Polychlorinated biphenyls (PCBs) in stormwater from the Pajarito Plateau, northern New Mexico.

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Polychlorinated Biphenyls (PCBs) in Stormwater From the Pajarito Plateau, Northern New Mexico.

By

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Committee Approval

The Master of Water Resources Professional Project Report of Marwin Shendo, entitled “Polychlorinated Biphenyls (PCBs) in Stormwater From the Pajarito Plateau, Northern New Mexico” is approved by the committee:

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Abstract

Polychlorinated Biphenyls (PCBs) are distributed throughout the globe and represent an environmental threat to wildlife and human health. The New Mexico Water Quality Control Commission has established surface water standards for Wildlife Habitat and the Human Health of 14,000 and 640 pg/L respectively. Preliminary studies identified elevated levels of PCBs in stormwater samples collected from Los Alamos National Laboratory (LANL) watersheds draining the Pajarito Plateau in northern New Mexico, including the Los Alamos County town site. PCB samples were collected at 59 stormwater runoff Site Monitoring Areas (SMAs) from 1996 to 2008 at LANL. PCB Aroclor concentrations ranged from 218,070 ng/L (highest) to 50 ng/L (lowest), with the highest detections found in Los Alamos and Pueblo watersheds. The New Mexico Environmental Department (NMED) collected PCB samples around Los Alamos as part of a Total Maximum Daily Load (TMDL) evaluation in 2006 using the congener analytical method; which has a much lower detection limit of approximately 0.002 ng/L than the Aroclor method. Average blank corrected total PCB values ranged from 1.2 to 11456.7 ng/L. Runoff from Los Alamos County town site was collected and analyzed as well with values ranging from 59.2 to 10201.8 ng/L. These studies demonstrate that multiple sources of PCBs exist on the Pajarito Plateau and must be defined. To better understand the distribution of PCBs in stormwater, background concentrations of PCBs in surface and stormwaters were characterized. Understanding background concentrations of PCBs is critical to quantifying sources of PCBs in stormwater on the Pajarito Plateau.

LANL was granted a National Pollutant Discharge Elimination System (NPDES) Individual Permit for Stormwater discharges from Environmental Protection Agency (EPA) on November 1, 2010. With multiple sources of PCBs running onto Laboratory property, understanding the regional background, baseline concentrations of PCBs and contributions from additional industrial and urban sources will aid permit compliance. Quantifying offsite PCB concentrations is critical to identifying the Laboratory’s contribution to PCBs in stormwater runoff. This project presents data collected by the LANL Stormwater Program and NMED and defines background PCB concentrations on the Pajarito Plateau.

Stormwater monitoring was conducted from 2009 through 2010. Thirty five reference samples were collected using automated stormwater samplers and analyzed for PCBs by method 1668A. PCB concentrations from the reference watersheds range from 23 to 24,000 pg/L. PCB concentrations from the western boundary locations ranged from 33.1 to 16,800 pg/L. Twenty urban samples were collected, fifteen from Los Alamos County and five from the Laboratory parking lot. The county samples ranged from 1,270 to 19,600 pg/L and the Laboratory ranged from 7,560 to 31,200 pg/L.
1. INTRODUCTION
1.1 Problem Statement
Polychlorinated biphenyls (PCBs) are a class of chlorinated hydrocarbons that were manufactured for their inert chemistry and insulating properties and were used in capacitors, transformers, and other electrical equipment as they do not easily burn, evaporate or conduct electricity (DeGrandchamp and Barron 2005). It is estimated that greater than a million pounds of PCBs have been released to the global environment and are distributed throughout the biosphere, geosphere, and hydrosphere. PCBs are present in the atmosphere in gaseous, aerosol, and particulate adsorbed forms. The New Mexico Water Quality Control Commission (NMWQCC) recognized the threat PCBs pose and established surface water Wildlife Habitat (14,000 pg/L) and Human Health (640 pg/L) standards for PCB total concentrations. Preliminary studies by the New Mexico Environment Department (NMED) and the Los Alamos National Laboratory (LANL), identified elevated levels of PCBs in stormwater samples collected from LANL watersheds draining the Pajarito Plateau in northern New Mexico, including the Los Alamos County town site.

Sediment transport via stormwater runoff is believed to be the predominant mechanism for redistributing PCBs on the Pajarito Plateau. Sediment transport occurs during floods, snowmelt events, and sustained releases from outfalls.

The largest floods, and thus the largest potential for sediment redistribution, are caused by summer thunderstorms. Runoff may contain PCBs from atmospheric deposition, urban sources, and additional recognized and unrecognized sources. Without controls the runoff can enter surface waters (canyon bottoms and potentially the Rio Grande) where New Mexico surface water quality standards apply. Figure 1 shows the transport and exposure pathways for PCBs in the environment most relevant to the Los Alamos watershed.

2006 studies by NMED and LANL, identified elevated levels of PCBs in stormwater samples collected from tributaries draining the Pajarito Plateau, including Los Alamos County town site and Laboratory watersheds. Results indicated levels above the NMWQCC Wildlife Habitat and the Human Health surface water standard occur in stormwater runoff. To better understand the distribution of PCBs in stormwater, regional background concentrations of PCBs in surface and stormwater must be known.
1.2 PCB Sources and Properties
PCBs are manmade chlorinated organic compounds composed of two connected biphenyl rings with 1 to 10 chlorine atoms bonded at 10 possible positions around each ring (Figure 2). There are 209 possible PCB compounds known as congeners. Individual congeners have different physical and chemical properties (Parsons and Terragraphics 2007). The number and position of chlorine atoms determine a molecule's physical and chemical properties. The 10 positions are numbered 2–6 on one ring and 2'–6' on the other. For example, the congener 2, 4, 2', 5'-tetrachlorobiphenyl has chlorines in positions 2 and 4 of one ring and 2' and 5' of the other. Positions 2, 6, 2', and 6', adjacent to the bond, are called ortho positions; 3, 5, 3', and 5', meta positions; 4 and 4' (the outermost), para positions (Gonzales and Fresquez 2003).
Although PCB mixtures were manufactured in many countries, all PCBs produced in North America were made by a single producer, Monsanto Corporation, and are referred to as Aroclors. In formulating and manufacturing Aroclors, Monsanto developed a numbering system to identify an individual PCB mixture with a particular physical property, rather than a particular chemical composition. Thus, Aroclors are numbered with a 4-digit code where the first two digits are 12 and the last two digits represent the percentage by weight of chlorine. For example, Aroclor 1260 is a mixture of more than a hundred individual PCB congeners in which the mixture is 60 percent (by weight), chlorine, which is a highly chlorinated mixture (DeGrandchamp and Barron 2005).

Groups of individual PCB congeners having the same number of chlorine atoms are called PCB homologues. For example, the group of PCB homologues referred to as monochlorinated biphenyls has only one chlorine on the biphenyl ring while the hexachlorinated biphenyl homologue group has six chlorines. Because of the many different congeners with the same overall chemical formula Aroclor mixtures may consist of many homologues with the same number of chlorine atoms which are located at different locations on the biphenyl rings (DeGrandchamp and Barron 2005). In general, PCBs are relatively insoluble in water, with the solubility decreasing with increased chlorination. PCBs are also freely soluble in nonpolar organic solvents and biological lipids (Gonzales and Fresquez 2003).

PCBs are mixtures of synthetic organic chemicals that range from oily liquids to waxy solids. Due to their nonflammability, chemical stability, high boiling point, and electrical insulating properties, PCBs were used in hundreds of industrial and commercial applications. An important property of PCBs is their general inertness; they resist both acids and alkalis and have thermal
stability. This made them useful in a wide variety of applications, including dielectric fluids in transformers and capacitors, heat transfer fluids, and lubricants. Many other less common miscellaneous applications for PCBs were also developed, including plasticizers, carbonless copy paper, lubricants, inks, laminating agents, impregnating agents, paints, adhesives, waxes, additives in cements and plasters, casting agents, de-dusting agents, sealing liquids, fire retardants, immersion oils, and pesticides (De Voogt and Brinkman 1989).

PCBs were commercially produced for almost 50 years and were widely used in a variety of equipment and consumer products (Mandalakis and Stephanou 2007). The production and use of PCBs was terminated in 1977. PCBs were released to the air during Aroclor production and processing and when PCB-contaminated equipment was destroyed. Similarly, transformer and capacitor producers discharged PCB-containing wastes to the environment during filling and disposal processes. Emissions are no longer discharged into the air through production activities; however, emissions may be discharged during the overhaul, repair, or reuse of materials containing PCBs (Gonzales and Fresquez 2003).

Congress enacted the Toxic Substances Control Act (TSCA), which became law on October 11, 1976 to become effective on January 1, 1977 that included, among other things, prohibitions on the manufacture, processing, and distribution in commerce of PCBs.

1.3 PCB Fate and Transport in the Environment
PCBs occur as mixtures of congeners, but in the environment, the composition differs from the original commercial mixtures. The composition of PCB mixtures changes over time, through partitioning, chemical transformation, and preferential bioaccumulation (USEPA 1996).

Partitioning refers to processes by which different fractions of a mixture separate into air, water, sediment, and soil. PCBs adsorb to organic materials, sediments, and soils. Adsorption tends to increase with chlorine content and organic content of the soil or sediment. PCBs can volatilize or disperse as aerosols, providing an effective means of transport in the environment (Callahan et al. 1979). Congeners with low chlorine content tend to be more volatile and also more soluble in water. Vaporization rates and water solubility of different Aroclors and individual congeners vary over several orders of magnitude (USEPA 1996).

Bioaccumulation is a process by which chemicals (PCBs) are accumulated by an organism (human) either by direct exposure to a contaminated medium or by consumption of food contaminated by the chemical. PCB bioaccumulation in humans occurs via partitioning of PCBs from air and water into terrestrial plants and aquatic autotrophs and invertebrates of the lowest trophic levels, followed by transfer through the food web. Although it has long been assumed to be insignificant compared to dietary exposure, little is known about the relative importance of PCB inhalation (Norstrom et. Al 2010). In the Norstrom et al study, they investigated the
potential contribution of inhalation to the overall human exposure to PCBs in an urban area. A non-steady state bioaccumulation model ACC-HUMAN was applied to predict the PCB body burden in an adult living in the Midwestern United States who eats a typical North American diet and inhales air contaminated with PCBs. Dietary exposure was estimated using measured data for eighteen PCB congeners in different food groups (fish, meat and egg, dairy products). The model predicted that exposure via inhalation increases the accumulated mass of PCBs in the body by up to 30% for lower chlorinated congeners, while diet is by far the dominant source of exposure for those PCB congeners that accumulate most in humans.

Atmospheric transport is the most important mechanism for toxic material such as PCBs to reach surface waters and the other environments (Birgül and Tasdemir 2011). The lower chlorinated biphenyls (CBs) are more subject to volatilization and atmospheric transport. The higher CBs remain closer to the source. PCBs enter the atmosphere from volatilization from both water surfaces (Fang et al. 2008) and soil (Saba and Boehm 2011). In the atmosphere, PCBs are present both in the vapor phase and airborne particles (Birgül and Tasdemir 2011). PCBs are more mobile in the vapor phase and appear to be transported further than particle-bound PCBs (Birgül and Tasdemir 2011). Wet (rain) and dry deposition remove PCBs from the atmosphere (Birgül and Tasdemir 2011; Teil et al. 2004 and Agrell et al. 2002). Wet processes consist in rain which dissolves gaseous compounds in cloud aerosols; washout occurs when clouds turn to precipitation which also washes down atmospheric particles (Teil et al. 2004). Sediment-bound PCBs also accounts for water concentrations. PCBs are removed from the water column by sorption to suspended solids and sediments as well as by volatilization from water surfaces (ATSDR 2000).

Biodegradation transforms PCB mixtures in the environment. The effectiveness of biodegradation depends on many environmental factors. These factors include the structure of the compound, their position in the molecule, solubility of the compound and concentration of the pollutant (Borja et al. 2005). Other environmental factors affecting degradation are temperature, pH, presence of toxic or inhibitory substance and competing substrates, availability of suitable electron acceptors, and interactions among microorganisms (Borja et al. 2005). Anaerobic bacteria in sediments selectively remove chlorines from meta and para positions, resulting in a depletion of highly chlorinated PCB congeners with corresponding increases in lower chlorinated PCB congeners (Borja et al. 2005 and Abramowicz 1995). The lightly chlorinated PCB congeners resulting from the dechlorination of highly chlorinated congeners may subsequently serve as substrate for aerobic bacteria (Borja et al. 2005). Aerobic bacteria remove chlorines from PCBs with low chlorine content (1–4 chlorines) and break open the carbon rings through oxidation. Highly chlorinated PCB congeners remain biorefractory to aerobic bacteria sequence of anaerobic decomposition followed by aerobic may completely mineralize these compounds. Overall, dechlorination processes are slow and altered PCB mixtures can persist in the environment for many years (USEPA 1996).
Humans are exposed to PCBs through multiple pathways. Levels in air, water, sediment, soil, and foods vary in orders of magnitude, often depending on the closeness of the source that was released into the environment. Ingestion has usually been assumed the primary route of exposure to PCBs but inhalation and dermal absorption are also possible routes of exposure (Carpenter 2006). Average daily intake by humans via ambient air is about 100 ng, and about an order of magnitude higher if indoor concentrations are considered. Average daily intake via drinking water is less than 200 ng (ATSDR 1993).

PCBs have been demonstrated to cause multiple health effects. The toxicity depends on the type and quantity of congeners and the number of chlorine atoms. Congeners containing chlorine only in the meta and para positions tend to assume a planar configuration and show “dioxin-like” activity, whereas those having chlorine in the ortho position do not show significant “dioxin-like” activity (Carpenter 2006). One dozen congeners out of 209 congeners are considered “dioxin-like”. The 12 PCBs listed in Table 2 act through the aryl hydrocarbon receptor (AHR - is best known for mediating the toxicity of dioxin) to cause the full range of toxic responses elicited by 2,3,7,8-tetrachlorodibenzo-p-dioxin. Hence, these PCB congeners are referred to as the dioxin-like PCBs (Henry and De Vito 2003). PCBs have been known to cause cancer in animals and EPA has designated PCBs as a probable human carcinogen. People who ingest PCB contaminated animal products and contact PCB contaminated sediment may be exposed to PCB mixtures that are more toxic than the mixtures contacted by workers (EPA 2008). PCB exposure has caused the following health effects in human according to Carpenter 2006: immune system function; cause adverse alterations of the nervous system, skin, thyroid, and sex steroid hormonal systems; liver, kidney, pancreas, and the cardiovascular system. As a result of these actions on multiple organ systems, humans who are exposed to PCBs are at increased risk of cancer, infections, reduced cognitive function accompanied by adverse behavioral effects, hypothyroidism, infertility, ischemic heart disease, hypertension, diabetes, liver disease, asthma and arthritis, as well as giving birth to infants of lower than normal birth weight.

The EPA has established a maximum contaminant level (MCL) of 0.5 µg/L PCBs in drinking water (ATSDR 2000). The MCL in drinking water is regulated by the Safe Drinking Water Act which requires EPA to determine safe levels of contaminants in drinking water which may cause health problems. Discharges, spills, or accidental releases of PCBs into the environment must be reported to the EPA. Many states have established fish and wildlife consumption advisories for PCBs (ATSDR 2000). The NMWQCC as established surface water Wildlife Habitat and the Human Health standards for surface water PCB concentrations in New Mexico.

1.4 Description of Study Area
LANL is located in Los Alamos County, in north-central New Mexico; approximately 60 miles north northeast of Albuquerque and 25 miles northwest of Santa Fe (see Figure 2). The 40-
square-mile Laboratory is situated on the Pajarito Plateau, a series of mesas separated by deep east-to-west-oriented canyons cut by stream channels (Environmental Surveillance 2009). Listed from north to south, are Los Alamos, Sandia, Mortandad, Pajarito, Water, Ancho, and Chaquehui canyons. Each of these watersheds includes tributary canyons of various sizes.

Figure 3. Study Area. (Modified from the Environmental Surveillance 2009).

Mesa tops range in elevation from approximately 7,800 ft at the base of the Jemez Mountains to about 6,200 ft at White Rock Canyon. The Laboratory is bordered to the south by Bandelier National Monument, managed by the US National Park Service; US Forest Service property lies to the west, and to the east is the Pueblo of San Ildefonso.
Watercourses in the Los Alamos area occur primarily as short-lived or intermittent reaches of streams. Of the more than 80 miles of watercourse, approximately three miles of canyon in the western part of the Laboratory have streams that are naturally perennial and fed by springs. These perennial segments are located in Water Canyon, Cañon de Valle (a major tributary to Water Canyon), and Pajarito Canyon and its tributaries. Approximately four miles of canyon on Laboratory land have perennial streams created by discharges of treated effluent from wastewater treatment plants (WWTPs) in Pueblo and Sandia Canyons (Environmental Surveillance 2009).

The remaining stream channels are dry for varying lengths of time. The driest segments flow only after local precipitation events or during snowmelt periods, and flow in these streams is ephemeral. Other stream segments sometimes have alluvial groundwater that discharges into the stream bed and/or experience extensive snowmelt runoff and are considered intermittent. Intermittent streams may flow for several weeks to a year or longer (Environmental Surveillance 2009).

1.4.1 Weather and Climate

The climate on the Pajarito Plateau is characterized as temperate, semiarid mountain climate. Four distinct seasons occur in Los Alamos County. Spring is the windiest season. Summer is the rainy season, with occasional afternoon thunderstorms. Winters are generally mild, with occasional winter storms. Fall is typically dry, cool, and calm.

Summer produces the greatest percentage of precipitation, primarily as rainfall. The topography of Los Alamos heavily influences the spatial variability of precipitation. Mean annual precipitation increases from east to west across the Laboratory, see Figure 4, ranging from 12” on the east edge to about 27” to the western edge (Reneau et.al 2003). The months of July and August account for 36% of the annual precipitation and encompass the bulk of the rainy season, which typically begins in early July and ends in early September (Environmental Surveillance 2009). Summer temperatures during the day range between 70°F to 88°F, dropping to 50’s during the night. Winter in the area usually produces numerous episodes of snow and freezing temperatures and below freezing temperatures during the night and early mornings.

The topography of the Pajarito Plateau influences local wind patterns. Daytime winds are predominately from the south, consistent with the typical upslope flow of heated daytime air moving up the Rio Grande valley. Nighttime winds (sunset to sunrise) on the Pajarito Plateau are typically from the west, resulting from a combination of prevailing winds from the west and downslope flow of cooled mountain air (Figure 5). Winds atop Pajarito Mountain are more representative of upper-level flows and primarily range from the northwest to the southwest, mainly because of the prevailing westerly winds (Environmental Surveillance 2009).
Figure 4. Maps showing east to west variations in (a) mean annual precipitation (b) Summer (July to September) mean precipitation across the Pajarito Plateau. Taken from Reneau et. al 2003.
Figure 5. 2010 Day and night windroses on the Pajarito Plateau. Map created by Dave Frank of EP-ET-ER GIS Team.
1.5 Historical PCB Data at LANL

Previous data have shown that elevated concentrations of PCBs are found in fish at Cochiti and Abiquiu reservoirs (Fresquez and Gonzales 2000; Fresquez et al. 2001, 2002). The concentrations measured in fish were high enough that consumption restrictions have been considered by the State of New Mexico according to U.S. Environmental Protection Agency (EPA) guidance (USEPA 2000). Concerns have repeatedly been posed as to how much, if any, of this PCB burden is contributed by the Los Alamos National Laboratory (LANL). This concern arose because LANL has ephemeral streams in canyons that discharge to the Rio Grande. Like many other industrial sites, LANL historically used PCB-containing devices such as electrical transformers and unanticipated outfall releases into the environment may have occurred (Gonzales and Fresquez 2003).

The previous LANL studies on PCBs in fish have resulted in three main conclusions: (1) while the levels of PCBs measured in fish in the Rio Grande and Cochiti Reservoir did not exceed guidance limits for even the most sensitive piscivores or other biota in related food chains, restrictions on human fish consumption have been consistently indicated by the PCB levels measured in edible portions of fish on the basis of recent EPA guidance (USEPA 2000); (2) focus in future years regarding health risk from PCBs in fish in the Rio Grande and Cochiti Reservoir should be on humans, not biota; and (3) on the basis of sampling and analysis of fish for PCBs, there is no clear evidence that LANL is a major source (Gonzales and Fresquez 2003).

As a result of recent public interest concerning PCBs in fish and in LANL surface water, a PCB cooperative working group was organized in March 2002 to attempt to:

- quantify the contribution of PCBs, if any, by LANL to nearby bodies of water,
- determine the spatial variability of PCB concentrations (including background) in regional soils,
- determine the spatial variability of PCB concentrations in surface water, sediments, and fish from LANL watersheds, and
- determine the spatial variability of PCB concentrations in the Rio Grande upstream and downstream of LANL (Mullen et al. 2002).

LANL received its National Pollutant Discharge Elimination System (NPDES) Individual Permit for Stormwater discharges, which was issued by U.S. EPA Region 6 Office in Dallas, Texas. The permit came into effect on November 1, 2010. The purpose of the Permit is to establish a compliance program for the regulation of stormwater discharges from Solid Waste Management Units (SWMUs) and Areas of Concern (AOCs) point source of contaminants at the Laboratory that are managed under the Resource Conservation and Recovery Act (RCRA). SWMUs meet the definition of an “industrial activity” that may be subject to NPDES stormwater permitting. Collocated SWMUs are generally compiled into Site Monitoring Areas (SMAs). Stormwater that
contained PCBs was collected at 59 SMAs from 1996 to 2008. PCB Aroclor concentrations ranged from 218,070 ng/L (highest) to 50 ng/L (lowest) in these unpublished data, with the highest detections occurring in Los Alamos and Pueblo watersheds (See Table 1). Table 1 list some of the stormwater collected at the 59 sites that contained PCBs ranked by detection rates. The first letter in the SMA IDs describes the canyon associated with the SMA (i.e. S=Sandia Canyon, LA=Los Alamos Canyon) and the number at the end determines the site number in the associated canyons.

Table 1. Summary of Statistical Results and Sample Collection Information from the Federal Facilities Compliance Agreement (FFCA).

<table>
<thead>
<tr>
<th>Ranking</th>
<th>SMA ID</th>
<th>Mean ^aPCBs (ug/L)</th>
<th>Mean ^bHI Value</th>
<th>Median PCBs (ug/L)</th>
<th>Detections</th>
<th>Number of ^cSRs</th>
<th>^dDetection Rate (%)</th>
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<td>0.15</td>
<td>11</td>
<td>0.10</td>
<td>3</td>
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<tr>
<td></td>
<td>T-SMA-1</td>
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<td>6</td>
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<td>PJ-SMA-15</td>
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<tr>
<td></td>
<td>CDB-SMA-4</td>
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<td>13</td>
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<tr>
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<td>5</td>
<td>0.08</td>
<td>1</td>
<td>5</td>
<td>20</td>
</tr>
</tbody>
</table>

A. PCB concentrations represent sum of Aroclor results.  
B. HI is the hazard index (PCB result/wild life criteria of (0.014 ug/L).  
C. SR is sample round.  
D. Detection rate is calculated as follows: (detections/SRs)x100.

NMED collected PCB samples as part of a Total Maximum Daily Loading (TMDL) evaluation in 2006 using the congener analytical method, EPA Method 1668A (See Section 2.2 Analytical Method). The results indicate that PCBs are present in remote locations at concentrations similar to the NMWQCC surface water standards and are at or above these thresholds at locations influenced by industrial and urban activities. Overall, blank corrected (See Section 2.3 Blank Correction Method) total PCB values ranged from 1.2 to 11,456.7 ng/L (0.00122 ug/L to
Background PCB concentrations range from 1.2 to 39.8 ng/L. Runoff from Los Alamos County townsite concentrations range from 59.2 to 10,201.8 ng/L. Runoff from the Laboratory ranged from 6.0 to 11,456.7 ng/L (unpublished data).

These studies demonstrated that multiple sources of PCBs exist on the Pajarito Plateau. Under the newly signed NPDES Individual Permit, the Laboratory must monitor and control discharges of stormwater associated with industrial activities from specified SWMUs and AOCs to receiving waters (tributaries or main channels). However, controlling runoff from these locations is complicated by multiple potential sources of PCBs running onto Laboratory property. Therefore, understanding the regional background (non-urban watersheds in remote locations in the region) of PCBs and contributions from other industrial and urban sources is critical to determining the Laboratory’s contribution to PCBs in stormwater runoff.

1.6 Target Total PCB Concentration in Water
Under the NPDES Individual Permit, LANL must monitor stormwater discharges from sites at associated SMAs to ensure such discharges do not exceed applicable target action levels. The target action levels are based on and equivalent to state of New Mexico surface water quality criteria for PCBs (Table 2).

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Method</th>
<th>NMWQCC Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCBs</td>
<td>EPA Method 1668A</td>
<td>0.64 ng/L &amp; 14 ng/L</td>
</tr>
</tbody>
</table>

1.7 Objectives and Approach of this Study
The objective of this study was to identify the regional background concentrations of PCBs in stormwater on the Pajarito Plateau. NMED’s TMDL study and LANL’s SMA data showed a rising concern of PCB concentrations in stormwater. Runoff from Laboratory property has the potential of entering the Rio Grande and potentially affect the quality of the river. With a rigorous compliance program and studies that show PCB concentrations at or over NMWQCC surface water standards, understanding the regional background and baseline concentrations of PCBs on the plateau is needed to stay in compliance. Background PCBs result from atmospheric gas or vapor phases or adsorbed to fine particulates and aerosols and are thought to be attributed to non-LANL distal sources. Regional background samples were collected at locations distant from the influence of the Laboratory and Los Alamos County processes.

Urban landscapes are characterized by a wide variety of land uses, including residential and industrial areas as well as impervious areas such as roofs, asphalt roads, and concrete (Jartun et al. 2008). In this environment, only a small amount of stormwater infiltrates, evaporates, is
detained, or retained by vegetation resulting in episodes of high volume runoff and consequently a direct discharge to receiving waters (Jartun et al. 2008). In order to evaluate the contribution of PCBs emanating from the urban landscape, samples collected from the town of Los Alamos as well as Laboratory parking lot runoff were analyzed.

PCB concentration in rainfall on the Pajarito Plateau was measured to determine the contribution from wet deposition. Concentrations of PCBs from remote locations around the world is reported to range from a low of 0.02 ng/L to a high of 6.1 ng/L (Gregor and Gummer 1989; Franz and Eisenreich 1993; Offenberg and Baker 1997; Franz, Eisenreich et al. 1998; Backe, Larsson et al. 2002; Mandalakis and Stephanou 2004). Significantly higher concentrations have been observed in precipitation near industrial and urban centers. Maximum values of 122 and 189 ng/L were observed in Paris and Chicago (Teil et al. 2004).

PCBs were analyzed by method 1668A (EPA 2003), with a detection potential of 209 congeners and ten possible PCB homologue groups. Generally, 134 unique congener results were reported per sample and another 32 results were reported that were a combination of 2 or more of the remaining 75 congeners that could not be separated and analyzed independently (co-elutors).

2. RESEARCH METHODS
2.1 Field Procedures
The following sections describe field methods used to sample storm water. Location descriptions are included in Table 3 and sample locations are shown in Figure 6.

Stormwater samples were collected using ISCO® and Global Water® automated samplers. Each ISCO sampler was installed on the bank of a channel and anchored to prevent the sampler from being washed away. Water was sampled through a tube connected to an internal peristaltic pump. A 12 volt battery powered the sampler and data logger. The sampler collected water when a liquid level actuator detected flow in the channel. When the sensor was activated, up to 24 samples were collected by drawing water up through the tube and into the sample bottles. To prevent cross contamination, a rinse and flush sequence occurred before and after every sample collected.

The Global Water sampler, also referred to as a suitcase sampler, was also installed on the bank of the channel. Two tubes were connected to two separate peristaltic pumps; both were powered by one 12 volt battery. The sampler collected water samples when the liquid actuator detected flow in the channel. Both motors then pumped simultaneously through the tube and into two 1-gallon glass bottles. To prevent overflow each bottle was equipped with a float switch that automatically turns the pump off when the bottle was full. An automatic 15 second back flush cycle cleared any debris from the sampler's strainer and emptied the water from the hose so the next sample was not contaminated.
Rainfall was collected with ADS/NTN Atmospheric Precipitation Samplers from N-CON Systems Co., Inc. Each sampler consisted of a stainless steel bucket with an automated movable lid with a sensor that detected precipitation, as well as drizzle, heavy fog or light snow. When rain was detected by the sensor, the lid automatically moved off the bucket to collect rainfall in the bucket. When precipitation ended the compressed seal cover moved back over the bucket to prevent evaporation and deposition of windblown dust.

Two different locations were monitored in this study: (1) regional stations that are either upstream of Laboratory sources or distant from Laboratory sources; and (2) urban nonpoint locations that represent a local source. All regional locations were selected, using a geologic map of New Mexico, based on similar terrain and geology to the Laboratory. Monitoring locations are shown in Figure 6.
### Townsite/Laboratory Locations

<table>
<thead>
<tr>
<th>Location Name</th>
<th>Run-On</th>
<th>Urban or Industrial Area Catchment</th>
<th>Potential Releases</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACID-ROM-1</td>
<td>Run-on</td>
<td>Culvert draining parking lot of apartments adjacent to IHM Catholic Church; old catholic church. Urban area west and east of Ashley Pond; roof tops, impervious surfaces.</td>
<td>inorganic chemicals, organic chemicals, pesticides, PCBs, and radionuclides.</td>
</tr>
<tr>
<td>ACID-ROM-2(a)</td>
<td>Run-on</td>
<td>In stream below confluence of two arms, adjacent and west of the Jewish Synagogue. Urban area west and east of Ashley Pond; roof tops, impervious surfaces.</td>
<td>inorganic chemicals, organic chemicals, pesticides, PCBs, isotopic plutonium, total uranium, and americium-241</td>
</tr>
<tr>
<td>ACID-ROM-2(b)</td>
<td>Run-on</td>
<td>Timber Ridge town site south of Ashley Pond; roof tops, impervious surfaces.</td>
<td>inorganic chemicals, organic chemicals, and radionuclides.</td>
</tr>
<tr>
<td>LA-ROM-2</td>
<td>Run-on</td>
<td>Urban run-on and run-off from affected media.</td>
<td>inorganic chemicals, organic chemicals, pesticides/PCBs, and radionuclides</td>
</tr>
<tr>
<td>P-ROM-2.2(a)</td>
<td>Run-on</td>
<td>TA-3 parking lot, road, and roof top drainage</td>
<td>inorganic chemicals, organic chemicals, and PCBs</td>
</tr>
<tr>
<td>S-ROM-0.2</td>
<td>Run-on</td>
<td>South west corner of the power plant in drainage, after culvert TA-3 drainage, roofs and parking lot run-off; elevated PCBs associated with process water and facility plumbing.</td>
<td>inorganic chemicals, organic chemicals, radionuclides, organochlorine pesticides, herbicides, and PCBs</td>
</tr>
</tbody>
</table>

### Reference Background Locations

<table>
<thead>
<tr>
<th>Location Name</th>
<th>Run-On</th>
<th>Urban or Industrial Area Catchment</th>
<th>Potential Releases</th>
</tr>
</thead>
<tbody>
<tr>
<td>E240</td>
<td>Run-on</td>
<td>None/No Imperious Surfaces</td>
<td>Atmospheric/Global Fallout</td>
</tr>
<tr>
<td>E252</td>
<td>Run-on</td>
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<td>Atmospheric/Global Fallout</td>
</tr>
<tr>
<td>E025</td>
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<td>Atmospheric/Global Fallout</td>
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<td>LAS-LATAS-REF-1</td>
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<tr>
<td>GARCIA-REF-1</td>
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<td>LAS-LATAS-REF-2</td>
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<td>LAS-MAJAS-REF-1</td>
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<tr>
<td>CORRAL-REF-1</td>
<td>Run-on</td>
<td>None/No Imperious Surfaces</td>
<td>Atmospheric/Global Fallout</td>
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</table>

Table 3. Site Justification and Description Table
Figure 6. Project Sampling Locations
2.2 Analytical Method
Method 1668A, with corrections and changes through August 20, 2003 (EPA 2003), was used to analyze PCBs in the unfiltered samples. Method 1668A was developed by the EPA’s Office of Water, Office of Science and Technology to determine chlorinated biphenyl congeners in environmental samples by isotope dilution and internal standard high-resolution gas chromatography/high-resolution mass spectrometry (HRGC/HRMS).

Prior to the development of EPA Method 1668A, analytical methods for PCBs in water used gas chromatographic identification of isomeric mixtures (Aroclors). Identifying the Aroclors turned out to be difficult because of the different weathering rates of the isomers. Method 1668A, which identifies individual PCB congeners, has the following advantages over the Aroclor method (Columbia Analytical Services).

- The detection limits are lower than the traditional Aroclor analysis, typically in the low pg/L range
- There are fewer problems with matrix interferences in an environmental sample
- The identification and quantification of individual PCB congeners is more accurate
- The quantification of the 12 toxic congeners can accurately determine the ecological risks
- Aroclor concentrations can be estimated from the congener concentrations

However, the congener-specific analysis is expensive and the general lack of toxicity data for most congeners has not been identified. Most of the currently available toxicity data are for Aroclor mixtures. Toxicity equivalency factors (TEFs) for fish, birds, and mammals have been developed for one dozen congeners (i.e., PCB-77, 81, 105, 114, 118, 123, 126, 156, 157, 167, 169, 189). Congener-specific analyses demand greater effort in terms of data reduction, quality assurance, and processing. A problematic area in congener analyses is comparability between analytical laboratories. Variability include differences in coelution patterns, each laboratory analyze different congeners. Coelution of analytes is a major impediment in PCB congener-specific analyses. The use of dual column chromatography ECD or single column GC/MS-SIM (selective ion monitoring) screens out interferences, minimizes coelution of PCB congeners, and increases reliability of the data. Congener data generated by a single column GC-ECD should be interpreted cautiously. A strong quality assurance program is essential in conducting reliable congener-specific analyses (Bernhard and Petron 2001).

Congener results were summed and reported as total PCB results. Homologue results represent summed congeners having the same level of chlorination.

2.3 Blank Correction Method
The ubiquity of PCB contamination in the environment, including most analytical laboratories, and the extreme sensitivity of Method 1668A has resulted in the identification of PCBs in most
laboratory method blanks. Based on this, method blank subtraction was approved by the EPA for this analytical method. For method blank subtraction, the average of a running blank population, generally ten or more laboratory blanks not including the blank associated with the sample, plus two standard deviations for each congener was calculated. This average blank value, called the method blank correction value (MBCV) represented the ambient background value of the analytical laboratory. The MBCV was subtracted from each congener result for the sample batch to obtain the method blank corrected result (MBCR). In addition, for each congener the MBCV was subtracted from the method blank result to determine any elevated batch specific contamination. When elevated batch specific contamination was identified, any sample results that were less than five times the MBCR for the method blank were “B” qualified for having blank contamination. This process is called the 5X rule. All MBCRs, as well as any applicable qualification for blank contamination, were provided to LANL by the contract analytical laboratory (GEL Laboratory and Desert Research Institute) performing the analyses. In addition the analytical laboratory calculated homologue totals by summing all detected MBCRs (excluding MBCRs that failed the 5X rule) with the same level of chlorination. PCB Totals for each sample were calculated by summing all detected congener MBCRs (excluding MBCRs that failed the 5X rule). All samples were unfiltered.

NMED calculated MBCV in-house after the results were received from their analytical laboratory (AXYS Laboratory and Desert Research Institute). They used the previous year’s method blanks to calculate the MBCV for the current year’s samples.

2.4 Data Validation
Results were validated by an independent third party according to U.S. Department of Energy NNSA Service Center Model Data Validation Procedure and LANL standard operating procedure (SOP-5170). Results qualified by the analytical laboratory for being less than five times the MBCR of the method blank were reviewed by the validator and were usually given a U qualifier indicating that the congener was not detected. In the instances when the validator determined that data should be rejected, the “B” qualifier was applied to data that should be considered detected or other types of qualification that changed the homologue and PCB Total results; totals were then recalculated by the validator using the appropriate results to determine the data as rejected or undetected. When congeners were rejected the associated homologues were qualified as incomplete, “I”, or rejected, “R”, depending on the number of rejected congeners.

2.4.A. Equipment Blanks
HPLC-grade ultra clean water was used for equipment blanks after collection of at least one field sample. This protocol was used to identify residual contamination in the intake lines resulting from re-use of tubing for multiple samples at the same location. Equipment blanks were
collected using the same equipment and procedure used to collect samples to maintain effectiveness. Equipment blanks were method blank corrected like regular samples.

2.4. B. Field Duplicates
Three field duplicate samples were collected at Las-Latas-1 (twice) and Garcia-1. These samples were based on the amount of runoff the storm event produced. Each field duplicate was analyzed for identical chemical and physical parameters. Other water quality parameters analyzed from the samples included general inorganics, particle size, metals, and radiation. Sample volumes were split into identical aliquots and submitted to the contract analytical laboratory.

3. Sampling Results
The principal focus of this study was stormwater, from ephemeral drainages that respond only to rainfall and urban runoff. Two types of automated samplers as described in Section 2.1 were used to collect stormwater. Stormwater was collected immediately after the liquid level detector sensed runoff from a rain event. The first 15 minutes of the initial first flush was collected at each location. The next section shows concentration data from the first 15 minutes of the stormwater runoff.

3.1 Total PCB
A total of 15 samples were collected during 2009 and 2010 from Los Alamos County town site locations, all 15 exceeded the WQCC surface water human health criteria of 640 pg/L. Results for these 15 total PCB (sum of all congeners) samples ranged from 1,270 to 19,600 pg/L (Figure 7) and had a calculated mean of 5,431 pg/L (Table 11 in Appendix D). These results are lower than the 2006 TMDL study conducted by NMED, which ranged from 59,200 to 10,201,800 pg/L. Only two samples out of the 15 collected exceeded the surface water wildlife habitat criteria of 14,000 pg/L. These samples had total PCB concentrations of 17,000 pg/L and 19,600 pg/L.
Run-on samples from the Laboratory (Parking Lot) had total PCB concentrations ranging from 7,560 pg/L to 31,200 pg/L (Figure 8) and had a calculated mean of 20,972 pg/L (Table 12 in Appendix D). All 5 samples collected exceeded the surface water human health criteria and three surpassed the surface water wildlife habitat criteria with concentration levels of 26,600, 28,800, and 31,200 pg/L.
A total of 20 background samples were collected from the northern watersheds in 2009 and 2010. These locations were north (Figure 6) of the Laboratory and Los Alamos town site and thereby less likely to be affected by industrial and urban activities. The results are representative of baseline PCB concentrations in stormwater. Total PCB concentrations ranged from 23 pg/L to 24,000 pg/L (Figure 9) with a calculated mean of 3,287 pg/L (Table 13 in Appendix D). The 24,000 pg/L result was a grab sample, by hand, collected during a flood event. Automated samplers collected the rest of the 19 samples during the first flush of the storm events. A total of 8 samples exceeded the surface water human health criteria and the single grab sample taken throughout the two sampling seasons exceeded both criteria.

![Figure 9. Water Samples from Northern Watershed Total PCB Values (pg/L)](image)

Upstream baseline (Western Boundary) samples were collected just west of the laboratory along SR 502 and in upper Los Alamos Canyon (Figure 4). A total of 15 samples were collected and analyzed. Total PCB concentrations ranged from 33.1 pg/L to 16,800 pg/L (Figure 10). The calculated mean from all 15 samples was 2,930 pg/L (Table 14 in Appendix D); 10 out of the 15 samples exceeded the surface water human health standard and one exceeded both human health and wildlife surface water standards. These locations were located closer to industrial and urban activities on the Pajarito Plateau.

Out of all the sampling locations, a sample taken from a LANL parking lot produced the highest total PCB concentration of 31,200 pg/L, S-ROM-2(a). This location had the highest average of 20,972 pg/L but only five samples were collected at this location. The lowest concentration level of 23 pg/L came from a sample collected in the reference watershed, Garcia Canyon on 4/30/2010.
Figure 10. Stormwater samples from Western Watershed total PCB values (pg/L)

Wet deposition as rainfall was collected by the New Mexico Environment Department, Department of Energy Oversight Bureau. Precipitation collectors were placed in two separate locations on the Pajarito Plateau; one on top of the mesa above Bandelier National Monument and the other at the Los Alamos County Airport (locations not shown). Both locations collected 13 samples. The Los Alamos location had 2 samples exceeding the surface water human health criteria and none exceeding the wildlife criteria (Figure 11). Results ranged from 66 pg/L to 3,865 pg/L with a calculated mean of 608 pg/L (Table 9 in Appendix C). Bandelier had total PCB concentrations ranging from 129 pg/L to 4,028 pg/L with a calculated mean of 813 pg/L (Table 10 in Appendix C). Three of the 13 samples exceeded the human health criteria however; all results were below the wildlife habitat criteria.
3.2 PCB Homologue Evaluation

Graphs were prepared of the average concentration of homologues for samples collected at each site. Homologue graphs from each location showing individual samples collected at each sampling location can be found in Appendix E.

Homologues can be used to compare and contrast samples from different locations. These patterns exhibit unique “fingerprints” to determine various sources that could be ruled out or implicated as a contributing factor in the PCB loading of surface waters. The homologue distribution also gives qualitative information about transport and degradation of PCBs at each location.

Average PCB homologue patterns from the baseline watersheds/locations were dominated by higher-chlorinated congeners. The western boundary watersheds showed a greater amount of hexa, hepta, and octachlorobiphenyls than the northern reference locations. Lower-chlorinated congeners dominated the northern samples by more than 5% and showed a bimodal distribution (Figure 12).
Average urban homologue patterns also showed a preponderance of higher-chlorinated congeners. LANL samples had greater tetra and pentachlorobiphenyls percentages than the Los Alamos county samples. The county samples had greater hepta and octachlorobiphenylels percentages and also had a spike in the lower-chlorinated congeners (Figure 13).
Average homologue patterns in the NMED rain data showed a high fraction of the lower-chlorinated congeners but were dominated by tetra and pentachlorobiphenyls. Bandelier rain had the higher concentrations of di and trichlorobiphenyls while the county rain had higher tetra and pentachlorobiphenyls. Lower-chlorinated congeners are more subject to volatilization and higher-chlorinated congeners tend to remain closer to the source. This was consistent with observed homologue patterns, Bandelier had higher concentrations of lower-chlorinated congeners and Los Alamos County had higher concentrations of higher-chlorinated congeners (Figure 14).

Figure 14. Average PCB homologue data from precipitation in Bandelier National Monument and Los Alamos County Airport

4. DISCUSSION
This study focused on PCB concentrations and characteristics in rainwater and stormwater samples from reference, Laboratory and urban watersheds at locations that would provide insight to PCB concentrations on the Pajarito Plateau. Stormwater runoff in an arid landscape has the potential of producing large sediment transport and a corresponding potentially high amount of PCB contaminants that bind to sediment particles.

Stormwater was sampled in reference watersheds that had similar geologic material to that at the Laboratory, Bandelier Tuff, to determine whether a background atmospheric source of PCBs has created a PCB reservoir that could be used as an aid in permit compliance. Total PCB results exceeded the PCB human health water quality criteria eight times out of 20 samples, 40% of the time in the northern reference watersheds and ten times out of 15 samples, 66.7% of the time in
the western boundary (Table 15 Appendix F). The wildlife habitat standard was surpassed once in each watershed. The average distribution of homologues was bimodal in the northern watershed with peaks at the dichlorobiphenyl homologue and the hexachlorobiphenyl homologue while the western watershed was dominated by higher-chlorinated congeners. Low-chlorinated PCBs are more volatile and may be deposited with precipitation which is a likely source of low-chlorinated PCBs in the northern drainages. High-chlorinated PCB can be carried in suspended dust and then deposited at local distances from the original source. This may be a possible source of heavier PCBs in the reference watersheds (Figure 15).

![PCB Homologue Data](image)

**Figure 15. Average PCB homologue data from precipitation and storm flow from the Pajarito Plateau**

Urban and Laboratory PCBs on the Pajarito Plateau can be attributed to local, LANL and non-LANL sources. A total of fifteen samples were taken from the Los Alamos County townsit and five from parking lots flowing off LANL property. Total PCBs from all twenty samples exceeded the human health standard and five surpassed the wildlife habitat criteria, two from the county and three from LANL parking lots. Average homologue distributions were dominated by high-chlorinated PCBs from both locations. The county had a slight bimodal peak in the dichlorobiophenyls. LANL parking lot runoff samples had higher concentration of tetra-CB and penta-CB; Los Alamos county runoff had greater hepta-CB and octa-CB concentrations. Homologue patterns indicated that urban sources are contributing factors of PCB loading in stormwater. Both urban samples had low-chlorinated congeners that were higher or equal to the western boundary concentrations and the high-chlorinated congeners were lower or equal to the western concentrations. The northern samples had higher low-chlorinated homologue
concentrations than both urban samples and the urban samples had high-chlorinated congeners equal to or higher than the northern concentrations (Figure 15).

Average precipitation homologue patterns had higher concentrations of lower-chlorinated congeners than all stormwater samples which was expected due to higher volatility. Bandelier samples had higher concentration of lower-chlorinated congeners and the Los Alamos Airport samples had higher concentrations of high-chlorinated congeners (Figure 15). Homologue patterns shows that lower-chlorinated congeners found in stormwater samples from all four sampling areas could have an atmospheric component due to the global fallout.

### SUMMARY of Total PCBs

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**ANOVA**

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### SUMMARY of HexaCB Homologues

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<th>Average</th>
<th>Variance</th>
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<td>4840107.3</td>
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<td>3606559.8</td>
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**ANOVA**

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<th>MS</th>
<th>F</th>
<th>P-value</th>
<th>F crit</th>
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Table 4. ANOVA Single Factor tables of Total PCBs and hexachlorobiphenyl from Los Alamos County, Northern and Western locations.
LANL is an industrial site with facilities which had many uses of PCB-containing devices. Industrial processes that used PCBs took place in the Los Alamos County town site as well. Both the Laboratory and the town site contain buildings and structures containing PCBs. Similarities in sources make it difficult to define a unique source of PCBs at either location. Table 4 shows how indistinguishable PCB concentrations are on the Pajarito Plateau. The test statistic is the F value of .89 and 1.04. Using an ϵ of .05, we have that $F_{0.05; 2, 47} = 3.19$. Since the test statistic is much smaller than the critical value, we accept the null hypothesis of equal population means and conclude that there is not a (statistically) significant difference among the population means. The summary of sample results for the homologue groups and total PCB concentrations from each sampling location are summarized in tables in Appendix C.

5. CONCLUSION
Total PCB concentrations in this study were lower than in the TMDL study done by NMED in both the Laboratory and background samples. However, differences in analytical labs and sampling methods exist between the studies. Background samples exceeded the surface water human health criteria of 640pg/L, 40 percent of the time in the Northern reference watersheds and 67 percent of the time in the Western boundary watersheds. The homologue distributions indicate PCB concentrations in the northern reference watersheds are likely from the global fallout. The high concentrations of high-chlorinated PCBs in the western boundary watersheds could be a contribution from the local origin because high-chlorinated PCBs become entrained in suspended dust and other particulates and then deposited by aeolian transport at a more localized distance.

Total PCB concentrations at Los Alamos county and LANL-sampling locations all exceeded the surface water human health criteria 100% of the time and the wildlife habitat criteria 60% on LANL and 13% of the time on county property (Table 15, Appendix F). These concentrations can be credited to local, LANL, and non-LANL sources. NMED has reported high PCB concentrations in the Rio Grande above Alameda, which are a couple orders of magnitude greater than the urban samples in this study. Elevated PCB concentrations could be attributed to the industrial sources in Albuquerque where many uses of PCB-containing devices and other applications occurred similar to other industrial sites such as LANL and Los Alamos County (www.nmenv.state.nm.us). Large urban area generally have a wide variety of sources, such as traffic (exhaust, oil spills, wear and tear of tires, vehicles), buildings (weathering, renovation, demolition, paint, plaster), and city fires that could store pollutants in urban soils and in sediment from urban basins (Jartun et al. 2008).

Environmental processes will shift distribution of PCB congeners. When the mixtures enter the environment, their compositions change over time, through portioning, chemical transformation and preferential bioaccumulation. Lower-chlorinated PCBs are more subject to volatilization and transported with major atmospheric currents. Studies have also shown that lower-chlorinated
PCBs (di-, tri-, and tetrachlorinated biphenyls) are dominant in ambient air and rain samples (Mandalakis and Stephanou 2007 and Birgül and Tasdemir 2011). NMED’s precipitation samples had greater concentrations of lower-chlorinated PCBs from both sampling locations than the stormwater samples collected. The precipitation data also showed a slight increase in higher-chlorinated PCBs in the Los Alamos county Airport which could indicate source pollutants from the industrial activity from the county and possibly the Laboratory.

LANL is an industrial site with facilities which had many uses of PCB-containing products. Many of the same industrial processes took place in the Los Alamos County town site as well. There are over 100 SWMUs at the Laboratory that may contain PCBs and they could have been sources of PCBs into canyons; however, only one canyon (Sandia) that cuts through the Laboratory has a consistent flow of water, an effluent-supported base flow. None of the canyon drainages consistently flow or consistently flow into the Rio Grande. This study shows contamination at locations not likely influenced by LANL or urban activities exceeding the New Mexico surface water quality standards indicating that regulations of stormwater discharges from Solid Waste Management Units at the Laboratory may be unattainable when natural background locations in this study are exceeding the surface water standards.

6. RECOMMENDATIONS
The results of this project identified areas requiring further research to determine the extent LANL’s influence on the Rio Grande’s water quality. More background and urban sampling data and locations are needed to fully understand background and urban PCB concentrations on the Pajarito Plateau. Background locations need to be remote, possibly much further away from the current locations and be minimally influenced by the surrounding industrial activities. The additional sampling data will provide a better statistical analysis and give a good understanding of PCB concentration levels at background and urban locations.

Another helpful analysis would be a correlation between PCB concentrations and suspended sediment in the stormwater. The suspended sediment could identify sources in background and urban samples on the Pajarito Plateau by eliminating the variability in the stormwater measurements due to the variable suspended sediment concentrations.

Run-on/runoff sampling will also need to be sampled at PCB contaminated Site Monitoring Areas (SMAs) that are affected by large impervious areas. This will determine the amount of PCB contamination running on to the SMAs and the amount running off the SMAs. The comparison will determine if the SMAs are solely responsible for the PCB concentrations running off the site and possibly into the Rio Grande. If run-on and runoff amounts are equal, additional PCB source investigations need to be conducted. Los Alamos county and the Laboratory need to work together to control stormwater runoff from county property that flow into canyons that may contain PCBs.
Continue to improve in controlling stormwater run-on and runoff from all SMAs on the Pajarito Plateau by conducting routine inspections and by placing best management practices on flow paths that are within the sites. Controlling stormwater run-on and runoff will help aid permit compliance and minimize PCB loading in the canyons on the Pajarito Plateau that have a potential of reaching the Rio Grande.

This study provided insight to background PCB concentrations on the Pajarito Plateau exceeding the New Mexico surface water human health standard 40% percent of the time at locations minimally affected by industrial activity. This will make it difficult for the Laboratory to stay in compliance with the newly appointed NPDES Individual Permit. To stay in compliance the Laboratory will need to suggest having the established target action levels, benchmarks, that are based on and equivalent to New Mexico State water quality criteria set to natural background. Natural background pollutants are those substances that are naturally occurring in soils, groundwater, etc.

7. REFERENCES


http://www.nmenv.state.nm.us/doe_oversight/documents/FinalSubmittalStormWaterMonitoringalongtheRioGrandeandChamaRiver4-19-10.pdf


SOP-5170. Routine Validation of Chlorinated Biphenyl Congener Analytical Data. LANL 2011


Appendix A: Stormwater sampling data from the Pajarito Plateau

CD-ROM
### Appendix B: Total PCB/Homologue Tables by Locations

#### Table 5. Los Alamos County Townsite Locations

<table>
<thead>
<tr>
<th>Sample Location</th>
<th>Collection Date</th>
<th>Total PCB (sum of congeners) pg/L</th>
<th>MonoCB (pg/L)</th>
<th>DiCB (pg/L)</th>
<th>TriCB (pg/L)</th>
<th>TetraCB (pg/L)</th>
<th>PentaCB (pg/L)</th>
<th>HexaCB (pg/L)</th>
<th>HeptaCB (pg/L)</th>
<th>OctaCB (pg/L)</th>
<th>NonaCB (pg/L)</th>
<th>DecaCB (pg/L)</th>
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Table 6. Los Alamos National Laboratory Parking Lot Locations

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<th>TetraCB (pg/L)</th>
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Appendix C: NMED Precipitation Total PCB/Homologue Tables
Table 10. Bandelier National Monument Precipitation

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Appendix D: Summary of Data for PCB Concentrations in Stormwater by Locations

Table 11. Los Alamos County Townsite Data Summary

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Table 12. Los Alamos National Laboratory Parking Lot Data Summary

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<tr>
<th>Homologue Group</th>
<th>Minimum</th>
<th>Mean</th>
<th>Median</th>
<th>Maximum</th>
<th>Std Dev.</th>
<th>% of Total PCB</th>
</tr>
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<tr>
<td>MonoCB</td>
<td>0</td>
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<td>10</td>
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### Table 13. Northern Baseline Data Summary

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<th>Median</th>
<th>Maximum</th>
<th>Std Dev.</th>
<th>% of Total PCB</th>
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### Table 14. Western Reference Data Summary

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<th>Median</th>
<th>Maximum</th>
<th>Std Dev.</th>
<th>% of Total PCB</th>
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<td>MonoCB</td>
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50
Appendix E: PCB Homologue Data

Figure 17. PCB homologue data from all storm flows collected from the Western Watershed
Figure 18. PCB homologue data from all storm flows collected from the Northern Watershed
Figure 19. PCB homologue data from all storm flows collected from the Laboratory Parking Lot
Figure 20. PCB homologue data from all storm flows collected from the Los Alamos Townsite
Figure 21. PCB homologue data from precipitation samples collected from Bandelier National Monument

The graph shows the percentage of total PCBs for each homologue from 8/3/2009 to 4/20/2010. Each data point is represented by a marker of a different color, corresponding to a specific date. The x-axis represents the PCB homologues, ranging from MonoCB to DecaCB, while the y-axis shows the percentage of total PCBs.
Figure 22. PCB homologue data from precipitation samples collected from Los Alamos County Airport
### Appendix F: Exceedance Table

Table 15. Human Health and Wildlife Habitat exceedances in storm flow data from the Pajarito Plateau

<table>
<thead>
<tr>
<th>Location</th>
<th>ANALYTE</th>
<th>Watershed</th>
<th># of Analyses</th>
<th># of Detects</th>
<th>Min</th>
<th>Avg</th>
<th>Max</th>
<th>WH Exceedance</th>
<th>% WH Exceedances</th>
<th>HH Exceed</th>
<th>% HH Exceedances</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACID-ROM-2(a)</td>
<td>Total PCB</td>
<td>Urban (LA County)</td>
<td>4</td>
<td>4</td>
<td>1270</td>
<td>6318</td>
<td>19600</td>
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<td>25</td>
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<td>ACID-ROM-2(b)</td>
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<td>Total PCB</td>
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<td>6490</td>
<td>11500</td>
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<td>1330</td>
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<tr>
<td>S-ROM-2(a)</td>
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