Voluntary Phase-Out of Polychlorinated Biphenyls (PCBs) in Current Use in the Chesapeake Bay Watershed

Chesapeake Bay Program

Science. Restoration. Partnership.

Program Feasibility Study

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The comments of the members of the Chesapeake Bay Program Toxic Contaminants Workgroup are appreciated.

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Purpose of this report

This report examines current and future sources of polychlorinated biphenyl (PCB) contamination in the Chesapeake Bay watershed, and identifies categories of sources that could be targeted for a voluntary PCB reduction initiative. Under such an initiative, entities would agree to eliminate or remove PCB sources and uses. In exchange, those entities could receive positive recognition that would enhance their reputation and standing within the Chesapeake region. Another option, at the discretion of applicable regulatory authorities, could be some form of limited regulatory relief (e.g., release from civil liability) for entities that participate in such a program.

What are PCBs?

PCBs are a class of man-made organic chemicals manufactured from the 1920s through 1977. They were used in many applications – as insulating fluids in electrical equipment (such as transformers and capacitors); as a plasticizer in paints, plastics and rubber products; and in pigments, dyes and carbonless copy paper. Because of their toxicity and persistence in the environment, the manufacture of PCBs was banned under the 1976 Toxic Substances Control Act (15 U.S.C. 53). However, their continued use in any "totally enclosed manner" remains authorized, and their historical use in other products means they continue to be a risk to human health and the environment today.

What is the impact of PCBs in the Chesapeake Bay watershed?

In the Chesapeake Bay watershed, water quality in many tidal and non-tidal areas is impaired due to the presence of PCBs. Specifically, PCB concentrations in fish and shellfish mean some waters do not meet "fishable" use designations under Section 303(d) of the Clean Water Act. This requires states to issue advisories recommending people limit or avoid eating fish and shellfish from such waterbodies, and to promulgate Total Maximum Daily Load (TMDL) regulations aimed at reducing such contamination.

What are the sources and quantities of PCBs in the Chesapeake Bay watershed?

The table below shows the sources of PCBs examined in this report, and the estimated quantities remaining in the Chesapeake Bay watershed. Due to data or methodological limitations, the number of sources that could be quantified was restricted to electrical equipment, fluorescent lamp ballasts, and paint. While these are not the only sources, the other sources discussed would be much more challenging to address under a voluntary initiative.

Table 1. Estimated Quantities of PCBs from Sources Within the Chesapeake Bay Watershed			
Source		**Range of Estimates**	**Estimated Quantity of PCBs**
Electrical Equipment			
PCB Equipment (≥500 PPM)		1,425 – 9,665 units	176.2 – 445.1 lbs
PCB-Contaminated Equipment (50-500 PPM)		14,901 – 97,407 units	
Fluorescent Lamp Ballasts (FLBs)			
Buildings	Schools	805 – 978 buildings	
	Other Buildings	10,889 – 12,134 buildings	
	Total	11,695 – 13,031 buildings	
FLBs	Schools	0.60 – 0.67 million FLBs	14,842 - 31,434 lbs
	Other Buildings	6.36 – 7.09 million FLBs	156,375 - 331,193 lbs
	Total	**6.97 – 7.77 million FLBs**	**171,216 – 362,628 lbs**
PCB-Contaminated Paint			
Applied annually		0.51 grams per square mile	70.55 lbs (annual)
Caulks and Sealants		Not estimated	
Legacy Sources/Sites		Not estimated	

Source: ERG estimates.

How were sources prioritized for voluntary program targeting?

Ideally, a voluntary program would engage with entities that can be readily identified, have control over the largest quantities of PCBs, could reduce or eliminate PCB sources and uses at low cost, and would value public recognition for their reduction efforts. After applying these criteria, this report recommends targeting the following:

- Electrical equipment owned by utilities and transmission and distribution line operators
- Capacitors in fluorescent lamp ballasts in school buildings
- Traffic and road marking paint purchased by state transportation departments

What could a voluntary program targeting these sources cost?

The report presents two options for structuring a voluntary program. The first (lower cost) would require an estimated 2,500 hours of support in Year 1 (startup) and 4,100 hours in Year 2. Under this option, sources that agree to participate would self-certify when they have met their PCB reduction goals.

A more robust program would provide more support to partners in the form of technical assistance (online resources, partner forums), monitor partner progress through a reporting component, and include an awards and recognition component. Such a program would require an estimated 3,750 hours in Year 1 (startup) and 7,700 hours per year in Year 2 and subsequent years.

1 Introduction

Although the manufacturer of polychlorinated biphenyls (PCBs) has been banned in the U.S. since 1977, their widespread use and persistence in the environment continues to impact the Chesapeake Bay watershed today. Many areas of the Chesapeake Bay and its watershed are under fish consumption advisories for PCBs, and many areas have developed (or are required to develop) plans to reduce PCB pollution, under the Total Maximum Daily Load (TMDL) provisions of the Clean Water Act (CWA).

This report identifies a number of ongoing sources of PCB contamination in the Chesapeake Bay watershed, and the potential to address these through one or more voluntary programs. These sources exist because of provisions in the law that allowed "totally enclosed" uses of PCBs to continue for the life of the equipment. The report also examines sources that may be associated with "inadvertent" production of PCBs (i.e., PCBs that are created as a byproduct during manufacture of other products).

To the extent possible, these sources are quantified here to assist Chesapeake Bay watershed jurisdictions in focusing efforts to maximize PCB pollution prevention, particularly within PCB TMDLs. The report then considers a number of options for voluntary approaches to eliminate these sources, and the potential costs and benefits of each.

Total Maximum Daily Loads (TMDLs). Under Section 303 of the Clean Water Act, states are required to determine whether water bodies meet established water quality standards for specific pollutants, including PCBs. States must develop a plan, known as a TMDL, to help each "impaired" water body meet the standards. Currently, TMDLs are in place for PCBs in the following:

DC - Potomac River, Rock Creek, Anacostia River, Kennelworth Aquatic Gardens.

DE – C&D Canal (from MD border to Route 301 crossing).

MD – *Tidal*: Anacostia River, Back River, Baltimore Harbor, Bird River, Bohemia River, Breton Bay, Bush River, C&D Canal (Back Creek), Corsica River, Gunpowder River, Magothy River, Northeast River, Lower Patuxent River, Middle Patuxent River, Upper Tidal Potomac River, Middle Tidal Potomac River, Lower Tidal Potomac River, Sassafras River, Severn River, South River, Upper and Lower Elk River, West River. *Nontidal*: Anacostia River. *Impoundments*: Jones Falls.

PA – Susquehanna River (PA Route 92 bridge at Falls to confluence with West Branch Susquehanna River).

VA – Potomac River watershed (Fairfax County): Accotink Creek, Bull Run, Giles Run, Indian Run, Little Hunting Creek, Mills Branch. Shenandoah River: North Fork, South Fork, Mainstem Shenandoah.

WV – Shenandoah River.

2 Background on PCBs

Commercially produced PCBs were manufactured under a number of different trade names, the most common in the U.S. being “Aroclor.” Each PCB product consisted of a mixture of PCB “congeners” containing between one and ten chlorine molecules (U.S. EPA, 2003).

PCBs were used in many different consumer, industrial and commercial products, including:

- Insulating fluid in electrical, heat transfer and hydraulic equipment
- Plasticizers in paints, plastics and rubber products
- Pigments, dyes and carbonless copy paper

EPA has estimated that approximately 1.4 billion pounds of PCBs were manufactured in the U.S., with 77 percent of that total used in electrical transformers and capacitors (U.S. EPA, 1976).

PCBs have been shown to cause cancer in animals as well as a number of serious non-cancer health effects in animals, including: effects on the immune system, reproductive system, nervous system, endocrine system and other health effects. Studies in humans support evidence for PCBs having potential carcinogenic and non-carcinogenic effects.

PCBs are also bioaccumulative, meaning their concentration may increase through the food chain, and persistent, meaning they remain stable and difficult to break down in the environment.

In response to concerns over their persistence, bioaccumulation potential, and toxicity, Congress made specific provisions within the 1976 Toxic Substances Control Act to ban the further manufacture of PCBs and restrict their ongoing use. Under regulations finalized in 1979, EPA prohibited the manufacture, processing, distribution in commerce, and "non-enclosed" (open to the environment) uses of PCBs unless specifically authorized or exempted. "Totally enclosed" uses, however, were allowed to continue for the life of the equipment, on the assumption that the PCBs would be contained, and exposure unlikely.

Prior to the 1979 ban, PCBs entered the air, water, and soil during manufacture and use, and they continue to enter the environment today. Wastes from manufacturing processes that contained PCBs were often placed in uncontrolled dump sites or landfills. Scrapped equipment containing PCBs was often dismantled or crushed, releasing PCBs into the environment. Accidental spills and leaks, from either manufacturing facilities or from PCB-containing equipment, released PCBs into the environment. These “legacy” practices continue to impact water quality today, because of the persistence of PCBs and their tendency to attach to soils and sediment. Dredging and site development activities may disturb contaminated soils and sediments, introducing them or reintroducing them into the water column. Storm water flows and surface runoff from these sites transport contaminants into the waterways.

PCBs have impacted the Chesapeake Bay in a number of ways, including:

- Widespread PCB contamination of fish and extensive fish consumption advisories.
- Extensive impairments of both tidal and non-tidal waters due to PCBs.
- Numerous existing PCB TMDLs across the watershed, as well as additional PCB TMDLs under development.(Chesapeake Bay Program, 2012).

3 Sources of PCBs in the Chesapeake Bay Watershed

This section reviews key sources of PCB contamination within the Chesapeake Bay Watershed.

3.1 Legacy Sources

As noted above, prior to 1977 PCBs were manufactured in large volumes and used in many different types of industrial, commercial and consumer products. Management practices for PCBs and PCB-containing products and equipment at the time resulted in widespread contamination of soil and sediment. Many of the sites where past contamination occurred continue to contribute PCB loadings into the Chesapeake Bay Watershed today. These include both point sources and nonpoint sources.

Under Section 303(d) of the Clean Water Act (CWA) and its implementing regulations, states use water quality monitoring, fish tissue sampling, and source tracking to identify contributing sources of water quality impairment due to PCBs. Through these efforts, the states have identified many PCB-contaminated sites (nonpoint sources), was well as many permitted point source discharges that include PCBs. For example, in establishing the 2003 TMDL for the tidal Delaware River (Zones 2-5), EPA and the states evaluated 49 contaminated sites and determined these sites contributed up to 57 percent of PCB loadings in certain zones (DRBC, 2003). Examples of NPDES-permitted point sources of PCBs include industrial facilities, municipal separate storm sewer systems (MS4s), and combined sewer overflows (CSOs).[1] In the Delaware River case, the DRBC identified 142 separate point sources. Among the industrial sources were municipally-operated wastewater treatment plants, steel mills, refineries and chemical plants, scrapyards, landfills, railroads, power generating stations, and marine terminals (DRBC, 2003).

Under NPDES regulations, states may require point sources to develop a Pollutant Minimization Plan (PMP).[2] Such plans, in the case of the DRBC, "require owners and operators to perform a systematic analysis of their facilities and sites in order to locate pollutant sources and to design and implement measures to achieve the necessary reductions." (DRBC, 2005).

All states within the Chesapeake Bay Watershed have made efforts to identify point and nonpoint sources of PCBs through source tracking and other activities. Most if not all of the TMDLs include lists of such sites, and state TMDL programs may be able to provide comprehensive lists of all sites across the watershed. Such a list could provide the basis for a voluntary program aimed at accelerating completion of actions identified in the PMPs. Information about the sites, such as historic and current activities, pollutant loadings, and actions taken to date, could be used to prioritize site owners for participation in such a program.

3.2 PCB-Containing Electrical Equipment

As noted in Section 2, the largest use of PCBs was as a dielectric fluid, or insulator, in electrical equipment. This included equipment such as transformers, capacitors, voltage regulators, switches, circuit breakers,

[1] Though designated as point "sources" under the NPDES program, MS4s, CSOs, and publicly-owned treatment works (POTWs) and not "sources" of PCBs. Rather, they receive PCBs into their systems from other sources. These PCBs pass through their systems and are conveyed into receiving waters.

[2] May also be referred to as a Waste Minimization and Reduction Plan (WMRP).

rectifiers, and other miscellaneous equipment. Such equipment was and continues to be used at electricity generation stations (power plants), along transmission and distribution lines, at substations, and at customer locations.[3] For a description of some of this equipment see Eastern Research Group (2019a).

All PCB-containing electrical equipment that remains in service or storage (e.g., as replacement) today was manufactured prior to the 1979 ban, and is thus approaching 40 years of age. Generally, the expected lifespan of PCB-containing electrical equipment is less than this. Large transformers such as those found at power generating stations or substations could last between 30 and 50 years, if maintained properly (Battelle, 2012). On the other hand, smaller, pole-mounted transformers (such as those found along distribution lines) have been reported to last between eight and 15 years (Battelle, 2012). All such equipment populations have a lifespan distribution, with a small number falling beyond the expected averages. Figure 1 depicts a hypothetical population of 1,000 "large" transformers installed in 1964, showing the number of failures predicted (through an engineering model) by year. As seen, past 2015 very few transformers are predicted to remain in service.

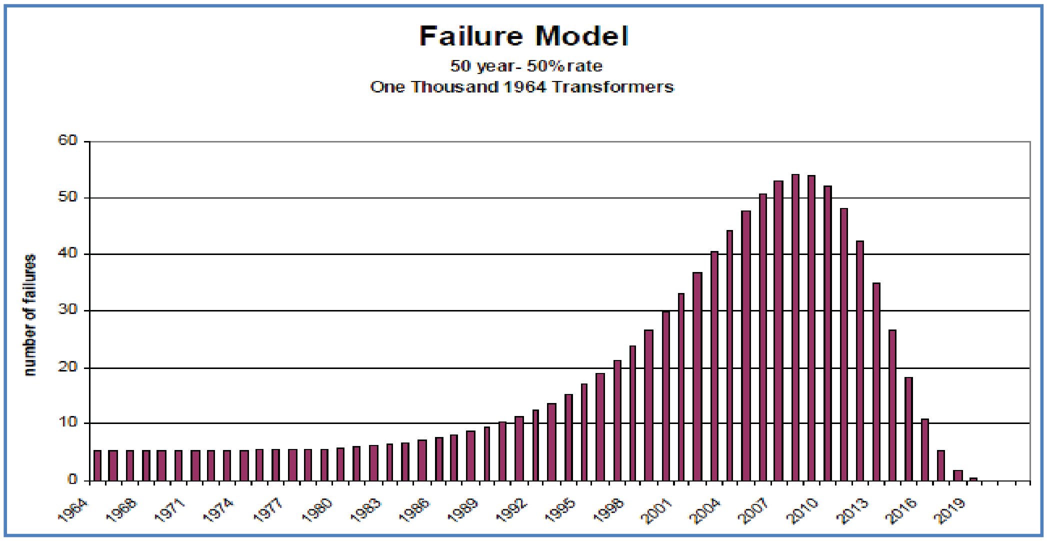


Figure 1. Predicted Failures for Transformers Installed in 1964

Source: (Bartley, 2002).

Based on its age, any equipment remaining in service today is, by any measure, at the far end of the lifespan distribution. Many utilities have reported they have completed (or have plans in place to complete) replacement of most PCB equipment.[4] Equipment that does remain, however, is at increased risk of failure. Failure does not always imply leakage and spill of PCB fluid, but this is often the case. A

[3] Railroads, steel mills and large government installations are examples of "heavy industry" that might use or have used utility-scale electrical equipment.

[4] The utility industry reports that many utilities have "voluntarily removed known categories of PCBs (e.g., ≥ 500 PPM) from service. Other efforts include procedures to ensure that equipment containing PCBs in concentrations of ≥50 PPM that is removed from the field is either disposed of and not returned to service or retrofilled with non-PCB mineral oil before being returned to service" (Rower, 2010). See also Figure 2.

common cause of transformer failure, for example, is a breakdown in the conductor insulation. This can weaken the insulation to the point where it can no longer sustain mechanical stress (Bartley, 2003).

Under the Comprehensive Environmental Response, Compensation and Liability Act of 1990 (CERCLA), any release of PCBs in excess of one pound must be reported to the U.S. Coast Guard National Response Center (NRC). Table 2 shows an analysis of PCB releases reported under CERCLA between 1999 and 2014. The largest cause of release was equipment failure, followed by natural phenomenon. This illustrates the importance of removing any remaining PCB-containing equipment from service, before it can fail, leak, and further contaminate the Chesapeake Bay watershed.

Table 2. CERCLA-Reportable PCB Releases (U.S.), 1990-2014

Cause	Number of Incidents	Percent of Total
Equipment Failure	1,572	32.6%
Natural Phenomenon	956	19.8%
Other	789	16.4%
Unknown	685	14.2%
Operator Error	387	8.0%
Hurricane	183	3.8%
Transport Accident	152	3.2%
Dumping	61	1.3%
Tornado	22	0.5%
Explosion	9	0.2%
Flood	4	0.1%
Derailment	2	0.0%
Over Pressuring	2	0.0%
Nationwide Total	**4,824**	**100.0%**

(Source: USCG, 2015).

3.2.1 National Equipment Inventory

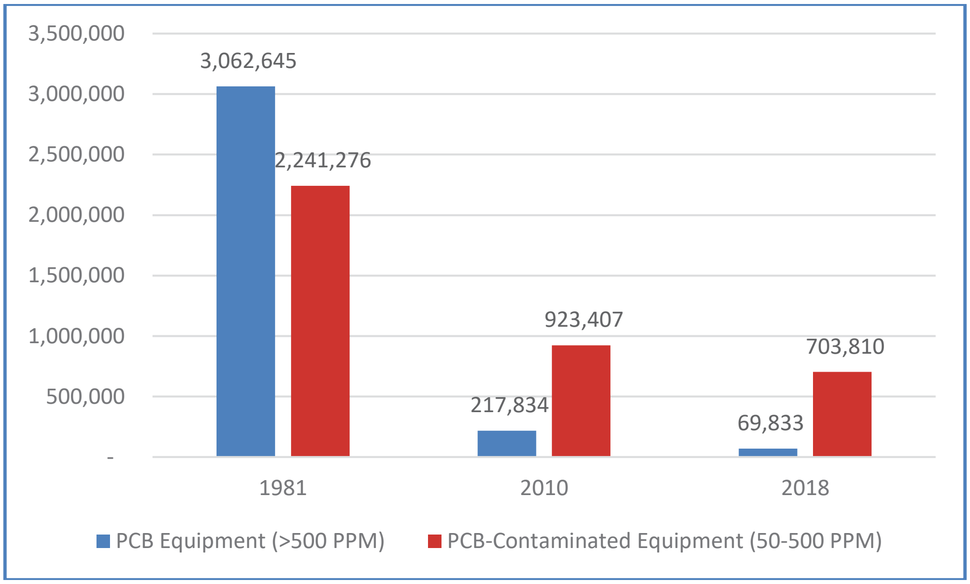
To estimate the amount of PCB-containing electrical equipment remaining in service today, a detailed analysis was conducted of PCB equipment population estimates and projections (Eastern Research Group, 2019a). These estimates were produced using a model developed for EPA during its 2008-2015 reassessment of the PCB use authorization, under which "fully enclosed" uses of PCBs were allowed to continue beyond the 1977 PCB manufacturing ban.[5,6] The model was used to generate EPA's estimates of the costs industry would incur if the use authorizations were lifted under alternative phase out date options.

Briefly, the approach to estimating this population begins with utility industry estimates of the 2010 equipment population, by type of equipment. This inventory itself was an update to earlier estimates developed in 1989 and 1981. Additions to and retirements from the initial inventory were estimated from

[5] See 75 Federal Register 66 (page 17645). Polychlorinated Biphenyls (PCBs); Reassessment of Use Authorizations. Advance notice of proposed rulemaking. April 7, 2010.

[6] Note: As of 2016 the Office of Management and Budget's Unified Agenda and Regulatory Plan classified this proposed rulemaking as a "long term action."

utility filings with the Federal Energy Regulatory Commission (FERC) between 1982 and 1987. EPA extrapolated changes to the inventory based on changes observed between the 1981 and 2010 industry inventories to derive estimates of the 2018 population. EPA also estimated, based on the 2018 equipment population and retirement rates, the year in which 100 percent of remaining equipment would be retired. Figure 2 shows the 1981, 2010 and 2018 estimates for two classes of PCB-containing equipment: PCB Equipment and PCB-Contaminated Equipment. PCB Equipment is defined under TSCA as equipment containing PCBs at concentrations in excess of 500 ppm, while PCB-Contaminated Equipment is defined as equipment containing between 50 and 500 ppm PCBs. Generally, higher concentrations of PCBs are associated with higher voltage equipment. As seen in Figure 2, the population of PCB Equipment fell by more than 90 percent between 1981 and 2010, from 3.0 million units to 217,000 units, while the population of PCB-Contaminated Equipment dropped by 60 percent, from 2.2 million units to 923,000 units. From 2010 to 2018, EPA estimated that the population of PCB Equipment declined a further 68 percent, to 69,000 units, while the population of PCB-Contaminated Equipment population fell a further 24 percent, to 700,000 units.



Source: ERG estimates.

Figure 2. PCB Electrical Equipment Population Estimates (U.S.), 1981-2018

3.2.2 Portion of the Equipment Inventory Located in the Chesapeake Bay Watershed

The estimated U.S. inventory of PCB-containing equipment was next examined to establish the potential share of the inventory located within the Chesapeake Bay watershed. Several partitioning factors were considered, including the share of population located within the watershed, the share of population adjusted for density, and the share of total U.S. electricity consumption. Table 3 shows these estimates.

Population and population density is available at the county level, so the first two estimates reflect equipment located within the CBP's watershed boundaries.[7] Electricity consumption data is available at the state level, but not the county level. The estimates shown in the final column of Table 3 include equipment located within all of the states, and is thus an overestimate.

The population estimates adjusted for density may reflect the most realistic partition of the U.S. inventory (Eastern Research Group, 2019a). This method accounts for the fact that the Chesapeake Bay region is roughly three times more densely populated than the U.S. as a whole, and adjusts the number of transformers per square mile for the U.S. to reflect this denser population.

Table 3. PCB Equipment Located in the Chesapeake Bay Watershed

Type of Equipment	Estimated U.S. Inventory (2018)	Chesapeake Bay Watershed Inventory (2018) By Partitioning Method		
		Share of Population[a]	Share of Population, Density-Adjusted[a]	Share of Electricity Consumption[b]
PCB equipment (>500 ppm)	69,833	3,935	1,425	9,665
PCB-Contaminated Equipment (50-500 ppm)	703,810	39,662	14,901	97,407
Total	773,643	43,597	16,326	107,072

[a] Partitioning uses the percent of population residing in *counties located within the Chesapeake Bay Watershed*, based on the map available at *https://www.cbf.org/about-the-bay/maps/geography/counties-in-the-chesapeake-bay-watershed.html*.

[b] Partitioning uses the percent of electricity sales in states located in whole or in part within the Chesapeake Bay Watershed.

Source: ERG estimates

3.2.3 Quantity of PCBs Remaining in Electrical Equipment

The estimated quantity of PCBs contained in electrical equipment located within the Chesapeake Bay Watershed is based on industry estimates of the quantity of PCBs contained in different types of equipment. As shown, this is generally well below one pound for the types of equipment still believed to be in use today. Multiplying the pounds of PCBs per unit by the number of units of each type located in the Chesapeake Bay Watershed, the total pounds of PCBs in electrical equipment in the watershed is between 176 and 445 pounds.

[7] The source used for this is the county-level map of the Chesapeake Bay Watershed boundaries found at *https://www.cbf.org/about-the-bay/maps/geography/counties-in-the-chesapeake-bay-watershed.html*.

Table 4. Estimated Quantity of PCBs in Electrical Equipment Located in the Chesapeake Bay Watershed

Type of Equipment[a]	Estimated Pounds of PCBs per Unit	Estimated Pounds of PCBs in Electrical Equipment Located in the Chesapeake Bay Watershed	
		Method A Share of Population	Method B Share of Population, Density-Adjusted
Askarel transformers	1,882	0	0
Mineral oil transformers	0.0130	422.24	153.32
Large PCB capacitors	31	0	0
Voltage regulators	0.05	17.99	17.99
Oil-filled circuit breakers	0.07	4.03	4.03
Oil-filled reclosers	0.0024	0	0
Oil-filled switches	0.0009	0.86	0.86
TOTAL	**--**	**445.12**	**176.20**

[a] Includes equipment estimated to have been completely phased out by now.
Source: ERG estimates based on (EEI, 1982).

3.2.4 Identifying Equipment Owners

Any voluntary program aimed at reducing sources of PCB contamination in the Chesapeake Bay Watershed will need to identify potential owners of such PCB-containing equipment and to target them for recruitment. PCB-containing electrical equipment may be owned by firms engaged in the generation, transmission or distribution of electric power, by industrial firms or installations that use and distribute high voltage power within their own facilities, or by firms in miscellaneous industries such as railroads, scrapyards or recyclers. Some equipment may also have been “inherited” by firms in unrelated industries, as part of assets they may have purchased from prior owners (e.g., former industrial sites purchased for redevelopment).

This section focuses on potential owners in the electric power generation, transmission and distribution sector within the Chesapeake Bay Watershed, as well as large government installations that may have such equipment onsite. These were determined to be the entities that would account for the largest share of PCB-containing electrical equipment, and the ones most readily identifiable.

Electric Power Generation, Transmission and Distribution

Historically, the electric utility sector was composed of vertically integrated firms regulated as “natural” monopolies.[8] Governments recognized that a single firm could operate most efficiently and provide reliable service at lowest cost, but needed to be regulated to ensure they did not abuse their market power. That began to change in the 1970s and 1980s, when a series of legislative and regulatory developments opened these markets to competition. Utilities which previously operated facilities that generated, transmitted, and distributed electricity to customers gave way to a more fragmented industry.

[8] In industries where large start-up costs create barriers to entry, economists predict one firm, often the first supplier in the market, may be able to attain monopoly status. The term “natural” monopoly reflects the idea that the market power of the firm is a natural outcome of market forces.

While many utilities still operate according to the traditional model, there are many variations today (see text box).

There are a number of data sources useful for identifying potential owners of PCB-containing electrical equipment in the Chesapeake Bay Watershed. These are reviewed and summarized below.

Energy Information Administration Form 860

On an annual basis, electric utilities in the U.S. use Form 860 (Electric Generator Report) to submit data on electric power generating plants to the DOE Energy Information Administration (EIA). EIA compiles and releases several data files based on these submissions, corresponding to the different "schedules" or sections of Form 860. These include:

- **Schedule 1: Utilities**. This file identifies the utilities responding to the EIA data request and includes their name, mailing address, and an indication of whether they are the owner, operator, or asset manager of the reporting plants. It also indicates the utility ownership type, based on the categories shown in Figure 3.

- **Investor-Owned Utilities**: Entities that are privately owned and provide a public service.
- **Municipal**: Entities that are organized under authority of state statute to provide a public service to residents of that area.
- **Cooperative**: Member-owned organizations.
- **Federal**: Government agencies with the authority to deliver energy to end-use customers.
- **State**: Entities that own or operate facilities or provide a public service.
- **Wholesale Power Marketer**: Entities that buy and sell power in the wholesale market.
- **Retail Power Marketer**: Entities that market power to customers in restructured markets.
- **Municipal Marketing Authority**: Voted into existence by the residents of a municipality and given authority for creation by the state government. They are nonprofit organizations.
- **Behind the Meter**: Entities that install, own, and/or operate a system (usually photovoltaic), and sell, under a long term power purchase agreement (PPA) or lease, all the production from the system to the homeowner or business with which there is a net metering agreement. Third Party Owners (TPOs) of PV solar installations use this ownership code.
- **Nonutility DSM Administrator**: Only involved with Demand-Side Management activities.
- **Community Choice Aggregation**: Public agency that aggregates end user's electricity demand for a particular area and manages supply for those users.
- **Political Subdivision** (also called "public utility district"): Independent of city or county government and voted into existence by a majority of the residents of any given area for the specific purpose of providing utility service to the voters. State laws provide for the formation of such districts.
- **Independent Power Producer or Qualifying Facility**: Entities that own power plants and sell their power into the wholesale market.
- **Transmission**: Entities that operate or own high voltage transmission wires that provide bulk power services.

Source: Energy Information Administration, Form EIA-860, Electric Generator Report.

Figure 3. Forms of Utility Ownership Reported on Form EIA-860

- **Schedule 2. Generating Plants**. This file identifies individual electricity generating plants or locations owned or operated by each reporting utility. The file includes each plant's name and detailed location (county, zip code, latitude/longitude), name of water source (if applicable), transmission or distribution system owner (i.e., the entity that owns the lines carrying the power generated by the plant), and the grid voltage.

- **Schedule 3: Generating Units**. This file identifies individual power generating units located at each of the plants described in Schedule 2, and includes such information as the power generating technology (e.g., coal, natural gas, nuclear, wind/solar), generating capacity (MW), operational status (operating, standby, out of service), month and year operation started, planned retirement year, and various other operational data elements.
- **Schedule 4: Ownership**. This file identifies, for each generating unit (Schedule 3), the unit owner(s) and, in the case of multiple owners or joint ventures, each owner's share of ownership.

Respondents to this data collection also report information about plant environmental controls, such as type of emission control systems in place, but these schedules do not include information about ownership of PCB-containing equipment or the status of PCB-containing equipment removal.

Together, the Form 860 files can be used to identify electric power generating plants located within the Chesapeake Bay Watershed (using Schedule 2 detailed location data), the nameplate generating capacity and age of generating units located at each plant (Schedule 3), and the owner(s) of each plant (Schedule 4). They can also be used to identify the owner(s) of transmission and distribution lines through which the electricity generated by these plants is carried.

Energy Information Administration Form 861

On an annual basis, entities involved in the generation, transmission, distribution, marketing and sale of electricity in the U.S. use Form 861 (Electric Power Industry Report) to submit data that help EIA characterize the broader market for electric power. As with Form 860, EIA compiles and releases several data files based on these submissions, corresponding to the different Form 861 schedules. These include:

- **Schedules 1 and 2A: Utilities.** This file identifies the utilities responding to the EIA data request and includes their name, state, ownership type, and operating territories (NERC regions and RTOs),[9,10] and also identifies their "activities" (see text box on the following page.)
- **Schedules 2B and 2C: Operations.** This file identifies, for each utility , the peak summer and winter demand (MW), the sources of electricity managed by the utility (generation, wholesale purchase, "wheeled" power received and delivered),[11] the disposition of all energy managed (sold at retail, sold for resale, energy losses), and the revenue from all energy sold or transmitted.
- **Schedule 3: Distribution System and Reliability.** This file identifies the number of distribution circuits serving end-use customers and various system reliability indicators, such as system interruption frequency and duration.

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[9] The North American Reliability Council (NERC), is an organization of entities that work to ensure the reliability of the electricity grid. NERC's jurisdiction includes users, owners and operators of the bulk power system. There are eight NERC regions covering the North American continent.

[10] In the U.S., a group of regional transmission organizations (RTOs) have been established to coordinate, control, and monitor the electric grid, and to ensure non-discriminatory access by utilities to the grid. RTOs are regulated and approved by the Federal Energy Regulatory Commission (FERC).

[11] The term "wheeled" power refers to power transferred from one utility's service area to another.

- **Schedule 4: Sales.** This file identifies the number of residential, commercial, industrial and transportation customers for the utility, the amount of electricity sold in each market (in MWHr), and the revenue from such sales.

- Generation from company owned plant. Owned power generation.
- **Transmission**. Owned or leased transmission lines.
- **Buying transmission services on other electrical systems**. Types of services include borderline customers, transmission line rental, transmission capacity, transmission wheeling, and system operational services.
- **Distribution using owned/leased electrical wires**. Power delivery to your own end-use customers over distribution facilities.
- **Buying distribution on other electrical systems**. Types of support include customer billing, distribution system support charges for energy delivered, line maintenance, and/or equipment charges.
- **Wholesale power marketing**. Wholesale transactions with other electric utilities, purchases from power producers, and transactions to export and/or import electricity to or from Canada or Mexico. Also includes electrical sales and purchases among Federal Energy Regulatory Commission (FERC) registered power marketers and similar participation in transactions with electric utilities.
- **Retail power marketing**. Provision of electrical energy to end-use customers in areas where the customer has been given the legal right to select a power supplier other than the "traditional electric utility."
- **Combined services**. Provision of electricity in combination with gas, water, cable, Internet, and/or telephone for a single price.

Source: Energy Information Administration, Form EIA-861, Annual Electric Power Industry Report Instructions.

Figure 4. Utility Activities Reported on Form EIA-861

- **Schedule 5: Mergers and Acquisitions.** This file identifies newly-acquired corporate entities whose operations are being include in the utility's reporting.
- **Schedules 6-7: Efficiency and Demand-Side Management data.** This file contains information about utility demand-side management (i.e., efforts to reduce consumption and manage peak loads), including information about the costs and impacts of such efforts.
- **Schedule 8: Service Territories.** This file identifies all of the service territories (state and county) served by each utility.

Energy Information Administration Form 923

On an annual basis, entities involved in the generation of electricity in the U.S. use Form 923 (Power Plant Operations Report) to submit data that help EIA characterize the operations of power plants across the country. Data collected on this form include electric power generation, fuel consumption, and fossil fuel stocks, delivered fossil fuel cost, combustion by-products, operational cooling water data, and operational data for NOx, SO2, particulate matter, mercury, and acid gas control equipment. EIA compiles and releases several data files based on these submissions, corresponding to the different Form 923 schedules. These include:

- **Schedules 2-5:** This file covers, for each generating unit located at reporting plants: power generation amounts and fuel types; sources; quality (e.g., sulfur, moisture content), consumption' and cost.

- **Schedules 6-7:** This file covers, for each reporting plant: the sources and disposition of energy (similar to Form 861 Schedules 2B and 2C, above).
- **Schedule 8:** This file covers, for each reporting plant: the quantities and disposition of byproducts (fly ash, gypsum, surplus steam); the cost of byproduct management; the cost of air pollution control equipment acquisition, operation, and maintenance; and descriptions of installed air pollution control equipment.

Together, the EIA Forms 860, 861 and 923 provide comprehensive details on utilities, power plants, and power generating units in the U.S. Data from these forms can be linked through the unique identification numbers assigned to each utility, plant, and generating unit. This may be helpful, for example, in exploring characteristics (identified through EIA-860) of utilities operating in different service territories (identified through EIA-861).

EIA State Energy Profiles

EIA also publishes an annual “energy profile” for each U.S. state, in the form of an Excel workbook. Each workbook includes numerous tables. Tables 2A and 2B of each state profile lists the top ten electricity generating plants, ranked by generating capacity (Table 2A) and generation (Table 2B). Each plant’s location and owner is also listed.

Table 5 below shows the owners of the largest generating plants by capacity in each state, after excluding plants located within the state but not within the Chesapeake Bay Watershed boundaries (based on plant county location). The table illustrates one way the electric utility data available from EIA could be used to identify entities that may own PCB-containing equipment located at generating stations or at ancillary facilities (e.g., offsite equipment storage yards or warehouses). To the extent these entities also own and operate transmission and distribution lines then any PCB-containing equipment associated with such lines can also be addressed.

As noted above, however, deregulation has led to a certain amount of “decoupling” of electric power generation from its transmission and distribution. There are now numerous entities engaged in transmission and distribution that own no electric power generating units. To identify these, it may be useful to refer to Form EIA-860, Schedule 2, which identifies the owner of the transmission or distribution system that connects each plant to the grid. Table 6 below shows such data for electric power plants in Delaware. In the case of Delaware, it turns out that all transmission and distribution system owners are entities based in the state. This is not the case for all states within the Chesapeake Bay region. For example, grid owners in Maryland include not only firms based in Maryland (e.g., Baltimore Gas and Electric), but also Pennsylvania (PECO Energy Co.), the District of Columbia (Potomac Electric Power), Delaware (Delmarva Power) and even Arkansas (First Electric Coop).

Table 5. Largest Electric Power Plants in the Chesapeake Bay Watershed, by State

Electric Generating Plants in the Chesapeake Bay Watershed (Capacity Ranking Within Each State)		Primary energy source	Operating company	Net summer capacity (MW)
District of Columbia				
1	DC Water CHP	Other biomass	DC Water	23
2	US GSA Heating and Transmission	Natural gas	US GSA Heating and Transmission	9
Delaware*				
Maryland				
1	Chalk Point LLC	Natural gas	NRG Chalk Point LLC	2,177
2	Calvert Cliffs Nuclear Power Plant	Nuclear	Exelon Nuclear	1,708
3	Morgantown Generating Plant	Coal	GenOn Mid-Atlantic LLC	1,423
4	Brandon Shores	Coal	Brandon Shores LLC	1,273
5	Herbert A Wagner	Coal	H.A. Wagner LLC	959
6	Dickerson	Coal	GenOn Mid-Atlantic LLC	831
7	CPV St Charles Energy Center	Natural gas	CPV Maryland LLC	726
8	Essential Power Rock Springs LLC	Natural gas	Essential Power Rock Springs LLC	654
9	Conowingo	Hydroelectric	Exelon Power	572
10	Perryman	Natural gas	Constellation Power Source Gen	404
New York				
3	Nine Mile Point Nuclear Station	Nuclear	Exelon Nuclear	9,196
4	Oswego Harbor Power	Petroleum	NRG Oswego Harbor Power Operations Inc	1,638
8	Blenheim Gilboa	Pumped storage	New York Power Authority	1,167
Pennsylvania				
1	TalenEnergy Susquehanna	Nuclear	TalenEnergy Susquehanna LLC	2,494
3	Peach Bottom	Nuclear	Exelon Nuclear	2,450
10	TalenEnergy Montour	Coal	TalenEnergy Montour LLC	1,515
Virginia				
1	Bath County	Pumped storage	Virginia Electric & Power Co	3,003
2	North Anna	Nuclear	Virginia Electric & Power Co	1,893

Table 5. Largest Electric Power Plants in the Chesapeake Bay Watershed, by State

Electric Generating Plants in the Chesapeake Bay Watershed (Capacity Ranking Within Each State)		Primary energy source	Operating company	Net summer capacity (MW)
3	Possum Point	Natural gas	Virginia Electric & Power Co	1,733
4	Surry	Nuclear	Virginia Electric & Power Co	1,676
5	Chesterfield	Coal	Virginia Electric & Power Co	1,663
6	Warren County	Natural gas	Virginia Electric & Power Co	1,472
8	Yorktown	Petroleum	Virginia Electric & Power Co	1,113
9	Tenaska Virginia Generating Station	Natural gas	Tenaska Virginia Partners LP	944
West Virginia				
6	Mt. Storm	Coal	Virginia Electric & Power Co	1,640

* None of the 10 largest plants in Delaware are located within that part of the state that lies within the Chesapeake Bay Watershed.
(Source: U.S. Department of Energy, 2016)

Table 6. Electric Power Transmission and Distribution Line Ownership in Delaware

Plant Name	Utility Name	City	County	Transmission or Distribution System Owner
Ameresco Delaware Central	AMERESCO Delaware Central	Sandtown	Kent	Delaware Electric Cooperative
Ameresco Delaware South	AMERESCO Delaware South	Georgetown	Sussex	Delaware Electric Cooperative
Christiana	Calpine Mid-Atlantic Generation LLC	Wilmington	New Castle	Delmarva Power
Delaware City 10	Calpine Mid-Atlantic Generation LLC	Delaware City	New Castle	Delmarva Power
Edge Moor	Calpine Mid-Atlantic Generation LLC	Wilmington	New Castle	Delmarva Power
West Station (DE)	Calpine Mid-Atlantic Generation LLC	Wilmington	New Castle	Delmarva Power
Hay Road	Calpine Mid-Atlantic Generation LLC	Wilmington	New Castle	Delmarva Power
Croda Atlas Point CHP	Croda Inc.	New Castle	New Castle	Delmarva Power
ESS Lewes	Customized Energy Solutions	Lewes	Sussex	City of Lewes - (DE)
Delaware City Plant	Delaware City Refining Company LLC	Delaware City	New Castle	Delmarva Power
Bruce A Henry Solar Farm	Delaware Electric Cooperative	Georgetown	Sussex	Delaware Electric Cooperative
Warren F Sam Beasley Generation Station	Delaware Municipal Electric Corp	Smyrna	Kent	Delmarva Power
DG AMP Solar Smyrna	DG AMP Solar, LLC	Smyrna	Kent	Delmarva Power
Brookside Newark	Diamond State Generation Partners, LLC	Newark	New Castle	Delmarva Power
Red Lion Energy Center	Diamond State Generation Partners, LLC	New Castle	New Castle	Delmarva Power
WHA Southbridge Solar Park	Ecogy Delaware II LLC.	Wilmington	New Castle	Delmarva Power
University of Delaware Wind Turbine	First State Marine Wind	Lewes	Sussex	City of Lewes - (DE)
Garrison Energy Center LLC	Garrison Energy Center LLC	Dover	Kent	Delmarva Power
Indian River Generating Station	Indian River Operations Inc	Dagsboro	Sussex	Delmarva Power
Seaford Delaware Plant	Invista	Seaford	Sussex	Delmarva Power
South Campus Solar	JPMorgan Chase Bank	Wilmington	New Castle	Delmarva Power
Kent County Wastewater Treatment Solar	Kent County Levy Court Dept of Pub Work	Milford	Kent	Delaware Electric Cooperative
DD Hay Road Solar 23 LLC	Laurel Capital Partners	New Castle	New Castle	Delmarva Power

Table 6. Electric Power Transmission and Distribution Line Ownership in Delaware

Plant Name	Utility Name	City	County	Transmission or Distribution System Owner
Milford Solar Farm	Milford Solar LLC	Milford	Kent	City of Milford - (DE)
McKee Run	NAES Corporation - (DE)	Dover	Kent	City of Dover - (DE)
Van Sant Station	NAES Corporation - (DE)	Dover	Kent	City of Dover - (DE)
NRG Energy Center Dover	NRG Energy Center Dover LLC	Dover	Kent	City of Dover - (DE)
Onyx - Allen Harim	Onyx Asset Services Group	Harbeson	Sussex	Delmarva Power
Perdue Bridgeville Photovoltaic	WGL Energy Systems, Inc	Bridgeville	Sussex	Delmarva Power
Dover Sun Park	White Oak Solar Energy LLC	Dover	Kent	City of Dover - (DE)

Non-Utility Owners

In addition to utilities, PCB-containing electrical equipment may have been used at large industrial and governmental sites with unique electric power needs. For example, facilities such as steel mills, railroad yards, pulp and paper mills, auto manufacturing plants, mining operations, chemical plants, and even medical facilities and university campuses may operate processes and equipment requiring voltages above typical commercial or residential line voltage. At such locations, it may be common to have a step down transformer to convert transmission voltage to the voltage needed at the site – for example to drop 69 kV down to 13.8 kV needed at the site – and even some higher voltage distribution equipment (Figure 5). Such substations and distribution systems may feature transformers, capacitors, switches, and other equipment similar to that found at power generating facilities. Depending on the age of the facility and equipment, some of this may contain PCBs.

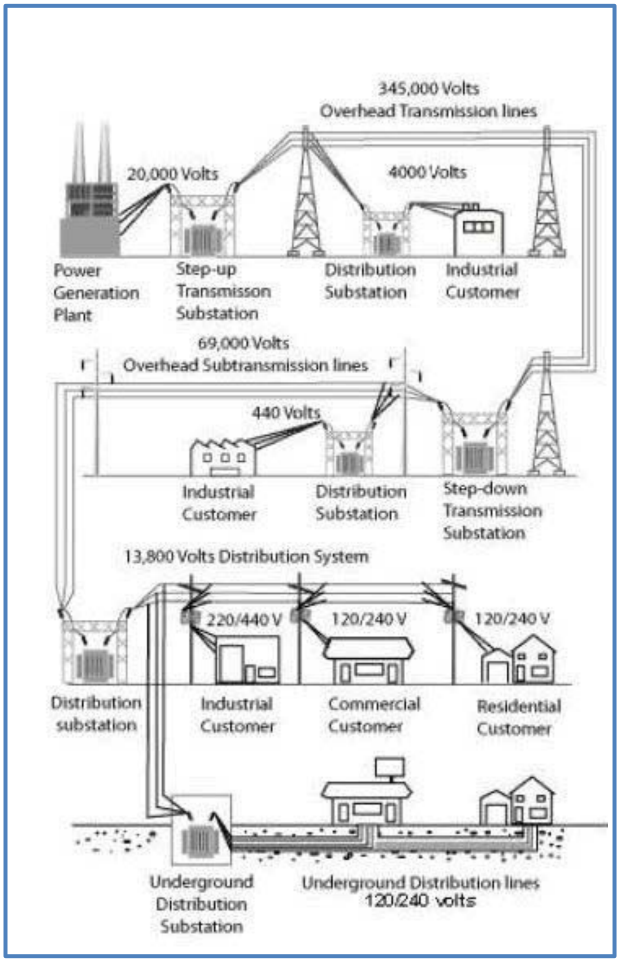

Figure 5. Transmission and Distribution Networks

CBP determined, following some investigation, that it would be challenging to identify potential industrial owners of PCB-containing equipment. This is because of likely changes in site ownership that have occurred since 1979, the last year PCB-containing equipment would have been installed. Many of the industrial facilities of the type mentioned above have ceased operations as the regional and national economy has evolved. Current site owners are likely to be already involved in legacy PCB contamination issues.

One exception to this that became a focus for further research was federal facilities. Federal facilities are numerous throughout the Chesapeake Bay region and some of them, such as military bases, may have (or historically have had) high voltage needs. To the extent that these can be identified, they could be targeted for a voluntary PCB removal program.

To identify such sites, a search was performed on EPA's PCB Transformer database. Under 40 CFR 761, owners of PCB Transformers (i.e., transformers containing >500 ppm PCBs) were required to register such transformers with EPA and provide information on the owner, transformer location, and total weight of PCBs they contain. This requirement went into effect in 1998. Anyone who subsequently discovered an unregistered PCB transformer was also required to register the transformer within 30 days of discovery. EPA maintains these registrations in a database. Discussions with EPA officials responsible for maintaining the database indicated that owners are able to remove transformers from the database when they are removed from service or reclassified (i.e., retrofilled with non-PCB fluids), but there is no requirement for them to do so. As a result, the database is simply a list of PCB Transformers identified by owners and registered after 1998. The database includes information on approximately 12,000 registered transformers.

A search of the transformer database identified a number of "federal" owners who registered PCB Transformers at some point after 1988. These located within the watershed boundaries are shown in Table 7, along with the number of PCB Transformers they have registered.

Table 7. Federal Government Owners of PCB Transformers Registered with EPA and Located Within the Chesapeake Bay Watershed

Owner	City	State	Number of PCB Transformers
Capitol Power Plant (Architect of the Capitol)	Washington	DC	8
National Gallery of Art (Smithsonian Institution)	Washington	DC	1
National Railroad Passenger Corp. (AMTRAK)	Washington	DC	8
U.S. Army Corp of Engineers CENAB	Baltimore	MD	12
U.S. Army Garrison, Aberdeen Proving Ground	Aberdeen Proving Ground	MD	2
U.S. Department of the Army	Carlisle	PA	2
Federal Aviation Administration, Chesapeake Bay	Leesburg	VA	12
Fort Myer Military Community	Arlington	VA	6

Source: U.S. EPA. "Most Recent" EPA Regulated PCB Transformer Data.
Available at https://www.epa.gov/pcbs/registering-transformers-containing-polychlorinated-biphenyls-pcbs

3.3 Fluorescent Lamp Ballasts

Fluorescent lamp ballasts (FLBs) regulate the current supplied to fluorescent lighting fixtures and provide the initial high voltage needed to start the lamp (National Lighting Product Information Program, 2003). PCBs were used as a dielectric (insulator) in small capacitors used in the first generation of FLBs brought to market, known as the "T12" type.[12]

By the 1980s, PCBs were no longer being used in manufacturing FLBs (as a result of the TSCA ban), and advances in design meant that lighting systems based on T12 lamps were being displaced by slimmer, more efficient T8 lamps coupled with more efficient electronic ballasts (National Lighting Product Information Program, 2006; Pacific Northwest National Laboratory, 2009). Consequently, PCB-containing ballasts would only be found today in older (pre-1980) T12 lighting systems (U.S. EPA, 2016).[13]

Several factors have led to a decline in the number of PCB FLBs in use since EPA banned further manufacture in 1979:

- The average service life of an FLB is estimated to be only 10 to 15 years (U.S. EPA, 2016); thus, any pre-1980 FLBs still in service are more than 35 years old, well beyond their rated lifespan.
- T8 (and now, T5) systems are more energy efficient than T12s. The resulting lower operating costs give equipment owners a financial incentive to upgrade their lighting systems (U.S. EPA, 2008), (Pacific Gas and Electric Company, 2012). This has led to replacement even before these systems reach the end of their service life.[14]

[12] Fluorescent lamps are, in part, identified by their diameter, measured in 1/8 inch increments. The "T" stands for "tube", and a T12 is a lamp (or bulb) with a diameter of 12/8ths of an inch, or 1-1/2 inches. Likewise, a T8 is a lamp with a diameter of 8/8ths of an inch (1 inch), and a T5 is a lamp with a diameter of 5/8ths of an inch (National Lighting Product Information Program, 1993).

[13] Newer T8 and T5 lamps cannot be easily used in a fixture designed for T12 lamps without changing the ballast because of differences in the type of ballast, sockets, and length (National Lighting Product Information Program, 2000).

[14] In economic terms, it may be rational to replace a still-functioning lighting system if the present value of the newer system's reduced energy costs exceeds the cost of replacement.

- To help them meet mandated conservation targets, some electric utility companies have offered financial incentives and rebates for customers who switch from T12s to T8s (Pacific Gas and Electric Company, 2012; Pacific Power, 2016; Public Utility District #1 of Clallam County, 2013).
- A number of Department of Energy (DOE) rulemakings have brought about more stringent energy efficiency standards for T12 lamps, which likely has induced some users to upgrade to other lighting systems. The 2009 DOE "lamps rule" (74 FR 34080-34179) required all linear fluorescent lamps manufactured or imported for sale in the U.S. to meet more stringent efficiency standards by July 14, 2012. Although this rule did not ban T12 lamps outright, it created a performance standard that was difficult to meet with the most common types of T12 lamps. In a subsequent 2015 rule (80 FR 4042–4153) DOE further tightened its efficiency standard for lamps through a rule requiring compliance by January 26, 2018.

A typical pre-1979 PCB-containing fluorescent light ballast (FLB)

A typical Non-PCB containing fluorescent light ballast. The ballast has a "No PCBs" marking on the top of the ballast and the text "electronic ballast". Only magnetic fluorescent light ballasts contained PCBs.

Source: EPA.

Figure 6. PCB and Non-PCB Fluorescent Lamp Ballasts

The decline in use of T12 lamps is reflected in industry data. Figure 7 shows the trend in shipments of T12 lamps, compiled by the National Electrical Manufacturers Association (National Electrical Manufacturers Association, 2017). Indexed to 2011, Figure 7 shows a steady decline in shipments of T12s over the 2001-2017 period. Since 2011 alone, when the NEMA index was approximately 100, shipments have declined by 70 percent.

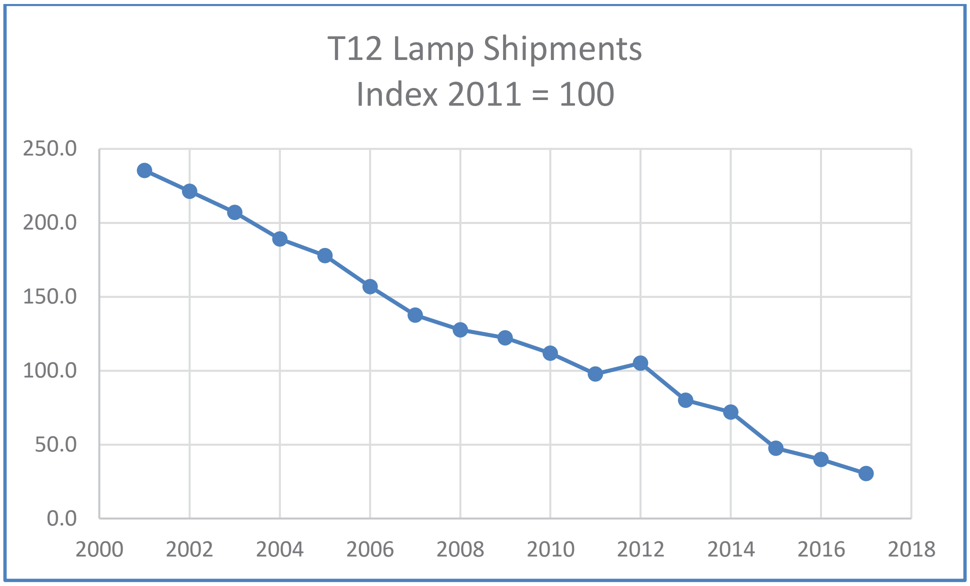

Figure 7. NEMA T12 Lamp Shipments (2000-2017)

3.3.1 FLB Failures and Leaks

As noted, PCB FLBs that remain in place and in service today are well past their rated lifetime of 10 to 15 years. As with most electrical equipment, the likelihood of failure increases the longer the equipment remains in use. Incidents of PCB FLB leaks have been periodically reported since the 1980s. For instance, in 1998, many FLBs in school buildings on the Standing Rock Indian Reservation in North Dakota were found to contain PCBs. Subsequent investigation found PCBs had leaked from the ballasts as a result of ballast failure, contaminating office equipment and carpeting. The cleanup for the four school buildings that contained leaking PCB FLBs resulted in expenditures for the Bureau of Indian Affairs of over $500,000, and the removal of non-leaking PCB FLBs from other buildings in the BIA region resulted in expenditures of $60,000 (75 FR 17645-17667).

More recently, high levels of PCBs have been found in New York City schools. In 2010, New York City Department of Education, in conjunction with EPA, sampled indoor air in schools that contained PCB FLBs that had never been remediated. PCB concentrations in the air were found to range up to 2,920 ng/m3, well exceeding EPA's recommended exposure limit of 300 ng/m3 for children aged 6 to 12 years of age (U.S. EPA, 2012). In a follow on investigation, NYC DOE identified 767 school buildings with T12 lighting fixtures in need of replacement (New York City Department of Education, 2015). As of December 2016, under a plan overseen by EPA Region 2, NYC DOE had concluded replacement work in all of these school buildings. The estimated total cost of replacement was approximately $1 billion (New York City School Construction Authority, 2016).

The incidents described above, along with others, have heightened awareness that some PCB FLBs continue to remain in service even long after their expected lifespan and that such equipment may be increasingly prone to failure. Depending on how they fail, PCB FLBs may rupture or leak, leading to the release of PCBs or PCB-contaminated potting material from the FLB enclosure. These materials may then fall or drip directly onto surfaces below the lighting fixture, or may simply volatilize and become airborne, contaminating the indoor air. In 2015, EPA published information targeted at schools and school administrators, recommending actions to be taken in schools built between 1950 and 1979 (U.S. EPA, 2015a). These actions include preventive removal of any remaining PCB FLBs.

Many schools and school districts have taken action to identify and remove PCB FLBs. As noted above, New York City has conducted a comprehensive assessment and removal program in its schools. Other school districts have reported to ERG anecdotally on similar activity across the country (see U.S. EPA, 2016).

Professional associations representing school administrators and school business officials have taken action to raise awareness of the issue and determine how school districts nationwide are responding. In 2014, the American Association of School Administrators (AASA), the Association of School Business Officials (ASBO) and the National School Boards Association (NSBA) conducted a survey of school superintendents, school business officials, school board members, and maintenance/facilities personnel. The survey found widespread awareness of the PCB issue in schools, and half of respondents reported that all schools constructed prior to 1980 had gone through lighting upgrades to remove PCB FLBs (The School Superintendents Association, 2014).

In 2014, the Centers for Disease Control and Prevention (CDC) conducted a national study to assess school health policies and practices (Centers for Disease Control and Prevention, 2015). As part of the survey, they asked respondents about their experience identifying and removing PCB FLBs. The survey found that 23.2 percent of schools had conducted inspections to identify PCB FLBs within the last 12 months, and that 40.6 percent had previously identified and remediated all PCB FLBs.

3.3.2 Number of Buildings and FLBs Containing PCBs

While the information above is focused on PCB FLBs in schools, PCB FLBs may be found in any pre-1980 buildings reliant on fluorescent lighting systems that have not undergone subsequent lighting upgrades. A separate memorandum (Eastern Research Group, 2019b) contains details concerning the method used to estimate the total number of such buildings, by type, and the number of FLBs they may contain. These estimates are based on the methodology used by EPA to support its 2008-2015 reassessment of the PCB use authorization (U.S. EPA, 2016).

The model used to generate these estimates begins with data from the DOE's Commercial Building Energy Consumption Survey (CBECS), a national survey of building owners last conducted in 2012 (U.S. Department of Energy, 2012). The survey collects details about building characteristics and building energy use. Key characteristics for the analysis are building age, building size, and type of lighting system. The model focuses on buildings constructed prior to 1980 (the year following the PCB manufacturing ban) that are primarily lit using fluorescent lighting systems. As part of the survey owners were asked whether their building had undergone different types of renovations and upgrades, including a full lighting upgrade. Buildings that had not undergone a full lighting upgrade could potentially contain PCB FLBs. Table 8 (Column D) indicates that approximately 1.7 million buildings nationally met these criteria in 2012. Next, using industry estimates of the number of square feet lit per fixture, EPA estimated that these buildings may contain over one billion FLBs (Column H).

Since the time of the CBECS survey in 2012, an unknown number of these buildings have undergone lighting upgrades or been demolished. Both activities will remove buildings from the population of buildings that may contain PCBs. EPA was unable to estimate the number of buildings demolished, due to lack of data, but did update the number of buildings since 2012 that may have undergone lighting retrofits. The adjustment was based on changes in the T12 shipments index (from Figure 7) between 2012 and 2017. Over this period, the index dropped from 105.1 to 30.4, a decline of 71 percent. Applying these reductions to the population of buildings and FLBs suggests that by 2018 there remained 492,000 buildings and 293 million FLBs that may potentially contain PCBs in lighting systems.

The next step is to estimate how many FLBs in pre-1980 buildings that have not undergone a complete lighting upgrade are still original, or at least pre-date the 1979 ban, and are thus likely to contain PCBs. This step accounts for the fact that all FLBs from this era are at least 35 years old and have exceeded their expected lifespan of 10 to 15 years (U.S. EPA, 2016), which means a large percentage are likely to have failed and been removed (and replaced with non-PCB FLBs) in the intervening period. In addition, some PCB FLBs that were still operating may have been removed during partial lighting upgrades, and thus not captured through the CBECS questionnaire.

The percentage of FLBs that may still contain PCBs is based on limited data from pre-1980 schools that have conducted thorough inspections of their lighting systems and have good records of the results. EPA contacted schools in various parts of the country and obtained a wide range of estimates. After evaluating the data, EPA estimated that 17 percent of FLBs in pre-1980 buildings that had not undergone a complete lighting upgrade by 2012 contained PCBs. Applying this factor reduces the number of buildings nationwide to 83,500, and the number of PCB FLBs to 49.7 million. The extent to which this proportion accurately reflects building types other than schools is unknown.

Table 8. Estimates of the Number of Buildings That May Contain PCB FLBs, and Number of FLBs (2012)

Principal Building Activity	A Buildings	B Fluorescent -Lit Buildings	C Pre-1980 Fluorescent -Lit Buildings	D Pre-1980, No Lighting Upgrade	E Avg. Square Footage	F Avg. % Lit by Fluorescent	G Fluorescent Square Footage/Building	H Estimated No. of FLBs (D x G / 100)
Education	388,659	381,700	183,195	117,020	85,623	87.6%	75,018	87,786,064
Enclosed mall	1,379	1,379	824	651	893,735	53.3%	476,534	3,102,236
Food sales	176,739	169,218	71,960	47,216	16,216	93.2%	15,118	7,138,115
Food service	379,711	352,083	180,689	128,531	6,349	67.1%	4,258	5,472,850
Inpatient health care	9,579	9,570	5,298	2,448	597,148	84.8%	506,166	12,390,944
Laboratory	15,505	13,837	3,920	1,646	180,327	89.4%	161,190	2,653,187
Lodging	128,389	95,892	51,297	34,501	175,865	51.5%	90,513	31,227,890
Non-refrigerated warehouse	787,169	500,115	184,169	156,815	107,284	80.1%	85,913	134,724,471
Nursing	29,535	28,743	11,574	6,943	90,604	69.0%	62,492	4,338,820
Office	1,012,373	949,352	485,879	336,294	138,745	85.0%	117,910	396,524,255
Other	109,260	90,449	31,095	20,377	76,598	85.7%	65,675	13,382,595
Outpatient health care	147,155	138,754	62,636	40,560	63,741	90.4%	57,646	23,381,218
Public assembly	352,014	298,594	165,043	124,819	141,541	65.3%	92,422	115,360,216
Public order and safety	83,841	71,707	26,386	17,636	119,609	81.8%	97,893	17,264,409
Refrigerated warehouse	8,499	8,436	3,305	3,023	180,714	51.6%	93,321	2,821,094
Religious worship	411,799	363,226	211,718	157,552	21,806	71.2%	15,530	24,467,826
Retail other than mall	438,261	406,900	219,014	167,481	38,045	79.7%	30,334	50,803,687
Service	618,544	552,040	309,605	265,809	16,835	86.0%	14,480	38,489,143
Strip shopping mall	162,687	161,610	69,970	42,720	79,307	84.5%	67,016	28,629,235
Vacant	296,041	55,793	32,867	27,213	50,590	92.6%	46,860	12,752,012
TOTAL	**5,557,139**	**4,649,398**	**2,310,444**	**1,699,255**	--	--	--	**1,012,710,266**

Source: ERG estimates.

3.3.3 Number of Buildings and FLBs Containing PCBs in the Chesapeake Bay Watershed

Two different approaches were used to estimate the share of buildings nationally that may contain PCB FLBs that are located within the Chesapeake Bay Watershed. The first approach uses the share of U.S. population living within the Chesapeake Bay Watershed, which is 5.6 percent. If the national population of buildings with PCB FLBs are distributed in proportion to population, then the number of buildings in the Chesapeake Bay watershed with PCBs is estimated at 4,678, and the number of FLBs in these buildings is 2.8 million. Of these, an estimated 322 buildings (6.9 percent of the total) are schools, and these schools contain 242,000 FLBs (8.7 percent of the total).

An alternative approach, which might be appropriate for a voluntary program focused on schools, involves apportioning the national building population to the Chesapeake Bay Watershed based on either the share of school-age population, or share of schools within the region. In this case, the allocations are only available at the state level, which results in a larger share of the U.S. total being allocated to the Chesapeake Bay region compared to the population approach above (as noted in Table 8, 50.4 million people reside in states bordering the Chesapeake, but CBP estimates only 18 million actually live within the Chesapeake Bay watershed) (Chesapeake Bay Program, 2019). Based on the share of school-age students residing in Chesapeake Bay states (see Table 9), the percent of buildings and FLBs located in these states could be estimated at 14.6 percent of the total. This is not much different than an allocation based on the Chesapeake Bay states' share of U.S. public and private schools, which is 13.6 percent (Table 10). For purposes of these estimates, the Chesapeake Bay states' share of U.S. schools (13.6 percent) is used to generate a low estimate while the Chesapeake states' share of U.S. population (15.6 percent) is used to generate a high estimate. These shares place the number of buildings in the Chesapeake Bay states with PCBs at between 11,695 and 13,031, and the number of FLBs in these buildings at between 7.0 and 7.8 million. Of these, between 805 and 897 buildings are schools, and these schools contain between 604,165 and 673,212 FLBs.

Table 9. Estimated Total and School-Age Resident Populations in Chesapeake Bay States, 2016 (thousands)

Population	U.S. Total	Chesapeake States (DE, DC, MD, NY, PA, VA, WV)	Chesapeake States as Percent of U.S. Total
Total Population	323,128	50,442	15.6%
School Age Population (5-17 Years)	53,715	7,826	14.6%

Source: (National Center for Education Statistics, 2019).

Table 10. Estimated Number of Public and Private Schools in Chesapeake Bay States, 2016

Type of School	U.S. Total	Chesapeake States (DE, DC, MD, NJ, NY, PA, VA, WV)	Chesapeake States as Percent of U.S. Total
Public	102,401	12,801	12.5%
Private	21,899	4,118	18.8%
Total	**124,300**	**16,919**	**13.6%**

Source: (National Center for Education Statistics, 2019).

3.3.4 Quantity of PCBs Remaining in Fluorescent Lamp Ballasts

Estimates of the quantity of PCBs contained in PCB FLBs vary between 10.0 grams (0.35 ounces) and 23.6 grams (0.83 ounces) per fixture (Environment Canada, 1991; General Electric, 2004). By combining low and high estimates of the number of FLBs in the Chesapeake region with low and high estimates of the quantity of PCBs found in each FLB, we can generate a range of estimates of the total quantity of PCBs that may be found in older FLBs still remaining in service in the Chesapeake region. As seen in Table 11 below, this results in estimates ranging from 69,697 kg (153,656 lbs) to 182,284 kg (404,071 lbs).

Table 11. Range of Estimates of Quantity of PCBs Contained in FLBs Remaining in Commercial Buildings in the Chesapeake Bay Region

Estimated No. of FLBs		Estimated Quantity of PCBs	
		Low - 10 grams/FLB	High - 23.6 grams/FLB
Low	6,969,715	69,697 kg (153,656 lbs)	164,485 kg (362,628 lbs)
High	7,766,254	77,663 kg (171,215 lbs)	183,284 kg (404,071 lbs)

Source: ERG estimates based on data sources above.

3.3.5 Identifying Equipment Owners

PCB-containing ballasts may be found in any building or structure using fluorescent lighting systems that pre-date the 1979 TSCA ban. As shown in Table 11, there are an estimated 6.9 to 7.8 million PCB FLBs remaining in buildings located in the Chesapeake Bay region. Without a central registry of buildings that contain information about building age and lighting, however, identifying individual building owners to approach for a voluntary program would be difficult. A more targeted sectoral approach may be more appropriate. Such an approach would focus on raising awareness among building owners and encouraging them to identify and remove PCB FLBs within their buildings.

CBP determined that a sectoral voluntary program focused on public school buildings would be worth exploring, for several reasons. First, school building owners are readily identifiable. Each state maintains a function that supports local school districts on construction and renovation issues. For example, in

Maryland this is the School Facilities Branch within the Maryland Department of Education.[15] These organizations are likely to have current information about school age and condition (including lighting system status) and could become a focal point for any voluntary program within each state. A secondary reason for focusing on school buildings is the potential exposure of school age children if PCB FLBs fail and leak. This could provide additional justification for schools to participate in a voluntary program that has the primary aim of preventing PCB contamination in the Chesapeake Bay. Based on data from Table 8, schools represent an estimated 6.9 percent of buildings that contain PCB FLBs and they contain an estimated 8.7 percent of the total PCB FLBs.

3.4 Paints and Pigments

In addition to the uses described above, PCBs were previously used in a range of other industrial and commercial products. Among these were adhesives, caulk, coatings, grease, paint, gaskets, sealants, and waxes. Although these uses were discontinued under the 1979 PCB ban, PCBs have been found in paints purchased at the retail level as recently as 2009 (Hu & Hornbuckle, 2009). The researchers involved tested these paints in an attempt to identify sources of seasonal variation in PCBs found in air samples in Chicago. The seasonal nature of the elevated PCB concentrations suggested volatilization from outdoor surfaces, possibly paint. In addition, the specific PCB congener identified, PCB-11, were rarely found in legacy commercial PCB mixtures (Rodenburg et al., 2015).

Further analysis determined that PCBs were associated with paints manufactured with azo and phthalocyanine pigments. These pigments are used to manufacture paints in yellow and green colors, and in some blue, orange and red hues. In addition to paints, these pigments are used for coloring inks, textiles, paper, cosmetics, leather, and plastics (Gregory, 2000) and (Stolz, 2001; cited in Hu and Hornbuckle, 2009).

Testing in Japan found that PCBs were present in 57 of 98 organic pigments analyzed, some at concentrations in excess of 50 ppm (Japan Ministry of Economy, 2012). Most recently, the City of Spokane, WA tested a variety of "municipal" products for PCBs, including paint, deicer, pesticides, dust suppressants, hydroseed, and firefighting foam, among others (City of Spokane, 2015). Samples of several traffic marking paints used in Washington State were sent to the Washington Department of Ecology laboratory for analysis. PCBs were found in all samples, with PCB-11 representing between 7 and 98 percent of the total PCBs detected.

The same PCB compounds found in these pigments and paints have been found in wastewater from a paper recycling facility in Spokane, Washington, and are believed to come from inks used in the recycled paper feedstock (Inland Empire Paper Company, 2018).

Because no PCBs are being intentionally used during the manufacture of these pigments, and the specific PCB congeners (e.g., PCB-11) found are not linked to legacy PCB production, it is hypothesized that the PCBs being found in paints form inadvertently as a byproduct of pigment manufacturing.

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15 See *http://marylandpublicschools.org/about/Pages/DBS/School-Facilities*.

3.4.1 Estimated Quantity of PCBs in Paint

This section presents estimates of the quantity of paint containing PCBs that may be used annually in the Chesapeake Bay watershed, and the amount of PCBs contained in such paint. The estimates are based on a variety of data sources, and some of the values reviewed were subject to wide variation. In some cases, conservative values for parameters used to generate the estimates were selected, which has likely resulted in an overestimate of the quantity of contaminated paint and the amount of PCBs they contain.

The approach to estimating these quantities is summarized briefly below, and in Table 12.

Concentration of PCBs in Pigments: In the paints examined in the study cited above (Hu & Hornbuckle, 2009), the maximum PCB concentration found was 200 nanograms/gram (ng/g) (i.e., ppb), with most detections centering roughly at 25 ng/g. Although concentrations up to 1,000 ppm (one sample) were found in the Japan study, most samples did not exceed 0.5 ppm, or 500 ppb (cited in Washington State Department of Ecology, 2014). Washington State's own testing of seven paints in 2014 found concentrations ranging from 4.3 to 45 ppb, although one phthalo green paint colorant showed a concentration of 320 ppm for PCB-209 (Washington State Department of Ecology, 2014). In 2015, the City of Spokane tested six traffic marking paints. Two were liquid yellow, two were liquid white, and two were solid thermoplastic. Total PCB concentrations ranged from 0.28 ppb (Sherwin Williams white) to 10.78 ppb (Ennis Flint Pre Mark thermoplastic) (City of Spokane, 2015). As the studies available in the United States did not report PCBs at higher than 330 ppb (and the one sample at that level appeared unique), we chose this maximum value as a reasonable worst-case estimate of an average concentration of PCBs in paint pigment. This is probably a conservative estimate, as most samples tested were below 50 ppb.

Percent of Paints That Contain PCBs: As determined by testing in the studies cited above, not all pigments are contaminated. Overall, about half of the paints sampled contained PCBs. To be conservative, we assumed that 80 percent of paints contain at least some pigment contaminated with PCBs.

Pigment as a Component of Paint: Paints contain a mixture of ingredients besides pigment, including fillers, binders, and the liquid solvent (water in the case of water-based paint or petroleum distillates in the case of oil-based paint). Based on industry sources, we assume that 25 percent of paint by volume is pigment.

Volume of Paint Sold Annually in the U.S.: According to market research performed by the industry trade magazine, Coatings World, 1.4 billion gallons of paint will be sold in the United States in 2019, which is 5.3 billion liters (Coatings World, 2018).

Volume of Pigments in Paint Sold: If 80 percent of paint sold in the United States contains pigment contaminated with PCBs, this means 4.2 billion of the 5.3 billion total paint volume sold annually may contain PCBs. Further, if 25 percent of this paint by volume is pigment then this represents 1.1 billion liters of pigment. If we assume further that 80 percent of pigment is contaminated with PCBs, then the quantity of pigment contaminated with PCBs is 848 million liters.

Mass of Pigments in Paint Sold: Using a typical pigment density of 2.05 g/mL we estimate that a liter of paint contains 2.05 kg of pigment. Given the 848 million liters of contaminated pigment estimated above, this suggests there are 1.738 billion kg of contaminated pigment in paint sold annually in the U.S. (848 million liters x 2.05 kg/liter=1.738 billion kg).

Mass of PCBs in Paint Pigments: Using 330 ppb as the typical concentration of PCBs in paint pigment, the 1.7 billion kg of contaminated pigments sold annually in the U.S. may contain 574,000 grams (1,265 lbs) of PCBs. This estimate is consistent with prior estimates made by the Color Pigments Manufacturers Association. CPMA estimated the amount of inadvertently generated PCBs in pigments imported to or manufactured in the U.S. at between 1,000 and 2,200 pounds (Color Pigments Manufacturers Association, 2010), with the lower end estimate considered more reasonable.

Table 12. Estimated Mass of PCBs in Contaminated Paint

Data Element	Amount	Notes
Volume of paint sold annually in the U.S.	1.4 billion gallons = 5.3 billion liters	3.78 liters per gallon
Percent of paint contaminated with PCBs	80 percent	Conservative (high) estimate
Volume of paint sold	4.2 billion liters	
Pigments as a percent of paint volume	25 percent	
Volume of pigment in paint sold	1.1 billion liters	
Percent of pigment contaminated	80 percent	Conservative (high) estimate
Volume of contaminated pigment in paint sold	848 million liters	
Mass of contaminated pigment	1,738 million kg	Pigment density = 2.05 g/ml
Concentration of PCBs in pigment	330 ppb = 3,300 ppm = 3,300 mg/kg	
Mass of PCBs in contaminated paint	574,000 grams = 574 kg = 1,265 lbs	
Mass of PCBs in contaminated traffic marking paint	Not available	Market data found for traffic marking paint was expressed in terms of dollar value, not volume. Estimates also varied widely.[16]

3.4.2 Estimated Quantity of PCBs in Paint Sold in the Chesapeake Bay Watershed

PCB-contaminated paints are assumed to be used in proportion to population density. The population density of the U.S. as a whole is 90.8 people per square mile (3.5 million square miles with a 2015 population of 321 million) (U.S. Census Bureau, 2018a, 2018b), while the density of the Chesapeake Bay Watershed is 282.7 people per square mile (64,000 square miles and a 2015 population of 18 million) (Chesapeake Bay Program, 2018a, 2018b). Thus, the Chesapeake Bay watershed is 3.1 times more densely populated than the United States as a whole (282.7/90.8 = 3.1).

[16] For example:

- "The global traffic road marking coatings market size was valued at USD 4.25 billion in 2018" *https://www.grandviewresearch.com/industry-analysis/traffic-road-marking-coatings-market*
- "The road marking materials market size is projected to grow from USD 6.8 billion in 2018 to USD 8.8 billion by 2023" *https://www.marketsandmarkets.com/Market-Reports/road-marking-material-market-13285598.html*

The average amount of PCBs in paint applied throughout the United States is estimated at 574,000 grams over 3.8 million square miles, or 0.16 grams per square mile. Assuming about three times as much paint is applied in the Chesapeake Bay watershed than in the United States overall, we estimate that 0.51 grams of PCBs in paint are applied per square mile of the watershed each year. In total, we thus estimate that over the 64,000 square miles of the watershed, about 32 kg (70.55 lbs) of PCBs in contaminated paint are applied annually. Because many conservative assumptions have been made throughout these calculations, however, this estimate could substantially overstate the amounts of PCBs being applied with paint in the watershed.

3.4.3 Efforts to Reduce Quantities of PCBs in Paint Used in the Chesapeake Bay Watershed

In response to an inquiry for this study, Maryland reported the following with respect to its efforts to reduce the quantities of PCBs used in municipal traffic paints (Dicerbo, 2019):

- Maryland is aware of the potential for PCB contamination in solvent-borne traffic paints.
- Maryland currently uses only water-borne traffic paints that are "PCB-free."
- Based on a three-year average, Maryland uses 7,900 "stripe miles" of traffic paint annually.
- Annual volume purchases of traffic paint were as follows:
    - 2017 – 600 gallons of white and 600 gallons of yellow paint.
    - 2018 – 2,000 gallons of white and 1,200 gallons of yellow paint
    - 2019 – 2,800 "units" of paint

Maryland did not indicate how it determined the paints it purchases are PCB-free (e.g., vendor claim, paint specification, testing). Similar information for other Chesapeake states (e.g., VA) was not available.

3.5 Caulks and Sealants

PCBs were known to be used in caulks and sealants used in buildings constructed prior to the 1979 PCB ban. Formulations that included PCBs were available from the 1950s through the 1970s (Diamond et al., 2010). As a result, buildings constructed during this period may potentially be contaminated.

Caulks and sealants are designed to adhere to the substrate (e.g., masonry) but over time they may crack and flake off. PCB-contaminated particles could then migrate to soil and eventually become entrapped in stormwater runoff. Fine particles may become airborne as dust and be deposited on soil or directly onto waterways. Building renovation and demolition activities may also loosen caulk and sealant and separate it from the substrate.

Until 2012, caulk or sealant containing PCBs that had been removed from a substrate was considered a "PCB bulk product waste", while renovation or demolition waste contaminated by the migration of PCBs from caulk or sealant was considered a "PCB remediation waste." This meant that the caulk or sealant itself could be disposed of in a permitted municipal or non-municipal non-hazardous waste landfill, while the contaminated masonry or other substrate material (presumably containing lower concentrations of PCBs) could only be disposed of in a TSCA-permitted facility. Under a 2012 "reinterpretation" rule, EPA reclassified contaminated substrate material from a remediation waste to a bulk product waste, thereby facilitating its disposal (Rudzinski, 2012). This decision was in part aimed at incentivizing building owners (and particularly schools) to remove and dispose of PCB caulk and materials contaminated by such caulk. EPA also relied on its assessment of the potential for PCBs in bulk product waste to leach from landfills:

> "EPA evaluated the fate and transport of PCBs leaching from landfills into groundwater using EPA's peer reviewed Industrial Waste Management Evaluation Model (IWEM). This evaluation supports EPA's determination that PCB bulk product waste can be safely disposed of in certain non-TSCA approved landfills as it showed that these wastes are unlikely to migrate into groundwater or soil." (U.S. EPA, 2019a)

EPA has made no estimates of the quantity of PCB-contaminated caulks and sealants either used in or remaining in buildings nationally, or the number of such buildings. As noted above, these products were in use during the 1950s through the 1970s, principally (though not exclusively) in masonry construction. Conservatively, any buildings constructed or renovated during this period could be considered to be potentially contaminated.

The state of Washington has outlined an approach to estimating the quantity of PCB-contaminated caulks and sealants in buildings statewide, as well as the amount released annually. The approach, documented in the state's 2015 PCB Action Plan, is as follows (Washington State Department of Ecology, 2015):

1. Estimate the total square footage of commercial masonry buildings constructed between 1945 and 1980, from county records.
2. Estimate the total cubic footage of such buildings by applying a mean number of stories and story height, based on county building records.
3. Assume a caulk and sealant application rate of 55g/m3 (Diamond et al., 2010).
4. Estimate the percent of caulk and sealant used that contains PCBs, and the PCB concentration distribution in such materials, based on a study done in Switzerland (Kohler et al., 2005).
5. Estimate the annual releases of PCBs to the environment, using a long-term release rate coefficient of 0.0018. This was based on an estimated 9 percent gross loss over 50 years, with volatilization being the primary route (Robson et al., 2010).

Using this methodology, Washington State estimated that 5.3 million kg (11.7 million lbs) of caulk was used in buildings during this era state-wide. Of this, 2.5 million kg (5.5 million lbs) contained PCBs. Based on the PCB concentration distribution found the study in Switzerland (Kohler et al., 2005), the total estimated quantity of PCBs in all buildings statewide was estimated at 87,208 kg, (192,260 lbs) with annual releases to the environment estimated at 157 kg (346 lbs) (Washington State Department of Ecology, 2015).

Estimates of the quantity of PCB caulks and sealants used in the Chesapeake Bay watershed, and potential releases to the environment, have not been made. CBP could potentially do so using an approach similar to that used by Washington State. Identifying the number and size of buildings of the type (masonry) and vintage (1950-1978) that may contain PCB caulk and sealant would be the most difficult task.

It is worth noting, however, that EPA's 2012 reinterpretation of disposal requirements was intended to accelerate the removal of PCB caulks, sealants, and contaminated substrate. This means that over time, the quantity of such material in place should decrease. Further, EPA has determined that disposal of such material into permitted non-hazardous waste landfills does not pose any risk of leaching or migration. For these reasons, PCBs in caulk or sealants may not be as significant a threat to the Chesapeake Bay watershed quality as other sources discussed here.

3.6 Summary of Quantitative Estimates

The sections above discussed a number of potential sources of current and future PCB contamination in the Chesapeake Bay Watershed. These include legacy sites where PCBs were manufactured or used in manufacturing, or where equipment containing PCBs was used, stored, maintained, recycled, or disposed. While the total number of such sites and quantity of PCBs present at such sites has not been estimated, they are almost certainly an important source of PCB contamination in the Chesapeake Bay Watershed, and will continue to be despite ongoing efforts to clean them up. States within the watershed have all made efforts to identify both point and nonpoint sources of legacy PCB contamination. In many cases, site owners or other responsible parties have been assigned responsibility for reducing discharges (e.g., via PMPs mandated under various PCB TMDLs).

Another source of PCB contamination is electrical equipment whose manufacture pre-dates the 1979 TSCA ban on PCB manufacturing, but that remains either in service or in storage (e.g., as backup equipment). Such equipment was authorized for continued use under TSCA until the end of its lifespan, as long as such use remained “totally enclosed.” The inventory of PCB-containing equipment that remains in service or storage is decreasing, but it has not been completely exhausted. Building on equipment inventory models developed for EPA, this report includes estimates of the remaining inventory of electrical equipment, and the potential quantity of PCBs it contains. This inventory includes various types of equipment used largely by the electric utility industry, and capacitors used in fluorescent lamp ballasts, which may be found in pre-1980 buildings that continue to use T12 fluorescent lighting systems.

A final source is PCBs that are inadvertently produced during pigment manufacturing, and that end up in paint. Of particular interest is paint used outdoors on solid surfaces, as the same PCB congeners found in such paint have been detected in ambient air pollution monitoring studies (Hu & Hornbuckle, 2009). These studies have implicated outdoor paint first because of the chemical signature of the PCBs detected, and second because of the seasonal variation in concentrations. This seasonal variation suggests there is some volatilization involved.

Table 13 compares estimates of relevant indicators for these sources of PCBs.

Table 13. Estimated Quantities of PCBs from Sources Within the Chesapeake Bay Watershed

Source		Range of Estimates	Estimated Quantity of PCBs
Electrical Equipment			
	PCB Equipment	1,425 – 9,665 units	176.2 – 445.1 lbs
	PCB-Contaminated Equipment (50-500 PPM	14,901 – 97,407 units	
Fluorescent Lamp Ballasts (FLBs)			
Buildings	Schools Other Buildings	805 – 978 buildings 10,889 – 12,134 buildings	
	Total	11,695 – 13,031 buildings	
FLBs	Schools Other Buildings	0.60 – 0.67 million FLBs 6.36 – 7.09 million FLBs	14,842 - 31,434 lbs 156,375 - 331,193 lbs
	Total	6.97 – 7.77 million FLBs	171,216 – 362,628 lbs
PCB-Contaminated Paint			
	Applied annually	0.51 grams per square mile	70.55 lbs (annual)
Caulks and Sealants		Not estimated	
Legacy Sources/Sites		Not estimated	

Source: ERG estimates.

4 Voluntary Programs to Reduce PCB Sources

4.1 Voluntary Programs Background

There is substantial experience in the U.S. and abroad with the use of voluntary programs to address environmental issues outside of the legal or regulatory framework. At one time it was estimated that state and federal governments in the U.S. operated more than 200 of these (Coglianese & Nash, 2016), although the popularity of such programs tends to ebb and flow. At the federal level, one of the first, largest, and longest-running voluntary programs is ENERGY STAR, launched by EPA in 1992. Now a widely-recognized "brand" that cuts across major sectors of the economy, ENERGY STAR operates on a budget of close to $50 million per year (U.S. EPA, 2019b), but is credited with saving over $30 billion in energy costs annually (U.S. EPA, 2018). Other important early EPA programs were Project XL, 33/50, and the National Environmental Performance Track.

In addition to government-initiated programs, many similar programs have developed within or across industries. Examples of these include Responsible Care (chemical industry), LEED (design, construction and building operation/maintenance), the Forest Stewardship Council (wood products), and Sustainable Slopes (ski industry), among many more.

Often, these programs evolve or are introduced to address problems that have not yet been addressed through regulation. For example, EPA's 33/50 Program challenged industry to reduce emissions of chemicals not yet regulated (by 33 and 50 percent). And until recently, EPA had operated more than 25 programs aimed at encouraging voluntary action to reduce (unregulated) greenhouse gas emissions (Coglianese & Nash, 2016).

Research has found that firms join or participate in voluntary programs for a variety of reasons. Among those cited are:

- To avoid regulation and its costs and uncertainties.
- To claim program benefits (e.g., reduced inspection frequency).
- To appeal to stakeholders.
- To deflect attention from consumer groups and NGOs.
- Programs align with management's values (they want to be viewed as a leader).
- Opportunities to network with other industry leaders.

(Borck & Cognianese, 2009; Coglianese & Nash, 2016; Potoski & Prakash, 2005; Prakash & Potoski, 2011)

Governments favor voluntary programs because they motivate firms without the cost, time, or burden of implementing and enforcing regulations (implementing and enforcing regulations is costly). Furthermore, voluntary programs can be initiated through administrative action, bypassing lengthy processes of legislative review and public consultation. Often, government cites such programs to demonstrate that government and business can work together in a non-adversarial way.

Voluntary programs tend to work best and have the greatest impact where government has the capacity and resources to establish and operate the program, includes processes for verifying participant's accomplishments, and ideally, backs up the program with some authority to regulate, if the program proves inadequate.

Most programs offer a combination of one or more of the following “benefits” to participants:

- Networking/learning
- Technical assistance
- Access to government officials
- Recognition as an environmental “leader”
- Use of program marketing logos
- Reduced regulatory oversight
- Exemption from reporting or administrative requirements

Performance monitoring of participants under these programs varies. If monitoring is inadequate, it can negatively impact program credibility (e.g., participants may practice “greenwashing”). The potential for such problems may be alleviated if the program includes sanctions for violating program guidelines or requirements, or if the program includes public disclosure of performance data and accomplishments.

4.2 Review of Existing Voluntary PCB Programs

To inform this project CBP performed an extensive search for programs addressing ways to reduce PCBs in the environment. We identified several programs undertaken by various organizations and agencies. It is worth noting that the number of such programs is, however, relatively limited.

This section summarized information about the most relevant programs for which there was sufficient information available. For each program we provide an overview of the program, identify the sources of PCBs and pathways addressed by the program, describe the program results, and discuss any lessons learned and recommendations made by these entities.

4.2.1 Minnesota Pollution Control Agency Transformer Phase-out

The Minnesota Pollution Control Agency (MPCA) is a participant in the Lake Superior Binational Program to Restore and Protect the Lake Superior Basin (LSBP). This program includes a Zero Discharge Demonstration, which is aimed at eliminating the release of nine toxic chemicals, including PCBs, in and around Lake Superior. MPCA designed the PCB portion of the program to help the LSBP achieve their goal of eliminating PCB releases around Lake Superior (Minnesota Pollution Control Agency, 2004).

MPCA focused the PCB project on finding and removing as many PCB-contaminated transformers as possible. The MPCA contacted and worked closely with several smaller utility companies to identify, target, and replace PCB-contaminated transformers close to Lake Superior Basin. The tentative goal of the project was to remove half of the suspect transformers. The project received funding through a combination of sources, including the Great Lakes National Program Office (GLNPO), the Legislative Commission on Minnesota Resources (LCMR), and the MPCA. Although the project received funding, the ultimate success of the project depended on cooperation between the MPCA and the utility companies, as well as partial volunteering by the utility companies to cover the costs of replacement that funding did not cover (Minnesota Pollution Control Agency, 2004).

The MPCA used manufacturer-supplied information to identify suspected contaminated transformers. Originally, the MPCA planned to pre-test suspected contaminated transformers, but eventually that process became too inefficient and cost prohibitive. Instead, the utility companies agreed to replace as many transformers identified as potentially contaminated as possible. The cooperation between the MPCA and the utility companies involved was crucial to the project's ultimate success, through a combination of analytics performed by the MPCA translating to action being taken by the utility companies (Minnesota Pollution Control Agency, 2004).

Sources and Pathways

The project focused on PCB-contaminated transformers near the Lake Superior Watershed. Specifically, the MPCA targeted transformers that were closest to bodies of water, where PCB contamination could have a direct impact with the most severe consequences to water quality. Removal of these was prioritized over transformers with similar PCB contamination but located further from water sources (Minnesota Pollution Control Agency, 2004).

Results

MPCA was able recruit three utility companies that succeeded in phasing out a portion of their suspected PCB-contaminated transformers. Table 14 presents data on number of transformers, number of suspected contaminated transformers, number of phased-out transformers, and percent reduction for each of these utility companies. Overall, for the three participating utilities, 82 percent of suspected contaminated transformers were anticipated to be phased out by the completion of the project (which occurred after this report was written). This was well above the initial target of 50 percent (Minnesota Pollution Control Agency, 2004).

Table 14. Minnesota Pollution Control Agency Project - Number of Transformers Phased Out

Utility	Number of Transformers in the Lake Superior Basin (approximate)	Number of Suspect Transformers	Number of Transformers Being Phased Out	Percent Reduction
Lake Country Power	10,500	292	292	100%
Cooperative Light and Power	4,184	241	145	60%
City of Grand Marais	162	15	15	100%
Total	**14,846**	**548**	**452**	**82%**

Lessons Learned and Recommendations

MPCA reported the following lessons learned from this project (Minnesota Pollution Control Agency, 2004):

- Contract directly with the utilities rather than a disposal company. MPCA learned that utilities prefer to do the work themselves or use subcontractors of their own choosing.
- Allot more time for the seasonal nature of the project. MPCA learned that some small utilities might be able to spend time on a project such as this at any time of the year, but there is typically a busy season (i.e., construction season) and a slower winter season. MPCA suggested that negotiations with utilities should begin in the winter, pause during construction season and allow

another winter (or even two, depending on the quantity of transformers) for completion of the work.

- Environmental stewardship awards would be appropriate. MPCA will be seeking opportunities to nominate the utilities for their efforts, as this could help provide encouragement to other utilities.
- Do not separate known versus suspect transformer phase-out efforts. MPCA determined that it would have been cost prohibitive to pre-test suspected transformers for PCB contamination. Instead, the agency handled the suspected and known contaminated transformers in the same manner and targeted both to be phased-out.
- Look for opportunities to change-out other types of PCB-containing equipment. Although it is reasonable to target distribution transformers because they may be located throughout the watershed, capacitors, substation transformers, bushings and some other types of electrical equipment also contain PCBs and could be the focus of other projects.

Applicability to the Chesapeake Bay Watershed

Although the MPCA project was a funded project that focused strictly on PCB-contaminated transformers, there are still important lessons that could be applied to a voluntary program for the Chesapeake Bay Watershed.

Most notable is the cooperation that took place between MPCA and local utilities, who eventually paid for a lot of the phase-out and replacement work themselves. That outcome is a testament to the close relationship established between MPCA and each utility. The attention and information given to utility companies helped encourage those companies to consider financing phase-out projects.

Another aspect of the project worth noting is the adaptability that MPCA demonstrated throughout the project. As noted above, MPCA deviated from the initial plan to pre-test suspected contaminated transformers for PCBs but learned that testing would be expensive and time-consuming, thus delaying removal. Instead, MPCA and the utilities agreed to move forward with removing suspected transformers without analytical confirmation.

4.2.2 State of Washington PCB Chemical Action Plan

The State of Washington develops Chemical Action Plans (CAPs) to address the impacts from chemicals it identifies as posing the highest risk to human health and the environment. Each CAP identifies, characterizes, and evaluates uses and releases of specific persistent, bioaccumulative, and toxic chemicals (PBT) or groups of chemicals, and recommends actions to protect human health and the environment (Washington State Department of Ecology, 2015).

The Washington State PCB CAP estimated releases of PCBs from various sources to air, land, and water. It also describes the physical and chemical properties of PCBs and why they are considered toxic to humans and other organisms. The recommendations made by this plan are a set of actions to phase out uses and reduce releases, and exposures in Washington. The state also performed an economic analysis on the cost of these recommendations and included descriptions of the most promising options in the CAP (Washington State Department of Ecology, 2015).

The CAP program does not carry out any of the recommendations it makes; the purpose of the plan is to provide information for the state to use in deciding whether to implement the recommendations and to what capacity.

Sources and Pathways

Current PCB levels in Washington State reflect both historical uses and ongoing manufacturing processes that create inadvertent PCBs. A large reservoir of past uses of PCBs includes electrical equipment such as transformers and capacitors and building materials such as caulk and paint (Washington State Department of Ecology, 2015).

Stormwater is the largest delivery pathway to surface waters for PCBs statewide. Loadings from water treatment plants and atmospheric deposition are each less than 10 percent of the total, although atmospheric deposition is less well studied. Several lesser pathways were also identified, such as that associated with salmon that accumulate PCBs while in the Pacific Ocean and then return to Washington to spawn (Washington State Department of Ecology, 2015).

Results

The plan indicates that the most important sources on which to focus remediation efforts include old lamp ballasts and building materials in schools (e.g., old caulk), and inadvertently created PCBs associated with pigments and dyes. Although the plan identified electrical equipment as the source of a large percentage of PCBs, it also notes that most of the contaminated equipment has been replaced. Table 15 summarizes the sources, exposure pathway concerns, and priorities for future action identified in the CAP (Washington State Department of Ecology, 2015).

Table 15. Washington State - PCB Sources, Reservoirs, Releases, Exposures and Priorities

Source	Legacy Reservoir of PCBs	Annual releases of PCBs (kg/yr)	Potential exposure pathways and concerns	Is the release contained?	Priorities
Historic Uses					
Transformers	100-200 kg	<2	Accidental spills, which are identified and cleaned up	Yes	
Large capacitors	20 metric tons	10 to 80	Accidental spills, which are identified and cleaned up.	Yes	
Lamp ballasts	100-350 metric tons	400 to 1,500	Continual release of lower concentrations, with high concentrations released when the ballast fails.	Yes	In school buildings as part of energy efficiency improvements.
Small capacitors	1-35 metric tons	3 to150	Disposal in landfills from a variety of old appliances.	Yes	
Other closed uses		Unknown		Yes	

Table 15. Washington State - PCB Sources, Reservoirs, Releases, Exposures and Priorities

Source	Legacy Reservoir of PCBs	Annual releases of PCBs (kg/yr)	Potential exposure pathways and concerns	Is the release contained?	Priorities
Caulk	87 metric tons	160	Continual release of lower concentrations into the air, with high concentrations released when materials are disturbed.	No	Remodeling and demolition, especially in schools.
Other open uses		Unknown		No	
Current Generation					
Pigments and dyes	N/A	0.02 to 31	Continual release of lower concentrations, with higher concentrations released during recycling.	No	Identify and promote safer alternatives.
Other inadvertent generation	N/A	900	Concerns about both continual releases and potential large releases.	No	Identify processes and products first and then identify and promote safer alternatives.
Residential waste burning	N/A	199	Released to air and already addressed by current regulations.	No	
Commercial marine vehicles	N/A	0.4	Released to air and already addressed by current regulations.	No	

Source: (Washington State Department of Ecology, 2015).

Lessons Learned and Recommendations

The plan makes the following recommendations for future state action in Washington. Accompanying each recommendation is a cost estimate. Because this program was designed to create recommendations, lessons learned are not available (Washington State Department of Ecology, 2015).

- Identify PCB-containing lamp ballasts in schools and other public buildings. Encourage replacement with more energy efficient PCB-free fixtures.
  - Goal: Remove remaining PCBs lamp ballasts from schools and other publicly owned buildings.
  - Cost estimate: $136,396 for identifying the ballasts. No estimate of the cost for replacing them.
- Develop and promote Best Management Practices (BMPs) to contain PCBs in building materials currently in use and those slated for remodel or demolition.
  - Goal: Reduce exposure to people from PCBs in historic building materials and prevent PCBs in building materials from getting into stormwater.
  - Cost estimate: $272,793.
- Assess schools and other public buildings for the presence of PCB-containing building materials.
  - Goal: Reduce children’s exposure to PCB-containing building materials in schools.
  - Goal: Prevent PCBs in building materials from getting into stormwater.

- Cost estimate: $363,724.
- Learn more about what products contain PCBs and promote the use of processes that don't inadvertently generate PCBs.
  - Goal: Reduce newly generated PCBs in manufacturing processes.
  - Cost estimate: $699,846.
- Survey owners of historic electrical equipment, including transformers and large capacitors.
  - Goal: Confirm estimates of EPA-regulated electrical equipment with more than 500 parts per million (ppm) PCBs, learn what is known about electrical equipment with PCBs greater than 2ppm, and find out when such electrical equipment is estimated to be replaced.
  - Cost estimate: $45,466.
- Expand environmental monitoring to identify any new areas requiring cleanup and investigate air deposition.
  - Goal: Find areas with highly concentrated PCBs and clean them up to prevent the wider release of PCBs.
  - Goal: Find about more about distribution of PCBs in the state to prioritize future actions.
  - Cost estimate: $941,129.
- Collaborate with DOH to conduct a public educational campaign.
  - Goal: Provide information to residents about ways they can minimize exposure.
  - Goal: Raise awareness of the problems associated with current and past production of PCBs.
  - Goal: Educate residents to identify and addresses possible household sources of PCBs.
  - Cost estimate: $557,742.
- Conduct a study on which PCB congeners are present in Washington residents.
  - Goal: Learn more about PCB congeners to which Washington residents are exposed.
  - Goal: Find out more about the distribution of PCBs in Washington to prioritize future actions.
  - Cost estimate: no costs.

Applicability to the Chesapeake Bay Watershed

The recommendations made by the plan could be used to inform design of a voluntary program to reduce PCB-contaminated substances, especially the public educational campaign and the promotion of processes that do not inadvertently produce PCBs.

4.2.3 Great Lakes Binational Strategy for PCB Risk Management

The Great Lakes Binational Strategy for PCB Risk Management is a strategy created to help the U.S. and Canada achieve goals set by the Canada–United States Great Lakes Water Quality Agreement (GLWQA), which include implementing risk mitigation and management actions aimed at reducing PCBs in the Great Lakes region.

Recommended risk mitigation and management strategies to diminish the presence of PCBs from the Great Lakes region include: creation of additional regulations and guidance that clarifies existing regulations, increased enforcement of existing regulations, green chemistry and pollution prevention strategies to address inadvertent manufacture of PCBs and releases into the Great Lakes Basin, and increased monitoring facilitated by the development of cost-effective monitors and sensors. Additional database refinement is also needed to ensure all data regarding PCB loadings and sources are accessible (Climate Change Canada & U.S. Environmental Protection Agency, 2017).

The two nations anticipated that through identification, review, and prioritization of risk mitigation and management options, stakeholders can begin to implement these options within the Great Lakes Basin and their respective communities (Climate Change Canada & U.S. Environmental Protection Agency, 2017).

Sources and Pathways

The primary sources of PCBs to the Great Lakes Basin are as follows (Climate Change Canada & U.S. Environmental Protection Agency, 2017):

- Releases from remaining in-service equipment, which may include articles, items, and products containing manufactured PCBs (e.g., accidental uncontrolled spills or releases, gradual leaks or emissions).
- Release from PCB-containing sealants, paints, finishes, building materials, and other features of the built environment.
- Accidental release from PCB storage and disposal facilities during the handling of PCB wastes
- Emissions from combustion or incineration of materials containing PCBs.
- Inadvertent by-product generation during poorly controlled combustion or certain chemical production processes (e.g., inks, dyes).
- Reservoirs of past PCB contamination and environmental cycling including contaminated sediments, soils, and sites (e.g., National Priority List Superfund sites, other uncontrolled reservoir sites, and areas of concern).
- Disposal of PCB-containing consumer products into municipal or other landfills not designated to handle hazardous waste.
- Illegal or improper disposal of PCB wastes (e.g., illegal dumping).
- Long-range transport (regional and international).

Results

Although the program provided no significant information on how this specific strategy has led to the mitigation of PCB contaminants, a report on the strategy noted how similar efforts in the past have remediated over four million cubic yards of contaminated sediments near the Great Lakes Basin between 2004 and 2015 (Climate Change Canada & U.S. Environmental Protection Agency, 2017).

Lessons Learned and Recommendations

The program report did not provide any lessons learned, but did suggest many policy recommendations for implementation, including those for risk mitigation, promotion and enforcement, pollution prevention, and monitoring, surveillance, and other research programs. The following sections present relevant recommendations that could apply to a voluntary program (Climate Change Canada & U.S. Environmental Protection Agency, 2017).

- Risk Mitigation
  - Update and maintain inventory estimates for PCB-containing equipment (U.S. and Canada).

- Review and update regulations to match current scientific understanding (U.S.).
- Continue to remediate PCB-contaminated sites and sediments (U.S. and Canada).

- Promotion and Enforcement Recommendations
  - Enhance support to State and Tribal programs that complement or enhance baseline Federal program requirements via compliance promotion activities (U.S.).
  - Enhance support to PCB inspectors that regulate firms that may be handling, storing, recycling, or disposing PCBs (U.S.).
  - Enhance support to industry associations and firms who seek to phase out or improve risk management within their sector (U.S. and Canada).
  - Develop structured data systems and plans for PCB source, manifest, and product tracking (U.S.).
  - Develop tracking and enforcement strategies for non-legacy PCB sources (U.S.).
- Pollution Prevention (P2) Recommendations
  - Enhance public outreach and educate the public and facility staff on potential sources of PCBs and proper actions to follow should products containing PCBs be found (U.S. and Canada).
  - Encourage industries to track their P2 activities and efforts in the Toxic Release Inventory (TRI) database or via P2 promotion activities (fact sheets, case studies) (U.S.).
- Monitoring, Surveillance, and Other Research Recommendations
  - Continue to monitor PCBs in environmental media in the Great Lakes (air, precipitation, sediment, fish and other wildlife) and publish results in a variety of publications (e.g., on-line and open data portals, government reports and scientific journals) in order to maximize the intended audience (U.S. and Canada).
  - Use monitoring and modeling to better characterize select PCB sources as a basis for decision making with respect to potential actions, measuring progress, and formulating an international decision-making framework (U.S. and Canada).
  - Develop uniform fish and wildlife consumption advice for the shared waters of the Great Lakes to reduce exposure to PCB contamination (U.S. and Canada).
  - Use existing data sources and exposure data to inform future strategic directions and plans (U.S. and Canada).
  - Develop more cost-effective tools for monitoring PCB concentrations from various sources (U.S. and Canada).
  - Determine the exposure impact of non-liquid materials containing low levels (<50ppm) of PCBs (U.S. and Canada).
  - Utilize Great Lakes datasets and apply to climate change analyses models (U.S. and Canada).
  - Create or modify current databases to include environmental information and human health survey information for use by government, public health practitioners, academic researchers, and community groups. (U.S.).
  - Conduct monitoring to identify water sources at appropriate detection limits to support water quality load-reduction decision-making and implementation (U.S.).

Applicability to the Chesapeake Bay Watershed

Many of the recommendations from the Great Lakes project report could be applicable to a voluntary program for the Chesapeake Bay Watershed. The most relevant recommendations include: enhancing public outreach to educate the public and industries on PCB sources; developing uniform fish and wildlife consumption advice; and creating or modifying current databases to include environmental information and human health survey information for use by government, public health practitioners, academic researchers, and community groups.

4.2.4 Spokane River (WA) Regional Toxics Task Force

The Spokane River Regional Toxics Task Force (SRRTTF) was formed with the goal of developing a comprehensive plan to bring the Spokane River into compliance with applicable water quality standards for PCBs. The task force plan is based on data drawn from studies by the Washington State Department of Ecology (Ecology) and recent monitoring efforts by the Task Force. The Task Force analyzed these data to estimate the mass of PCBs currently present in various source areas throughout the watershed, as well as the loading rate of PCBs to the Spokane River from various delivery mechanisms (Spokane River Regional Toxics Task Force, 2016).

The plan characterizes the Spokane River area where the efforts are concentrated, defines the key sources and their magnitudes on the Spokane River, outlines the possible actions and recommended actions to be taken to mitigate PCB contaminants, and describes future work to be conducted over a five-year period .

Sources and Pathways

The primary delivery mechanisms of PCBs to the Spokane River were determined to be cumulative loading across all wastewater treatment plants, contaminated groundwater, and stormwater/combined sewer overflows. PCB loading from Lake Coeur d'Alene and Spokane River tributaries are of similar magnitude to the other primary delivery mechanisms, due to much higher flow rates, but contain much lower concentrations of PCBs (Spokane River Regional Toxics Task Force, 2016).

Results

So far, no results from plan implementation have been made available, although the plan stipulates that the effectiveness of SRRTTF's implementation of Control Actions (defined as "any activity which prevents, controls, removes or reduces pollution") would be assessed, in part, via an annual Implementation Review Summary. Such summaries will compare actions conducted over the prior year to the timelines and effectiveness metrics. The summaries would help SRRTTF adjust strategies, such as phasing out actions that are not working or introducing new Control Actions as appropriate. In addition to annual reviews, the Comprehensive Plan calls for a five-year Implementation Assessment Report that will assess overall PCB loadings and system response in terms of observed PCB concentrations in the river (Spokane River Regional Toxics Task Force, 2016).

Lessons Learned and Recommendations

The plan outlines a range of recommendations or Control Actions to reduce PCB levels and ultimately attain water quality standards. No lessons learned were reported. The Task Force identified 45 Control Actions considered potentially applicable to address PCBs in the Spokane River and assessed them in terms of costs and effectiveness. SRRTTF determined the specific Control Actions to be included in the comprehensive plan at a Task Force workshop held in Spokane on July 27, 2016, which divided discussion of Control Actions into two tiers: 1) Control Actions already being implemented, some of which are addressed by existing regulatory mechanisms, and 2) potential new Control Actions. The workshop attendees placed Existing Control Actions into one of two categories. The first category contained the following Control Actions, for which the group decided to maintain and document current efforts (Spokane River Regional Toxics Task Force, 2016):

- Wastewater treatment
- Remediate known contaminated sites
- Stormwater controls
- Low impact development ordinance
- Street sweeping
- Purchasing standards

The second category contained existing Control Actions where the group identified improvements that could be made to current efforts. These consisted of (Spokane River Regional Toxics Task Force, 2016):

- Support of green chemistry alternatives
- PCB product testing
- Waste disposal assistance
- Regulatory rulemaking
- Compliance with PCB regulations
- Emerging end-of-pipe stormwater technologies

The workshop participants then reviewed potential new Control Actions and identified two actions to include in the Comprehensive Plan, with a commitment to implementation (Spokane River Regional Toxics Task Force, 2016):

- Identification of sites of concern for contaminated groundwater
- Building demolition and renovation control

Applicability to Potential Chesapeake Bay Watershed Voluntary Program

The workshop that was held to gather thoughts and ideas on potentially useful recommendations for future actions to mitigate PCB contaminants could be applied to a voluntary program.

Future Work

The Task Force plans to conduct a broad assessment of its efforts within five years to assess both PCB loading to the Spokane River from the primary delivery mechanisms and changes in loadings over the evaluation period. The assessment will also address Spokane River PCB concentrations and changes in concentration over the evaluation period. The Task Force will also consider the following control actions for potential future action (Spokane River Regional Toxics Task Force, 2016):

- Education on septic disposal
- Survey of schools and public buildings

- Accelerated sewer construction
- Emerging wastewater technology
- Survey of local electrical equipment
- Leak prevention/detection in electrical equipment
- Regulation of waste disposal and stormwater source tracing
- Removal of carp from Lake Spokane
- PCB identification during inspections
- Compliance with PCB regulations for imported products

4.3 Options for Voluntary PCB Programs in the Chesapeake Bay Watershed

4.3.1 Partnership Possibilities

Section 3 identified a number of sources contributing to, or with the potential to contribute to, PCB contamination in the Chesapeake Bay Watershed. These include legacy contamination, electrical equipment (utility- and industrial-owned), fluorescent lamp ballasts, and paints and pigments. As a first step, Table 16 lists several criteria that can be applied to help evaluate these sources when deciding on the scope of a voluntary program.

Table 16. Criteria for Evaluating Potential Voluntary Program Participants

PCB Source	Criteria for Voluntary Program Consideration			
	Contribution to PCB Problem	Ability to Identify Participants	Participants' Ability to Address Problem	Participant Leverage
Legacy contamination	High	Responsible parties may be unknown or difficult to identify. Nonpoint source identification is challenging.	Cost of remediation is high.	Identified sources may already be under regulatory scrutiny (e.g., TMDL PMPs).
Electrical equipment	Moderate	Moderate (see Section 3.2)	Equipment is old and a liability. Will need replacement soon. Newer equipment is more efficient.	Utilities have high public visibility. Federal facilities may or may not feel obligation to participate.
FLBs	High	Diverse mix of building types and owners. Schools may make the most logical target because they are readily identified.	Equipment is old and a liability. Will need replacement soon. Newer equipment is much more efficient. Incentives may be available.	Health risks compound concern about PCBs. Parental and community pressure has driven action elsewhere.
Traffic and road marking paint/pigments	Low	State and local transportation departments can be readily identified and approached.	Replacement products will require evaluation. Procurement specifications may need to be revised.	Public agencies are visible and may feel public pressure to engage.

A voluntary program that seeks to reduce PCB levels in the Chesapeake Bay Watershed would ideally involve different types of partners, demonstrating that a variety of stakeholders are helping to address the problem. With limited resources to administer such a program, however, CBP may need to consider a targeted approach. The sections below evaluate each of the sources shown in Table 16.

Legacy Sources

Based on a review of TMDLs in the region, there are hundreds if not thousands of legacy PCB contamination sources in the Chesapeake Bay Watershed. Through state and EPA efforts, these sources are being identified and becoming subject to monitoring requirements and discharge limitations. Some TMDLs include requirements for sources to develop PMPs, which include additional requirements for discharges to track down and reduce point and nonpoint discharge sources. Evidence from states such as Delaware indicate these efforts are working. The top ten dischargers responsible for 90 percent of the point-source PCB loading in the Delaware Estuary and Bay have reduced their contributions 76 percent from 2005-2016 (Cavallo, 2018).

It is unclear how much additional effort, if any, could be extracted from parties responsible for legacy contamination through a voluntary program. Sources are likely to defend their current efforts and point to the success those efforts are having. Given the large number of sources and their diversity, CBP is likely to expend substantial effort to first identify these sources and then develop a proposal that reflects the unique characteristics of each source, site, discharges, and ongoing actions. These efforts could be reduced by working with state TMDL and toxics programs, who are likely to have some information available on legacy sources, but would still be substantial.

Electrical Equipment Owners

Several states and regions (e.g., Minnesota) have realized a measurable reduction in PCB contamination and potential contamination by working with electric utilities to voluntarily identify, remove from service, and responsibly dispose of and/or recycle old PCB-containing equipment (e.g., transformers).

CBP could implement a similar voluntary program that would work hand-in-hand with utilities and owners of transmission and distribution lines within the target area. The partnership would be built around the utility's commitment to identify, remove from service, and responsibly dispose/recycle all remaining PCB-containing (or suspected PCB-containing) electrical equipment, such as transformers. To measure progress, utilities could be required to set goals and a timeframe for disposal and replacement, and to report progress to CBP each year.

Section 3.2.4 provides a starting point for identifying potential participants in the utility sector. CBP could further benefit from partnering with state energy offices who could help identify and provide access to potential utility partners within each state.

A voluntary program focused on utilities could be supported by a compelling business case for identifying and replacing PCB-containing or suspected PCB-containing equipment. The elements of the business case would include:

- PCB-containing equipment that is still in service or storage is 40 years or more in age. Even if it is still operating without problems, such equipment has a limited lifespan and will need to be replaced eventually.

- The true cost to utilities of replacing equipment now is not the total replacement cost, but the difference between the cost of replacing it now versus replacement sometime in the (near) future. If the equipment would be replaced anyway within, say three years, the true cost is the loss of three years of service life from the old equipment.
- The longer that PCB-containing equipment is left in place the more susceptible it becomes to failure or damage, resulting in PCB spills and leaks. This exposes equipment owners to additional costs, potential enforcement or litigation, and unwanted public attention.
- Newer equipment is more energy efficient, and replacing it now means the utility can benefit sooner from the lower operating costs associated with such equipment.

Non-utility owners of electrical equipment include large industrial facilities that have high voltage needs. As discussed in Section 3.2.4, there may be fewer of these in the Chesapeake Bay Watershed than there once were, due to economic changes in the region and the national and global economy. Many such locations may in fact now be legacy sources of contamination. One element of a utility voluntary program could involve the utility helping CBP identify remaining high-voltage industrial customers whose presence in the region pre-dates the 1979 PCB ban.

Section 3.2.4 identified a subset of possible non-utility owners of PCB-containing equipment, namely federal facilities located within the Chesapeake Bay Watershed that had previously registered known PCB Transformers (>500 ppm) with EPA. Although the number of these is small, there may be additional federal facilities that either have not complied with the registration requirement, have PCB Transformers that they have not yet identified (and thus, have not become subject to the registration requirement), or have PCB-containing equipment that is not subject to the registration rule (e.g., equipment containing 50-500 ppm PCBs). We are not aware of any comprehensive list of federal facilities and locations, but there are several potential starting points for such a list. For example, EPA maintains a list and map of federal facilities that are on the National Priorities List,[17] as well as a of federal facilities that report to the Toxics Release Inventory.[18] There is likely to be at least some overlap between NPL and TRI sites and sites that may have PCB-containing equipment in use or storage.

Fluorescent Lamp Ballast Owners

As described in Section 3.3, PCB FLBs may be found in any building constructed prior to 1979 that retain their original lighting fixtures based on T12 lamp configurations. While these systems have been supplanted by at least two generations of newer technology (T8 and T5 format), and data on lighting system upgrades has not been updated since 2012 (U.S. Department of Energy, 2012), the large installed base of these systems means there is still an estimated 492,000 buildings in the U.S. that may contain as many as 293 million PCB FLBs (see Table 8 and following discussion). These FLBs may be found in buildings of all types. By percentage, however, the building types accounting for the highest share of the total are office buildings (39 percent), followed by non-refrigerated warehouses (13 percent), public assembly buildings (11 percent) and education buildings (9 percent).

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17 *https://www.epa.gov/fedfac/federal-facilities-national-priorities-list-npl-your-area*

18 *https://www.epa.gov/trinationalanalysis/federal-facilities*

A voluntary program focused on schools in the Chesapeake Bay Watershed may make the most sense for the Chesapeake Bay Program for several reasons:

- Identifying and engaging with owners of non-school buildings (e.g., offices, warehouses, public assembly buildings) could be very time-consuming. There are no obvious central points of contact, such as business or trade associations, to work through as there would be for schools (local school districts and state education departments).
- The issue of PCBs in schools has been quite visible recently, and led to EPA efforts to introduce national regulations requiring schools to identify and remove PCB FLBs.[19] While this effort was eventually halted, it did increase awareness of the issue, as have the numerous incidents of PCB FLBs being discovered in school districts across the country (e.g., Brown, 2016; Navarro, 2011).
- EPA and states have already developed educational and technical support materials targeted at schools to help them identify, remove, and safely manage PCB FLBs (U.S. EPA, 2015). The CBP could leverage these materials as a way to reduce the costs of a voluntary program.
- Many schools and school districts have taken steps to identify and remove PCB FLBs despite limited resources available for doing so. This experience can help demonstrate the cost of doing so is manageable. Case studies of successful removal programs could be used to help convince schools in the Chesapeake Bay Watershed to take similar action.

Under a voluntary program, school districts that partner with CBP would commit to identify, remove from service, and responsibly dispose of all remaining FLBs. Districts would be required to set goals as well as timelines and would submit a progress report to CBP annually.

Public Agency Procurement

Recent research indicates that certain types of paint – often outdoor paint used in traffic marking and roadway striping—contain low levels of PCBs. PCBs are inadvertently created during the manufacture of certain types of paint pigments, and paints containing these pigments may shed PCBs, as they weather and wear under exposure to the elements. PCBs end up in the watershed via stormwater runoff.

For this component of the program, CBP would partner with public agencies to procure PCB-free paint. Agencies would commit to specifying the purchase of PCB-free outdoor paints (e.g., traffic marking) based on a vetted, verified product list. CBP would provide guidance on identifying and specifying PCB-free paints, and public agencies would agree to incorporate those specifications into relevant purchases. Under the partnership, agencies would report procurement to CBP.

As part of this effort, CBP should consider getting as much information as possible from states that have started implementing similar procurement programs. For example, in 2014, the State of Washington instituted a law that established a procurement preference for products that do not contain PCBs. With certain paint pigments identified as containing PCBs—specifically paints dyed yellow or orange, often used in roadway striping—in 2018, agencies flagged paint materials for a pilot to test the new procurement policy. Several manufacturers met the state's requirements either through testing or self-certification, and are listed in a database of preferred products. The program is currently in its beginning

[19] See 75 Federal Register 66 (page 17645). Polychlorinated Biphenyls (PCBs); Reassessment of Use Authorizations. Advance notice of proposed rulemaking. April 7, 2010.

stages, but CBP could follow up with the state to get more information on additional manufacturers, product verification process, and product effectiveness (Pond, 2019).

4.3.2 Program Implementation, Outreach, Stakeholder Engagement

A successful voluntary program hinges on stakeholder and partner buy-in, as well as a clearly defined programmatic structure. To be as successful as possible, a voluntary program should have a structured program – including clear guidelines and requirements – that supports its larger goals.

Program Structure

Before implementing a voluntary program it's essential to develop guidelines and requirements that form the backbone of how the program works with partners and stakeholders. These guidelines and requirements should answer important questions, such as:

- What does the program want from partners?
- What should partners expect from the program?
- How do organizations become partners?
- What are partners required to do to maintain their partnership with the program?
- What happens when partners do not comply with program requirements?

For the purposes of CBP's overall goals, we recommend that the organization consider the following structure and requirements:

- Partners sign a "partnership commitment letter" that includes a "pledge".
  - This letter details what CBP commits to and what the partner (varies by partner type) commits to and is signed by both parties.
- As part of the commitment letter, partners agree to report activities to CBP annually.
  - CBP could consider setting minimum targets and/or requirements for program partners that could be tracked as part of the reporting process.
  - CBP will use this data to track program progress, which could help estimate the degree to which the program is responsible for decreased presence of PCBs in the Bay.
  - Additionally, CBP could consider recognizing partners that exceed the minimum targets in some capacity.
    - Partners reaching a certain level could receive special partner status (e.g., Bay Benefactor)
    - CBP could give partners awards for exceeding targets for several years in a row

Table 17. Potential PCB Partnership Activities

Partners	CBP
▪ Sign partnership agreement and commit to undertaking a discrete set of activities.	▪ Develop outreach campaign tools and materials
▪ Conduct outreach campaigns to educate public	▪ Recruit partners
▪ Implement best practices	▪ Provide technical assistance via webinars, online tools, partner forums
▪ Submit annual report on activities	▪ Establish recognition/awards program
▪ Apply for award / recognition	▪ Compile annual accomplishments report; highlight partner stories and results

4.3.3 Stakeholder Engagement and Outreach

Engaging stakeholders is key to any voluntary effort. To do so successfully requires a well-defined program mission and value proposition (in other words, why stakeholders should *value* the program), as well as a clear list of program benefits.

Possible program benefits to partners include:

- An enhanced public image (Protect the Bay)
- Protection of human health
- Possibility of avoiding future risk
- Increased energy efficiency of newer equipment

Branding and Materials Development

Once these benefits are defined, CBP should conduct a full program branding exercise that articulates the program name, mission, and value proposition, as well as target audiences and key messages. The branding exercise should also include developing a program logo and overall "look and feel" that will be included in all materials.

With a program brand and overall look and feel, CBP can develop a suite of materials that partners can use. CBP could consider developing several pieces to help facilitate stakeholder engagement, including:

- Partner logo or icon
- General fact sheet on the issue (PCBs in the Chesapeake)
  - Supplemental fact sheets tailored to each partner type – e.g., PCBs in FLBs
- Brochures targeting different audiences
- "Shareable" content that can be used on different platforms, including websites and social media
  - Infographic showing impacts of PCBs on the Bay's health
- Customizable materials
  - CBP could create materials, such as brochures or one-pagers, that partners could customize with their logo and the CBP program logo to distribute to their stakeholders

Outreach

With materials in place, CBP can actively engage stakeholders and potential partners. There are many options for reaching out to different stakeholders, including:

- In-person meetings
- Conferences and workshops
- Co-hosted webinars
- Electronic newsletters
- State purchasing networks (for procuring PCB-free paint)

CBP could also provide content to trade associations, regional NGOs (state teachers association), and other relevant organizations (state procurement offices) to include in electronic newsletters and webinars. Doing so allows CBP to leverage the reach of other organizations and disseminate information about the possible partnership program to additional stakeholders.

4.3.4 Partnership Program Cost

Partnership program level of effort and cost vary, largely depending on program structure. For the purposes of this study, we have outlined below both a low- and a moderate-cost option. Tables showing costs both options are included below.

Moderate Cost Option (Option 1)

For this option (see Table 18), we have included elements that are found in more robust partnership programs, including a program helpline, annual reporting requirements, and an awards component. We have included costs for starting the program (Year 1), as well as estimated ongoing costs (Year 2 and beyond).

Based on our experience with other voluntary programs, this option would cost an estimate 3,750 hours in its first year and 7,700 hours in each subsequent year.

Low Cost Option (Option 2)

For a lower cost option (see Table 19), CBP could bypass reporting and simply allow partners to 1) commit to eliminating PCBs and 2) self-certify once they are done. While this could invite accusations of greenwashing, doing so would involve reputation risk if partners were later found to still have PCBs. To reduce costs further, CBP could also try to limit its own outreach and recruiting, and leverage stakeholders' reach instead. This option also eliminates the awards program as well as the proposed dedicated helpline.

Based on our experience with other voluntary programs, this option would cost an estimate 2,525 hours in its first year and 4,100 hours in each subsequent year.

Labor Mix for Voluntary PCB Programs

An appropriate labor mix for either the moderate or low cost voluntary program initiative targeting PCBs in the Chesapeake Bay watershed, using the federal Office of Personnel Management's General Schedule labor classifications (Office of Personnel Management, 2019), is as follows:

GS 5-7	50 percent
GS 8-12	35 percent
GS 13-15	15 percent
TOTAL	100 percent

Table 18. Estimated LOE for PCB Voluntary Program - Moderate Cost Option

Program Components	Year 1		Year 2	
	Activities	Estimated LOE	Activities	Estimated LOE
Program Design	▪ Develop program framework. ▪ Define partnership requirements. ▪ Define metrics and reporting requirements. ▪ Establish registration and verification procedures.	800 hours	▪ Update program guidelines, as necessary.	100 hours
Program Infrastructure	▪ Expand website. ▪ Develop data management and tracking system. ▪ Determine need for information helpline. ▪ Develop partnership forms, program guidelines. ▪ Design program materials.	1,200 hours	▪ Staff information helpline. ▪ Maintain and refresh website. ▪ Maintain data management system. ▪ Generate data summary reports. ▪ Update program materials, as necessary.	2,500 hours
Marketing, Education and Outreach	▪ Create brand; label design and trademark. ▪ Test program messaging and framework. ▪ Develop partner recruitment strategy. ▪ Develop outreach strategy.	750 hours	▪ Recruit partners. ▪ Conduct outreach/engage stakeholders. ▪ Recruiting campaigns/challenges.	2,000 hours
Technical Assistance and Partner Support	▪ Determine scope of partner support. ▪ Develop web-based technical assistance tools.	200 hours	▪ Hold partner forums. ▪ Share lessons learned, case studies. ▪ Develop online resources. ▪ Maintain partner communications.	850 hours
Awards and Recognition	▪ Design awards/recognition program. ▪ Develop evaluation criteria; application process. ▪ Develop instructions and application materials.	750 hours	▪ Launch awards program. ▪ Conduct outreach activities. ▪ Receive and compile application packages. ▪ Facilitate review and selection process.	1,500 hours

Table 18. Estimated LOE for PCB Voluntary Program - Moderate Cost Option

Program Components	Year 1		Year 2	
	Activities	Estimated LOE	Activities	Estimated LOE
	▪ Develop launch plan and outreach strategy.		▪ Notify applicants. ▪ Organize awards ceremony/event. ▪ Hold recognition event.	
Data Analysis and Program Evaluation	▪ Develop program evaluation component.	50 Hours	▪ Send out reporting reminders. ▪ Compile and QA/QC annual reports. ▪ Analyze results. ▪ Prepare accomplishments report. ▪ Review process and lessons learned.	750 hours
GRAND TOTAL	**3,750 Hours**		**7,700 Hours**	

Table 19. Estimated LOE for PCB Voluntary Program - Low Cost Option

Program Components	Year 1		Year 2	
	Activities	Estimated LOE	Activities	Estimated LOE
Program Design	▪ Develop program framework. ▪ Define partnership requirements. ▪ Define metrics and reporting requirements. ▪ Establish registration and verification procedures.	800 hours	▪ Update program guidelines, as necessary.	100 hours
Program Infrastructure	▪ Expand website. ▪ Develop data management and tracking system. ▪ Develop partnership forms, program guidelines. ▪ Design program materials.	1,000 hours	▪ Maintain and refresh website. ▪ Generate data summary reports. ▪ Update program materials, as necessary.	1,000 hours
Marketing, Education and Outreach	▪ Create brand; logo design. ▪ Develop partner recruitment strategy. ▪ Develop outreach strategy.	500 hours	▪ Recruit partners. ▪ Conduct outreach/engage stakeholders. ▪ Recruiting campaigns/challenges.	2,000 hours
Technical Assistance and Partner Support	▪ Determine scope of partner support. ▪ Develop web-based technical assistance tools.	150 hours	▪ Share lessons learned, case studies. ▪ Develop online resources. ▪ Maintain partner communications.	500 hours
Data Analysis and Program Evaluation	▪ Develop self-certification process.	75 hours	▪ Send out reporting reminders. ▪ Compile reports & analyze results. ▪ Prepare summary report	500 hours
GRAND TOTAL		**2,525 Hours**		**4,100 Hours**

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