Editorial review was completed by the Cooperative Agreement partner.

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UTAH APPLETREE
ATSDR's Partnership to Promote Localized Efforts to Reduce Environmental Exposures

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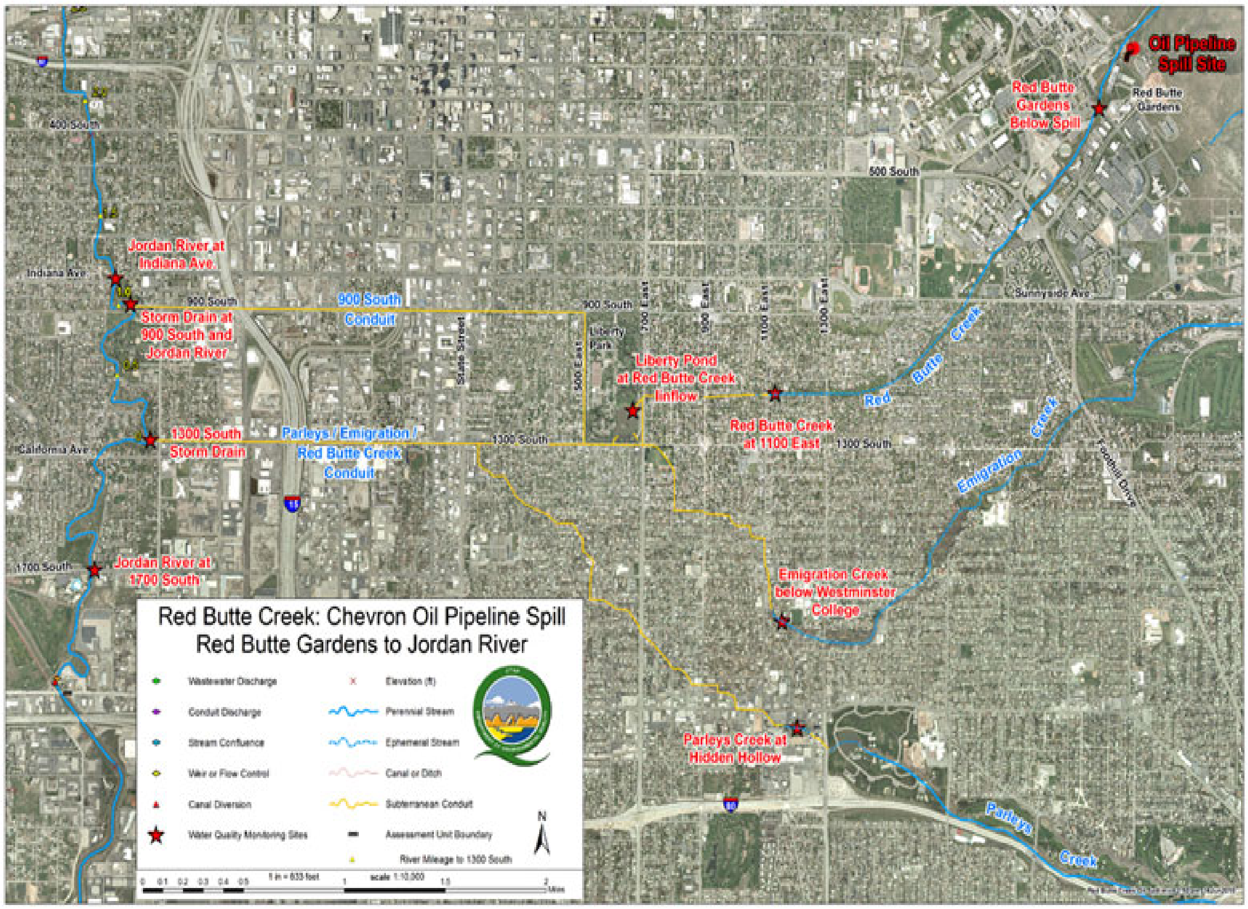
APPENDICES

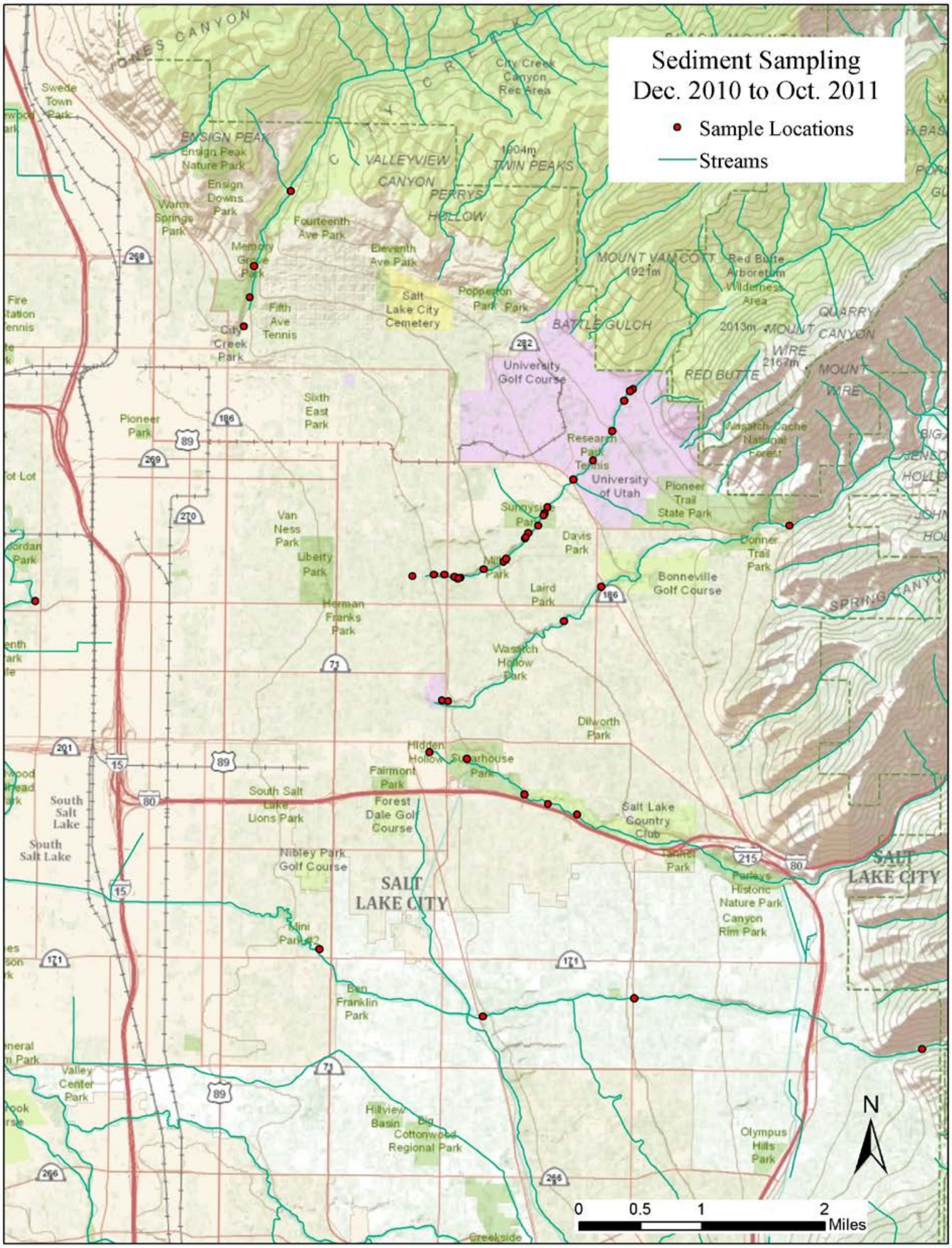
APPENDIX A – MAPS OF STUDY AREA

Figure 1. Sampling locations along Red Butte Creek, Salt Lake City, Utah, June 2010.



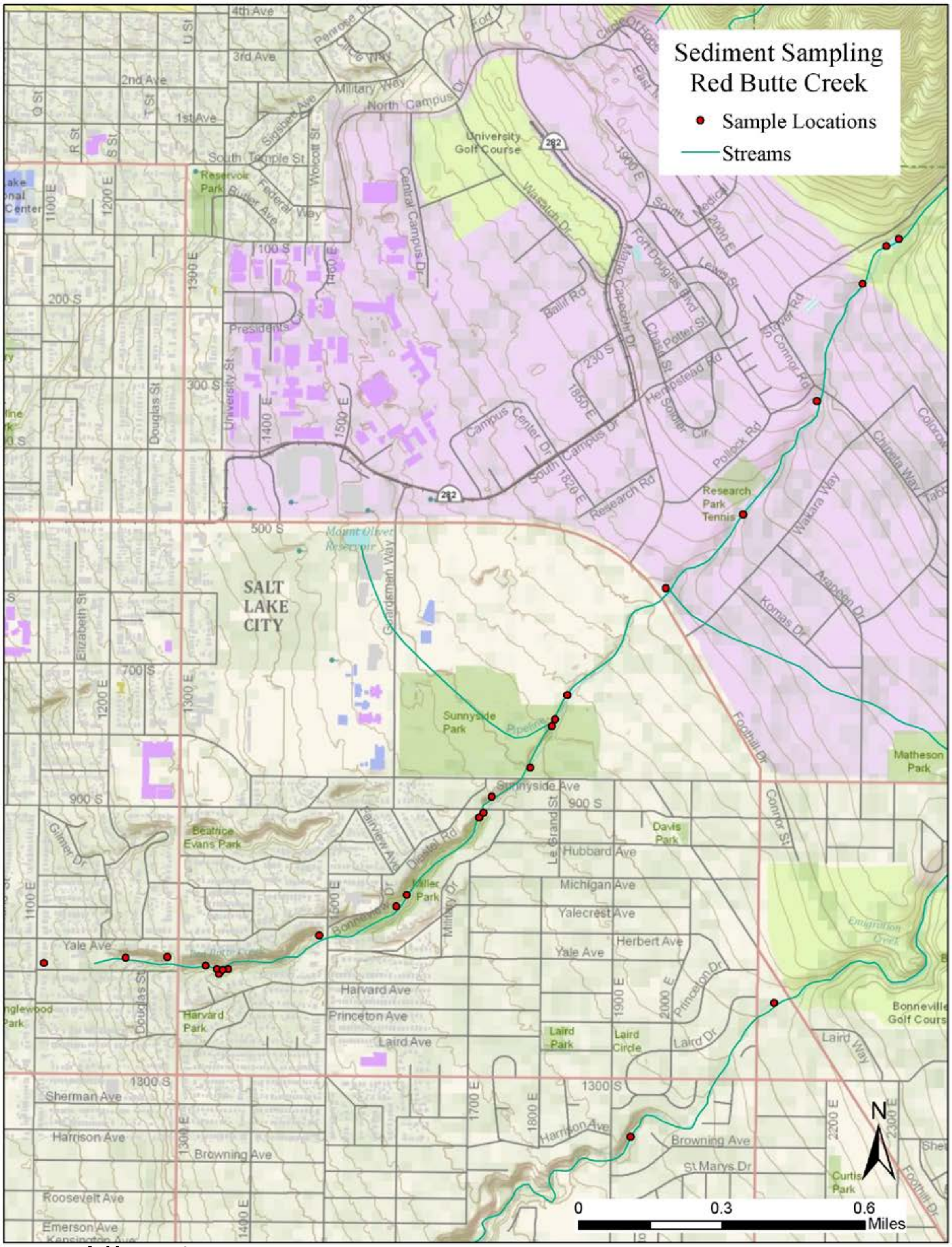
Courtesy UDEQ

Figure 2. Sediment sampling locations, Salt Lake City, Utah, December 2010 to October 2011.



Data provided by UDEQ

Figure 3. Sediment sampling locations, Red Butte Creek, Salt Lake City, Utah, December 2010 to October 2011.



Data provided by UDEQ

APPENDIX B – TABLES OF STUDY DATA

Table 1. Sediment Samples PAH Concentrations (ug/kg)

Date	Address	acenaphthene	anthracene	fluoranthene	fluorene	pyrene	benzo[a]pyrene	benz(a)anthracene	benzo(b)fluoranthene	dibenz(a,h,)anthracene	indeno(1,2,3-cd)pyrene
8/23/2011	900 S. - Red Butte Creek Below, Bank	nd	nd	28.3	nd	29.7	nd	365	352	nd	nd
8/23/2011	900 S. - Red Butte Creek	nd	nd	25.4	nd	35.8	nd	nd	nd	nd	nd

												Below, Bed
nd	nd	96.5	nd	94	42.3	51.6	nd				8/23/2011	1100 E. Bank below Red Butte Creek
nd	nd	37.8	nd	39.7	30.2	28.3	nd	nd	nd		7/7/2011	1100 E. Bank Sed.
nd	nd	115	nd	114	53.1	71.4	71.4	nd	28.4		7/7/2011	1100 E. Pond Sed.
											10/27/2011	1225 Harvard Ave Riedel

31	17	15	29	2.7	11			Pond Sed.	nd	4.1	31	2.9
73.5	40.4	37.7	54.2	nd	nd		8/23/2011	1300 East - Bank Red Butte Creek below	nd	nd	81.8	nd
36.6	nd	nd	nd	nd	nd		8/23/2011	1300 East - Bed Red Butte Creek below	nd	nd	30.2	nd

62.8	nd	46.3		8/9/2011	1340 East Yale Red Butte Creek Below Barton Bank	nd	nd	47.2	nd	50	52.8	53.7
70.2	**450**	562		8/9/2011	1340 East Yale Red Butte Creek Below Barton Bed	nd	nd	nd	nd	nd	27.4	78.5
nd	nd	32.6		8/9/2011	1340 East Yale West Spring Bed	nd	nd	nd	nd	nd	nd	nd

48.3		8/9/2011	1349 East Normandie Circle Red Butte Creek at Barton Bank	nd	nd	62.8	nd	603	nd	nd	nd	nd
47.1		8/9/2011	1349 East Normandie Circle Red Butte Creek at Barton	nd	33.1	123	nd	131	nd	nd	nd	nd

													Bed
larvard Avenue	nd	134	1150	28.4	1070	311	nd	nd	32.6	111		9/7/2011	1365 East F
larvard Avenue Bed	nd	nd	nd	nd	nd	nd	nd	nd	33.8	163		8/9/2011	1365 East F East Spring
larvard Avenue												8/9/2011	1373 East F

32.6	nd	35.4	43.8	nd	42.9	nd	39.1			Red Butte Creek Above Remund Bank	nd	nd
218	nd	164	96	129	122	**504**	780		8/9/2011	1373 East Harvard Avenue Red Butte Creek Above Remund Bed	nd	nd

267	288	nd	96.1		8/23/2011	1500 E. Bank above Red Butte Creek	nd	58.4	578	nd	648	nd
30.5	39.5	nd	nd		7/7/2011	1500 E. Bank Sed.	nd	nd	50.2	nd	49.3	29.6
nd	nd	nd	nd		8/23/2011	1500 E. Bed above Red Butte Creek	nd	nd	44.2	nd	43.3	nd

nd	nd		7/7/2011	1500 E. Bed Sed.	nd	nd	nd	nd	36.4	nd	nd	nd
nd	105		7/7/2011	1731 E 900 S - Hayes Prop Bank Sed.	nd	32.3	391	nd	330	205	257	353
nd	nd		7/7/2011	1731 E 900 S - Hayes Prop Bed Sed.	nd	nd	nd	nd	nd	nd	nd	nd
64.5	20.4		1/27/2011	1731 E 900 S - Hayes	19.5	108	95.9	32.2	107	102	130	73.8

	Property										
10/27/2011	1731 E 900 S - Hayes Property 1	nd	7.3	40	3.2	57	27	23	36	4.6	17

*Non-sediment sample, not compared with CV

Table 1. Sediment Samples PAH Concentrations (ug/kg) (continued)

Date	Address	acenaphthene	anthracene	fluoranthene	fluorene	pyrene	benzo[a]pyrene	benz(a)anthracene	benzo(b)fluoranthene	dibenz(a,h,)anthracene	indeno(1,2,3-cd)pyrene
8/23/2011	Amphitheater - Red Butte Creek above, Bank	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
8/23/2011	Amphitheater - Red Butte										
nd	nd	nd	nd	nd	nd	nd	nd	nd	nd		Creek above, Bed
nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	8/23/2011	Chipeta Way - Red Butte Creek Below, Bank
nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	8/23/2011	Chipeta Way - Red Butte Creek Below, Bed
nd	nd	nd	nd	nd	nd	8/23/2011	Foothills Drive - Red Butte Creek Above, Bank	nd	nd	nd	nd
nd	nd	nd	nd	nd	nd	8/23/2011	Foothills Drive - Red Butte Creek Above, Bed	nd	nd	nd	nd
51.1	nd	35.6	32.2	nd	nd	8/23/2011	Gaging Station - Red Butte	nd	nd	45.3	nd
				Creek, Bank							
nd	nd	nd	8/23/2011	Gaging Station - Red Butte Creek, Bed	nd	nd	nd	nd	nd	nd	nd
nd	nd	nd	7/7/2011	Gardens - Bed Sed. Red Butte Creek	nd	nd	nd	nd	nd	nd	nd
			8/23/2011	Lower Underflow Dam Site -							
nd		Red Butte Creek, Bank	nd	nd	nd	nd	nd	nd	nd	nd	nd
nd	8/23/2011	Lower Underflow Dam Site - Red Butte Creek, Bed	nd	nd	nd	nd	nd	nd	nd	nd	nd
79.3	7/7/2011	Miller Park Bed Sed	nd	nd	82.4	nd	64.4	nd	35.2	28.3	nd
et Diversion - reek, Bank	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	8/23/2011 Mount Oliv Red Butte C
et Diversion - reek, Bed	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	8/23/2011 Mount Oliv Red Butte C
Ave - Red Butte	nd	nd	129	nd	121	39.6	69.1	55.9	nd	nd	8/23/2011 Sunnyside A
									Creek, Bank		
nd	nd	nd	nd	nd	nd	nd	nd	8/23/2011	Sunnyside Ave - Red Butte Creek, Bed	nd	nd
97	nd	97.9	nd	38.8	29.6	nd	nd	8/23/2011	University Marriot - Red Butte Creek, Bank	nd	27.7
								8/23/2011	University Marriot - Red		
nd	nd	nd	nd		Butte Creek, Bed	nd	nd	nd	nd	nd	nd
3.8	6.2	nd	1.5	8/23/2011	Canyon Entrance Gate - City Creek, Bank	0.99	1.3	8	nd	7.2	5.1
0.83	1.6	nd	nd	8/23/2011	Canyon Entrance Gate - City Creek, Bed	nd	0.39	1.6	nd	2	1.7
nd	58.1	8/23/2011	Lower Natural Channel - City Creek, Bank	nd	nd	109	nd	120	63.2	67.5	88
nd	nd	8/23/2011	Lower Natural Channel - City Creek, Bed	nd	nd	nd	nd	nd	nd	nd	nd
nd	nd	8/23/2011	North Canyon Footbridge - City Creek, Bank	nd	nd	111	nd	79.9	nd	42.7	26.1
8/23/2011	North Canyon Footbridge - City Creek, Bed	nd	nd	31.6	nd	34	nd	nd	nd	nd	nd
8/23/2011	North Canyon Loop - City Creek, Bank	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
8/23/2011	North Canyon Loop - City										

Table 1. Sediment Samples PAH Concentrations (ug/kg) (continued)

Date	Address	acenaphthene	anthracene	fluoranthene	fluorene	pyrene	benzo[a]pyrene	benz(a)anthracene	benzo(b)fluoranthene	dibenz(a,h,)anthracene	indeno(1,2,3-cd)pyrene
8/23/2011	1900 E. - Emigration Creek above, Bed	nd	nd	104	nd	118	42.3	62	47.9	nd	nd
8/23/2011	2100 E. - Emigration Creek	nd	nd	32.5	nd	35.7	nd	45.5	71.5	nd	nd

												above, Bank
on Creek	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	8/23/2011	2100 E. - Emigrati above, Bed
ek below,	nd	nd	61.6	nd	62.5	nd	34.3	67.8	nd	nd	8/23/2011	2300 E. - Mill Cre Bank

nd	nd	nd	nd	nd	nd	nd	nd		Bed	nd	nd
nd	nd	nd	nd	nd	nd	nd	nd	7/8/2011	2300 E. - Mill Creek, Bank Sed.	nd	nd
nd	nd	nd	nd	nd	nd	nd	nd	7/8/2011	2300 E. - Mill Creek, Bed Sed.	nd	nd

1	29	42.1	50	3.7	9.1		8/23/2011	700 E. - Mill Creek below, Bank	nd	5.4	104	nd	11
00	50	88.2	83	nd	nd		8/23/2011	700 E. - Mill Creek below, Bed	nd	5.9	232	nd	2(
d	nd	nd	nd	nd	nd		8/23/2011	County Gage - Mill Creek above, Bank	nd	nd	nd	nd	n

72.4	nd	25.2		8/23/2011	County Gage - Mill Creek above, Bed	nd	42.9	237	nd	219	61.4	98.5
nd	nd	nd		8/23/2011	Donner Hill Marker - Emigration Creek, Bank	nd	nd	nd	nd	nd	nd	nd
nd	nd	nd		8/23/2011	Donner Hill Marker - Emigration Creek, Bed	nd	nd	nd	nd	nd	nd	nd

nd	59		8/23/2011	Highland Drive - Mill Creek below, Bank	nd	40	303	nd	321	125	126	144
nd	nd		8/23/2011	Highland Drive - Mill Creek below, Bed	nd	nd	93.2	nd	89	41.2	43.7	56.3

nd		8/23/2011	1300 E. - Parleys Creek below, Bank	nd	nd	nd	nd	nd	nd	nd	nd	nd
nd		8/23/2011	1300 E. - Parleys Creek below, Bed	nd	nd	29.8	nd	42.4	nd	nd	nd	nd
nd		8/23/2011	1700 E. - Parleys Creek Below, Bank	nd	nd	nd	nd	nd	nd	nd	nd	nd

1700 E. - Parleys Creek Below, Bed	nd	nd	73.7	nd	75.3	nd	30.6	28.2	nd	nd	8/23/2011
2000 E. - Parleys Creek above, Bank	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	8/23/2011
2000 E. - Parleys Creek	nd	nd	186	nd	170	50.1	79.6	95.3	nd	nd	8/23/2011
										above, Bed	

Table 2. Water Samples PAH Concentrations (ug/l)

Date	Address	acenaphthene	anthracene	fluoranthene	fluorene	pyrene	benzo[a]pyrene
12/1/2010	900 S. - Red Butte Creek at	nd	nd	nd	nd	nd	nd
6/1/2011	1100 E. - Red Butte Creek	nd	nd	nd	nd	nd	nd
6/1/2011	Gardens - Red Butte Creek above	nd	nd	nd	nd	nd	nd
6/1/2011	Greenhouse - Red Butte Creek at	nd	nd	nd	nd	nd	nd
6/1/2011	Liberty Park Outfall	nd	nd	nd	nd	nd	nd
6/1/2011	Miller Park - Red Butte Creek	nd	nd	nd	nd	nd	nd
6/1/2011	Pond at Mt. Olivet - Red Butte Creek Inlet	nd	nd	nd	nd	nd	nd
7/7/2011	1100 E. - Red Butte Creek	nd	nd	nd	nd	nd	nd
7/7/2011	Gardens - Red Butte Creek above	nd	nd	nd	nd	nd	nd
7/7/2011	Gardens - Red Butte Creek below	nd	nd	nd	nd	nd	nd
7/7/2011	Liberty Park - Red Butte Creek	nd	nd	nd	nd	nd	nd
7/7/2011	Miller Park - Red Butte Creek	nd	nd	nd	nd	nd	nd
8/9/2011	1340 East Yale Red Butte Creek at Barton Water	nd	nd	nd	nd	nd	nd
8/9/2011	1340 East Yale Red Butte Creek Below Barton Water	nd	nd	nd	nd	nd	nd
8/9/2011	1340 East Yale West Spring Water	nd	nd	nd	nd	nd	nd
8/9/2011	1365 East Harvard Avenue East Spring Water	nd	nd	nd	nd	nd	nd
8/9/2011	1365 East Harvard Avenue Middle Spring Water	nd	nd	nd	nd	nd	nd
8/9/2011	1373 East Harvard Avenue Red Butte Creek Above Remund Water	nd	nd	nd	nd	nd	nd
10/27/2011	1225 Harvard Ave Riedel Pond Inlet	nd	nd	nd	nd	nd	nd
10/27/2011	1225 Harvard Ave Riedel Pond Outlet	nd	nd	nd	nd	nd	nd
6/1/2011	Westminster - Emigration Creek	nd	nd	nd	nd	nd	nd
7/8/2011	Emigration Creek	nd	nd	nd	nd	nd	nd
8/23/2011	1300 E. Emigration Creek, Above	nd	nd	nd	nd	nd	nd
8/23/2011	1900 E. Emigration Creek, Above	nd	nd	nd	nd	nd	nd
8/23/2011	2100 E. Emigration Creek, Above	nd	nd	nd	nd	nd	nd
8/23/2011	Donner Hill Marker - Emigration Creek at	nd	nd	nd	nd	nd	nd

Table 2. Water Samples PAH Concentrations (ug/l) (continued)

Date	Address	acenaphthene	anthracene	fluoranthene	fluorene	pyrene	benzo[a]pyrene
6/1/2011	Hidden Hollow - Parleys Creek	nd	nd	nd	nd	nd	nd
7/8/2011	Parleys Creek	nd	nd	nd	nd	nd	nd
8/23/2011	1300 E. Parleys Creek, Below	nd	nd	nd	nd	nd	nd
8/23/2011	2000 E. Parleys Creek, Above	nd	nd	nd	nd	nd	nd
8/23/2011	1700 E. Parleys Creek, Below	nd	nd	nd	nd	nd	nd
8/23/2011	I-215 - Parleys Creek, Above	nd	nd	nd	nd	nd	nd
8/23/2011	800 S. - Jordan River	nd	nd	nd	nd	nd	nd
8/23/2011	1700 S. - Jordan River	nd	nd	nd	nd	nd	nd
7/8/2011	2300 E. - Mill Creek	nd	nd	nd	nd	nd	nd
8/23/2011	700 E. - Mill Creek Below, afternoon	nd	nd	nd	nd	nd	nd
8/23/2011	Canyon Entrance - City Creek, afternoon	nd	nd	nd	nd	nd	nd
		acenaphthene	anthracene	fluoranthene	fluorene	pyrene	benzo[a]pyrene
	Max. Value Water Samples	nd	nd	nd	nd	nd	nd
	Drinking Water Comparison Values (ppb)	600	3000	400	400	300	0.005

APPENDIX C – EXPOSURE DOSE CALCULATIONS

Exposure Dose (ED) calculation for incidental ingestion of soil [ATSDR, 2005]:

ED = (C x IR x EF x CF) / BW

Where:

C = Contaminant concentration (mg/kg)

IR = Intake rate of contaminated soil (kg/day)
= 100 mg/day for an adult
= 200 mg/day for a child

EF = Exposure Factor; an exposure factor of 0.11 was used for this health assessment (1 represents daily exposure to the contaminant, 365 days per year, whereas in this case, we assume recreational use of the creek for 40 days of the year.)

CF = Conversion Factor (10^{-6} mg/kg)

BW = Body Weight (kg)
= 70 kg for an adult
= 16 kg for a child

Soil Dermal Contact Dose Equation

Doses from dermal contact with soil can be calculated as follows [ATSDR, 2005]:
D = (C x A x AF x EF x CF) / BW

where,

D = dose (mg/kg/day)

C = contaminant concentration (mg/kg)

A = total soil adhered (mg)

AF= bioavailability factor (unitless)

EF = exposure factor (unitless). An exposure factor of 0.11 was used for this health assessment (1 represents daily exposure to the contaminant, 365 days per year, whereas in this case, we assume recreational use of the creek for 40 days of the year.)

CF = conversion factor (10^{-6} kg/mg)

BW= body weight (kg). 70 kg for an adult; 16 kg for a child

Default Dermal Exposure Values

Age (yrs)	Body Weight (kg)	Total Surface (cm^2)	% Area Exposed	Exposed Area (cm^2)	Total Soil Adhered (mg)
0-1	10	3,500	30	1,050	210
1-11	30	8,750	30	2,625	525
12-17	50	15,235	28	4,266	299
18-70	70	19,400	24	4,656	326

Total soil adhered (A) is estimated by multiplying the exposed area by the default soil adherence concentration of 0.07 mg/cm^2 for adults and 0.2 mg/cm^2 for children.

Derivation of Population Cancer Estimate

ER= CSF (or IUR) x dose (or air concentration)

where,

ER = estimated theoretical risk (unitless)

CSF/IUR = cancer slope factor [(mg/kg/day)$^{-1}$] or inhalation unit risk [(ug/m3)$^{-1}$]

Dose = estimated exposure dose (mg/kg/day) or (ug/m^3)

APPENDIX D - ACRONYMS AND TERM DEFINITIONS

ALL — **Acute Lymphocytic Leukemia** is a cancer of the blood and bone marrow that has a rapid onset and progression. ALL affects the white blood cells called lymphocytes. It is the most common cancer type in children, although it can occur in adults.

AML — **Acute Myelogenous Leukemia** is a cancer of the blood and bone marrow that affects the cells that are precursors to white blood cells. AML has a rapid onset and progression. It is one of the most common forms of leukemia in adults.

ATSDR — Agency for Toxic Substances and Disease Registry

Background Level — The amount of a chemical that occurs naturally in a specific environment.

BTEX — BTEX is an acronym for the four most common volatile organic compounds found in petroleum products: **Benzene, Toluene, Ethylbenzene** and **Xylene.**

Cancer Classes — Each health organization has a separate method of cancer classification:

Environmental Protection Agency (EPA) (Based on 1986 cancer assessment guidelines):

- A = Human Carcinogen.
- B1 = Probable Human Carcinogen (based on limited human and sufficient animal studies).
- B2 = Probable Human Carcinogen (based on inadequate human and sufficient animal studies).
- C = Possible Human Carcinogen (no human studies and limited animal studies).
- D = Unlikely to be a Human Carcinogen
- E = Evidence of non-carcinogenicity in humans

Environmental Protection Agency (EPA) (Based on 2003 cancer assessment guidelines):

- CA = Carcinogenic to humans
- LI = Likely human carcinogen (cancer potential established; but limited human data)
- SU = Suggestive evidence (human or animal data suggestive)
- IN = Inadequate (data inadequate to assess)
- NO = Robust data indicate no human carcinogen.

International Agency for Research on Cancer (IARC)

1 = Carcinogenic to Humans (sufficient human evidence).
2A = Probably Carcinogenic to Humans (limited human evidence; sufficient evidence in animals).
2B = Possibly Carcinogenic to Humans (limited human evidence; less than sufficient evidence in animals).
3 = Not Classifiable
4 = Probably Not Carcinogenic to Humans

National Toxicology Program (NTP)

1 = Known Human Carcinogen
2 = Reasonably anticipated to be a carcinogen
3 = Not Classified

CLL **Chronic Lymphocytic Leukemia** is a cancer that forms in the blood and bone marrow and affects white bloods cells called lymphocytes. It has a slower onset and progression than acute forms of leukemia, and typically affects adults.

CML **Chronic Myelogenous Leukemia** is a cancer that forms in the blood and bone marrow that affects cells that are precursors to white blood cells. It has a slower onset and progression than the acute form of leukemia, and is more common in adults than in children.

Completed Exposure Pathway A way in which humans can be exposed to a contaminant associated with a site. An exposure pathway is a description of the way a chemical moves from a source to where people can come into contact with it. A completed exposure pathway has all of the 5 following elements:
1) A source of contamination
2) Transport through environmental medium
3) A point of exposure
4) A route of human exposure
5) An exposed population

CREG **Cancer Risk Evaluation Guides** are based on a contaminant concentration estimated to increase the cancer risk in a population by one individual in one million people over a lifetime exposure ($1x10^{-6}$).

CV A **comparison value** is a calculated concentration of a substance in air, water, food, or soil that is unlikely to cause harmful (adverse) health effects in exposed people. The CV is used as a screening level during the public health assessment process.

DHHS The United States Department of Health and Human Services

EEP Environmental Epidemiology Program at the Utah Department of Health

EMEG **Environmental Media Evaluation Guides** are media-specific comparison values used to select contaminants of interest at hazardous waste sites. EMEGs are derived from Minimal Risk Levels (MRLs), developed by the Agency for Toxic Substances and Disease Registry (ATSDR), and are an estimate of human exposure to a compound that is not expected to cause noncancerous health effects at that level for a specified period. They are intended to protect the most sensitive individuals (i.e., children). MRLs are guidelines and are not used to predict adverse health effects. MRLs do not take into account carcinogenic effects, chemical interactions, or multiple routes of exposure.

EPA The **U.S**. **Environmental Protection Agency** is the federal agency that develops and enforces environmental laws to protect the environmental and public health.

EPHTN **Environmental Public Health Tracking Network** oversees the ongoing collection, integration, analysis, and interpretation of data about environmental hazards, exposure to environmental hazards, and health effects potentially related to exposure to environmental hazards

Exposure Dose At some sites, the existing conditions may result in exposures that differ from those used to derive Comparison Values such as the EMEG. In these situations, the health assessor can calculate site-specific exposures more accurately using an exposure dose. The exposure dose can then be compared to the appropriate toxicity values (MRL, RfC, RfD).

Hazard Index (HI) A sum of the hazard quotients for substances (in a given exposure) that affect the same organ or organ system.

Hazard Quotient The ratio of the potential exposure to the MRL or specific comparison value. A Hazard Quotient of less than 1 means that no adverse health effects are expected as a result of exposure. If the Hazard Quotient is greater than 1, then adverse health effects are possible.

Health-Based see "Screening values."

IARC The **International Agency for Research on Cancer** is part of the World Health Organization. The IARC studies and makes recommendations on the carcinogenicity of substances in terms of risks to human health.

LOAEL The **Lowest Observable Adverse Effect Level** is the lowest exposure level of a chemical that produces significant increases in frequency or severity of adverse effects.

MCL A **Maximum Contaminant Level** is an enforceable standard calculated by the United States Environmental Protection Agency. The MCL is the highest level of a contaminant that is allowed in drinking water.

MRL A **Minimal Risk Level** is defined as an estimate of daily human exposure to a chemical that is likely to be without an appreciable risk of deleterious non-cancer health effects over a specified duration of exposure. Thus, MRLs provide a measure of the toxicity of a chemical.

NA Needs Assessment

ND Chemicals that are **not detected** in a sample above a certain limit, usually the quantitation limit for the chemical in the sample.

NIOSH National Institute for Occupational Safety and Health.

NHL **Non Hodgkin Lymphoma** is a cancer of the lymphatic system, which is an important component of the human immune (disease fighting) system.

NOAEL The **No Observable Adverse Effect Level** is the exposure level of chemical that produces no significant increases in frequency or severity of adverse effects. Effects may be produced at this dose, but they are not considered to be adverse.

NPDWR **National Primary Drinking Water Regulations** are legally enforceable standards that apply to public water systems. Primary standards are available on the web at: http://www.epa.gov/safewater/mcl.html

NPL site The National Priorities List is a list published by EPA ranking all the Superfund sites. Superfund is the common name for the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), a federal law enacted in 1980. This law was preauthorized in 1986 as the Superfund Amendments and Reauthorization Act. CERCLA enables EPA to respond to hazardous waste sites that threaten public health and the environment. A site must be added to the NPL site list before remediation can begin under Superfund.

NTP The **National Toxicology Program** is part of the Department of Health and Human Services. NTP develops and carries out tests to predict whether a chemical will cause harm to humans.

PAH **Polycyclic aromatic hydrocarbons** are found in oil, tar and coal deposits, and are byproducts of fuel burning. They are not volatile in air or soluble in water. As a result, PAHs are often found in the soil or suspended in particulate matter in air. Health effects of PAH range from nontoxic to carcinogenic.

PEL **Permissible Exposure Limit** for a hazardous substance or condition in the workplace as defined by the Occupational Safety and Health Administration (OSHA) General Industry Air Contaminants Standard (29 CFR 1910.1000).

PHA **Public Health Assessment.** An ATSDR document that examines hazardous substances, health outcomes, and community concerns at a hazardous waste site to determine whether people could be harmed from coming into contact with those substances. The PHA also lists actions that need to be taken to protect public health.

PHAP Public Health Action Plan

PID A **Photoionization Detector** is a tool that measures the concentration of a volatile organic compounds or other gases in the air. Hazmat crews often use PID to determine if the area is safe for responders and residents to remain in an area after a spill or gas leak.

Potential Exposure Pathway A possible way in which people can be exposed to a contaminant associated with a site. An Exposure pathway is a description of the way a chemical moves from a source to where people can come into contact with it. A potential exposure pathway has 4 of the 5 following elements:

1) a source of contamination
2) transport through environmental medium
3) a point of exposure
4) a route of human exposure
5) a receptor population

POR Point of Release

PPB Parts Per Billion

PPM Parts Per Million

PRG Preliminary Remediation Goals. Used for EPA Planning Purposes only.

Public Health Hazard The category ATSDR assigns to sites that pose a health hazard to the public as the result of long-term exposures to hazardous substances. See “Public Health Hazard Categories”.

Public Health Hazard Categories Categories defined by ATSDR and used in public health assessments that assess if people could be harmed by conditions present at a site in the past, present or future. One or more hazard categories may be assigned to a site. The five categories are:

Urgent Public Health Hazard
Public Health Hazard
Indeterminate Public Health Hazard
No Apparent Public Health Hazard
No Public Health Hazard

PVC Polyvinyl chloride is a type of plastic that is commonly used in construction, as well as clothing, toys, hoses and tubing. Certain additives (plasticizers) that are used to produce PVC items have been linked to certain health risks.

REL **Recommended Exposure Limit** for a hazardous substance or condition in the workplace as defined by the National Institute for Occupational Safety and Health (NIOSH).

RfD A **Reference Dose** is an EPA estimate, with uncertainty of safety factors built-in, of the daily lifetime dose of a substance that is unlikely to cause harm in humans.

RMEG **Reference Dose Media Evaluation Guides** are media-specific comparison values used to select contaminants of interest at hazardous waste sites. RMEGs are derived from reference doses (RfDs), developed by the U.S. Environmental Protection Agency (EPA), and are an estimate of human exposure to a compound that is not expected to cause noncancerous health effects at that level for a specified period. They are intended to protect the most sensitive individuals (i.e., children). RfDs are guidelines and are not used to predict adverse health effects. RfDs do not take into account carcinogenic effects, chemical interactions, or multiple routes of exposure.

Screening Values Screening Values are health-based and media-specific concentrations that are used to select environmental contaminants for further evaluation in public health assessments. These values are not valid for other types of media, nor do concentrations above these values indicate that a health risk actually exists (agency that developed the value is in parenthesis for the examples below):

Examples of Comparison Values for non-cancer health effects

EMEG-c = Environmental Media Evaluation Guide for chronic (more than 365 days) exposure (ATSDR).

EMEG-I = Environmental Media Evaluation Guide for intermediate exposure (ATSDR).

EMEG-u = Environmental Media Evaluation Guides that are unpublished are designated with an asterisk by the authors of this health assessment and used only in the absence of published comparison values and are calculated using equations outlined in Appendix B.

RMEG = Reference Dose Media Evaluation Guide (ATSDR).

NPDWR = National Primary Drinking Water Regulations (EPA) accessed on web at: www.epa.gov/safewater/mcl.html

LTHA = Lifetime health advisory for drinking water (EPA).

Example of a Screening values for cancer health effects

CREG = Cancer Risk Evaluation Guide for $1x10^{-6}$ excess cancer risk (ATSDR).

SDWA **The Safe Drinking Water Act** is the main federal law that ensures the quality of Americans' drinking water. SDWA was originally passed by Congress in 1974 to protect public health by regulating the nation's public drinking water supply.

SDWS **National Secondary Drinking Water Standards** or secondary standards are non-enforceable guidelines that regulate contaminants that may cause cosmetic or aesthetic effects in drinking water.

SLCFD Salt Lake City Fire Department

SLVHD Salt Lake Valley Health Department

UCR Utah Cancer Registry

UDEQ Utah Department of Environmental Quality

UDOH Utah Department of Health

VA Utah Department of Veterans Affairs

VOCs **Volatile Organic Compounds** are a group of carbon-based chemicals that evaporate quickly at room temperature. VOCs are found in many different household items, including paint, cleaning products and vehicle exhaust. There are many different types of VOCs. Some VOCs have been linked to health effects, but the severity of effects depends on the exposure of the chemical.

WHO World Health Organization

ZCTA **Zip Code Tabulation Areas** are generalized area representations of U.S. Postal Service (USPS) ZIP Code service areas.