Submitted to:

The Virginia Department of Environmental Quality

Blue Ridge Regional DEQ Office
MS4 Stormwater Permitting Division
3019 Peters Creek Road
Roanoke, VA 24019

CITY OF ROANOKE

Effective July 1, 2016

PCB TMDL ACTION PLAN

Stormwater Utility
Public Works Service Center
1802 Courtland Road, NE
Roanoke, VA 24012

City of Roanoke

POLYCHLORINATED BIPHENYLS (PCB) TMDL ACTION PLAN

INTRODUCTION

In December 2009, a PCB TMDL was established for the Roanoke River. Within the City of Roanoke, the Roanoke River and three of its tributaries, Masons Creek, Peters Creek and Tinker Creek were found to be contaminated for polychlorinated biphenyls (PCBs); thus failing to meet their designated uses under Section 303(d) of the Clean Water Act and the Virginia Water Quality Monitoring, Information and Restoration Act.

Water quality standards designate a waterbody's uses. In Virginia, the designated uses for surface water bodies are: aquatic life, fish consumption, public water supplies (where applicable), recreation (swimming), shell fishing, and wildlife. If a water body is too polluted to meet its designated uses, it is listed as an impaired stream on the 303(d) list. A TMDL study is then conducted to create a pollution limit. A TMDL or total maximum daily load is established to define the limit of a pollutant that a water body can receive and process while still maintaining health for its designated uses. Due to the fact that PCBs bioaccummulate in fish tissue, the TMDL endpoints were developed to protect fish for human consumption and are more stringent than 1700pg/L which is what the state requires for human health (Tetra Tech, 2009). VA DEQ's Water Quality Criterion has been set a 640 ppq.

The Environmental Protection Agency contracted Tetra Tech to conduct a TMDL study which can be sourced from the box below. The study identifies sources of PCB, impaired stream segments and determines the reductions needed to achieve acceptable water quality standards. The TMDL study divides the Roanoke River into two segments; the Upper Roanoke River (29 miles in length) and the lower Roanoke or Staunton River (96 miles). The City of Roanoke is under mandate to develop and implement strategies that will positively influence PCB concentrations. This action plan will focus specifically on the City of Roanoke's jurisdictional limits and the associated watersheds and impaired streams. The background information and steps outlined in this Action Plan illustrate the City's compliance and stewardship plans.

Tetra Tech, Inc. (December 2009). *Roanoke River PCB TMDL Development*. United States Environmental Protection Agency, Region 3. Retrieved from: http://www.deq.virginia.gov/portals/0/DEQ/Water/TMDL/apptmdls/roankrvr/roanokepcb.pdf.

REGULATORY FRAMEWORK

In 2001, PCB's were banned globally by the Stockholm Convention on Persistent Organic Pollutants (Payne et al., 2013).

In the United States, PCBs are regulated through the Toxic Substances Control Act (TSCA). The TSCA oversees the production, importation, use, and disposal of regulated chemicals released into the environment. Under (5) (TSCA), the term ''environment'' includes water, air, and land and the interrelationship which exists among and between water, air, and land and all living things.

In 1979, under the TSCA, it became illegal to manufacture, distribute or use PCBs. Regulations specific for PCBs are found in 40 CFR Section 761.

The TSCA has recently been revised. On June 2015, the House of Representatives has also passed its own revised version, the TSCA Modernization Act of 2015. Similarly in December 2015, the Frank R. Lautenberg Chemical Safety for the 21st Century Act was passed by the Senate. On June 7, 2016 the US Senate passed the bipartisan House-Senate agreement of the Lautenberg Act. President Obama signed the Frank R. Lautenberg Chemical Safety for the 21st Century Act updating the TSCA on June 22, 2016.

The City of Roanoke has the authority to regulate PCBs as illicit discharges per the City Code, Chapter 11.3 Stormwater Discharge Requirements. Relevant sections are outlined below.

Section 11.3-3 defines Illicit discharge as any discharge to the storm sewer system or to the waters of the United States that is not composed entirely of stormwater, except discharges which are exempt pursuant to section 11.3-4(b) of this chapter. Any discharge in violation of an NPDES or VPDES or other stormwater discharge permit shall constitute an illicit discharge.

Sec. 11.3-4. - Prohibited discharges or connections to the storm sewer system.

(a) (1) Cause or allow any illicit discharges, including but not limited to the discharge of sewage, industrial wastes or other wastes, into the storm sewer system, or any component thereof, or onto driveways, sidewalks, parking lots, or any other areas draining to the storm sewer system.

(a) (4) Discharge any materials or items other than stormwater to the storm sewer system by spill, dumping, or disposal of any type without a valid federal and/or state permit or unless otherwise authorized by law.

Sec. 11.3-5. - Inspections and monitoring.

(a) The director shall have the authority to carry out all inspections and monitoring procedures necessary to determine compliance and/or noncompliance with this chapter, and to enforce this chapter, including the prohibition of illicit discharges to the storm sewer system. The director may monitor stormwater outfalls or other components of the storm sewer system as may be appropriate in the administration and enforcement of this chapter.

Sec. 11.3-6. - Enforcement of chapter and penalties.

(a) Any person who violates any of the provisions of this chapter shall be guilty of a Class I misdemeanor and upon conviction is subject to punishment by a fine of not more than two thousand five hundred dollars ($2,500.00) per violation per day and confinement in jail for not more than twelve (12) months, either or both.

(c) Any person who commits any of the acts prohibited by this chapter or violates any of the provisions of this chapter shall be liable to the city for all costs of testing, containment, cleanup, abatement, removal, disposal, and any other related costs or expenses that the city may incur in connection with the enforcement of this chapter and/or the prohibition and/or correction of a violation of this chapter and/or the abatement of any illicit discharge to the storm sewer system.

BACKGROUND

Historical "Legacy" PCB Loading Sources

PCBs are man-made chemicals that were commonly marketed in the US under the name Aroclor by Monsanto and Pyranol by General Electric (OR DEQ, 2003). PCBs are either in an oily liquid or solid form; colorless or light yellow in color; and with no known taste or smell. There are 209 individual compounds or congeners that are considered under the term, PCB. Each congener is represented by a four-digit number code; the first two digits indicate the parent molecule as a biphenyl. The difference between the 209 congeners is the number and position, or configuration of the chlorine atoms in the molecule. Therefore, the term PCB simply refers to any one of many congeners with a biphenyl root structure bonded to multiple chlorine atoms. These structures are extremely stable and resistant to degradation, properties which account for its widespread use historically and its continued presence in today's environment.

It has been estimated that nearly 1.7 million metric tons of PCBs were made worldwide between 1929 and 1989 (Grossman, 2013). In 1979, it became illegal to manufacture, distribute or use PCBs. PCBs were once found in the following product types: capacitors, transformers, plasticizers, surface coatings, inks, adhesives, pesticide extenders, paints, and carbonless duplicating paper (Tetra Tech, 2009). Most legacy PCB environmental loadings have been from point source contributions, spills and releases (Tetra Tech, 2009). PCBs were once released via sewers, smokestacks, stormwater runoff, spills and direct application to land for dust control and as a pesticide residue extender (OR DEQ, 2003). According to the Agency for Toxic Substances and Disease Registry (as cited in OR DEQ, 2003), massive amounts of PCBs have entered the environment through burning PCB-containing products, volatilization of paint and coatings, releases into surface waters and sewers, and improper PCB disposal in landfills and ocean dumping.

Through the NPDES program, established in 1972 within Section 402 of the Clean Water Act, and later revised in 1979 and 1987, point sources are now controlled; however, contamination can and does occur by the discharge of historical PCB loads as non-point source pollution resulting from runoff that flows over PCB contaminated soils. Due to PCBs widespread uses plus their stable molecular structure, PCBs are now in the water, sediment, soil and air in background concentrations. Sediment is a particular problem; hydrophobic PCB molecules attach to sediment particles, which settle on the bottom and remain in streams, rivers and other surface water bodies indefinitely.

However, PCBs are volatile enough, especially those congeners with 0-8 chlorine atoms, that they do vaporize from soil and water, thus releasing historical loadings of PCBs into the air. The airborne PCBs can travel on air currents and become redeposited during precipitation or air settling. This process is continuous and it is estimated that there are 1000 tons of PCBs in this atmospheric/deposition cycle (Hazardous Substance Data Bank as cited in OR DEQ, 2003). Temperatures appear to promote volatility; therefore greater atmospheric fluxes of PCBs tend to occur in warmer months (HSS, 2000). Biphenyls with 0-1 chlorine atom remain airborne in the atmosphere, PCBs with 1-4 chlorine atoms migrate towards the poles by volatilization and deposition cycles, PCB congeners with 4-8 chlorine atoms stay in the middle latitudes, and congeners with 8-9 chlorine atoms stay close to the original PCB source (HHS, 2000). PCBs in a volatile state become deposited on terrestrial vegetation and food crops (HHS, 2000) as well as other urban surfaces.

PCBs were commonly used in construction materials in buildings that were built or renovated between 1950 and 1979. Potential sources of PCBs include caulking used in windows, door frames, building joints, masonry columns and other masonry materials (EPA, 2015). Additional building materials that may contain PCBs are: paints, mastics and other adhesives, fireproofing materials, ceiling tiles and acoustic boards, high intensity discharge lamp ballast capacitors and capacitors of fluorescent light ballasts, window glazing, spray-on fireproofing and floor finishes (EPA, 2015). PCBs can be released into the air with normal light fixture use or if the ballast breaks (EPA, 2015). Adjoining surfaces to these PCB-source building materials can be contaminated as well as the building's air. Building occupants can be exposed to PCBs through off gassing and direct dermal contact. Outdoor soil and air contamination can result from exterior caulk leaching, paints and coatings when they come in contact with the elements.

Non-Legacy Loading Sources

Although PCBs were banned from manufacturing, processing, distribution, and use, PCBs are still made inadvertently in certain manufacturing processes. These non-legacy PCBs are made as a by-product when hydrocarbons, chlorine, salts and chlorinated hydrocarbons are combined under high temperatures. Products that can unintentionally contain PCBs are those containing or incorporating pigments, paints, inks, and dyes. Examples of such products are clothing, newspapers, magazines, cardboard boxes, food wrappers, cosmetics, colored leather, colored plastics, indoor and outdoor residential and commercial paints and colorprinted paper. Under TSCA, these products are allowed to contain PCBs in amounts up to 50 ppm, although a product's average should be 25 ppm. According to Grossman (2013) 250 million metric tons of pigments were produced worldwide in 2006 alone. Most printing inks contain about 40% of pigment (Grossman, 2013). Rodenberg (2012) makes the case that there is quite a discrepancy between inadvertently made PCBs and water quality criteria. In fact, the pigment from one cereal box can contaminate about 2,000 L of water at the water quality standard (WQS) of 64 pg/L (640ppq) (Rodenberg, 2012).

These non-legacy sources are being identified throughout the United States, showing up in wastewater, sediments, and air on top of legacy sources. PCB11 and PCB 206, 208, 209 are the most common non-legacy PCBs and are becoming markers for inadvertently made PCBs. PCB 11 is not a historically produced congener and it is not found as a breakdown product of the historical PCBs; therefore it is a result of current environmental loading (Grossman, 2013).

PCB 11 is inadvertently created during diarylide yellow pigment production (Grossman, 2013). Azo and diarylide pigments create mostly yellows but can also be used in orange and red pigment production. Phthalocyanine pigments are used to create blue and green products. Additionally, titanium dioxide production can also be a source of non-legacy PCBs (Grossman, 2013).

Chemicals with less chlorine atoms, like PCB11 are more volatile for release into the air from pigments, paints and inks (Grossman, 2013). In contrast, heavier pigments like the phthalocyanine-based blue and green pigments have more chlorinated atoms and are less likely to volatize and more likely to adhere to the product (Grossman, 2013). Adding more chlorine atoms creates additional molecular stability and therefore more lasting environmental effects (Hesselgrave, 2016).

BIOLOGICAL IMPLICATIONS

Each congener interacts uniquely with the environment and living organisms (Grossman, 2013). Exposure to PCBs, even at very low concentrations, measured in micrograms/kg or ppb, can have consequences on body systems, particularly those that regulate metabolism, hormones and development (Zoeller as cited in Grossman, 2013). PCBs are very slow to break down in the environment and therefore persist long after they were created and deposited in the environment. The additional danger is that PCBs bioaccummulate in organisms because they are fat soluble or lipophilic (Grossman, 2013). These two factors allow PCBs to migrate up the food chain, making them considerably more dangerous for larger aquatic organisms, birds of prey, mammals and humans.

There are several surface waters in the Upper Roanoke River Watershed that are impaired for PCB contamination which is monitored in fish tissue and sediment samples. For this reason, the Virginia Department of Health (VDH) has issued fish consumption advisories for several sections of the Roanoke River and affected tributaries since 1988 (Tetra Tech, 2009).

The following chart shows impaired waterbodies, specific to the City of Roanoke and the required pollution reductions from point and non-point sources of PCBs to meet the reduction percentage. Waste load allocations for MS4s are based on estimates of upland soil tPCB concentrations (Tetra Tech, 2009). This WLA does not reflect a Margin of Safety (MOS).

PCB Impaired Segments with City of Roanoke MS4 WLA

Waterbody	Impaired Segment Description	Responsible Jurisdiction	Miles	Initial Listing Date	City of Roanoke Baseline (mg/yr)	City of Roanoke Waste Load Allocation (WLA) (mg/yr)*no MOS	% Reduction
Roanoke River	Mason Creek confluence – Back Creek Mouth	City of Salem, City of Roanoke	15.47	1996	84,565.4	94.7	99.89
Peters Creek	Peters Creek headwaters – Roanoke River Confluence	Roanoke County, City of Roanoke	7.17	2004	1033.7	9.8	99.05
Tinker Creek	Deer Branch Confluence – Roanoke River Confluence	Roanoke County, City of Roanoke	5.35	2006	5081.3	48.3	99.05
Masons Creek	Not 303(d) listed	Roanoke County, City of Salem, City of Roanoke	N/A	N/A	14.6	0.1	99.05

PCB REGULATORY SITE GUIDANCE OVERVIEW

PCB contaminated property can be transferred or sold. However, the property ownership exchange is not a release of obligations of either party regarding proper handling, cleanup, or disposal of contaminated material (EPA, 2005). “The responsibility for the initial PCB contamination (e.g., spill or other release) resides with the person(s) who caused the contamination or who owned or operated the PCBs or PCB-containing equipment at the time of the contamination. However, after the property transfer, the new owner becomes responsible for controlling and mitigating any continuing and/or future releases of PCBs" (EPA, 2005).

Under Section 6(e)(2)(A) of TSCA, continued use of the property may be prohibited as use of the property constitutes use of the PCBs on it. The owner of the PCB-contaminated property must comply with applicable use authorizations (i.e. intended land use and type of PCB waste); thus in most cases, the owner must clean up the property prior to use (EPA, 2005).

The following is a general accounting of how EPA regulates contaminated property. Please note there is considerably more detail in the source document, EPA (2005), *Polychlorinated Biphenyl (PCB) Site Revitalization Guidance under the Toxic Substances Control Act (TSCA)* outlining environmental cleanup and the following summary should not be considered all inclusive.

PCB cleanup levels for high occupancy areas, such as schools, work environments, and residential structures call for PCB levels less than or equal to 1ppm in soils, residual waste or porous (building material) surfaces. PCB clean up levels for low occupancy areas call for PCB levels less than or equal to 25 ppm in soils, residual waste or porous surfaces and a deed restriction (EPA, 2005).

For water containing PCBs that is discharged to a treatment work or surface waters it must be less than 3 micrograms/L (~3 ppb). This is also the limit under a permit issued under 402 of the Clean Water Act. Lastly releases for unrestricted use must be less than or equal to 0.5 micrograms/L (less than or equal to 0.5 ppb) (EPA, 2005).

Currently, there is a disconnection in allowable PCB thresholds across various mediums as referenced above; inadvertently made PCBs in manufacturing products which can contain up to 50 ppm, if the product's annual average in less than 25 ppm (TSCA); and the Virginia water quality criterion of 0.00000064 ppm*. As stated in the section on Non-Legacy PCB Sources, the pigment from one cereal box can contaminate about 2,000 L of water at the WQS of 64 pg/L (640ppq) (Rodenberg, 2012). Current PCB loadings created by inadvertent PCB production will pose challenges in meeting the water quality criteria of 6.4×10^{-7} ppm (0.00000064 ppm) and thus these sources, due to their ability to move are relevant to the City of Roanoke meeting our WLA.

*The following are equivalent units of measurement frequently used in reference to PCB levels: 0.00000064 ppm = 6.4×10^{-7} ppm = 64pg/L = 640 ppq.

EMERGING RESEARCH FOR CLEAN UP STRATEGIES

PCB Remediation through Anaerobic and Aerobic Bacteria

Promising research is being conducted by the Institute of Marine and Environmental Technology at the University of Maryland. Granulated activated carbon (GAC) has been shown to sequester PCBs that are bioavailable to benthic organisms. Additionally when GAC is seeded with specific anaerobic and aerobic bacteria, impressive PCB degradation occurs. In research led by Payne et al., (2013), GAC was seeded with anaerobic halorespiring *Dehalobium chlorocoercia* DF1 and aerobic *Burkholderia xenovorans* LB400. The anaerobic bacteria acts to dechlorinate congeners leaving the PCBs vulnerable to further degradation by aerobic bacteria through aromatic ring cleavage or biphenyl degradation (Payne et al., 2013). Experiment results showed an 80% PCB mass reduction within 120 days (Payne et al., 2013).

Locally, the Town of Alta Vista has been a part of Payne's research with a project involving the town's wastewater overflow pond. This type of research is promising for a localized collaborative effort for legacy sources of sediment in tributaries and/or the Roanoke River as the research results indicate GAC bioaugmentation is more sustainable and lower cost approach to dredging.

Phytoremediation

The selective planting of trees and other vegetation to absorb and bind contaminants of concern is known as phytoremediation. When properly planned, phytoremediation can be a potentially viable option for PCB degradation. Research by Smith et al., (2007) found that high levels of organic amendment, initiating dechlorination, coupled with low-rate transpiring plants provided optimal reducing conditions. Work by Leigh et al., (2006) resulted in finding plants that produced secondary metabolites, such as terpenoids, phenols, resin acids and tannins with structures similar to PCBs attracting optimal microbial species that could degrade PCBs. Top culturable bacterial species were *Rhodococcus*, *Luteibacter* and *Williamsia* (Leigh et al., 2006). Genetic modification of plant species with introduced bacterial material (*Burkolderia xenovorans*) can produce enzymes to start PCB degradation and further stimulate the necessary microorganisms to complete the process (Mohammadi et al., 2007).

Other Strategies for Clean-up

Mechanical or vacuum dredging is an option for hot spot locations although this method is detrimental to the local environment. Dredging may add additional PCBs to the water column due to the disturbance of sediment which can facilitate PCB migration downstream. Since PCBs are hydrophobic, they form a strong relationship to fine sediments. The PCB/Sediment adsorption relationship is proportional to the TSS concentration, sediment organic content and chlorination (i.e. congener#) extent of PCBs (Tetra Tech, 2009).

Source tracking through identification, mapping and monitoring can be a valuable tool in the strategic deployment of both PCB assessment and remediation measures.

Atmospheric deposition has been shown to be a significant pathway of PCB cycling in freshwater systems (Tetra Tech, 2009). According to the Chesapeake Bay Program Atmospheric Deposition 1999 Study, the urban deposition rate is 16.3 micrograms/ m^2/yr (Tetra Tech, 2009). Partnering with or supporting the Greater Roanoke Valley Asthma and Air Quality Coalition and/or facilitating with Carilion or a Public Health graduate student to conduct atmospheric deposition studies will yield understanding of local atmospheric contributions of PCBs, assess volatility and levels of legacy and non-legacy PCBs in Roanoke Valley air and identify pathways and needed site remediation for contaminated sites.

Monitoring Program

Waste load allocations for MS4s are based on estimates of upland soil total PCB (tPCB) concentrations (Tetra Tech, 2009).

Monitoring will be the City's primary method of TMDL Action Plan assessment. Method 1668 is the preferred technique for monitoring low-levels of PCB congeners. Method 1668 has a high level of accuracy and specificity but it must be done by a qualified lab and is expensive, generally running about $750 per test.

Washington State's Department of Ecology (2014) has included a table of PCB testing methods developed for a wide range of media. Optimally, the City might be able to work with a lab on the Virginia Tech campus to establish a respectable, but relatively inexpensive method of PCB testing that will help us to establish locations that may need further analysis with EPA Method 1668. Once testing methods can be established, the City can determine hotspots and a monitoring program budget.

TMDL ACTION PLAN OUTLINE

Outreach Group	FY16-17 Goal	FY17-18 Goal	Long Term Goal
General Public Education			
PCB Webpage	x		
Digital Newsletter inclusion	x	x	
PCB Presentations		x	x
Point Sources			
Maintain current list/map of VPDES/Industrial permitees including:	x	x	x
• Specific PCB congeners associated with industry type (legacy and inadvertent); permit monitoring results	x		
• Congener volatility and deposition with the potential to affect MS4		x	
• Identify point sources may have connections to MS4	x		
• Form collaborative partnerships with entities for research and clean-up opportunities		x	x
Industry/Businesses (no VPDES permit)			
Identify industries and businesses that use closed systems containing PCBs	x	x	

Identify industries and businesses that may inadvertently make or release PCBs	x		
Provide education materials – mailers (ex: junkyards, painters)	x	x	x
City of Roanoke			
Obtain DEQ data from Roanoke River Floodplain Reduction Project benchcut sites	x		
Identify equipment types that may contain PCBs (lamp ballasts, PWSC equipment)	x		
work with department managers to assess PCB risk and develop BMPs		x	
Identify old landfill sites			x
Monitoring Programs			
DEQ – will there be ongoing monitoring at various sites?	x		
Determine initial monitoring sites – develop program growth and budget		x	
Work with VT to find applicable method for less expensive general test analysis - use method 1668/DEQ approved labs as needed	x		
Monitoring during dry weather		x	x
Identify areas in streams with pockets of heavy sediment/upstream sources			x
Monitoring during wet weather			x
Research and Clean Up Opportunities			
PCB remediation using bioaugmentation with anaerobic halorespiring and aerobic degrading bacteria - Institute of Marine and Environmental Technology		x	x
Phytoremediation/Mycoremediation			x
Assess need for dredging behind Mason's Mill dam (APCO, City, and County collaborative effort)			x
Air Quality Research – assessing volatility and levels of legacy and non-legacy PCBs in Roanoke Valley air - Partnership with local air quality group, Carilion, NGOs			x

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