Decision Rationale

Total Maximum Daily Load for
Total 2,3,7,8-TCDD for the Kanawha River, Pocatalico River and Amour Creek

I. Introduction

This document will set forth the Environmental Protection Agency's (EPA) rationale for establishing the Total Maximum Daily Load (TMDL) for total 2,3,7,8- TCDD (dioxin) for the Kanawha River and two tributaries of the Kanawha River: Pocatalico River and Amour Creek, which were sent out for public comment on July 5, 2000. Our rationale is based on the determination that the TMDL meets the following 8 regulatory conditions pursuant to 40 CFR §130.

1. The TMDLs are designed to implement applicable water quality standards.
2. The TMDLs include a total allowable load as well as individual waste load allocations and load allocations.
3. The TMDLs consider the impacts of background pollutant contributions.
4. The TMDLs consider critical environmental conditions.
5. The TMDLs consider seasonal environmental variations.
6. The TMDLs include a margin of safety.
7. The TMDLs have been subject to public participation.
8. There is reasonable assurance that the TMDLs can be met.

The Kanawha River, Pocatalico River and Armour Creek were placed on the State of West Virginia's 303(d) list of water quality impaired water bodies for dioxin. The applicable State standards specify that the maximum allowable concentration of dioxin shall not exceed 0.014 pg/L in the Kanawha River, and 0.013 pg/L in the Pocatalico River and Armour Creek. Water quality data collected in support of this study show that dioxin concentrations routinely exceed the State water quality standard.

The Kanawha River segment of concern extends 45.5 miles from the confluence of the Coal River near Nitro, West Virginia to where the Kanawha enters the Ohio River. The Pocatalico River and Armour Creek segments of concern each extend two miles upstream of their respective confluences with the Kanawha. A review of available monitoring data indicates that observed water column dioxin concentrations in the Kanawha River routinely exceed the water quality standard. No suitable water column data are available for the Pocatalico River or Armour Creek. Fish tissue data for all three systems also commonly exceed the water quality standard. The water column water quality standard was used as the endpoint of the TMDL for all three systems.

A mass balance dilution model was applied to define the maximum allowable dioxin load that will achieve compliance with water quality standards for the entire range of flow conditions that may occur in each river. Analyses indicate that a TMDL designed to achieve compliance with the water column concentration standard will also achieve compliance with the fish tissue standard, after the system has time to respond to the reduced loadings.

No direct dioxin loading data were available from any sources for any of the water bodies of concern. Dioxin loads were estimated from available information, and attributed to four source categories: 1) contaminated groundwater [1], 2) in-place river sediments, 3) surface erosion of contaminated soils in the watershed, and 4) upstream sources. Reductions from these sources will be required in order to achieve compliance with water quality standards.

Future monitoring activities are described that are designed to further identify sources and conditions contributing to dioxin impairment in the Kanawha River, the Pocatalico River, and Armour Creek.

II. Background

Section 303(d) of the Clean Water Act and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for water bodies that are not meeting designated uses under technology-based controls. The TMDL process establishes the allowable loading of pollutants or other quantifiable parameters for a water body based on the relationship between pollution sources and instream conditions. By following the TMDL process, states can establish water quality-based controls to reduce pollution from both point and nonpoint sources and restore and maintain the quality of their water resources (EPA, 1991b).

The West Virginia Division of Environmental Protection (DEP) has identified the Kanawha River, Pocatalico River, and Armour Creek as being impaired by dioxins, as reported on the 1998 303(d) list of water quality limited waters (WVDEP, 1998). The consent decree established in conjunction with the West Virginia TMDL lawsuit has identified the Kanawha River as a priority watershed, with a TMDL for dioxin to be completed by September, 2000.

2,3,7,8-TCDD (dioxin) is most commonly encountered as an unwanted by-product of incineration, production of chlorinated pesticides and herbicides, and the bleaching step of the papermaking process. Industrial activities in the study area, especially near the city of Nitro, West Virginia have resulted in several contaminated sites. Dioxin in the study area likely originated with the production of industrial solvents and the herbicide 2,4,5-T at facilities in and around Nitro. Disposal practices earlier in the century, including burial of drums, dumping of dioxin-contaminated liquid wastes, and incineration of dioxin-contaminated material, spread dioxin throughout the Nitro area. Areas downstream of Nitro likely became contaminated through the release and transport of dioxin into the Kanawha River and its tributaries. The Kanawha River and two of its tributaries, the Pocatalico River and Armour Creek, are the focus of this TMDL because of their noncompliance with water quality and fish tissue standards.

The Kanawha River is located in western West Virginia. The Kanawha River segment of concern (Figure 1) extends 45.5 miles from the confluence of the Coal River near Nitro, West Virginia

[1] Appendix B of the Kanawha River, Pocatalico River and Armour Creek TMDL for dioxin contains an exposition on the meaning of the term “ contaminated Groundwater”.

(Kanawha River Mile (RM) 45.5) downstream to its confluence with the Ohio River (Kanawha RM 0.0). The Kanawha River watershed covers a total of 518 square miles, with a land use primarily (>90%) of forest. The segments of concern for the Pocatalico River and Armour Creek each extend 2 miles upstream from their respective confluences with the Kanawha River (Figure 1). The Pocatalico River watershed spans 359 square miles, also primarily of forest. The Armour Creek watershed covers 9 square miles, and is the most highly developed, with over 20% of the land use listed as developed.

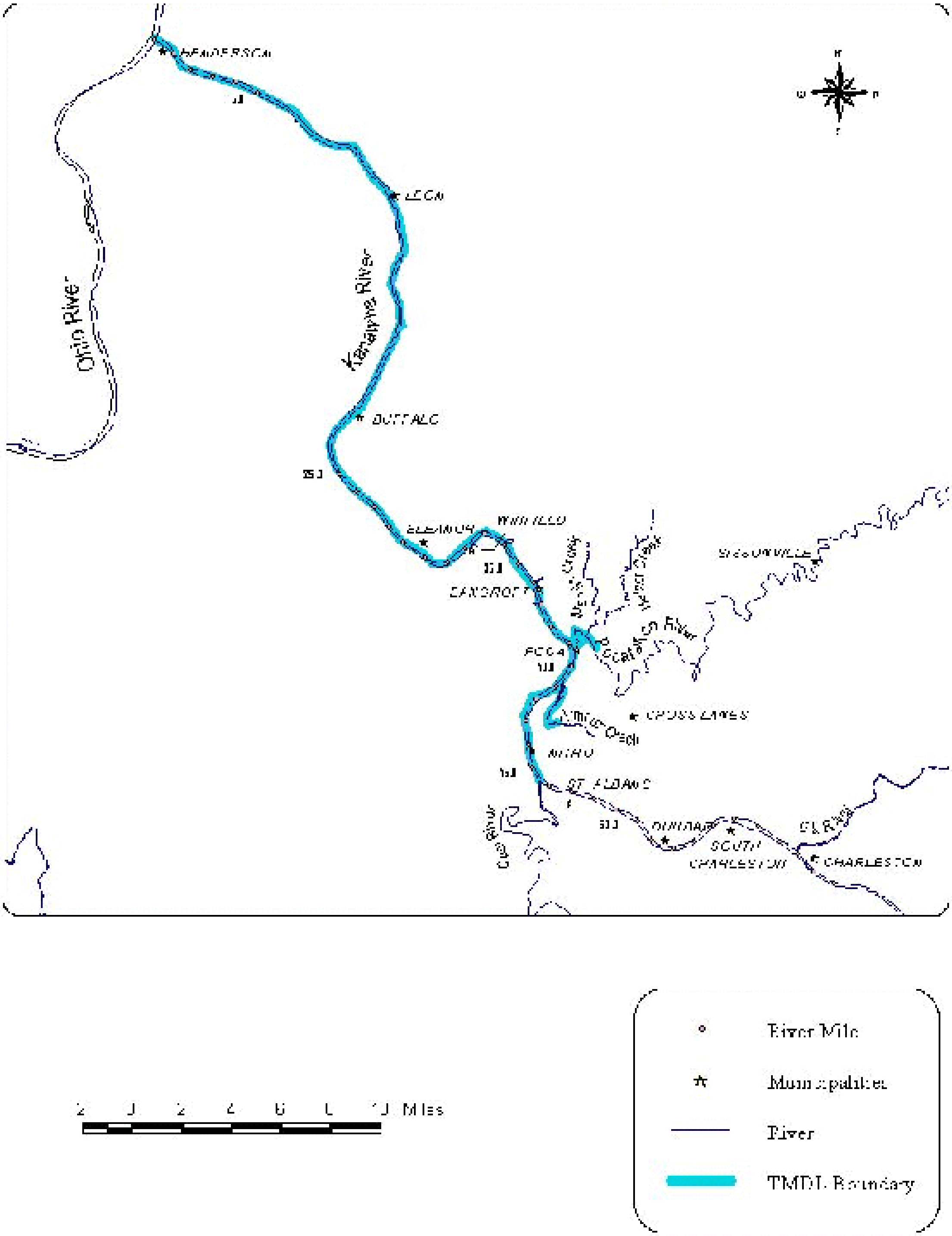

Figure 1. Kanawha River, Pocatalico River, Armour Creek Study Area

III. Discussion of Regulatory Conditions

EPA finds that sufficient information has been provided to meet all of the 8 basic regulatory requirements for establishing dioxin TMDLs on the Kanawha River, Pocatalico River and Armour Creek.

1) The TMDL is designed to meet the applicable water quality standards.

All waters of West Virginia are designated for the propagation and maintenance of fish and other aquatic life and for water contact recreation as part of State water quality standards (WV 46-1-6.1). In addition, the tributaries to the Kanawha River have been designated as Water Use Category A – public water supply (WV 46-1-7.2.a) and must be protected for this use. The Kanawha River mainstem is exempt from this designation (WV 46-1-7.2.d.19.1). The applicable water quality standards for water column concentrations of TCDD are:

Pocatalico River and Armour Creek – 0.013 pg/L

Kanawha River mainstem – 0.014 pg/L

West Virginia standards has contained limitations on the maximum dioxin concentration allowed in edible tissues of fish. The maximum fish tissue concentration of dioxin is 6.4 pg/g (8.22.2 of Appendix E cited in WV-1-8.1). (This has just been removed from the WV regulations, but this change has not been submitted to EPA for Approval.)

West Virginia water quality standards are written to apply at all times when flows are equal to or greater than the minimum mean seven consecutive day drought flow with a ten year return frequency (7Q10) (WV 46-1-7.2.b), with the exception of the Kanawha River, where the minimum flow shall be 1,960 cfs at the Charleston gauge (WV 46-1-7.2.d.19.2). EPA (1991a) guidance suggests that the average condition represented by the harmonic mean flow is the appropriate design condition for carcinogens such as dioxins. West Virginia water quality standards (WV 46-1-8-2.b) defer a specific decision on critical design flows for carcinogens, so the default approach of requiring compliance with standards for all flows above a minimum critical value is taken for this TMDL.

For the Kanawha River, Pocatalico River and Armour Creek TMDLs, the applicable endpoints and associated target values can be determined directly from the West Virginia water quality regulations. The in-stream dioxin targets are based on the water use designation of the water body. The Kanawha River is not designated as a public water supply and has a dioxin target of 0.014 pg/L. The tributaries to the Kanawha River are designated as public water supplies and have a dioxin target of 0.013 pg/L. As stated in the West Virginia water quality regulations, dioxin and the dioxin targets refer specifically to the 2,3,7,8-TCDD congener. While other dioxin congeners exist, they are not the subject of this TMDL.

The back-calculated, water column concentration from the fish tissue concentration is much higher than the applicable water column standard of 0.014 pg/L (0.013 pg/L for the tributaries), and indicates that a TMDL that achieves the water column standard will also be protective of the fish tissue standard. For that reason, the water column standard will be used as the TMDL endpoint. It should be recognized, however, that the procedure for relating fish tissue concentration to water column concentrations implicitly assumes steady state conditions between the water column and sediments. As a result, the actual response time of fish tissue to changes in water column concentration may be driven by the amount of time required for sediment concentrations to decrease in response to changes in the water column.

2) The TMDL includes a total allowable load as well as individual waste load allocations and load allocations.

TMDLs are comprised of the sum of individual waste load allocations (WLAs) for point sources, load allocations (LAs) for non-point sources, and natural background levels. In addition, the TMDL must include a Margin of Safety (MOS), either implicitly or explicitly, that accounts for uncertainty in the relation between pollutant loads and the quality of the receiving water body. Conceptually, this definition is denoted by the equation:

$$LC = TMDL = \Sigma WLAs + \Sigma LAs + MOS \qquad (1)$$

The term LC represents the Loading Capacity, or maximum loading that can be assimilated by the receiving water while still achieving water quality standards. The overall loading capacity is subsequently allocated into the TMDL components of waste load allocations (WLAs) for point sources, load allocations (LAs) for non-point sources, and the Margin of Safety (MOS).

Results of the allocation process are summarized in Table 1, which shows the individual TMDL allocations for each of the three systems. The TMDL changes as a function of river flow, so allocations are listed for a range of flows.

In order to determine the 2,3,7,8-TCDD reductions needed to achieve water quality and fish tissue standards and to allocate 2,3,7,8-TCDD inputs among the sources, it is necessary to consider the existing and potential 2,3,7,8-TCDD sources. The TMDL divides allowable loading into separate categories corresponding to point sources (which enter the river from a well-defined source location) and nonpoint (diffuse) sources. The TMDL defines allowable point source permit limits (called wasteload allocations) and necessary reductions in non-point and background sources (called load allocations). These sources must be characterized so that the waste load and load allocations can be assigned to ensure compliance with the TMDL.

Table 1. Summary of Allocations (ug/day) for a Range of Flow Conditions

Kanawha River	**1960 cfs**	**5000 cfs**	**10000 cfs**	**20,000 cfs**	**50,000 cfs**
WLA					
Point Sources	0.82	0.82	0.82	0.82	0.82
LA					
Upstream Sources	43	110	220	440	1100
Groundwater	16.5	16.5	16.5	16.5	16.5
In-place Sediments	0	20	64	152	416
Runoff	0	10.25	10.25	10.25	10.25
MOS					
Explicit MOS	6.7	17	34	69	171
Pocatalico River	**0.32 cfs**	**500 cfs**	**1000 cfs**	**2000 cfs**	**5000 cfs**
WLA					
Point Sources	0	0	0	0	0
LA					
Upstream Sources	0	0	0	0	0
Groundwater	0.0092	0.0092	0.0092	0.0092	0.0092
In-place Sediments	0	12	26	55	141
Runoff	0	5.91	5.91	5.91	5.91
MOS					
Explicit MOS	0.001	1.6	3.2	6.4	16
Armour Creek	**0 cfs**	**200 cfs**	**400 cfs**	**600 cfs**	**800 cfs**
WLA					
Point Sources	0	0	0	0	0
LA					
Upstream	0	0	0	0	0
Groundwater	0	0	0	0	0
In-place Sediments	0	1.4	7.1	13	19
Runoff	0	4.34	4.34	4.34	4.34
MOS					
Explicit MOS	0	0.64	1.3	1.9	2.5

LOADING CAPACITY

Because a simple dilution model is being used to describe dioxin fate and transport, the loading capacity for each TMDL segment can be calculated as a function of stream flow using a simple equation, i.e.

$$LC = Q_{riv} \times C_{WQS} \qquad (2)$$

Where:

LC = Loading Capacity (M/T)
Q_{riv} = River flow (L^3/T)
C_{WQS} = Water Quality Standard concentration (M/L^3)

The loading capacity defined in Equation 2 applies to all river flows for which water quality standards apply. This corresponds to flows above the minimum stream flow of 1960 cfs in the Kanawha River, and flows above the 7Q10 flows of 0.32 cfs in the Pocatalico River and 0.0 cfs in Armour Creek. The resulting loading capacities for the three systems are shown in Figures 2 through 4.

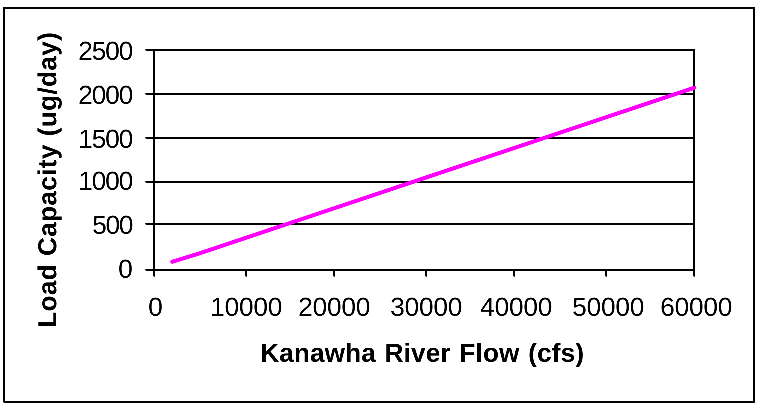

Figure 2 . Kanawha River Loading Capacity

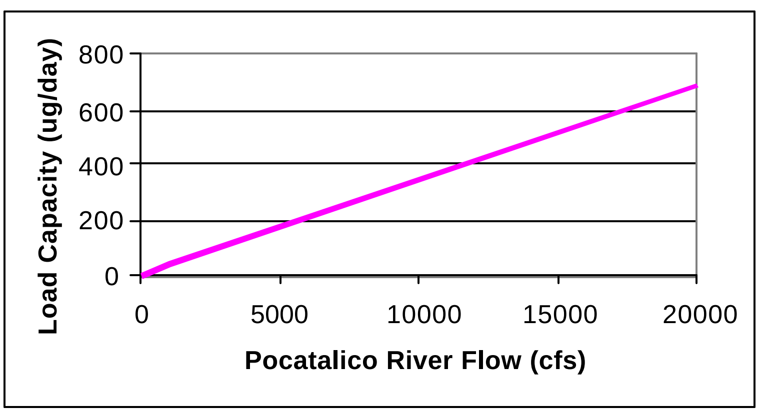

Figure 3. Pocatalico River Loading Capacity

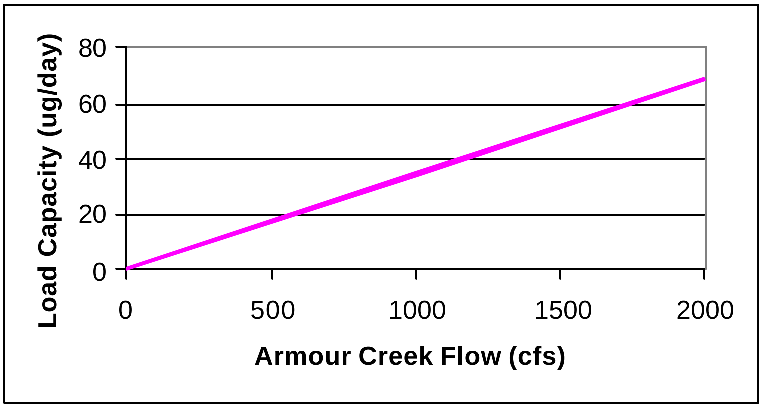

Figure 4. Armour Creek Loading Capacity

WASTE LOAD ALLOCATION

Point sources within the watershed discharging at their current levels were considered negligible in their impact on instream dioxin levels. An allocation is given to the Nitro WWTP in response to their treatment of runoff from the Fike Chemical Co. site. The magnitude of the allocation is set to the required pretreatment limit, which is 0.82 ug/day. The allocation to remaining point sources is set to zero. It is noted here that due to the lack of data within the study area concerning point source contribution of dioxin to the waterbodies, the actual loading of dioxin maybe significantly greater than 0.82 ug/ per day, and hence significant reductions in dioxin loading to the waterbodies may be possible.

Table 2. Wasteload Allocations to Point Sources

Point Sources	Existing Load (ug/day)	Allocated Load (ug/day)	Percent Reduction
Kanawha River	0.82	0.82	0
Pocatalico River	0	0	NA
Armour Creek	0	0	NA

LOAD ALLOCATIONS

Discussion of load allocations to nonpoint sources is divided into categories of upstream sources, contaminated groundwater, in-place sediments, and contaminated soil. A wide range of reduction alternatives could theoretically meet the loading capacity limitations in Figures 2 through 4. The overall allocation strategy can be constrained by considering two conditions:

Drought, or minimum, flow conditions, where the predominant sources contributing to contamination are upstream sources and contaminated groundwater.

High flow, erosional conditions, where the additional sources of in-place sediment resuspension and erosion of surface contamination become important.

Consideration of drought conditions places an upper bound on allowable upstream source and contaminated groundwater allocations. Additional loading capacity at flows above drought flow can be allocated to erosion of in-place sediments and contaminated soil.

Upstream sources

The Ohio River Valley Water Sanitation Commission (ORSANCO) conducted field sampling in May, 1999 to provide a measurement of the dioxin concentration entering the study area at the upstream boundary. The dioxin concentration determined in that sample, 0.009 pg/L, is being used as the upstream boundary concentration for the TMDL. The draft TMDL assumes that the upstream boundary concentration will remain constant at this concentration for all river flows. The uncertainty inherent in this assumption will be reflected in the Margin of Safety.

No evidence exists of dioxin contamination upstream of the Pocatalico River and Armour Creek segments of concern, so upstream boundary concentrations for these segments were assumed to be zero.

Table 3. Load Allocations to Upstream Sources

River	Existing Load (ug/day)	Allocated Load (ug/day)	Percent Reduction
Kanawha	0.009 pg/L x Flow (cfs) x 2.447 = 43 ug/day @ 1960 cfs = 110 ug/day @ 5000 cfs = 440 ug/day @ 20000 cfs	0.009 pg/L x Flow (cfs) x 2.447 = 43 ug/day @ 1960 cfs = 110 ug/day @ 5000 cfs = 440 ug/day @ 20000 cfs	0%
Pocatalico	0	0	NA
Armour	0	0	NA

Contaminated groundwater[2]

Contaminated groundwater was identified as a major contributor of dioxin to the Kanawha River. The upper bound of the maximum allowable groundwater load to the Kanawha can be calculated by performing a mass balance calculation at the location where the groundwater enters the Kanawha (and assuming no loss of dioxin between the upstream boundary and this location) during minimum river flow. The mass balance equation calculates the maximum load that just achieves compliance with the water quality standard, assuming no source other than upstream.

[2]Appendix B of the Kanwaha River, Pocatalico River and Armour Creek TMDL for Dioxin contains a discussion on the meaning of the term “contaminated groundwater”.

The resulting equation is:

$$LA_{GW} \leq Q_{min} \text{ x } (C_{WQS} - C_{up}) \quad (3)$$

Where

LA_{GW} = Load Allocation to contaminated groundwater (M/T)
Q_{min} = Minimum stream flow at which water quality standards apply (L^3/T)
C_{WQS} = Water Quality Standard concentration (M/L^3)
C_{up} = Dioxin concentration at upstream boundary of segment (M/L^3)

Equation 3 is expressed as an inequality, because the LA must be set less than or equal to this value to ensure compliance with water quality standards at minimum flow. The potential reasons for setting the LA less than (as opposed to equal to) this upper bound value include providing allowance for a Margin of Safety and/or achieving greater than absolutely necessary reductions in one source category in order to lessen the amount of reductions required in another source category.

The maximum possible LA for contaminated groundwater in the Kanawha River was determined from application of Equation 3 to be 24 ug/day. The upper bound LAs for contaminated groundwater in the Pocatalico River and Armour Creek are 0.0102 and 0.0 ug/day, respectively.

For purposes of this TMDL, 16.5 ug/day is provided as an allocation to contaminated groundwater in the Kanawha River. This allocation is based upon providing the fullest allocation possible to this source (24 ug/day), minus the wasteload allocation (0.82 ug/day) and minus 10% of the Loading Capacity (6.7 ug/day) which will be allocated to the Margin of Safety as discussed below. This corresponds to a 99% reduction in the estimated existing load.

The LA for contaminated groundwater to the Pocatalico River is 0.0092 ug/day. This allocation is also based upon providing the fullest allocation possible to this source, minus 10% of the Loading Capacity which will be allocated to the Margin of Safety. No allocation is given to Armour Creek, because the 7Q10 flow is zero. No explicit reductions are expected to be required for these sources, based upon the conclusion of Kanetsky (1987) that the primary source of dioxin impairment to these streams is caused by backflow from the Kanawha, which will be corrected through source loading reduction to the Kanawha River.

Table 4. Load Allocations to Contaminated Groundwater

River Segment	**Existing Load** (ug/day)	**Allocated Load** (ug/day)	**Percent Reduction**
Kanawha	3324	16.5	99%
Pocatalico	NA	0.0092	NA
Armour	NA	0.0	NA

Contaminated soils

Once loads have been allocated to the sources described above that must be controlled in order to meet water quality standards during low flow conditions, the remainder of the loading capacity (except for the Margin of Safety) can be allocated to the wet weather/higher flow categories. The first of these to be considered is erosion from contaminated soils in the watershed. Remediation efforts are planned to control the soil contamination at Heizer Creek landfill. This load allocation assumes that soils will be cleaned to a Removal Action Level dioxin concentration of 1.0 ppb (units of TEQ, but treated for allocation purposes as TCDD), resulting in an allowable load of 4.53 ug/day to the Pocatalico River. This same allocation is given to the Kanawha River, because runoff delivered to the Pocatalico River will eventually reach the Kanawha. Additional runoff load of 1.38 ug/day is calculated for the Pocatalico River and subsequently to the Kanawha River from contaminated soils near the Manila Creek landfill. No additional remediation is assumed in allocating this load. Runoff of 4.34 ug/day is calculated for Armour Creek and subsequently to the Kanawha River from contaminated soils at the Midwest Steel site. No additional remediation is assumed in allocating this load.

Table 5. Load Allocations to Contaminated Soils (wet weather)

River Segment	Existing Load (ug/day)	Allocated Load (ug/day)	Percent Reduction
Kanawha	88 ug/day	10.25 ug/day	88%
Pocatalico	83 ug/day	5.91 ug/day	93%
Armour	4.34 ug/day	4.34 ug/day	0%

In-place sediment

The final remaining source category is contaminated in-place sediments. With load reductions assigned to all other loading categories, the allowable load for this source category can be calculated from the difference between load capacity and the other allocated sources (plus the Margin of Safety). The resulting allocation is a function of river flow, and is calculated as:

$$LA_{\text{in-place, Kanawha}} = \text{Load Capacity} - WLA - LA_{\text{Upstream, Kanawha}} - LA_{\text{GW, Kanawha}} - LA_{\text{Soils, Kanawha}} - MOS$$
$$= 0.00881 \times \text{Kanawha River flow (cfs)} - 27.6 \quad (4)$$

$$LA_{\text{in-place, Pocatalico}} = \text{Load Capacity} - LA_{\text{GW, Pocatalico}} - LA_{\text{Soils, Pocatalico}} - MOS$$
$$= 0.0286 \times \text{Pocatalico River flow (cfs)} - 5.92 \quad (5)$$

$$LA_{\text{in-place, Armour}} = \text{Load Capacity} - MOS$$
$$= 0.0286 \times \text{Armour Creek flow (cfs)} - 4.34 \quad (6)$$

Table 6. Load Allocations to in-place Sediments (wet weather)

River Segment	Existing Load	Allocated Load	Percent Reduction
Kanawha	See Table 3-4	See Equation 5-4 = 0 ug/day @1960 cfs = 16 ug/day @5000 cf	>90 %

		= 149 ug/day @20000 cfs	
Pocatalico	NA	See Equation 5-5 = 0 ug/day @0.3 cfs = 8.4 ug/day @500 cfs = 51 ug/day @2000 cfs	NA
Armour	NA	See Equation 5-6 = 0 ug/day @0 cfs = 1.4 ug/day @200 cfs = 13 ug/day @600 cfs	NA

Hazardous Waste Sites

A list of sites that could be potential sources of dioxin loading to the Kanawha River, Pocatalico River and Armour Creek was compiled with input from the WVDEP, EPA Region III and internal investigation. These sites are listed below:
Armour Creek/Solutia Landfill
Clark Property*
Don's Disposal*
Dupont Belle Plant*
Fike Chemical, Inc.
Fleming Landfill*
George's Creek Landfill*
Heizer Creek Landfill
Holmes and Madden Landfill*
Old Avtex Landfill
Landfill adjacent to Midwest Steel/Nitro Landfill
Manila Creek
Flexsys Property
Old Nitro Landfill/Monsanto Dump 1929-1956
Kanawha County Lanfill
Poca Strip Mines/Poca Drum Dump*
South Charleston Landfill*
Union Carbide Plant at Institute*
Western Kanawha Landfill*
*indicates landfills up-watershed of the TMDL study reaches

These sites were researched using three of the EPA's databases for hazardous waste sites: the Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS); Record of Decision System (RODS); and No Further Response Action Planned (NFRAP) database. EPA has categorized sites within its CERCLIS database to one of three lists. List 8T includes all sites that were previously listed as contaminated or were suspected of being contaminated, but have been subsequently cleared of contamination or are no longer suspected of contamination. These sites can also be found in the NFRAP database, indicating that Superfund has completed its assessment of a site and has determined that no further steps will be taken to list that site on the National Priority List. The SCAP 11 list includes all sites/incidents on the Superfund National Priority List (NPL). The SCAP 12 list includes all Superfund sites/incidents that are not on the NPL but have planned or actual remedial/removal activities. Most of the sites in question were on one of these three lists.

3) The TMDL considers the impacts of background pollution.

The Ohio River Valley Water Sanitation Commission (ORSANCO) conducted field sampling in May, 1999 to provide a measurement of the dioxin concentration entering the study area at the upstream boundary. The dioxin concentration determined in that sample, 0.009 pg/L, is being used as the upstream boundary concentration for the TMDL. The draft TMDL assumes that the upstream boundary concentration will remain constant at this concentration for all river flows. The uncertainty inherent in this assumption will be reflected in the Margin of Safety.

No evidence exists of dioxin contamination upstream of the Pocatalico River and Armour Creek segments of concern, so upstream boundary concentrations for these segments were assumed to be zero

4) The TMDL considers critical environmental conditions.

EPA regulations at 40 CFR 130.7 (c)(1) require TMDLs to take into account critical conditions for stream flow, loading, and water quality parameters. The intent of this requirement is to ensure that the water quality of the Kanawha River Watershed is protected during times when it is most vulnerable.

Concurrent with the selection of a numeric concentration endpoint, TMDL development must also define the environmental conditions that will be used when defining allowable loads. The critical condition is defined as the set of environmental conditions which, if controls are designed to protect, will ensure attainment of objectives for all other conditions. For example, the critical condition for control of a continuous point discharge is the drought stream flow. Pollution controls designed to meet water quality standards for drought flow conditions will ensure compliance with standards for all other conditions. The critical condition for a wet weather-driven sources may be a particular rainfall event.

Dioxin sources to the Kanawha River study area are believed to arise from a mixture of continuous and wet weather-driven sources, and there may be no single critical condition that is protective for all other conditions. For example, contaminated groundwater loading is assumed to be relatively constant over time, and its control will be most critical during low stream flow conditions. Resuspension of contaminated in-place sediments, on the other hand, will be most critical during high river flow periods. For this reason, the TMDL will examine the entire range of flow conditions and will define load allocations that will be protective for all conditions.

5) The TMDLs consider seasonal environmental variations.

Seasonal variations involve changes in stream flow as a result of hydrologic and climatological patterns. In the continental United States, seasonally high flow normally occurs during the colder period of winter and in early spring from snow melt and spring rain, while seasonally low flow typically occurs during the warmer summer and early fall drought periods. Seasonality in this TMDL is addressed by expressing the TMDL in terms of river flow, as changes in flow will be the dominant seasonal environmental factors affecting the TMDL.

6) The TMDLs include a margin of safety.

This requirement is intended to add a level of safety to the modeling process to account for any uncertainty. Incorporation of a margin of safety (MOS) in the TMDL analysis. The MOS accounts for any uncertainty or lack of knowledge concerning the relationship between pollutant loading and water quality. The MOS can either be implicit (e.g., incorporated into the TMDL analysis through conservative assumptions) or explicit (e.g., expressed in the TMDL as a portion of the loadings). This TMDL uses both explicit and implicit components of the Margin of Safety.

An implicit MOS is provided through the use of a conservative dilution model for allocation purposes. This implicit MOS is as protective as possible for modeling purposes as it assumes complete conservation of mass. Another component of the implicit margin of safety is the State requirement that the water quality standard for dioxin be met for all flow conditions above the critical minimum flow. This will result in an allowable load much smaller than would be derived using the EPA-recommended harmonic mean flow conditions as the design condition.

An additional explicit Margin of Safety is also provided, to account for uncertainty in loading entering each system across the upstream boundary, as well as other potential dioxin sources not identified during the source assessment. The explicit Margin of Safety is set at 10% of the LA.

7) The TMDLs have been subject to public participation.

This TMDL was subject to a number of public meetings. The meetings started in March 1999. All the meetings listed below were held at the Nitro Senior Center, in Nitro West Virginia:

July 26, 1999 7:00 pm -9:00 pm with court reporter

November 5/1999 (2 meetings) 2:30 to 5:00 pm and 7:00 pm to 9: 00pm

January 11, 2000 (2 meetings) 2:30 to 5:00 pm and 7:00 pm to 9: 00pm

March 14, 2000 (2 meetings) 2:00 to 4:00 pm and 7:00 pm to 9: 00pm

May 11, 2000 (2 meetings) 2:00 to 4:00 pm and 7:00 pm to 9: 00pm

July 25, 2000 public hearing from 7:00pm to 9:00 pm with hearing officer and court reporter.

Information repository locations in Nitro West Virginia, with all site information was available to the public. Recently collected data at various sites in the Kanawha River Valley were also available at each of the meetings stated above. This information was presented and supplied at the public meetings. At each meeting, various offices of EPA and state DEP were represented, including: Water Protection Division; EPA Superfund; EPA Site Assessment, Superfund; EPA RCRA program; Agency for Toxics Disease Registry(ATSDR); USGS and Ohio River Sanitary Commission (ORSANCO).

During these meetings EPA's technical approach for the development of this TMDL was presented and discussed. The document was also subject to a 45-day public comment period. The TMDL was public noticed on July 5, 2000 and closed on August 18, 2000.

8) There is a reasonable assurance that the TMDL can be met.

EPA requires that there be a reasonable assurance that the TMDL can be implemented. WLAs will be implemented through the NPDES permit process. According to 40 CFR 122.44(d)(1)(vii)(B), the effluent limitations for an NPDES permit must be consistent with the assumptions and requirements of any available WLA for the discharge prepared by the state and approved by EPA. Furthermore, EPA has authority to object to issuance of an NPDES permit that is inconsistent with WLAs established for that point source.

The Kanawha River/Pocatalico River/Armour Creek TMDL site data confirm that dioxin concentrations exceed water quality standards. However, additional data are needed to define many of the sources of dioxin entering these systems. For this reason, implementation activities must first focus on better identifying existing sources in order to control them.

EPA has initiated activity at over 16 sites throughout the watershed with the intent of collecting the data necessary to define the magnitude of dioxin loading from each site and/or identify necessary control actions. In addition to the land sites, monitoring is recommended to define the contribution of the ambient air as a source to the watershed.

Armour Creek/Solutia

EPA HSCD will be conducting a Preliminary Assessment (PA) under CERCLA at the site in Summer 2000.

Clark Property

EPA HSCD will be reviewing (PA) available site information in Summer 2000 to determine if any further reassessment of the site is necessary.

Don's Disposal

EPA HSCD will be reviewing (PA) available site information in Summer 2000 to determine if any further reassessment of the site is necessary.

DuPont Belle Plant

EPA's Hazardous Site Cleanup Division's Site Assessment Program will review the current conditions at this property to determine whether it is a possible source or contributor of dioxin to the Kanawha River, Armour Creek or the Pocatalico River. This review will be based on EPA's existing information and new data collected in September 1999.

Fike Chemical Co.

EPA HSCD will be conducting a sampling assessment of stormwater sewers of the Nitro WV area in Summer 2000. Sampling will include collection of sediment and surface water from drainages used by the old CST.

Fleming Landfill

EPA HSCD will be reviewing (PA) available site information in Fall 2000 to determine if any further reassessment of the site is necessary.

George's Creek Landfill

EPA HSCD will be reviewing (PA) available site information in Fall 2000 to determine if any further reassessment of the site is necessary.

Heizer Creek Landfill

EPA HSCD conducted a CERCLA site inspection at the site in May 2000 and is currently awaiting the results of the sampling event. EPA HSCD will determine future remedial actions at the site pending receipt of the SI data.

Kanawha Western Landfill

EPA's Hazardous Site Cleanup Division's Site Assessment Program will review the current conditions at this property to determine whether it is a possible source or contributor of dioxin to the Kanawha River, Armour Creek or the Pocatalico River. This review will be based on EPA's existing information, which had earlier resulted in a Superfund "No Further Response Action Planned" (NFRAP) classification, plus additional information as needed.

Landfill adjacent to Midwest Steel

EPA HSCD will be conducting a sampling assessment (SI) at the site in Fall 2000 to further characterize potential migration of dioxin from the site to Armour Creek.

Manila Creek Landfill

EPA HSCD conducted an Expanded Site Investigation (ESI) at the site in May 2000 which included the installation of four off-site groundwater monitoring wells and collection of samples to determine if dioxin and other contaminates are migrating off site. EPA will determine what actions, if any are necessary upon receipt of the data.

Flexsys Plant Property

EPA HSCD is currently in the process of negotiating a consent order with Solutia to address the removal of drums and dioxin contamination at the part of the facility, formerly owned by AES.

Old Nitro Landfill

EPA HSCD will be conducting a PA of the site in Summer 2000 to determine if any further assessment of the site is necessary.

Poca Strip Mines/Poca Drum Dump

EPA HSCD will be reviewing (PA) available site file information in the Fall 2000 to determine if any further reassessment of the site is necessary.

South Charleston Landfill

EPA HSCD is currently awaiting a health consultation by ATSDR on data collected at the site in September 1999, before determining what future actions if any are necessary at the site.

Union Carbide (Rhone Poulanc) Institute Plant

EPA HSCD will be reviewing (PA) available site file information in the Fall 2000 to determine if any further reassessment of the site is necessary

CONTROL OF IN-PLACE SEDIMENTS

Resuspension of contaminated in-place sediments has been identified as contributing to violations of water quality standards for dioxin during high flow events. The primary implementation options under consideration are natural attenuation and physical removal of contaminated sediments (e.g. dredging). Natural attenuation processes can include burial of contaminated sediments as cleaner sediments are deposited upon them, and/or the flushing of contaminated sediments out of the system during high flows. Since the data to adequately characterize the site contamination, and dioxin fate and transport pathways in the river, is inadequate the preferred course of action to control in-place sediments is not evident. Additional monitoring activities are needed to better define the benefits of natural attenuation compared to physical removal of contaminated sediments.

Dioxin TMDL Development for Kanawha River, Pocatalico River, and Armour Creek, West Virginia

Prepared for:

U.S. EPA Region III
Philadelphia, PA

Under Subcontract to:
Tetra-Tech, Inc.
Fairfax, VA

September 14, 2000

Limno-Tech, Inc.
Excellence in Environmental Solutions Since 1975
Ann Arbor, Michigan

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EXECUTIVE SUMMARY

The Kanawha River, Pocatalico River and Armour Creek were placed on the State of West Virginia's 303(d) list of water quality impaired water bodies for 2,3,7,8-TCDD (dioxin). The applicable State standards specify that the maximum allowable concentration of dioxin shall not exceed 0.014 pg/L in the Kanawha River, and 0.013 pg/L in the Pocatalico River and Armour Creek. Water quality data collected in support of this study show that dioxin concentrations routinely exceed the State water quality standard.

The Kanawha River segment of concern extends 45.5 miles from the confluence of the Coal River near Nitro, West Virginia to where the Kanawha enters the Ohio River. The Pocatalico River and Armour Creek segments of concern each extend two miles upstream of their respective confluences with the Kanawha. A review of available monitoring data indicates that observed water column dioxin concentrations in the Kanawha River routinely exceed the water quality standard. No suitable water column data are available for the Pocatalico River or Armour Creek. Fish tissue data for all three systems also commonly exceed the water quality standard. The water column water quality standard was used as the endpoint of the TMDL for all three systems.

A mass balance dilution model was applied to define the maximum allowable dioxin load that will achieve compliance with water quality standards for the entire range of flow conditions that may occur in each river. Analyses indicate that a TMDL designed to achieve compliance with the water column concentration standard will also achieve compliance with the fish tissue standard, after the system has time to respond to the reduced loadings.

No direct dioxin loading data were available from any sources for any of the water bodies of concern. Dioxin loads were estimated from available information, and attributed to four source categories: 1) contaminated groundwater[1], 2) in-place river sediments, 3) surface erosion of contaminated soils in the watershed, and 4) upstream sources. Reductions from these sources will be required in order to achieve compliance with water quality standards.
Future monitoring activities are described that are designed to further identify sources and conditions contributing to dioxin impairment in the Kanawha River, the Pocatalico River, and Armour Creek.

[1] Appendix B contains an exposition on the meaning of the term "contaminated groundwater".

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1.0 INTRODUCTION

1.1 BACKGROUND

Section 303(d) of the Clean Water Act and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for water bodies that are not meeting designated uses under technology-based controls. The TMDL process establishes the allowable loading of pollutants or other quantifiable parameters for a water body based on the relationship between pollution sources and instream conditions. By following the TMDL process, states can establish water quality-based controls to reduce pollution from both point and nonpoint sources and restore and maintain the quality of their water resources (EPA, 1991b).

The West Virginia Division of Environmental Protection (DEP) has identified the Kanawha River, Pocatalico River, and Armour Creek as being impaired by dioxins, as reported on the 1998 303(d) list of water quality limited waters (WVDEP, 1998). The consent decree established in conjunction with the West Virginia TMDL lawsuit has identified the Kanawha River as a priority watershed, with a TMDL for dioxin to be completed by September, 2000.

The Kanawha River is located in western West Virginia. The Kanawha River segment of concern (Figure 1-1) extends 45.5 miles from the confluence of the Coal River near Nitro, West Virginia (Kanawha River Mile (RM) 45.5) downstream to its confluence with the Ohio River (Kanawha RM 0.0). The Kanawha River watershed covers a total of 518 square miles, with a land use primarily (>90%) of forest. The segments of concern for the Pocatalico River and Armour Creek each extend 2 miles upstream from their respective confluences with the Kanawha River (Figure 1-1). The Pocatalico River watershed spans 359 square miles, also primarily of forest. The Armour Creek watershed covers 9 square miles, and is the most highly developed, with over 20% of the land use listed as developed.

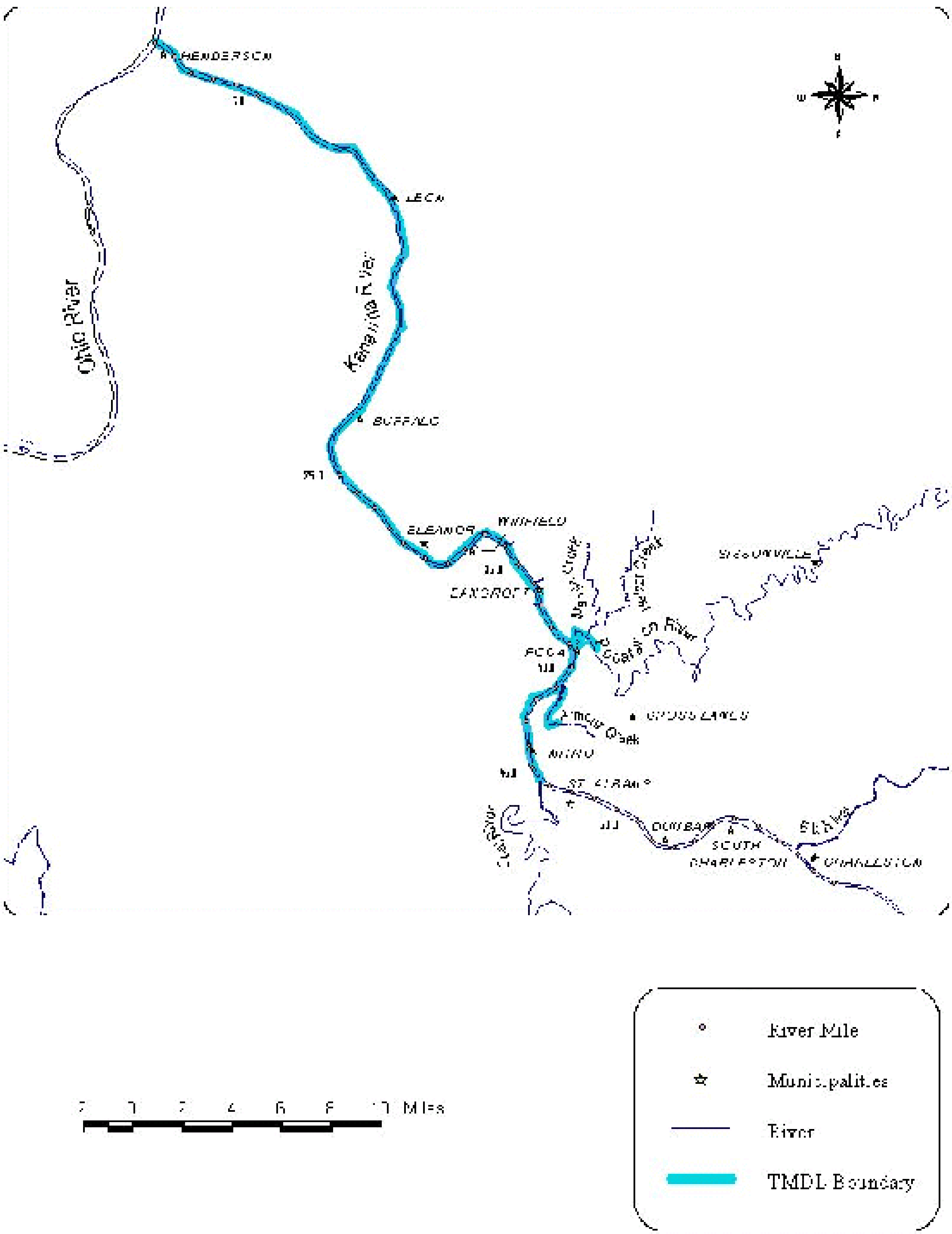
1.2 APPLICABLE WATER QUALITY STANDARDS

All waters of West Virginia are designated for the propagation and maintenance of fish and other aquatic life and for water contact recreation as part of State water quality standards (WV 46-1-6.1). In addition, the tributaries to the Kanawha River have been designated as Water Use Category A – public water supply (WV 46-1-7.2.a) and must be protected for this use. The Kanawha River mainstem is exempt from this designation (WV 46-1-7.2.d.19.1). The applicable water quality standards for water column concentrations of TCDD are:

Pocatalico River and Armour Creek – 0.013 pg/L

Kanawha River mainstem – 0.014 pg/L

Figure 1-1. Kanawha River, Pocatalico River, Armour Creek Study Area


HENDERSON
LEON
BUFFALO
ELEANOR
WINFIELD
POCA
NITRO
Ohio River
Kanawha River
Pocatalico River
Armour Creek
SOUTH
CHARLESTON
Miles
River Mile
Municipalities
River
TMDL Boundary

West Virginia standards also contain limitations on the maximum dioxin concentration allowed in edible tissues of fish. The maximum fish tissue concentration of dioxin is 6.4 pg/g (8.22.2 of Appendix E cited in WV-1-8.1).

West Virginia water quality standards are written to apply at all times when flows are equal to or greater than the minimum mean seven consecutive day drought flow with a ten year return frequency (7Q10) (WV 46-1-7.2.b), with the exception of the Kanawha River, where the minimum flow shall be 1,960 cfs at the Charleston gauge (WV 46-1-7.2.d.19.2). EPA (1991a) guidance suggests that the average condition represented by the harmonic mean flow is the appropriate design condition for carcinogens such as dioxins. West Virginia water quality standards (WV 46-1-8-2.b) defer a specific decision on critical design flows for carcinogens, so the default approach of requiring compliance with standards for all flows above a minimum critical value is taken for this TMDL. It should be recognized that this approach provides a significant additional safety factor beyond use of harmonic mean flow conditions, resulting in an allowable load much smaller than would be derived using the average flows as the design condition.

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2.0 TMDL ENDPOINT AND WATER QUALITY ASSESSMENT

2.1 SELECTION OF A TMDL ENDPOINT

One of the major components of a TMDL is the establishment of in-stream numeric endpoints, which are used to evaluate the attainment of acceptable water quality. In-stream numeric endpoints, therefore, represent the water quality goals that are to be achieved by implementing the load reductions specified in the TMDL. The endpoints allow for a comparison between observed in-stream conditions and conditions that are expected to restore designated uses. The endpoints are usually based on either the narrative or numeric criteria available in state water quality standards. For the Kanawha River, Pocatalico River and Armour Creek TMDLs, the applicable endpoints and associated target values can be determined directly from the West Virginia water quality regulations. The in-stream dioxin targets are based on the water use designation of the water body. The Kanawha River is not designated as a public water supply and has a dioxin target of 0.014 pg/L. The tributaries to the Kanawha River are designated as public water supplies and have a dioxin target of 0.013 pg/L. As stated in the West Virginia water quality regulations, dioxin and the dioxin targets refer specifically to the 2,3,7,8-TCDD congener. While other dioxin congeners exist, they are not the subject of this TMDL. The fish tissue standard of 6.4 pg/g also applies throughout the study area, and serves as a potential endpoint for the TMDL.

Two potential endpoints exist in terms of numeric criterion, the water column standard and the fish tissue standard. Application of a bioaccumulation factor relating fish tissue to water column concentrations (EPA, 1995) using parameter values representative of the Kanawha River indicates that the fish tissue standard of 6.4 pg/g corresponds to a water column dioxin concentration of about 0.1 to 0.2 pg/L. This back-calculated water column concentration is much higher than the applicable water column standard of 0.014 pg/L (0.013 pg/L for the tributaries), and indicates that a TMDL that achieves the water column standard will also be protective of the fish tissue standard. For that reason, the water column standard will be used as the TMDL endpoint. It should be recognized, however, that the procedure for relating fish tissue concentration to water column concentrations implicitly assumes steady state conditions between the water column and sediments. As a result, the actual response time of fish tissue to changes in water column concentration may be driven by the amount of time required for sediment concentrations to decrease in response to changes in the water column.

2.1.1 Selection of Critical Condition

Concurrent with the selection of a numeric concentration endpoint, TMDL development must also define the environmental conditions that will be used when defining allowable loads. Many TMDLs are designed around the concept of a "critical condition." The critical condition is defined as the set of environmental conditions which, if controls are designed to protect, will ensure attainment of objectives for all other conditions. For example, the critical condition for control of a continuous point discharge is the drought stream flow. Pollution controls designed to meet water quality standards for drought flow conditions will ensure compliance with standards for all other conditions. The critical condition for a wet weather-driven sources may be a particular rainfall event.

Dioxin sources to the Kanawha River study area are believed to arise from a mixture of continuous and wet weather-driven sources, and there may be no single critical condition that is protective for all other conditions. For example, contaminated groundwater loading is assumed to be relatively constant over time, and its control will be most critical during low stream flow conditions. Resuspension of contaminated in-place sediments, on the other hand, will be most critical during high river flow periods. For this reason, the TMDL will examine the entire range of flow conditions and will define load allocations that will be protective for all conditions.

2.2 DISCUSSION OF INSTREAM WATER QUALITY

2.2.1 Inventory of Available Water Quality Monitoring Data

This section provides an inventory and analysis of available dioxin data in the water column and fish of the Kanawha River, Pocatalico River, and Armour Creek. The main sources of data for the Kanawha River and its tributaries were:

ORSANCO High Volume Water Sampling

STORET

EPA

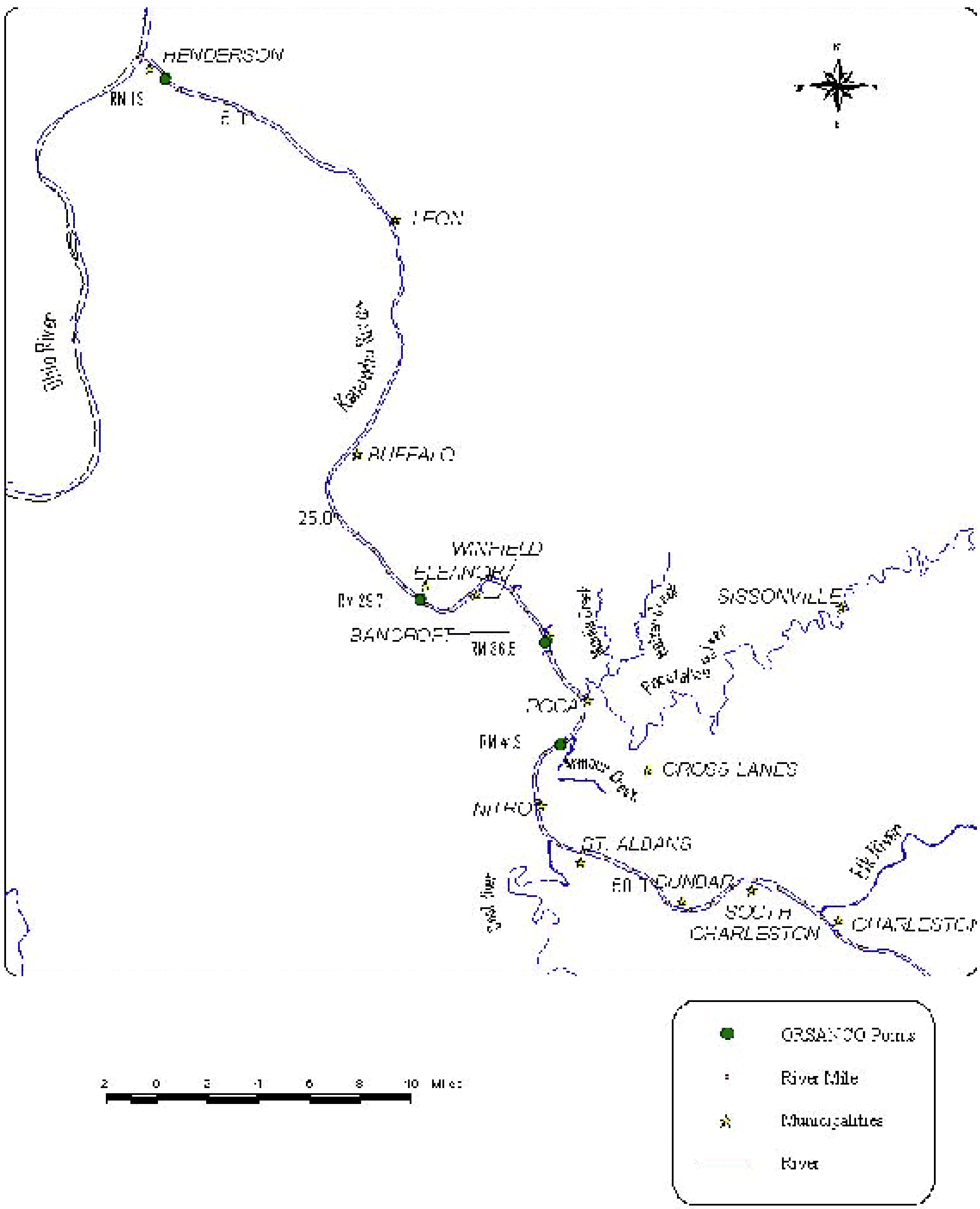
ORSANCO High Volume Water Sampling

The Ohio River Valley Water Sanitation Commission (ORSANCO) conducted high volume water sampling at one location on the Kanawha River in 1997 and at four locations during 1998. Station locations are shown in Figure 2-1. The high-volume sampling technique filters and extracts dioxins from a large volume of water, typically 1000 liters. The sample water is passed through a 1 um glass fiber filter which separates and collects the particulate phase dioxin adsorbed onto the suspended solids. The dissolved phase dioxin is extracted from the sample water by passing the water through an XAD-2 resin column. The filters and columns are analyzed separately to quantify the dioxin concentration in the particulate and dissolved phases, respectively. Approximately 1,000 liters of water were collected at nine locations along the cross section of each station and analyzed for total suspended solids (TSS), 2,3,7,8-TCDD (dioxin), and dioxin TEQ. This study provided the majority of the dioxin water column concentrations used for this TMDL. ORSANCO also conducted bimonthly sampling of TSS at one location.

STORET

Historical data were available from EPA's database for the STOrage and RETrieval of chemical, physical and biological data (STORET) for numerous stations along the Kanawha River and its tributaries. This database contains data collected by the West Virginia Division of Environmental Protection (WVDEP), the United States Geological Survey (USGS) and the United States Army Corps of Engineers (COE). Data from the 1970s through 1998 are collected in this database. Parameters of interest to this study include water column dioxin, fish tissue dioxin, % lipids, TSS, organic carbon, and flow.

Figure 2-1. ORSANCO Sampling Points



The U. S. Environmental Protection Agency (EPA) conducted a sediment and fish survey in 1986, a sediment survey in 1987 and another sediment and fish survey in 1998. The 1986 survey was a collaborative effort between EPA Region III and the West Virginia Department of Natural Resources (WVDNR) to study TCDD contamination in this region of the Kanawha in response to the U.S. Food and Drug Administration (FDA, 1983) advisory regarding the consumption of fish containing 50 pg/g or more of TCDD (Smith and Ruggero, 1986). The 1987 sediment survey was a follow-up study to the 1986 survey and focused on the sediments of the tributaries to the Kanawha River (Kanetsky, 1986). The objective of the 1998 sediment and fish survey was to assess the levels of dioxin coming from four landfills in the Nitro area and their impact on the local fish population (SATA, 1999). Data collected by the EPA included sediment dioxin concentration, percent moisture, fish tissue dioxin concentration, and percent lipids. Several stations along the Kanawha River and its tributaries were monitored.

2.2.2 Analysis of Instream Water Quality Monitoring Data

Water column dioxin concentrations

A limited number of total, particulate, and dissolved water column dioxin measurements were available from ORSANCO for the Kanawha River. No water column dioxin measurements were available for the Kanawha River tributaries. A summary of the available Kanawha River water column dioxin data is given in Table 2-1.

Table 2-1. Kanawha River Water Column TCDD

Station	Analysis Type	Maximum (pg/L)	Minimum (pg/L)	Average (pg/L)	Number	Dates
R.M. 1.3	Total	0.463	0.094	0.181	7	6/97 – 11/98
	Particulate	0.447	0.087	0.1667	7	6/97 – 11/98
	Dissolved	0.020	0.008	0.014	7	6/97 – 11/98
R.M. 29.7	Total	0.306	0.245	0.270	3	6/97 – 11/98
	Particulate	0.275	0.222	0.243	3	6/97 – 11/98
	Dissolved	0.031	0.023	0.027	3	6/97 – 11/98
R.M. 36.5	Total	0.376	0.235	0.329	3	6/97 – 11/98
	Particulate	0.351	0.202	0.293	3	6/97 – 11/98
	Dissolved	0.051	0.024	0.036	3	6/97 – 11/98
R.M. 41.3	Total	0.412	0.130	0.294	3	6/97 – 11/98
	Particulate	0.365	0.115	0.264	3	6/97 – 11/98
	Dissolved	0.047	0.015	0.030	3	6/97 – 11/98

The data were compared to the Kanawha River dioxin WQS of 0.014 pg/L and show exceedances of the standard throughout the sampling area (Figure 2-). All of the total dioxin concentrations exceed the standard, by an average factor of five. The West Virginia standard for dioxin is expressed in terms of total chemical; Figure 2-2 indicates exceedances even if the standard were expressed in terms of dissolved concentrations.

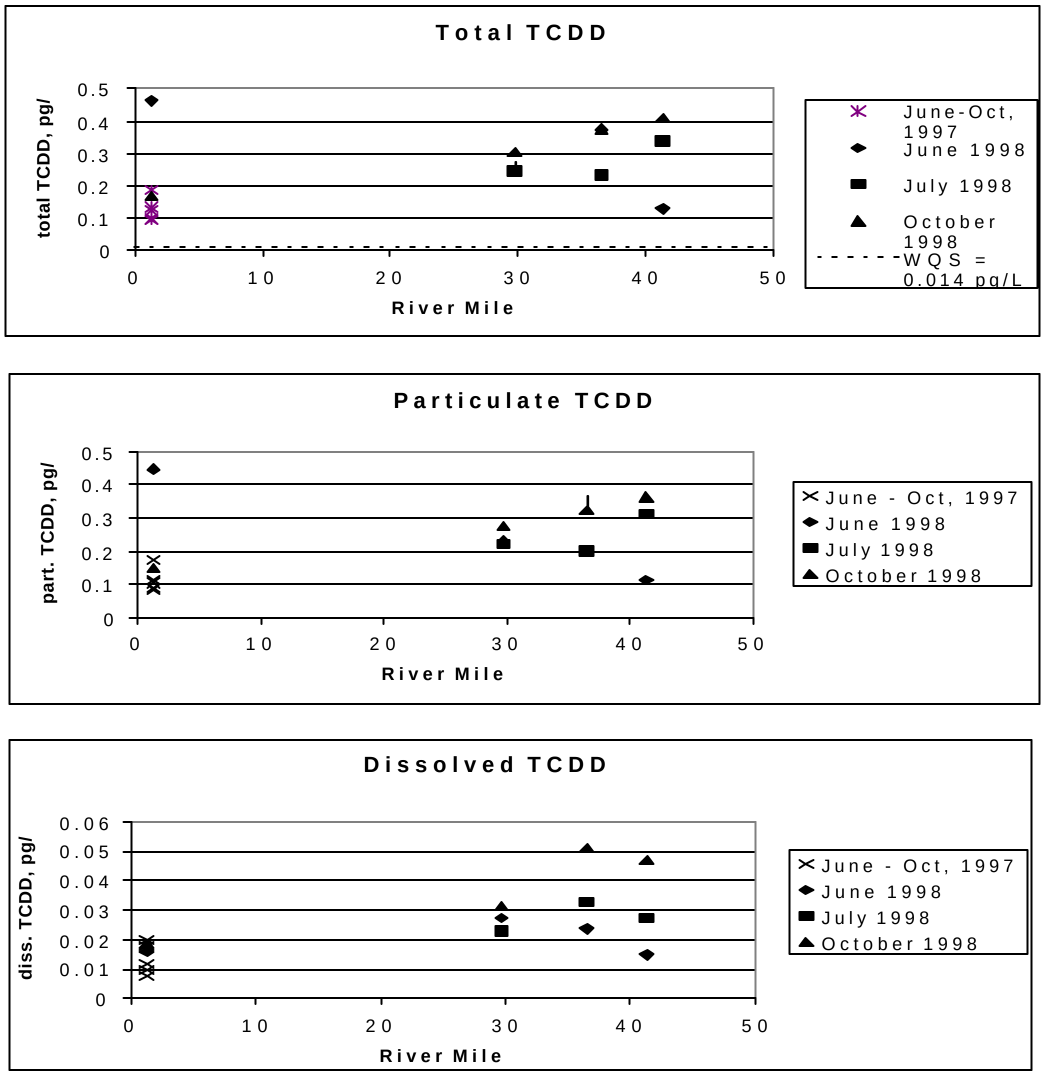


Figure 2-2. Comparison of Observed Kanawha River Water Column Dioxin Concentration to Water Quality Standard

No recent water column dioxin measurements exist for the Pocatalico River and Armour Creek; however, the available fish tissue data can also be used to infer water column concentrations. Application of a bioaccumulation factor (BAF) relating fish tissue to water column concentrations (EPA, 1995), using parameter values representative of the Kanawha River, indicates that all of the Pocatalico River and Armour Creek fish tissue samples correspond to water column dioxin concentrations that exceed the water quality standard. Back-calculated Pocatalico River water column dioxin concentrations exceed the water quality standard by a factor of 6.1 to 540. Back-calculated Armour Creek water column dioxin concentrations exceed the water quality standard by a factor of 2.8 to 93. While application of this BAF involves numerous simplifying assumptions, its results conclusively demonstrate the existence of a problem. The specific back-calculation procedure, the required assumptions, and the resulting data are provided in Appendix A.

2.3 FISH TISSUE DIOXIN CONCENTRATIONS

Dioxin was measured in fish tissues by several agencies at many locations throughout the Kanawha River, Armour Creek and the Pocatalico River beginning in the early seventies and continuing through 1998. These data are summarized in Table 2-2.

Table 2-2. Summary of Available Fish Tissue TCDD Data

Receiving Water	Max., pg/g	Min., pg/g	Avg., pg/g	Number	Dates
Kanawha River	172.0	0.6	21.4	121*	9/74 – 11/98
Armour Creek	62.6	1.5	17.2	13	4/86 – 11/98
Pocatalico River	21.9	3.4	9.2	14	4/86 – 11/98

* Collected RM 2 to RM 87.2

A comparison of the data to the applicable fish tissue criterion of 6.4 pg/g shows exceedances in all three of the receiving waters (Figure 2-3 through Figure 2-6). 105 fish samples were collected in the Kanawha River study area ranging from RM 2 to RM 44. 73.5% of these fish samples had concentrations above the 6.4 pg/g standard. 50% of the 14 fish samples collected in the Pocatalico River exceeded the 6.4 pg/g criterion. However, fish taken from the Pocatalico River show a decreasing trend in dioxin concentration and the most recent fish data are compliant with the state standard. 53.8% of the 13 fish samples collected in Armour Creek exceeded the 6.4 pg/g criterion. It must be noted that the fish tissue database contains a mixture of whole fish samples, edible fillets, and unidentified portions. All of these data are shown in Figures 2-3 through 2-6.

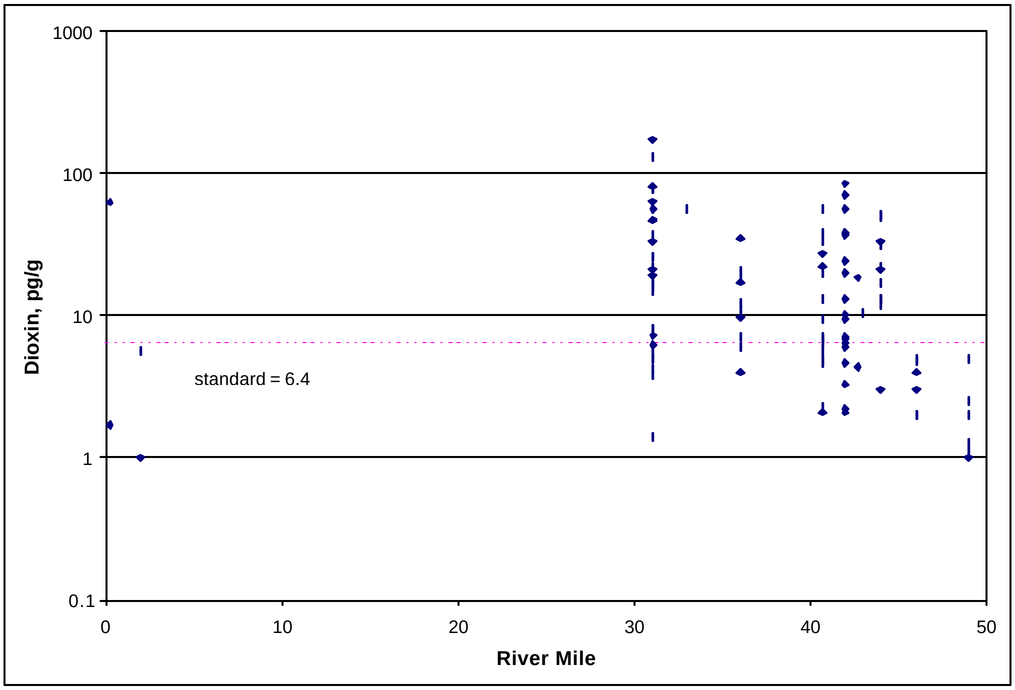
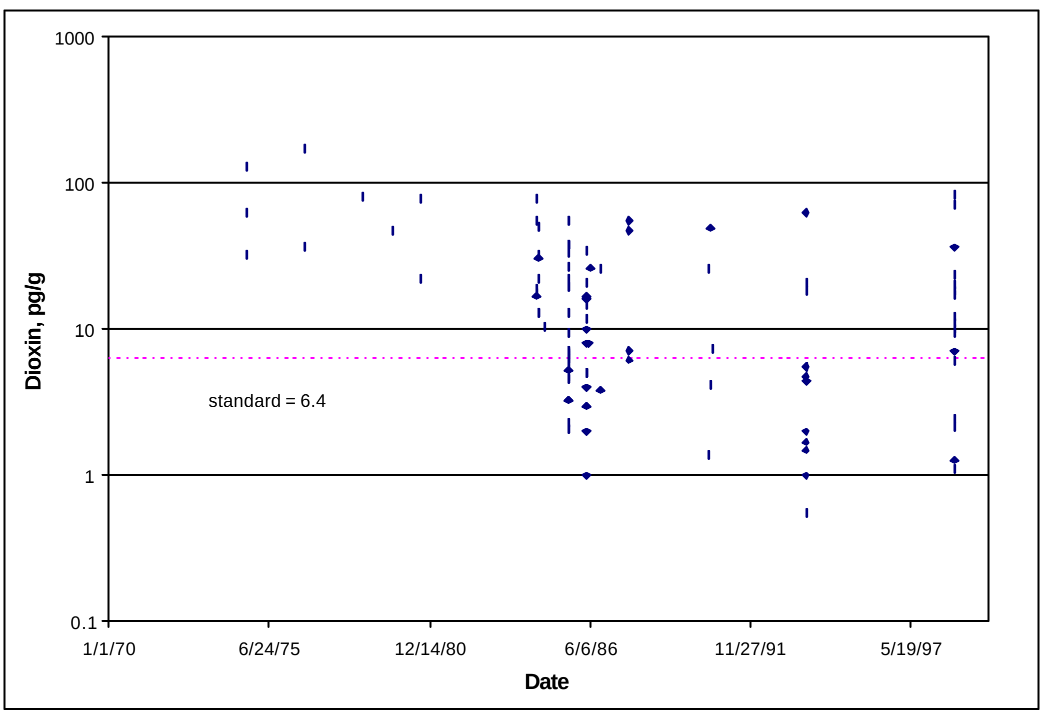


Figure 2-3. Comparison of Observed Kanawha River Fish Tissue Dioxin to Water Quality Standard by River Mile

Figure 2-4. Comparison of Observed Kanawha River Fish Tissue Dioxin to Water Quality Standard by Date



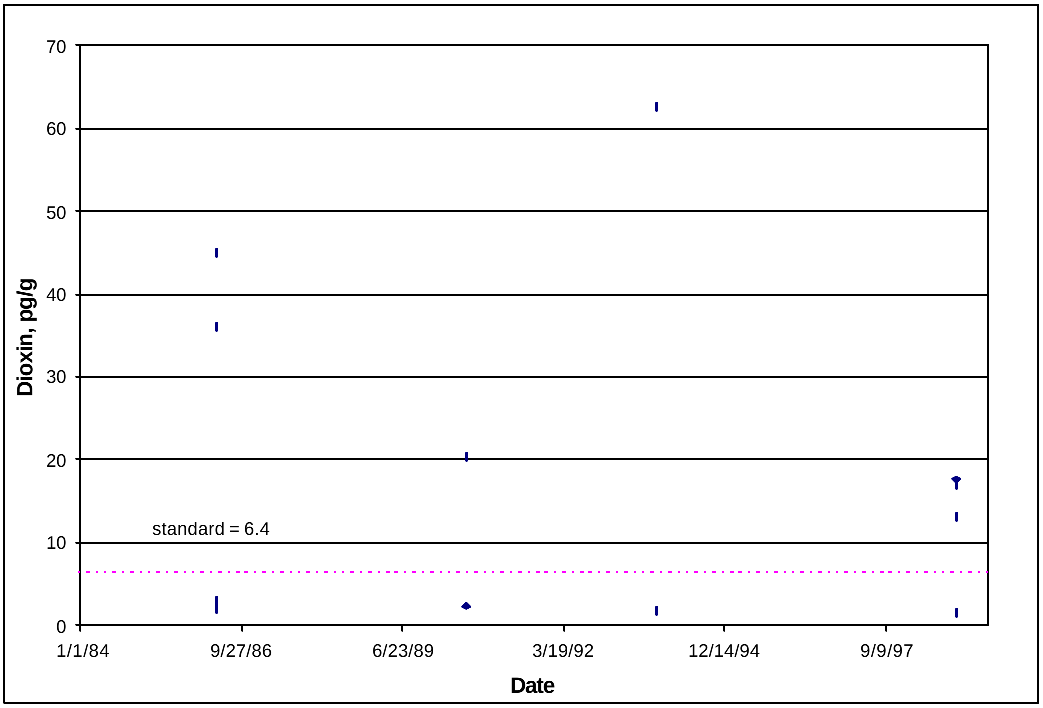
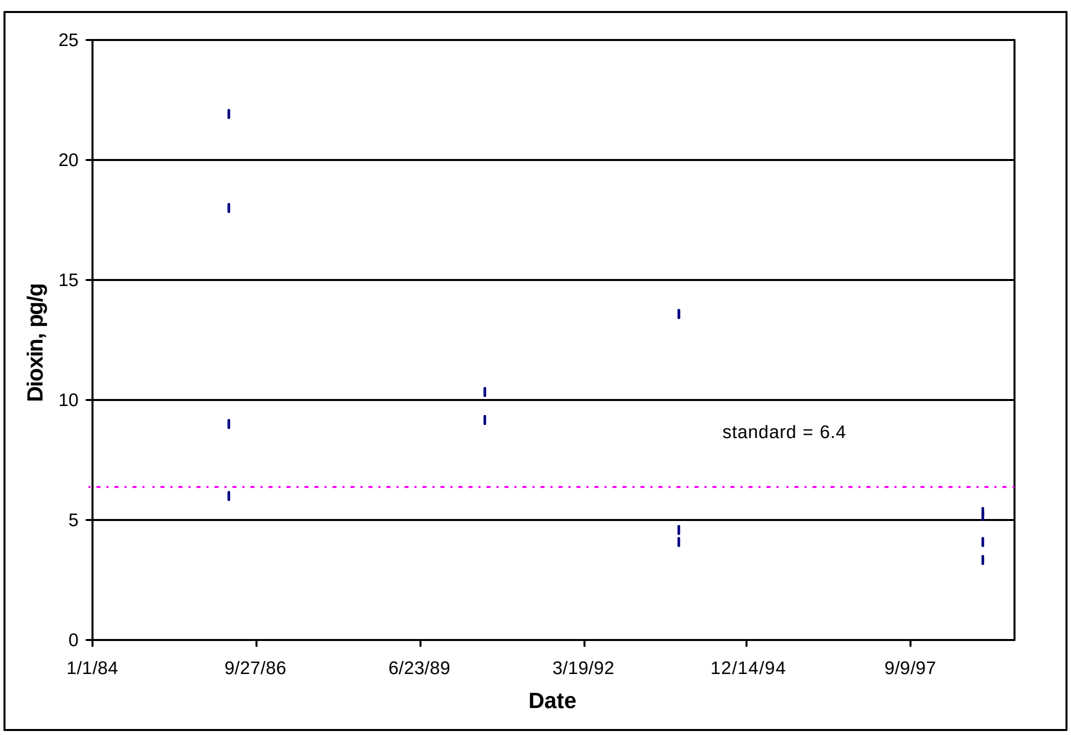


Figure 2-5. Comparison of Observed Armour Creek Fish Tissue Dioxin to Water Quality Standard by Date

Figure 2-6. Comparison of Pocatalico River Observed Fish Tissue Dioxin to Water Quality Standard by Date



3.0 SOURCE ASSESSMENT

3.1 INTRODUCTION

In order to determine the 2,3,7,8-TCDD reductions needed to achieve water quality and fish tissue standards and to allocate 2,3,7,8-TCDD inputs among the sources, it is necessary to consider the existing and potential 2,3,7,8-TCDD sources. The TMDL divides allowable loading into separate categories corresponding to point sources (which enter the river from a well-defined source location) and nonpoint (diffuse) sources. The TMDL defines allowable point source permit limits (called wasteload allocations) and necessary reductions in non-point and background sources (called load allocations). These sources must be characterized so that the waste load and load allocations can be assigned to ensure compliance with the TMDL.

2,3,7,8-TCDD (dioxin) is most commonly encountered as an unwanted by-product of incineration, production of chlorinated pesticides and herbicides, and the bleaching step of the papermaking process. Industrial activities in the study area, especially near the city of Nitro, West Virginia have resulted in several contaminated sites. Dioxin in the study area likely originated with the production of industrial solvents and the herbicide 2,4,5-T at facilities in and around Nitro. Disposal practices earlier in the century, including burial of drums, dumping of dioxin-contaminated liquid wastes, and incineration of dioxin-contaminated material, spread dioxin throughout the Nitro area. Areas downstream of Nitro likely became contaminated through the release and transport of dioxin into the Kanawha River and its tributaries. The Kanawha River and two of its tributaries, the Pocatalico River and Armour Creek, are the focus of this TMDL because of their noncompliance with water quality and fish tissue standards.

Determining the dioxin load that these industrial and landfill/dump sites have contributed to the Kanawha River, Pocatalico River, and Armour Creek is a formidable task; no direct dioxin loading data to any of these systems exist. Consequently, historical reports from the EPA's Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) and the West Virginia Department of Environmental Protection (WVDEP) as well as the best available (anecdotal) information were used to identify these sites. Available water, sediment, soil and fish monitoring data and literature values were used to estimate the magnitude of their load contribution to the Kanawha, Pocatalico, and Armour. This section documents the available information and interpretation for the modeling analysis.

3.2 ASSESSMENT OF POINT SOURCES

A search of the Permit Compliance System (PCS) database revealed that there are no permitted discharges of dioxin to the Kanawha River, the Pocatalico River or to Armour Creek. Conversations with officials from the WVDEP Office of Water confirmed this.

A potential point source could exist with the City of Nitro wastewater discharge to the Kanawha River. This facility has been receiving on-site treated surface runoff from the Fike Chemical Company Superfund site. This site has documented dioxin contamination in its surface soils. The site is permitted to discharge up to 144,000 gallons per day of pretreated wastewater to the City of Nitro wastewater treatment plant. Pretreatment discharge limits are imposed on the City of Nitro at 1.5 pg/L for dioxin based on a quarterly monitoring frequency. Dioxin has not been detected in any of the samples monitored under this requirement from 1996 to 1998 (however, the method detection limit is 5.6 pg/L). The City of Nitro discharges its treated effluent to the Kanawha River at River Mile 41.

Using the conservative assumptions that the Fike/Artel wastewater contains 1.5 pg/L of dioxin and that all of the dioxin passes through the City of Nitro system, the maximum daily load to the

Kanawha River is 0.82 ug/day, which is less than one percent of the estimated total daily load received by the Kanawha. However, it is more likely that a large portion of any dioxin in the pretreated Fike/Artel wastewater will be tied up in the biological sludge generated in the City of Nitro's wastewater treatment process, thereby reducing the load to the Kanawha River. The current practice of land applying the biological sludge at various farms throughout the valley may need to be re-evaluated.

EPA HSCD is currently in the process of collecting high-volume water samples from various points within the Kanawha River, Pocatalico River, and Armour Creek as well as a select few NPDES outfalls, e.g., Flexsys/Solutia WWTP, Nitro WWTP, PB&S/Kincaid as well as sampling surface water and sediments from approximately 70 point discharges (storm water and permitted outfalls) to assess potential point sources of dioxin to these waterbodies. Until this data is obtained, it is premature to definitely state that the only possible source of dioxin in the area is from the Nitro WWTP.

3.3 NONPOINT SOURCE ASSESSMENT

Nonpoint loadings to surface water can occur via a number of mechanisms: contaminated groundwater or base flow, surface runoff of contaminated soil, diffusion from contaminated sediments in the river, and scouring or resuspension of contaminated sediments. Two categories of nonpoint sources were identified: nonpoint sources originating within the river itself, which includes contaminated sediment, and nonpoint sources which are land based, such as contaminated landfills, that may contribute dioxin loading to the river through contaminated groundwater or surface runoff of contaminated soil. Two tasks were required to complete the nonpoint source assessment: source identification and source quantification.

3.3.1 Source Identification

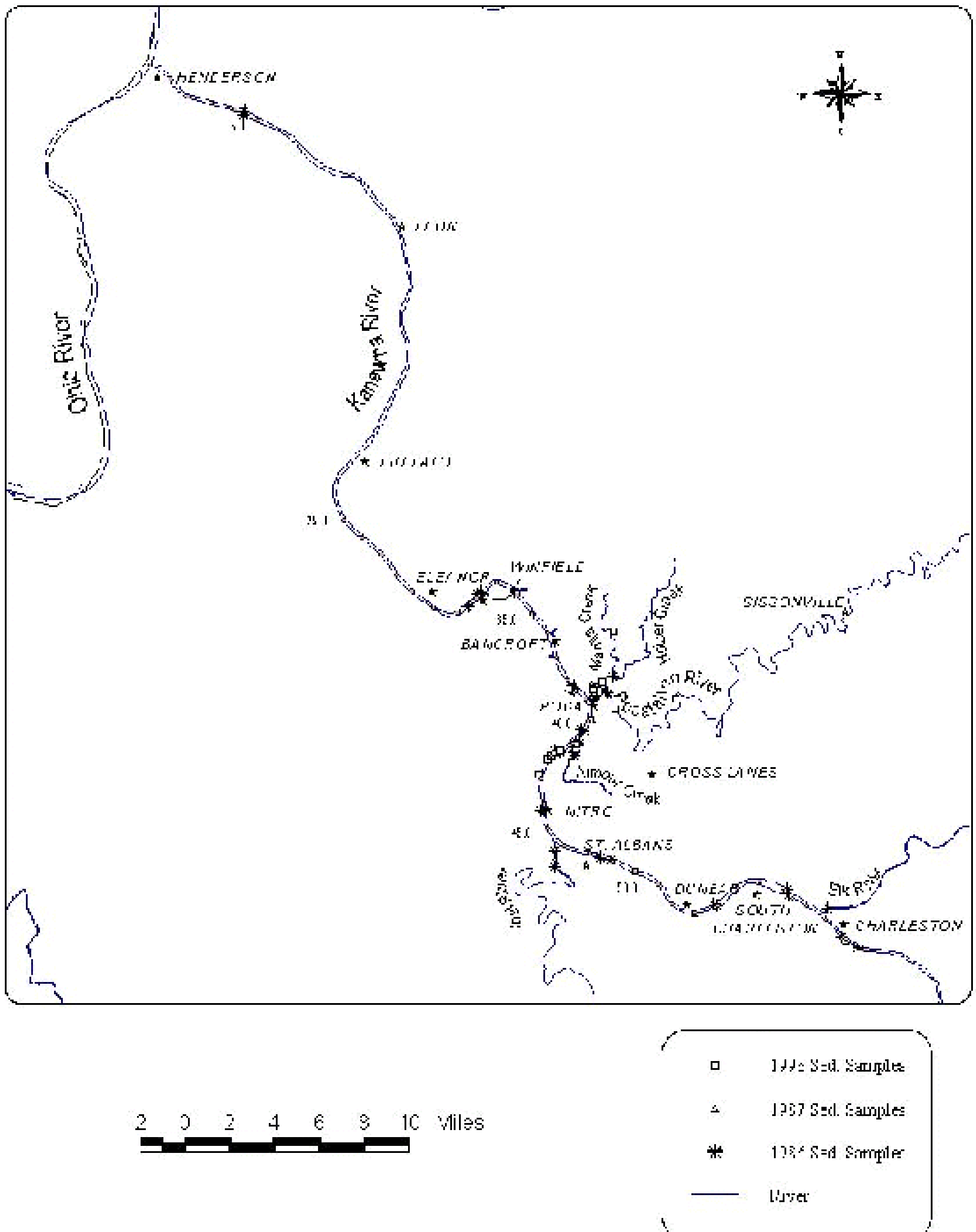
This section describes the data available to identify existing nonpoint sources, and is divided into categories discussing in-place sediments and hazardous waste sites.

In-Place Sediments

The extent and magnitude of contaminated sediment in the Kanawha River, Pocatalico River and Armour Creek were assessed by reviewing the available sediment monitoring data. EPA collected sediment samples in these three systems in 1986, 1987 and 1998. Concentrations of dioxin in the sediment ranged from non-detected to approximately 1600 ng/Kg in the Kanawha, 3000 ng/Kg in the Pocatalico, and 2000 ng/Kg in Armour Creek. Sediment sampling locations for each survey are shown in Figure 3-1. The magnitude of these data indicates that in-place sediments could be a major source of dioxin to the water. EPA conducted sampling in 1998 in response to public concern that four landfills in the area, Armour Creek landfill, Poca Drum Dump, Manilla Creek Dump, and the Heizer Creek landfill, were still actively contributing dioxin to the Pocatalico River and to Armour Creek. Results from this survey indicate that the sediments within the TMDL study area in the Pocatalico River, the Kanawha River and Armour Creek have concentrations of dioxin ranging from non-detect to several thousand nanograms per kilogram. Details of this survey's results are also discussed in the Hazardous Waste Sites section, which specifically discusses the aforementioned landfills.

Sampling by the EPA during 1986 and 1987 attempted to determine the origin of contaminated sediment around the mouths of the tributaries draining into the Kanawha River. The high sediment concentrations near the mouths of the Pocatalico River and Armour Creek could have been the result of deposition of contaminated solids entering these streams upstream of the mouth or the result of contaminated solids from the Kanawha depositing in these areas during low flow periods. Discussions with area consultants and USGS personnel familiar with the flow patterns of the Kanawha River indicate that under low flow conditions, flow in the Kanawha River and its tributaries is almost stagnant, which could allow contaminated solids in the Kanawha to be deposited in the tributaries. Sediment sampling results from 1987 also supported the hypothesis that the contaminated solids from the Kanawha River were being deposited in tributaries (Kanetsky, 1987). Nevertheless, the viability of sources other than the Kanawha River to potentially load dioxin to the Pocatalico River and Armour Creek was assessed.

Figure 3-1. Sediment Sampling Locations



Hazardous Waste Sites

A list of sites that could be potential sources of dioxin loading to the Kanawha River, Pocatalico River and Armour Creek was compiled with input from the WVDEP, EPA Region III and internal investigation. These sites are listed below:

Armour Creek/Solutia Landfill
Clark Property*
Don's Disposal*
Dupont Belle Plant*
Fike Chemical, Inc.
Fleming Landfill*
George's Creek Landfill*
Heizer Creek Landfill
Holmes and Madden Landfill*
Old Avtex Landfill
Landfill adjacent to Midwest Steel/Nitro Landfill
Manila Creek
Flexsys Property
Old Nitro Landfill/Monsanto Dump 1929-1956
Kanawha County Lanfill
Poca Strip Mines/Poca Drum Dump*
South Charleston Landfill*
Union Carbide Plant at Institute*
Western Kanawha Landfill*

*indicates landfills up-watershed of the TMDL study reaches

These sites were researched using three of the EPA's databases for hazardous waste sites: the Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS); Record of Decision System (RODS); and No Further Response Action Planned (NFRAP) database. EPA has categorized sites within its CERCLIS database to one of three lists. List 8T includes all sites that were previously listed as contaminated or were suspected of being contaminated, but have been subsequently cleared of contamination or are no longer suspected of contamination. These sites can also be found in the NFRAP database, indicating that Superfund has completed its assessment of a site and has determined that no further steps will be taken to list that site on the National Priority List. The SCAP 11 list includes all sites/incidents on the Superfund National Priority List (NPL). The SCAP 12 list includes all Superfund sites/incidents that are not on the NPL but have planned or actual remedial/removal activities. Most of the sites in question were on one of these three lists. Table 3-1 lists these identified sites and summarizes currently available information on 2,3,7,8-TCDD contamination at these sites.

Interviews with WVDEP staff, EPA staff and an EPA Superfund consultant were conducted to gather more information about dioxin contaminated sites in the study area. This was followed by a qualitative attempt to assess whether each site is currently contributing a dioxin load to the river by one of the mechanisms cited above.

Research on potential sites was hindered by the fact that several of the landfills/sites have been referred to by various names over the years. Figure 3-2 shows the locations of the identified sites. Table 3-1 contains a summary of the information gathered for each site.

Armour Creek/Solutia Landfill:

The Armour Creek Landfill is operated by Flexsys Corporation (a joint venture between Solutia and Akzo Nobel corporations in Nitro, West Virginia). The site is approximately 45 acres in size and is located north of Nitro along State Route 25 and drains into Armour Creek. The landfill has been under closure since 1994 with no additional disposal since that period (Randy Sovic, WVDEP).

The sediments in Armour Creek were sampled in November 1998 in response to public concern that this landfill was contributing to the persistent dioxin problem in Armour Creek (Pam Hayes, WVDEP Office of Environmental Remediation). No dioxin was detected at the site (soils, surface water and groundwater) though dioxin was detected in nearby soil. This detection of dioxin may not be attributable to the landfill itself. EPA's Removal Program revisited the site in the spring of 1999 for a subsequent round of sampling. Data from this survey are included in summary table 3-1. EPA HSCD will be conducting a Preliminary Assessment (PA) under CERCLA at the site in the summer of 2000.

Clark Property:

The Clark property is approximately 20 acres in size and is located upstream of the TMDL study area near the intersection of State Route 62 and Dutch Hollow Road in Kanawha County. The WVDNR conducted a preliminary assessment of the site in March 1985 and observed leaking and broken containers of several materials, including unspecified herbicides. Soil and water were also contaminated with pesticides and herbicides. In August 1985 a removal action was initiated by the EPA, resulting in the removal of 442 tons of contaminated soils and bulk waste by May 1986. Sampling performed in October 1988 indicated that there was no evidence of off-site migration of any contaminants. The EPA has included this site on its NFRAP 8T list. This site is not believed to contribute a dioxin load to the Kanawha.

Table 3-1. Summary of Dioxin (2, 3, 7, 8-TCDD) Information Available by Site

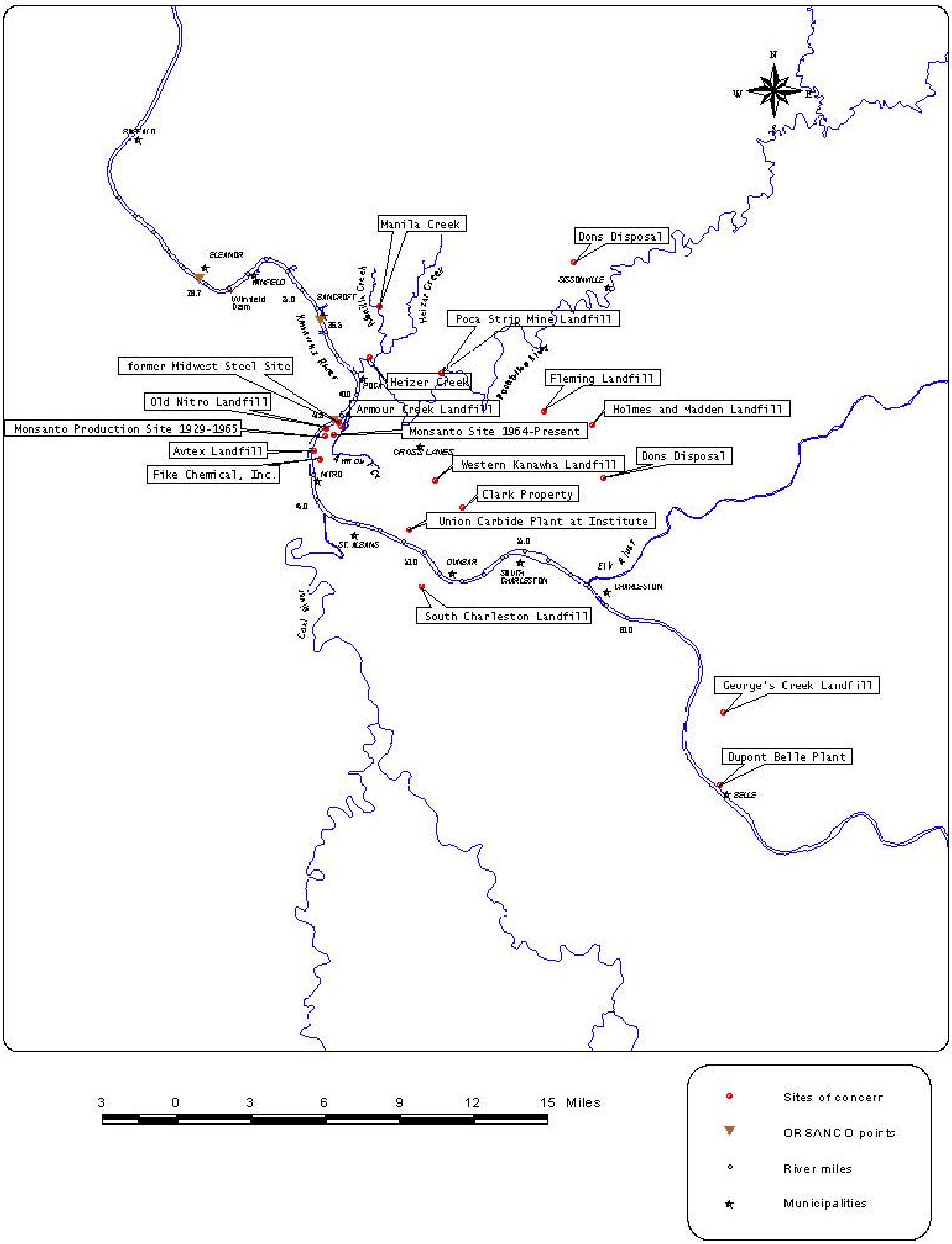
Site Name	Receiving Water	Accepted/Stored Dioxin Material?	Dioxin Detected in Soil on-site?	Conc. (pg/g)	Dioxin Detected in Surface Water on-site?	Conc. (pg/L)	Dioxin Detected in Groundwater on-site?	Conc. (pg/L)	Dioxin Detected nearby (stream or soil)?	Conc. (pg/g or pg/L)	Most Recent Sampling Date
Armour Creek Landfill [1]	Armour Creek	Unknown	No		N/D		N/D		Yes (1998)	17 (nearby soil)	1998
former Avtex Landfill Site [1]	Kanawha River	Unknown	N/D		N/D		N/D		Yes (1998)	0-1,598 (Kanawha sediment)	1998
Clark Property [1,3]	Kanawha River	Unknown	N/D		N/D		N/D		N/D		1988
Don's Disposal [2,3]	Pocatalico River	Unknown	N/D		N/D		N/D		N/D		1981
Dupont Belle Plant [1,3]	Kanawha River	Unknown	No (1983)		Yes (1999)	0-0.10	N/D		Yes (Sediment)	0-0.212 pg/g	1999
Fike Chemical Company [1] (Production Area and WWTP)	Kanawha River	Yes	Yes (1999)	0-14,000	Yes (1993) Yes (1998)	n/a 20.5 (tank near WWTP)	Yes (1993)	n/a	No		1999
Fleming Landfill [2,3]	Pocatalico River	Unknown	N/A		No		N/D		Yes	0-2.2 pg/g	1999
George's Creek Landfill [2,3]	Kanawha River	Unknown but used by Monsanto-1959-1960	N/A		N/D		N/D		N/D		
Heizer Creek Site Landfill [1]	Pocatalico River	Yes (Monsanto-1958-1959)	Yes (1984) Yes (1998)	1,000-3,720 18,325	N/D		N/D		N/D		1998 2000 N/A
Holmes and Madden Landfill [1,3]	Pocatalico River	Unknown but used by Fike Chemical	Yes (1999)	0-63.5	Yes	0-3.4	N/D		Yes	0-2.2 pg/g	1999
Manila Creek Landfill [1]	Pocatalico River	Yes (Monsanto-1956-1957)	Yes (1983) Yes (1999)	3720 22-385 0-767	Yes (1999)	0-1.1	Yes (1999)	Waste: 0 - 170,000 ng/Kg GW: 0 - 1,628	Yes (1999)	5.751 (creek) 0-46.8 pg/g	1999 2000 N/A
former Midwest Steel Site [1]	Armour Creek	Unknown	Yes (1999)	0-36.30	N/D		N/D		Yes (1999)	5.92 (sediment in Armour Creek) 6-123 (soil along railroad line)	1999
Flexsys Property [1] (including WWTP)	Kanawha River	Yes	Yes (1983) No (1999)	100-1,080,000	N/D		Yes (1998)-kerosene layer only	313.6	Yes (1998)	0-1,598 (Kanawha sediment)	1999 (area near WWTP)
Nitro Landfill [2]	Armour Creek	Unknown	N/D		N/D		N/D		Yes (1998)	17 (nearby soil)	
Old Nitro Landfill/Monsanto Dump (1929-1956) /Nitro Sanitation Landfill [2]	Kanawha River	Unknown but used by Monsanto-1929-1956	N/D		N/D		N/D		Yes (1998)	0-1,598 (Kanawha sediment)	Kanawha County Landfill [2]Kanawha RiverUnknown but possibly used for wastes from MonsantoYes (1985) only 1 sampleN/DN/DN/DN/D1985
Poca Strip Mine Pits/Poca Drum Dump/Nitro City Dump/Poca Landfill/Putnam County Drum Dump [2,3]	Pocatalico River	Yes (Monsanto-1959-1960)	No	0	N/D		N/D		N/D		
South Charleston Landfill [2,3]	Kanawha River	Unknown but used by Monsanto-1961-1964	Yes	0-92	Yes	0-0.4	N/D		Yes	0-24 pg/g	1999

Site Name	Receiving Water	Accepted/Stored Dioxin Material?	Dioxin Detected in Soil on-site?	Conc. (pg/g)	Dioxin Detected in Surface Water on-site?	Conc. (pg/L)	Dioxin Detected in Groundwater on-site?	Conc. (pg/L)	Dioxin Detected nearby (stream or soil)?	Conc. (pg/g or pg/L)	Most Recent Sampling Date
Union Carbide Plant @ Institute [3]	Kanawha River	No	No (1983)		N/D		N/D		N/D		1983
Western Kanawha Landfill [2,3]	Kanawha River	Unknown	No (1980)		N/D		N/D		N/D		

N/D = Not Determined
N/A = Not Available

[1] = Cited as potential concern by EPA
[2] = Cited as potential concern by WVDAP
[3] = Not within TMDL Study Area

Figure 3-2. Location of Potentially Contributing Landfill Sites



Don's Disposal:

Both locations of Don's Disposal are located upstream of the 2-mile TMDL study reach of the Pocatalico River. The WVDEP initially identified this site as a potential source, although subsequent conversations indicate that the active site accepts municipal waste only (Sudhir Patel, WVDEP Office of Waste Management). The second location for Don's Disposal, now inactive, may have accepted some chemical wastes prior to closing. The site was evaluated as a CERCLIS site in 1981 and has been placed on the NFRAP 8T list. It is not believed to be contributing a dioxin load to the Pocatalico River. Results of recent sampling conducted in July 1999 are awaited. EPA HSCD will be reviewing (Preliminary Assessment) available site file information in summer 2000 to determine if any further reassessment of the site is necessary.

DuPont Belle Plant:

DuPont Belle plant was used for the disposal of organic and inorganic waste materials from 1926-1977. The site is located on the Kanawha River near Belle West Virginia upstream of the TMDL area. A preliminary assessment and site inspection were complete in the mid-1980's as part of a CERCLIS evaluation. Samples collected from the site initially indicated the presence of dioxin. However, the subsequent reanalysis of these samples using a dioxin - specific protocol did not detect dioxin. The EPA has archived this site to it NFRAP 8T list. In 1999 HSCD collected samples from the surface waters and sediments from the Kanawha River and Simmons Creek upstream from, adjacent to and downstream from the facility. At this time, it would appear dioxin (TEQs) levels upstream of the DuPont Belle Facility are similar to dioxin levels adjacent to and downstream of the facility. Only one water sample (out of eight samples taken) showed any detectable level of 2,3,7,8- TCDD (at an estimated level of 0.1 pg/L) and a duplicate sample taken at the same location at the same time showed not detectable level of 2,3,7,8-TCDD.

Based on 1999 data no dioxin "hot spots" in the area of the DuPont Belle facility have been identified . EPA will be conducting a study to determine background levels of dioxin in the Kanawha River area. This study will help to further identify whether areas of elevated dioxin contamination exist in the area.

Fike Chemical Co.:

The Fike Chemical site, located in Nitro, West Virginia, consists of an 11-acre parcel used to produce custom chemicals and a one-acre parcel containing a treatment plant which treated stormwater and wastewater generated at the plant. The site was placed on the EPA's National Priority List in 1983 and is identified in the CERCLIS database on their SCAP11 list. The EPA's Superfund at Work publication characterized the site as follows: "The site contamination is extensive. The groundwater, surface water and soil contain a variety of volatile organic compounds, dioxin, and PCBs (polychlorinated biphenyls). The Kanawha River is contaminated as well." (EPA520-F-93-010, Summer, 1993).

The hazards posed by the materials were addressed through a series of removal actions and RODs (records of decision) that began in 1988 and were completed in 1997 by the EPA and the responsible parties. The EPA is currently conducting an investigation to determine the extent of contamination in soils and groundwater (Mark Slusarski, WVDEP Office of Waste Management; Kate Lose, EPA). Approximately 40 on-site surface soil samples were collected and analyzed for dioxin in early 1999. Most of the samples revealed low levels of 2,3,7,8-TCDD (Kate Lose, EPA). No 2,3,7,8-TCDD was detected in the single 1999 sample analyzed for dioxins. A final remedial action is expected to be selected and completed in the next four years.

Until remediation begins, all surface runoff from the 11 acre portion of the site is contained by berms, treated at a new (1996) on-site treatment plant, and released to the city of Nitro's sewer system (Mark Slusarski, WVDEP Office of Waste Management). There is a less than one acre portion of the site, where the surface water is not treated. The on-site wastewater treatment plant has a permit limiting the concentration of 2,3,7,8-TCDD to 1.5 pg/L. The detection limit for 2,3,7,8-TCDD is 5.6 pg/L. Effluent samples taken quarterly to date have been non-detect. In turn, the facility is considered to be in compliance at a non-detect level (Kate Lose, EPA).

Prior to the operation of the waste water treatment plant, surface run-off from the site was either treated and discharged via the old Cooperative Sewage Treatment Plant (CST) or other drainage to the Kanawha River. There is a possibility that both of these old sources contained dioxin contaminated surface water and acted as both point and nonpoint sources. The CST plant was decommissioned in March 1997 (Kate Lose, EPA). Because remedial actions at the site are not complete, the Fike Chemical site may be a source of dioxin load to the Kanawha River.

This site was sampled twice recently in June and October of 1999. Analytical results from these sampling surveys are included in summary table 3-1. EPA HSCD will also be conducting a sampling assessment of stormwater sewers in the Nitro, WV area in summer 2000. Sampling will include collection of sediment and surface water from drainages used by the old CST.

Fleming Landfill:

The Fleming landfill drains to the Pocatalico River, although it is located upstream of the 2-mile TMDL study reach. This site was identified as a possible source by the WVDEP. The EPA and WVDNR evaluated the site in 1985 and archived it on the NFRAP 8T list. Conversations with an official in the WVDEP Office of Waste Management (Sudhir Patel, WVDEP Office of Waste Management) indicate that this landfill is currently operating as a municipal landfill. Because there is no direct evidence of dioxin contamination, this site is not believed to be a source of dioxin loading to the Pocatalico River. Results of sampling conducted in September 1999 are included in summary Table 3-1. EPA HSCD will be reviewing (Preliminary Assessment) available site file information in fall 2000 to determine if any further reassessment of the site is necessary.

George's Creek Landfill:

George's Creek landfill is located upstream of Charleston near Malden, West Virginia. It drains to George's Creek, which then feeds into the Kanawha River, but upstream of the TMDL study area. George's Creek landfill accepted waste from Monsanto from 1959-1960 (Eckhardt survey, ca. 1977). It is not known if the Monsanto waste contained dioxin. There is no direct evidence of dioxin contamination at this site. EPA and WVDEP conducted a preliminary assessment in 1980 and put the site on its NFRAP 8T list. EPA's Removal Program visited and sampled this site for off-site migration of dioxin contaminated soils in the spring of 1999. The results of this survey are included in summary Table 3-1. In addition, EPA's Hazardous Site Cleanup Division's Site Assessment Program will review the "No Further Response Action Planned" (NFRAP) determination for this site. Based upon the sample results and NFRAP review, EPA will determine whether any additional assessment work or cleanup should be performed. Results of sampling conducted in July 1999 are included in summary Table 3-1. EPA HSCD will be reviewing (Preliminary Assessment) available site file information in fall 2000 to determine if any further reassessment of the site is necessary.

Heizer Creek Landfill:

Heizer Creek Landfill is located northeast of the town of Poca and drains to the Pocatalico River within the 2-mile TMDL study reach. The one-acre landfill was owned and operated by the City of Nitro from the late 1950s to the early 1960s (EPA Site Inspection Report, 1985). Monsanto Company disposed of approximately 170,000 cubic feet of unknown plant trash and wastes from 1958 to 1959, which may have included 2,4,5-T-manufacturing wastes and floor sweepings (EPA Site Inspection Report, 1985). Wastes were also burned at this landfill. A preliminary assessment and site inspection completed in the mid-1980s revealed dioxin-contaminated soil in the range of less than 1 to 3.72 parts per billion (ppb) (WVDEP Site Investigation & Response, date unknown). In 1987, Monsanto removed several drums of contaminated soil (EPA Removal Response Section Trip Report, 1998). The Removal Action Level is 1.0 parts per billion.

The sediments in Heizer Creek and the Pocatalico River were sampled in November 1998 in response to public concern that this landfill was contributing to the persistent dioxin problem in the Pocatalico River (Pam Hayes-WVDEP Office of Environmental Remediation). Although the site has been archived on the EPA's NFRAP 8T list, EPA HSCD team sampled an ash pile on the site in 1998 and discovered that it was contaminated with approximately 18 ppb of dioxin. Based on this result, it appears that surface runoff of contaminated soil from this site could be a source of dioxin loading to the Pocatalico River. Data from recent sampling surveys conducted in 1999 are included in summary table 3-1. The site is currently undergoing a potentially responsible party (PRP) lead removal action under a consent order. Dioxin contaminated soil will be removed to 1 ppb (TEQ). EPA HSCD also conducted a CERCLA Site Inspection at the site in May 2000 and is currently awaiting the results of the sampling event. EPA HSCD will determine future remedial actions at the site pending receipt of the SI data and site conditions upon the removal action.

Holmes and Madden Landfill:

This landfill is a five acre inactive facility located approximately 5 miles north of Charleston, West Virginia. From 1970 until its closure in 1975, the facility operated as a nonpermitted landfill receiving industrial, municipal, and hospital wastes from the surrounding area.

EPA HSCD is currently awaiting a health consultation by the Agency for Toxic Substance and Disease Registry (ATSDR) on data collected at the site in September 1999 before determining what future actions, if any are necessary at the site. While the report does indicate that the site could be a minor source of dioxin to the Pocatalico River, it is doubtful that the site could even be a minor source of 2, 3, 7, 8- TCDD in consideration of the small amount of 2, 3, 7, 8- TCDD (3.77 ppt) and distance to the waterway (5 miles). Closer evaluation of the sample results indicate that heptachlorodibenzodioxin (H_pCDD) and octachlorodibenzodioxin (OCDD) congeners were found in the highest concentration. The presence of these dioxin congeners are often associated with open burning activities. The site inspection report for the site acknowledges that the sample exhibiting the highest dioxin TEQ (63.5 ppt) and 2, 3, 7, 8- TCDD (3.77 ppt) concentration was located in close proximity to a residential burning area. The SI report also indicates that due to local area topography, it is unlikely that dioxins would travel from the Site to the water body in which this sample was collected. Based on this data and observations, the site is not a likely source of dioxins to the Pocatalico River.

Avtex Landfill:

The old Avtex Landfill site is located on a portion of property owned by PAR Industrial Corporation in Nitro, Putnam County, WV. The site encompasses 10 acres and is located in an industrial area. Included within the site is a landfill and a subsurface drainage system that eventually drains into the Kanawha River. This site was referred to EPA HSCD by WVDEP in Fall 1999 as a potential disposal area which may contain dioxin contaminated wastes. EPA HSCD conducted a CERCLA PA in January 2000 which recommended further assessment of the site. EPA HSCD anticipates conducting a sampling SI at the site in Summer 2000 and will determine what further actions if any are necessary at the site based upon that information.

Landfill Adjacent to Midwest Steel (Nitro Landfill):

The Midwest Steel and 20-acre adjacent landfill are located in Nitro, West Virginia and drain to Armour Creek. According to officials at WVDEP, this site was used by the City of Nitro and called the Nitro Landfill (Steve Stutler, WVDEP Office of Water Resources). Monsanto, the city of Nitro and FMC used this site to dispose of hazardous and nonhazardous waste from approximately 1954 until approximately 1974 (Tetra-Tech Site Inspection Report, date unknown). Although PCBs were detected at this site, it is not known if the waste contained dioxin. It has been mentioned anecdotally as a possible source of dioxin loading to Armour Creek, although no dioxin sampling has been done at the site (Perry Gaughan, Roy F. Weston). EPA's Removal Program sampled the site in spring 1999. The results are included in summary table 3-1. EPA HSCD will be conducting a sampling assessment (SI) at the site in fall 2000 to further characterize potential migration of dioxin from the site to Armour Creek.

Former Midwest Steel Site:

This site is located north of the Armour Creek Landfill along State Route 25 in Nitro, Putnam County, West Virginia. The Kanawha River flows along the northwest edge of the property and Armour Creek is located northeast of the site. During the mid 1990s EPA entered into a consent agreement with owners of Midwest Steel to clean up PCB and heavy metal contamination from the site. Cleanup activities were completed in 1996. No dioxin sampling was conducted as part of that cleanup effort. Four samples collected in 1998 showed soils contaminated at levels ranging from 0.19 to 128.88 pg/g. A further round of sampling was conducted in May 1999. In this round 11 of 14 samples detected 2,3,7,8-TCDD at levels ranging from 5.92 to 123 pg/g. 2,3,7,8-TCDD was non-detect at the remaining three samples. Surface runoff from this site is a likely contributor of dioxin to the Kanawha River and Armour Creek. EPA HSCD will be conducting a sampling assessment (SI) at the site in fall 2000 to further characterize potential migration of dioxin from the site to Armour Creek.

Manila Creek Landfill:

The Manila Creek Landfill is approximately 0.5 acres in size and is located in Putnam County, West Virginia. It drains to Manila Creek, which then drains into the Pocatalico and is within the 2-mile TMDL study reach. The site was closed over 30 years ago. Monsanto Company used the site for disposal from 1956-1957 to dispose of general organic waste (Eckhardt survey, ca. 1977). A site inspection in 1983 revealed the presence of dioxin at approximately 3.7 parts per billion (ppb) in one of the surface soils. Nineteen samples collected in September, 1984 revealed 2,3,7,8-TCDD concentrations ranging from zero to 57.2 ppb. EPA and Monsanto entered a Consent Agreement in April, 1987 that called for Monsanto to dewater the landfill, block off an underground seep and to cap and fence the landfill. EPA is not aware of sampling of monitoring wells installed at the site by Monsanto.

The sediments in Manila Creek and the Pocatalico River were sampled in November 1998 in response to public concern that this landfill was contributing to the persistent dioxin problem in the Pocatalico River (Pam Hayes-WVDEP Office of Environmental Remediation). The results from this sampling revealed some potential off-site migration of dioxin contaminated soils. A subsequent round of sampling was conducted in September 1999 and revealed contamination of soils and groundwater at the site. The soil samples ranged from 0-385 pg/g TCDD. Groundwater sampling revealed dioxin concentrations ranging from 197 to/1,470 pg/L. These reported results are from water collected from monitoring wells installed within the waste layer at the landfill. The creek sediments are also contaminated in this region (0-38 pg/g TCDD).

In the three sediment samples collected downstream of the site TCDD was detected in only one sample at concentration of 2.22 pg/g. While the site can definitely be considered a potential source of dioxin, further sampling is required to determine whether dioxin is migrating from the site. EPA HSCD conducted an Expanded Site Investigation (ESI) at the site in May 2000 which included installation of four (4) off-site groundwater monitoring wells and collection of additional soil, sediment, surface water and groundwater samples to determine if dioxin and other contaminants are migrating off-site. EPA will determine what actions, if any are necessary upon receipt of the data.

Flexsys Property:

Flexsys' Nitro plant is located just north of the city of Nitro along the east bank of the Kanawha River. Part of the site was used (under the ownership of Monsanto) for the production of 2,4,5-T from 1948 until 1969 (Final Report, NUS, 1993). The soils in the area around the production facility were contaminated with dioxin, as was the area near the treatment plant, which was constructed over demolition debris from the production area (Final Report, NUS, 1993). EPA issued a Removal Order to Monsanto, which completed the work around 1986-1987 (Martin Kotsch, EPA RCRA Project Manager). The available detection limit for cleanup was approximately 1 ppb (Martin Kotsch, EPA RCRA Project Manager).

Groundwater beneath the former production facility was discovered to be contaminated with kerosene. Analysis of the kerosene layer indicates that there is some dioxin contamination in the kerosene. Solutia, under a joint Flexsys/Solutia corrective action permit, has been using a skimmer pump to remove the kerosene from the groundwater, which is contaminated with dioxins. The kerosene that is removed is then stored in drums until a sufficient quantity is collected before it is sent off site for disposal. The pumping action will continue until such time that the kerosene is either removed or concentrations fall below a health based risk level (Martin Kotsch, EPA RCRA Project Manager). Since a Notice of Violation issued by WVDEP is pending resolution the facility may no longer be removing the dioxin contaminated kerosene.

Badly deteriorated drums containing dioxin were recently discovered on land that had been sold to a real estate development company called AES (Ken Ellison/Pam Hayes, WVDEP).

This part of the facility was formerly owned by Monsanto and then Solutia. The drums were excavated and placed in overpacks for removal (Ken Ellison/Pam Hayes, WVDEP). Solutia has suggested that the drums were accidentally buried during the removal activities initiated under Superfund. Although Solutia is currently addressing this situation, this site may be a source of dioxin loading to the Kanawha River. EPA HSCD is currently in the process of negotiating a consent order with Solutia to address the removal of drums and dioxin contamination at this part of the facility.

Old Nitro Landfill//Monsanto Dump:

This landfill is located near the AES/Solutia property next to the Kanawha River. Part of it was used for the bridge of I-64 over the Kanawha River (Martin Kotsch, EPA RCRA Project Manager). The Eckhardt survey from the mid-1970s indicates that Monsanto had a dump near this location that was used from 1929-1956. Conversations with the WVDEP indicate that this landfill may also have been referred to as Nitro Sanitation Landfill (Steve Stutler, WVDEP Office of Water Resources) and "Monsanto-Old Landfill". The landfill has been capped and is no longer in use. There were two very high Kanawha River sediment sample dioxin results near this landfill in the 1998 sampling survey. EPA will determine if any additional assessment or cleanup is required at this site based on assessments conducted in October 1999. The sampling targeted drainage pathways at the site. The results are included in summary table 3-1. EPA HSCD will be conducting a PA of the site in Summer 2000 to determine if any further assessment of the site is necessary.

Kanawha County Landfill:

The site is an 14-acre inactive municipal landfill which operated from 1947 to 1970. This site was brought to EPA's attention by WVDAP in Fall 1999, but is not listed as a potential source of dioxin of the Kanawha River. WVDAP was concerned that wasted from Monsanto has been deposited in the landfill and requested that the site be assessed as a potential source of dioxin to the Kanawha River. It was alleged by a former employee that the landfill accepted drums and containers of hazardous waste and buried them on-site. WVDEP conducted a PA and SI at the site in 1984. No containers or drums were observed. EPA conducted a t dioxin screening assessment at the site in 1985. Dioxin was detected in only one (1) sample. EPA conducted a subsequent dioxin sampling event in 1985 focusing on the area of the previous positive hit for dioxin. All samples in this subsequent sampling event were negative for dioxin. EPA HSCD will be conducting a sampling SI at the site in Summer 2000 to reassess the site based upon current site conditions.

Poca Strip Mine Landfill/Putnam County Drum Dump/Nitro City Dump/Poca Landfill:

The Poca Strip Mine Landfill is located approximately 3 miles east of Poca, West Virginia and drains to the Pocatalico River, although it is outside of the 2-mile TMDL study reach. The site was used by the City of Nitro, FMC Corporation, Ohio Apex, and Monsanto Chemical Company from 1962-1963. A hazardous waste survey completed by Monsanto shows that the site was also utilized in 1959-1960 for open drummed hazardous waste and uncontained hazardous wastes (Preliminary Assessment Report, WVDNR, 1984). Open burning of wastes at the site also occurred.

Investigations by both EPA and Monsanto from approximately 1983-1985 revealed the presence of dioxin at the site. Monsanto entered into a Consent Agreement in 1986 to conduct a remedial investigation to determine the extent of dioxin contamination, to clean up the dioxin contamination and to cap the landfill. These activities were completed in the late 1980s (EPA Removal Response Section Trip Report, 1999). The EPA has archived this site on its NFRAP 8T list.

However, the sediments in the Pocatalico River were sampled in November 1998 in response to public concern that this landfill was contributing to the persistent dioxin problem in the Pocatalico River (Pam Hayes, WVDEP Office of Environmental Remediation). The results of this sampling did not reveal any off-site migration of dioxin contaminated soils. EPA will determine if any additional assessment or cleanup is required based on an analysis of the most recent sampling (May 1999). These results are included in summary table 3-1. EPA HSCD will be reviewing (PA) available site file information in Fall 2000 to determine if any further reassessment of the site is necessary.

South Charleston Landfill:

This landfill is located west of the Kanawha River off of Route 12 in Kanawha County, West Virginia. The site is approximately 30 acres and has been inactive since the mid-1970s. Records indicate that this site was used by Monsanto Corporation, Union Carbide Corporation, and the city of South Charleston for the disposal of hazardous and non-hazardous wastes from approximately 1949 until 1972 (Tetra-Tech Site Inspection Report, 1993). The Eckhardt report indicates that Monsanto used the site from 1961-1964. Although samples were collected as part of the site inspection, there is no mention of dioxin being detected. The site has been archived by the EPA on the NFRAP 8T list. It is not believed that this site is a source of dioxin loading to the Kanawha River. Results of sampling conducted in September 1999 are included in summary table 3-1. EPA HSCD is currently awaiting a health consultation by the Agency for Toxic Substances and Disease Registry (ATSDR) on data collected at the site in September 1999 before determining what future actions, if any are necessary at the site.

Union Carbide Plant at Institute:

The Union Carbide Plant is located near the Kanawha River in Institute, West Virginia, which is upstream of the TMDL study reach. Because this site was known to have handled 2,4-dichlorophenol (which can react to form dioxin), a dioxin sampling survey was conducted in 1983. Results of those analyses revealed no evidence of dioxin contamination at this site (NUS Site Inspection Report, 1983). It is not believed that this site is a source of dioxin loading to the Kanawha River. Results of new sampling conducted in October 1999 are included in summary table 3-1. EPA HSCD will be reviewing (PA) available site file information in Fall 2000 to determine if any further reassessment of the site is necessary.

Western Kanawha Landfill:

This landfill is located east of Nitro, West Virginia and is currently operating as a municipal landfill (Sudhir Patel, WVDEP Office of Waste Management). It was evaluated under CERCLIS in 1980 and reevaluated in 1986 by the state and placed on the EPA's NFRAP 8T list. A copy of the preliminary assessment and site inspection reports have been requested for this site but currently it is not believed that this site is contributing a dioxin load to the Kanawha River. Results from sampling conducted in July 1999 are included in summary table 3-1.

3.3.2 Source Quantification

Dioxin originating from nonpoint sources can enter a river in several ways: through contaminated groundwater, surface runoff of contaminated soil, diffusion from contaminated sediments in the river and scouring or resuspension of contaminated sediments. The magnitudes of these processes were estimated using the available data and literature values.

Contaminated Groundwater

The ORSANCO water quality data show an increase in water dioxin concentration downstream at RM 41.3, relative to the upstream boundary at RM 45.5. The increase in concentration occurs even at the lowest flows. This loading is assumed to be attributable to contaminated groundwater entering the Kanawha River near this area, due to the absence of any other known sources. It is recognized that, in the absence of organic solvents, dioxin has very low solubility in water and would not normally be expected to be present in significant quantities in groundwater. Given the heavily industrialized nature of the area and past presence of groundwater contamination, it is quite plausible that dioxin is in solution with contaminated groundwater moving as base flow. An estimate of the dioxin load from the groundwater was made using a mass balance between the upstream boundary water concentration (RM 45.5) and the most upstream ORSANCO sampling station (RM 41.3) as follows:

$$W_{gw} = [(C_{downstream} * Q_{Kanawha}) - (C_{upstream} * Q_{Kanawha})] * 2.447 \qquad (3\text{-}1)$$

where

W_{gw} = dioxin load from the groundwater, ug/day
$C_{downstream}$ = dioxin concentration measured at RM 41.3, pg/L
$Q_{Kanawha}$ = Kanawha River flow cfs
$C_{upstream}$ = dioxin concentration estimated at RM 45.5, pg/L

2.447 = unit conversion factor

Kanawha River flows were estimated using data and empirical equations provided by the USGS (Ron Evaldi, USGS). Equation 3-1 was applied for each of the ORSANCO data values collected at RM 41.3, and assuming that the upstream concentration was constant at the only measured value of 0.009 pg/L. Application of Equation 3-1 using the available data is shown in Table 3-2, an average dioxin groundwater load of 3324 ug/day.

It is noted here that data on groundwater concentrations of dioxin is extremely limited. Thus the observed increases in the surface water concentrations could also arise from as yet, unidentified point sources in the area, as well as from contaminated ground water.

Table 3-2. Groundwater Loading Calculation

Date	**Kanawha River Flow (cfs)**	**RM 41.3 Dioxin Concentration** (pg/l)	Back-Calculated Dioxin Mass Load (ug/day)
6/9/98	9160	0.123	2707
7/21/98	5479	0.340	4429
10/27/98	2878	0.412	2836

Contaminated surface erosion

The Heizer Creek landfill, the Manila Creek landfill, and the Midwest Steel site have been identified as sites that could contribute dioxin load to the TMDL study areas by surface erosion of contaminated soil. The magnitudes of these loads were estimated using the Universal Soil Loss Equation (USLE). This is an empirical equation that will predict the average annual soil loss by sheet and rill erosion from source areas. The equation is (Wischmeier and Smith, 1978):

$$X = E * K * ls * C * P \tag{3-2}$$

where

X = soil loss, in tons/acre/year
E = rainfall/runoff erosivity index (10^2 m-tonne-cm/ha-hr)
K = soil erodibility (tons/acre per unit of E)
ls = topographic factor, unitless
C = cover/management factor, unitless
P = supporting practice factor, unitless

The Soil Conservation Service in the Capital district supplied values for the Heizer Creek landfill site, which are: E = 150, K = 0.32, ls = 10, and C = 0.038. P is assumed to be 1.0 in the absence of specific erosion control practices. The USLE predicts that the total amount of soil lost due to erosion is 18.24 tons/acre/year or 16,550 kg/acre/year. This value was also applied for the Manila Creek and Midwest Steel sites.

The total annual dioxin loading is estimated by multiplying the annual amount of soil erosion by the average concentration of dioxin in the soil. For Heizer Creek, assuming that the contaminated area covers 10% of the landfill, this results in an annual dioxin loading of 30,000 ug/year. Converting to a daily basis, this works out to 82 micrograms of dioxin loaded to the Pocatalico per day. While the units for loading are listed as ug/day, it should be noted that this is based on an annual loading rate and significant day to day variations occur. For Manila Creek, based on an average concentration of 305 pg/g for duplicate samples taken on the southern boundary of the landfill and an estimated 0.1 acres of area between the landfill and the receiving water, 1.38 ug/day of dioxin is estimated to be loaded to the Pocatalico River. For the Midwest Steel site, based on an average concentration of 19.15 pg/g for five samples and an estimated 5 acres of area, 4.34 ug/day of dioxin is estimated to be loaded into Armour Creek.

The dioxin loading due to contaminated surface erosion at the three identified sites are rough estimates at best because they are based upon very few biased sampling points. Sampling conducted at these sites are biased towards finding hot spots of contamination, therefore the average dioxin concentration values used for these sites to determine the dioxin load from each site is possibly overestimated considering the actual average concentration of dioxin present in surface soils at these sites is much lower.

In-Place Sediment Diffusion:

The contribution of dioxin to the water column attributable to diffusion from the contaminated river sediment was estimated for three reaches of the TMDL study area: the Kanawha from RM 45.5 to RM 42.25, the Kanawha from RM 42.25 to RM 39 (the confluence of the Pocatalico), and the Kanawha from RM 39 to the mouth. The net diffusive flux from the sediment to the water column was calculated at each sediment sampling location within a reach, then calculating an average net diffusive flux for the reach area.

Sediment percent moisture data, typical literature values for density and fraction organic carbon, and guidance from EPA (EPA, 1995) were used to estimate the fraction of the sediment bed contamination in the dissolved phase according to the equation:

$$\text{Dissolved bed fraction} = 1/(1 + (D_d * k_{ow} * (f_{oc}/N)) \qquad (3\text{-}3)$$

where

D_d = dry bulk density = $(D_s * D_w) / [(D_w + D_s * (\% \text{ moisture} / \%\text{dry}))]$
D_s = density of the solids, assumed at 2.5 gm/cm^3
D_w = density of water, assumed at 1.0 gm/cm^3
k_{oc} = organic carbon partitioning coefficient for dioxin = $k_{ow} = 10^{7.02}$
f_{oc} = fraction organic carbon, assumed to be 0.01
N = porosity = $[(1-D_d)/D_s]$

For this analysis, the assumption was made that k_{oc}, the organic carbon partitioning coefficient for dioxin can be approximated by k_{ow}, the octanol-water partitioning coefficient.

The concentration of dioxin in the pore water was estimated from the sediment dioxin concentration using the following equation:

$$C_{pw} = C_{sed} * D_d * DBF * 1000 \qquad (3\text{-}4)$$

where

C_{pw} = pore water dioxin concentration, pg/L
C_{sed} = measured sediment dioxin concentration, ng/kg
D_d = dry bulk density, gm/cm^3
DBF = dissolved bed fraction as calculated in Equation 3-3

The diffusion velocity from the sediment pore water to the overlying water column was estimated using the equation:

$$k_L = [(D_{eff} * 86{,}400) / (100*(H_2/2))] \qquad (3\text{-}5)$$

where

k_L = diffusion velocity, m/day
D_{eff} = effective diffusion constant, cm^2/s, = $(D_m * N^2 * MEF)$
Dm = molecular diffusion constant, cm^2/s
= $(1.326*10^{-4})*(S_w^{-1.14})*(MW^{-0.589})$
S_w = viscosity of water = 1.002 (20^{o}C)
MW = molecular weight = 321.97
N = porosity
MEF = mixing enhancement factor associated with bioturbation, assumed = 10
H_2 = active bed depth, cm, assumed = 5

The average diffusive velocity calculated as 0.006 m/day and was based on 108 data points.

The mass flux of dioxin from the sediment pore water to the overlying water column, in pg/m^2/day, was estimated using the pore water dioxin concentration, the porosity of the sediment and the (sample specific) diffusive velocity in the following equation:

$$\text{flux} = C_{pw} / (N * 1000 * k_L) \qquad (3\text{-}6)$$

The fluxes ranged from 0.088 pg/m^2/day to 369.4 pg/m^2/day. This range in values is reflective of sediment data that had dioxin concentrations greater than the detection limit. To correct for this high bias, the calculated fluxes were adjusted by the ratio of number of sediment results with positive dioxin concentrations (47) to the total number of samples analyzed for dioxin (108). The average flux in reach one, from RM 45.5 to RM 42.25 was assumed to be zero as there were no detectible dioxin measurements. In reach two, from RM 42.25 to RM 39, the flux was calculated to be 6.21 pg/m^2/day. In reach three, from RM 39 to the mouth, the flux was calculated to be 0.435 pg/m^2/day.

The mass flux of dioxin from the water column to the sediment pore water or "back diffusion", in pg/m^2/day, can be estimated in a similar fashion using the water quality standard as the water column dioxin concentration:

$$flux = k_L * C_{H2O} * f * 1000 \quad (3\text{-}7)$$

where

C_{H2O} = water column concentration, assumed = 0.014 pg/L
f = fraction of dioxin in the water column in the dissolved state, assumed = 0.10
1000 = conversion factor

The back diffusion was calculated to be 0.008 pg/m^2/day. This value is negligible in comparison to the flux from the sediment to the water column and can be ignored. Thus, the sediment to water flux is representative of the net diffusive mass flux in the system.

The overall mass loading to the water column due to diffusive mass flux can be calculated from the area of the sediment bed for each reach. The results of the calculation used to estimate the diffusive flux are summarized below in Table 3-3.

Table 3-3. Mass Flux Calculation for Sediment Porewater Diffusion

Reach	**Upstream River Mile**	**Downstream River Mile**	**Surface Area (m^2)**	**Avg. net diffusive flux** (pg/m^2/day)	Mass loading (ug/day)
1	45.5	42.25	$1.33x10^6$	0	0
2	42.25	39	$1.34x10^6$	6.206	8.3
3	39	0	$1.45x10^7$	0.435	6.3

In-Place Sediment Resuspension

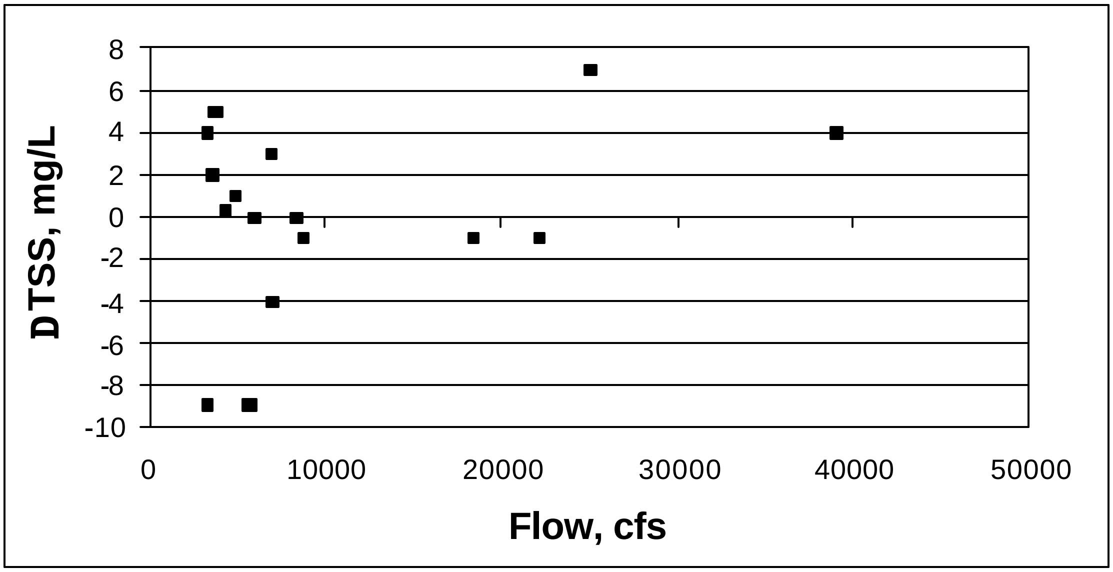
The final nonpoint source category to be quantified is resuspension of contaminated in-place sediments. Existing loading rates in the Kanawha were estimated by combining two data sources:

Observed downstream increases in Kanawha River total suspended solids (TSS) data, used to empirically estimate sediment resuspension as a function of river flow;

Observed Kanawha River sediment dioxin concentrations.

The historical water quality database was examined to define the synoptic sampling events that collected TSS data along the length of the TMDL segment. Three locations were found to have multiple observations, corresponding to St. Albans (RM 46.1), Winfield Lock and Dam (RM 31.1), and Point Pleasant (RM 1.3). These three locations allowed separate analyses to be conducted for the segments upstream and downstream of Winfield Lock and Dam.

Figure 3-3 displays the downstream increase in observed TSS concentrations (i.e. TSS at RM 31.1 – TSS at RM 46.1) for the segment upstream of Winfield Lock and Dam. No statistically significant increase in TSS was observed for any range of flows for this segment, and



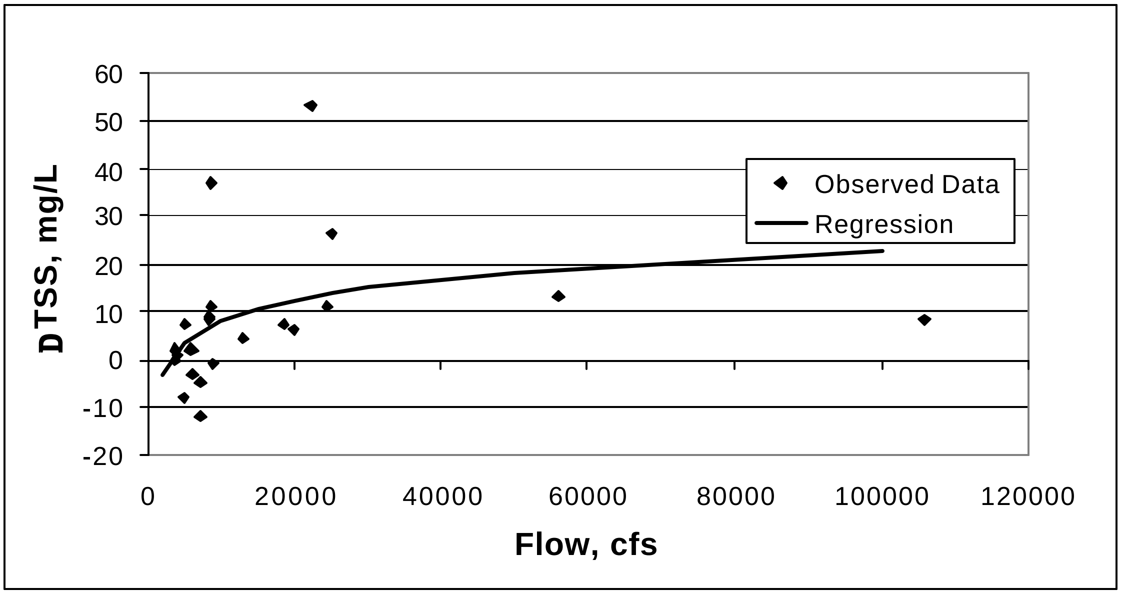
resuspension was deemed to be an insignificant component of the solids budget (for purposes of a screening-level estimate).

Figure 3-3. Increase in Observed TSS Concentration between St. Albans and Winfield Lock and Dam as a Function of River Flow

The same analysis was conducted using the downstream increase in observed TSS concentrations (i.e. TSS at RM 1.3 – TSS at RM 31.1) for the segment downstream of Winfield Lock and Dam. These data, shown in Figure 3-4, indicate a significant correlation between increase in TSS and Kanawha River flow. This correlation was described mathematically by the equation:

$$DTSS = -53.7 + \ln(\text{Kanawha River flow})*6.66 \qquad (3\text{-}8)$$

The effect of this sediment resuspension, in conjunction with an average sediment dioxin concentration in this segment of 27 pg/g, is shown in Table 3-4 for a range of Kanawha River flows. It is recognized that this empirical sediment resuspension analysis is only a rough approximation that ignores components such as tributary loading of solids to the study reach. Nonetheless, results from this analysis are roughly consistent with the only high flow dioxin measurement for the Kanawha River. During the June, 1998 survey on the Kanawha River, the dioxin measured at Point Pleasant was 0.46 pg/L during a river flow of 45,000 cfs. This



measurement represents an increase in dioxin of 0.21 pg/L over the lower stretch of river, compared to a predicted resuspension-induced concentration of 0.48 pg/L.

Figure 3-4. Increase in Observed TSS Concentration between Winfield Lock and Dam and Point Pleasant as a Function of River Flow

Table 3-4. Mass Flux Calculation for Sediment Resuspension

Kanawha River Flow (cfs)	Net Increase in TSS (mg/l)	Dioxin mass load (ug/day)	Predicted increase in dioxin concentration (pg/l)
3200	0	0	0
10000	7.6	5,020	0.205
50000	18.3	60,400	0.494
100000	23.0	152,000	0.621

4.0 MODELING PROCEDURE: LINKING THE SOURCES TO THE ENDPOINT

Modeling procedures are used to create a direct predictive relationship between system boundary conditions, external loadings, and in-stream processes and the resulting water quality condition, e.g. dioxin concentration. Once the model is developed, load allocations and wasteload allocations can then be selected to define the conditions under which predicted water quality will meet water quality standards. Available modeling techniques include empirical relationships, analytical equations, and numerical (computer) models of a wide range of complexity. This section discusses model selection, some aspects of model process representation, and the ranges of stream conditions covered.

4.1 MODELING FRAMEWORK SELECTION

4.1.1 Consideration of Model Type

A wide range of model frameworks are available to predict the relationship between external loadings and resulting concentration, covering a wide range of complexity. The most appropriate model for a given situation is chosen as a function of site characteristics, model objectives, and available resources. Relevant characteristics of this modeling application that affect model selection are:

The model must be capable of predicting the relationship between external dioxin loadings and maximum in-stream dioxin concentrations.

No direct dioxin loading data are available, and only a single measurement of upstream boundary concentrations.

The primary loading sources are the upstream boundary, contaminated groundwater loading near the upstream boundary, and (at high river flows only) resuspension of contaminated in-place sediments.

Downstream boundary conditions should be consistent with, and provide a loading input to the Ohio River TMDL.

The above characteristics led to the selection of a conservative dilution model, as described below.

4.1.2 Model Selection

Application of a spatially variable, deterministic model requires the explicit specification of the location and magnitude of all source loads. The model typically then undergoes a calibration process, whereby site-specific chemical fate process coefficients are estimated, and model credibility established, based upon the ability of the model to describe observed in-stream concentration data. The absence of upstream boundary and source loading data would provide too many degrees of freedom to allow for a credible calibration of a model of this type for the Kanawha River. Simply put, the model calibration process would be driven strictly by the assumptions made regarding un-measured inputs, and would provide little information on process coefficients or model reliability. It was therefore concluded that application of a spatial model such as SMPTOX4 or WASP was not appropriate, given the available data.

The approach that has been chosen is to use an analytical dilution model (Equation 4-1).

$$C_{Total} = (C_{Upstream} * Q_{Upstream} + \Sigma Load) / Q_{total} \qquad (4\text{-}1)$$

where C_{Total} is the resulting concentration after loading, $C_{Upstream}$ is the upstream concentration, $Q_{Upstream}$ is the upstream flow, ΣLoad is the total loading, and Q_{Total} is the resulting flow after loading.

This simple model framework assumes that dioxin loss processes are insignificant, and that the sole factor controlling dioxin concentration is dilution. The biggest potential limitation to this approach is that, by ignoring loss processes, the model may over-predict the dioxin concentration resulting from a given set of loads. Fortunately, the characteristics of the Kanawha River site are such that loss processes appear to have relatively little impact on *peak* dioxin concentrations, which are the desired endpoint of the TMDL analysis.

The appropriateness of the analytical dilution model is discussed below, categorized into two types of flow conditions:

Low flow (non-eroding) conditions: Where peak concentrations occur in the immediate vicinity of loading sources. The low flow loading sources are located closely together, such that insufficient time of travel exists to allow loss processes to greatly affect peak concentrations.

High flow (eroding) conditions: When sediment erosion occurs, and the most potentially significant loss process, settling, is negligible. In these cases, peak concentrations are expected to occur near the mouth of the Kanawha.

The resulting TMDL must be protective of both of these flow conditions, as the high volume sampling data has shown violations of water quality standards during both low and high flow.

4.1.3 Suitability of Dilution Model under Low Flow

Under low flow conditions (i.e. 1960 cfs in the Kanawha River as specified in West Virginia water quality standards), the highest dry weather dioxin concentrations in the Kanawha River are typically located at the most upstream ORSANCO monitoring station. The relatively short travel time between the upstream boundary and this location limits the potential effect of loss processes. The peak concentration will then be governed by the combination of steady dry weather sources and the low flow.

The same rationale of short river stretches limiting travel time and therefore limiting losses will apply to the Pocatalico River and Armour Creek tributaries to the Kanawha River. For each of these water bodies, the study area includes the 2 mile stretch above their confluence with the Kanawha River.

Loss processes considered include decay (such as biodegradation or hydrolysis), settling, volatilization, and photolysis. Process considerations included consistency with the ongoing ORSANCO (1999) modeling, although this was not maintained in all cases. Dioxin modeling performed by Limno-Tech for a TMDL for the Columbia River (Oregon/Washington) was also referenced. Each of these processes is discussed below.

Dioxin decay processes are generally considered to be insignificant (LTI, 1992; ORSANCO, 1999), and were assumed to be zero in this study.

Using limited synoptic solids survey data for the Kanawha River above Winfield Dam, under low flow conditions the settling velocity was roughly estimated at 0.07 m/day. A settling velocity of 0.5 m/day was selected as a reasonable under bound value consistent with the limited site specific data and values reported for other systems. Using a particulate dioxin fraction of 0.9 (which is generally consistent with both sampling results and partitioning calculations), the equivalent upper bound decay rate for total concentration (assuming only particulate-bound dioxin is affected by particle settling) is 0.05/day.

Estimation of settling losses at low flow also requires definition of the time of travel between the upstream boundary and suspected source area. Modeling of the physical river system (i.e. stream geometry, water surface elevation, and velocity) was performed for the Kanawha River using the HEC2 model. Model input files for two river reaches 1) Mouth to Winfield Dam, and 2) Winfield Dam to the study area upstream boundary, were run substantially as received from the U.S. Army Corps of Engineers, Huntington District Office, except for modeling the study low flow condition (1960 cfs). HEC2 model results were used in support of contaminant modeling. Selected results are shown in Table 4-1.

Table 4-1. Selected HEC2 Model Results

HEC2 Model Result	Value	Units
Average Depth	8.73	m
Average Width, Coal River to Pocatalico River	249.10	m
Average Width, Pocatalico River to Ohio River	230.80	m
Average Velocity	0.04	m/s

This velocity in conjunction with the upper bound settling rate, indicates that up to 9% of the instream dioxin could settle between the upstream boundary and location of peak concentration.

Volatilization was estimated using the same procedure as used by ORSANCO (1999). Physical constants and input values are shown in Table 4-2.

Table 4-2. Volatilization Inputs

Constant	Value	Units
Molecular Weight	321.97	g/g-mol
Wind Speed	2	m/s
Henry's Constant	$2.1x10^{-6}$	atm-m^3/mol
Water Temperature	20	Celcius
Average Water Velocity	0.043	m/s
Average Depth	8.73	m/s

The mass transfer coefficient is estimated to be 0.0074 m/day. The equivalent dissolved concentration volatilization decay rate is 0.00085/day, which is negligible.

Photolysis rates were assumed to be zero by ORSANCO. The Columbia River study found photolysis rates to range from 0.00023 to 0.001/day. Rates in the Kanawha would differ due to the factors listed in Table 4-3.

Table 4-3. Photolysis Factors

Factor	Likely Effect
Latitude (39N vs. 45N)	Higher decay rate
Cloud cover	Variable
Depth	Higher decay rate (at low flow)
Light attenuation	Variable
Indirect photolysis	Unknown

Based on this analysis, the high end of the Columbia River study range was chosen: 0.001/day. This decay rate is similar to the volatilization decay rate, and is also considered negligible.

The primary conclusion from the loss process analysis is that settling is the dominant process, and that it is responsible for at most a 9% decrease in predicted peak dioxin concentrations at low flow. This analysis demonstrates that a dilution model approach will not be overly conservative, as the 9% level of safety will serve as a component of the margin of safety.

4.1.4 Suitability of Dilution Model Under High Flow (Eroding) System Condition

Under high flow conditions, several additional factors will influence dioxin concentrations in the Kanawha River, Pocatalico River, and Armour Creek. First, settling of suspended solids becomes negligible, because the same shear stresses that resuspend bottom sediments prevents deposition of suspended solids. Dioxin in the water column can be considered to behave as a conservative substance all the way to the Ohio River under these conditions, because its primary loss process has been negated. Second, two additional sources of dioxin appear: resuspension of contaminated bottom sediments due to flow-induced shear stress, and erosion of contaminated watershed soils.

The dilution model will be capable of describing the maximum allowable dioxin loading to each of the streams under high flow conditions, due to the insignificance of loss processes. The dilution model will not, however, be capable of predicting the amount of contaminated sediment that will be resuspended during a given flow period. Significant additional information would need to be collected in order to support a model with this capability, as discussed below in the implementation and future monitoring section. As such, the model will be suitable for defining the TMDL for these systems but will not be suitable for predicting the time required for natural attenuation of sediment contamination to occur, nor the efficacy of the physical removal of sediments.

4.2 SELECTION OF REPRESENTATIVE MODELING PERIOD

The discussion above demonstrates the appropriateness of the dilution model for predicting peak dioxin concentrations under two sets of river flow conditions: low flow (non-eroding) and high flow (eroding) conditions. Because these two sets of conditions span the entire spectrum of flows, the analytical model can provide predictions under all conditions. The TMDL allocation process, as discussed in the subsequent section, will therefore define allowable loading rates for all possible river flows.

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5.0 ALLOCATION

Total maximum daily loads (TMDLs) are comprised of the sum of individual waste load allocations (WLAs) for point sources, load allocations (LAs) for non-point sources, and natural background levels. In addition, the TMDL must include a Margin of Safety (MOS), either implicitly or explicitly, that accounts for uncertainty in the relation between pollutant loads and the quality of the receiving water body. Conceptually, this definition is denoted by the equation:

$$LC = TMDL = \Sigma WLAs + \Sigma LAs + MOS \qquad (5\text{-}1)$$

The term LC represents the Loading Capacity, or maximum loading that can be assimilated by the receiving water while still achieving water quality standards. The overall loading capacity is subsequently allocated into the TMDL components of waste load allocations (WLAs) for point sources, load allocations (LAs) for non-point sources, and the Margin of Safety (MOS).

Results of the allocation process are summarized in Table 5–1, which shows the individual TMDL allocations for each of the three systems. The TMDL changes as a function of river flow, so allocations are listed for a range of flows.

This section contains allocations to the identified point and nonpoint sources within the watershed. The section begins with a description of the loading capacity of the three waterbodies of concern, then proceeds to quantify the individual waste load allocations (WLAs) for point sources and load allocations (LAs) for nonpoint and background sources necessary for attainment of water quality standards. This section also discusses the incorporation of a margin of safety in the TMDL analysis and the consideration of seasonality.

Table 5-1. Summary of Allocations (ug/day) for a Range of Flow Conditions

Kanawha River	**1960 cfs**	**5000 cfs**	**10000 cfs**	**20,000 cfs**	**50,000 cfs**
WLA					
Point Sources	0.82	0.82	0.82	0.82	0.82
LA					
Upstream Sources	43	110	220	440	1100
Groundwater	16.5	16.5	16.5	16.5	16.5
In-place Sediments	0	20	64	152	416
Runoff	0	10.25	10.25	10.25	10.25
MOS					
Explicit MOS	6.7	17	34	69	171
Pocatalico River	**0.32 cfs**	**500 cfs**	**1000 cfs**	**2000 cfs**	**5000 cfs**
WLA					
Point Sources	0	0	0	0	0
LA					
Upstream Sources	0	0	0	0	0
Groundwater	0.0092	0.0092	0.0092	0.0092	0.0092
In-place Sediments	0	12	26	55	141
Runoff	0	5.91	5.91	5.91	5.91
MOS					
Explicit MOS	0.001	1.6	3.2	6.4	16
Armour Creek	**0 cfs**	**200 cfs**	**400 cfs**	**600 cfs**	**800 cfs**
WLA					
Point Sources	0	0	0	0	0
LA					
Upstream	0	0	0	0	0
Groundwater	0	0	0	0	0
In-place Sediments	0	1.4	7.1	13	19
Runoff	0	4.34	4.34	4.34	4.34
MOS					
Explicit MOS	0	0.64	1.3	1.9	2.5

5.1 LOADING CAPACITY

Because a simple dilution model is being used to describe dioxin fate and transport, the loading capacity for each TMDL segment can be calculated as a function of stream flow using a simple equation, i.e.

$$LC = Q_{riv} \times C_{WQS} \quad (5\text{-}2)$$

Where:

LC = Loading Capacity (M/T)
Q_{riv} = River flow (L^3/T)
C_{WQS} = Water Quality Standard concentration (M/L^3)

The loading capacity defined in Equation 5-2 applies to all river flows for which water quality standards apply. This corresponds to flows above the minimum stream flow of 1960 cfs in the Kanawha River, and flows above the 7Q10 flows of 0.32 cfs in the Pocatalico River and 0.0 cfs in Armour Creek. The resulting loading capacities for the three systems are shown in Figures 5-1 through 5-3.

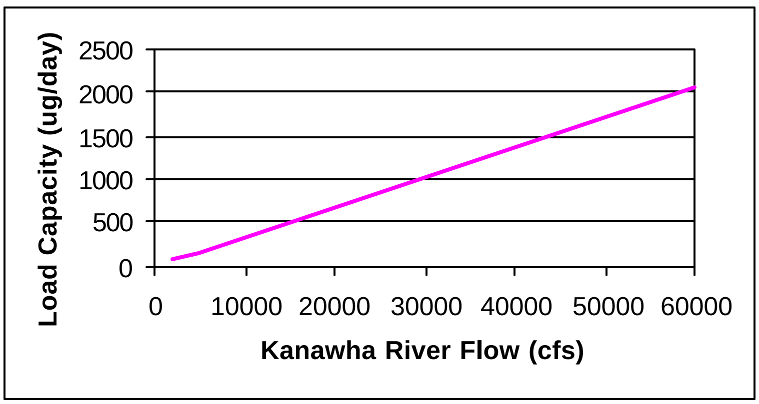

Figure 5-1. Kanawha River Loading Capacity

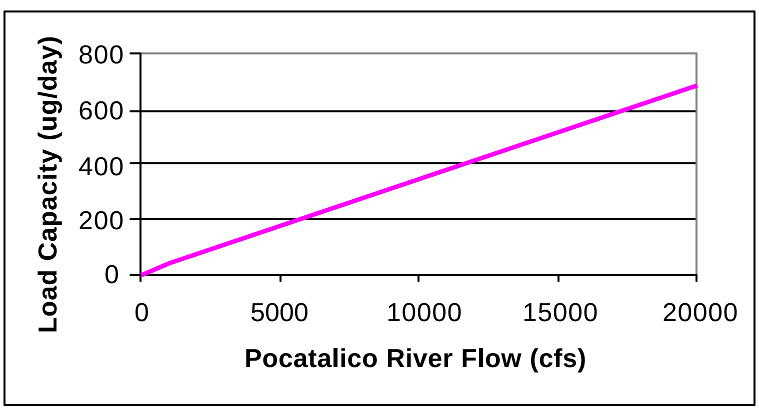

Figure 5-2. Pocatalico River Loading Capacity

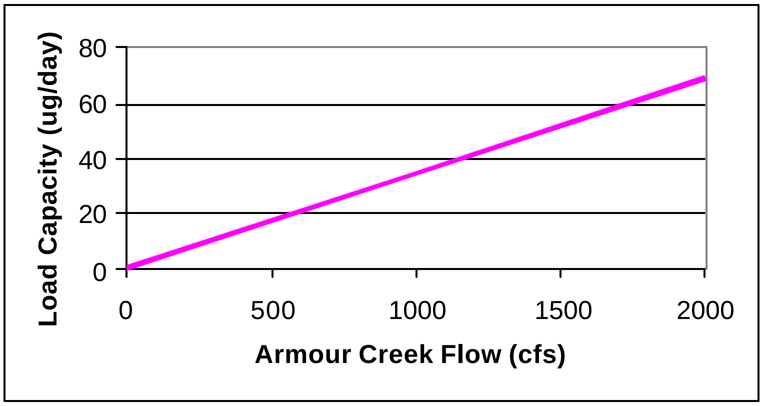

Figure 5-3. Armour Creek Loading Capacity

5.2 WASTE LOAD ALLOCATION

Point sources within the watershed discharging at their current levels were considered negligible in their impact on instream dioxin levels. An allocation is given to the Nitro WWTP in response to their treatment of runoff from the Fike Chemical Co. site. The magnitude of the allocation is set to the required pretreatment limit, which is 0.82 ug/day. The allocation to remaining point sources is set to zero. It is noted here that due to the lack of data within the study area concerning point source contribution of dioxin to the waterbodies, the actual loading of dioxin maybe significantly greater than 0.82 ug/ per day, and hence significant reductions in dioxin loading to the waterbodies may be possible.

Table 5-2. Wasteload Allocations to Point Sources

Point Sources	Existing Load (ug/day)	Allocated Load (ug/day)	Percent Reduction
Kanawha River	0.82	0.82	0
Pocatalico River	0	0	NA
Armour Creek	0	0	NA

5.3 LOAD ALLOCATIONS

Discussion of load allocations to nonpoint sources is divided into categories of upstream sources, contaminated groundwater, in-place sediments, and contaminated soil. A wide range of reduction alternatives could theoretically meet the loading capacity limitations in Figures 5-1 through 5-3. The overall allocation strategy can be constrained by considering two conditions:

Drought, or minimum, flow conditions, where the predominant sources contributing to contamination are upstream sources and contaminated groundwater.

High flow, erosional conditions, where the additional sources of in-place sediment resuspension and erosion of surface contamination become important.

Consideration of drought conditions places an upper bound on allowable upstream source and contaminated groundwater allocations. Additional loading capacity at flows above drought flow can be allocated to erosion of in-place sediments and contaminated soil.

5.3.1 Upstream sources

The Ohio River Valley Water Sanitation Commission (ORSANCO) conducted field sampling in May, 1999 to provide a measurement of the dioxin concentration entering the study area at the upstream boundary. The dioxin concentration determined in that sample, 0.009 pg/L, is being used as the upstream boundary concentration for the TMDL. The draft TMDL assumes that the upstream boundary concentration will remain constant at this concentration for all river flows. The uncertainty inherent in this assumption will be reflected in the Margin of Safety.

No evidence exists of dioxin contamination upstream of the Pocatalico River and Armour Creek segments of concern, so upstream boundary concentrations for these segments were assumed to be zero.

Table 5-3. Load Allocations to Upstream Sources

River	Existing Load (ug/day)	Allocated Load (ug/day)	Percent Reduction
Kanawha	0.009 pg/L x Flow (cfs) x 2.447 = 43 ug/day @ 1960 cfs = 110 ug/day @ 5000 cfs = 440 ug/day @ 20000 cfs	0.009 pg/L x Flow (cfs) x 2.447 = 43 ug/day @ 1960 cfs = 110 ug/day @ 5000 cfs = 440 ug/day @ 20000 cfs	0%
Pocatalico	0	0	NA
Armour	0	0	NA

5.3.2 Contaminated groundwater

Contaminated groundwater was identified as a major contributor of dioxin to the Kanawha River. The upper bound of the maximum allowable groundwater load to the Kanawha can be calculated by performing a mass balance calculation at the location where the groundwater enters the Kanwha (and assuming no loss of dioxin between the upstream boundary and this location) during minimum river flow. The mass balance equation calculates the maximum load that just achieves compliance with the water quality standard, assuming no source other than upstream. The resulting equation is:

$$LA_{GW} \le Q_{min} \times (C_{WQS} - C_{up}) \quad (5\text{-}3)$$

Where

LA_{GW} = Load Allocation to contaminated groundwater (M/T)
Q_{min} = Minimum stream flow at which water quality standards apply (L^3/T)
C_{WQS} = Water Quality Standard concentration (M/L^3)
C_{up} = Dioxin concentration at upstream boundary of segment (M/L^3)

Equation 5-3 is expressed as an inequality, because the LA must be set less than or equal to this value to ensure compliance with water quality standards at minimum flow. The potential reasons for setting the LA less than (as opposed to equal to) this upper bound value include providing allowance for a Margin of Safety and/or achieving greater than absolutely necessary reductions in one source category in order to lessen the amount of reductions required in another source category.

The maximum possible LA for contaminated groundwater in the Kanawha River was determined from application of Equation 5-3 to be 24 ug/day. The upper bound LAs for contaminated groundwater in the Pocatalico River and Armour Creek are 0.0102 and 0.0 ug/day, respectively.

For purposes of this TMDL, 16.5 ug/day is provided as an allocation to contaminated groundwater in the Kanawha River. This allocation is based upon providing the fullest allocation possible to this source (24 ug/day), minus the wasteload allocation (0.82 ug/day) and minus 10% of the Loading Capacity (6.7 ug/day) which will be allocated to the Margin of Safety as discussed below. This corresponds to a 99% reduction in the estimated existing load.

The LA for contaminated groundwater to the Pocatalico River is 0.0092 ug/day. This allocation is also based upon providing the fullest allocation possible to this source, minus 10% of the Loading Capacity which will be allocated to the Margin of Safety. No allocation is given to Armour Creek, because the 7Q10 flow is zero. No explicit reductions are expected to be required for these sources, based upon the conclusion of Kanetsky (1987) that the primary source of dioxin impairment to these streams is caused by backflow from the Kanawha, which will be corrected through source loading reduction to the Kanawha River.

Table 5-4. Load Allocations to Contaminated Groundwater

River Segment	**Existing Load (**ug/day)	**Allocated Load (**ug/day)	**Percent Reduction**
Kanawha	3324	16.5	99%
Pocatalico	NA	0.0092	NA
Armour	NA	0.0	NA

5.3.3 Contaminated soils

Once loads have been allocated to the sources described above that must be controlled in order to meet water quality standards during low flow conditions, the remainder of the loading capacity (except for the Margin of Safety) can be allocated to the wet weather/higher flow categories. The first of these to be considered is erosion from contaminated soils in the watershed. Remediation efforts are planned to control the soil contamination at Heizer Creek landfill. This load allocation assumes that soils will be cleaned to a Removal Action Level dioxin concentration of 1.0 ppb (units of TEQ, but treated for allocation purposes as TCDD), resulting in an allowable load of 4.53 ug/day to the Pocatalico River. This same allocation is given to the Kanawha River, because runoff delivered to the Pocatalico River will eventually reach the Kanawha. Additional runoff load of 1.38 ug/day is calculated for the Pocatalico River and subsequently to the Kanawha River from contaminated soils near the Manila Creek landfill. No additional remediation is assumed in allocating this load. Runoff of 4.34 ug/day is calculated for Armour Creek and subsequently to the Kanawha River from contaminated soils at the Midwest Steel site. No additional remediation is assumed in allocating this load.

Table 5-5. Load Allocations to Contaminated Soils (wet weather)

River Segment	**Existing Load (**ug/day)	**Allocated Load (**ug/day)	**Percent Reduction**
Kanawha	88 ug/day	10.25 ug/day	88%
Pocatalico	83 ug/day	5.91 ug/day	93%
Armour	4.34 ug/day	4.34 ug/day	0%

5.3.4 In-place sediment

The final remaining source category is contaminated in-place sediments. With load reductions assigned to all other loading categories, the allowable load for this source category can be calculated from the difference between load capacity and the other allocated sources (plus the Margin of Safety). The resulting allocation is a function of river flow, and is calculated as:

$$LA_{\text{in-place, Kanawha}} = \text{Load Capacity} - WLA - LA_{\text{Upstream, Kanawha}} - LA_{\text{GW, Kanawha}} - LA_{\text{Soils, Kanawha}} - MOS$$
$$= 0.00881 \times \text{Kanawha River flow (cfs)} - 27.6 \quad (5\text{-}4)$$

$$LA_{\text{in-place, Pocatalico}} = \text{Load Capacity} - LA_{\text{GW, Pocatalico}} - LA_{\text{Soils, Pocatalico}} - MOS$$
$$= 0.0286 \times \text{Pocatalico River flow (cfs)} - 5.92 \quad (5\text{-}5)$$

$$LA_{\text{in-place, Armour}} = \text{Load Capacity} - MOS$$
$$= 0.0286 \times \text{Armour Creek flow (cfs)} - 4.34 \quad (5\text{-}6)$$

Table 5-6. Load Allocations to in-place Sediments (wet weather)

River Segment	Existing Load	Allocated Load	Percent Reduction
Kanawha	See Table 3-4	See Equation 5-4 = 0 ug/day @1960 cfs = 16 ug/day @5000 cf = 149 ug/day @20000 cfs	>90 %
Pocatalico	NA	See Equation 5-5 = 0 ug/day @0.3 cfs = 8.4 ug/day @500 cfs = 51 ug/day @2000 cfs	NA
Armour	NA	See Equation 5-6 = 0 ug/day @0 cfs = 1.4 ug/day @200 cfs = 13 ug/day @600 cfs	NA

5.4 INCORPORATION OF A MARGIN OF SAFETY

This section addresses the incorporation of a margin of safety (MOS) in the TMDL analysis. The MOS accounts for any uncertainty or lack of knowledge concerning the relationship between pollutant loading and water quality. The MOS can either be implicit (e.g., incorporated into the TMDL analysis through conservative assumptions) or explicit (e.g., expressed in the TMDL as a portion of the loadings). This TMDL uses both explicit and implicit components of the Margin of Safety.

An implicit MOS is provided through the use of a conservative dilution model for allocation purposes. This implicit MOS is as protective as possible for modeling purposes (yet not overly conservative, as discussed in Section 4), as it assumes complete conservation of mass. Another component of the implicit margin of safety is the State requirement that the water quality standard for dioxin be met for all flow conditions above the critical minimum flow. This will result in an allowable load much smaller than would be derived using the EPA-recommended harmonic mean flow conditions as the design condition.

An additional explicit Margin of Safety is also provided, to account for uncertainty in loading entering each system across the upstream boundary, as well as other potential dioxin sources not identified during the source assessment. The explicit Margin of Safety is set at 10% of the LA.

5.5 SEASONALITY

Seasonality in the TMDL is addressed by expressing the TMDL in terms of river flow, as changes in flow will be the dominant seasonal environmental factors affecting the TMDL.

6.0 ONGOING ACTIVITIES AND FUTURE MONITORING

The Kanawha River/Pocatalico River/Armour Creek TMDL site data confirm that dioxin concentrations exceed water quality standards. However, additional data are needed to define many of the sources of dioxin entering these systems. For this reason, implementation activities must first focus on better identifying existing sources in order to control them.

This section describes activities that are currently ongoing and/or planned, designed to ensure that the TMDL can be implemented. It is divided into separate sections describing:

- Control of watershed sources
- Control of contaminated in-place river sediments
- Additional monitoring

6.1 CONTROL OF WATERSHED SOURCES

EPA has initiated activity at 16 sites throughout the watershed with the intent of collecting the data necessary to further define the magnitude of dioxin loading from each site and/or identify necessary control actions. In addition to the land sites, monitoring is recommended to define the contribution of the ambient air as a potential source to the watershed.

6.1.1 Armour Creek/Solutia

EPA HSCD will be conducting a Preliminary Assessment (PA) under CERCLA at the site in Summer 2000.

6.1.2 Clark Property

EPA HSCD will be reviewing (PA) available site information in Summer 2000 to determine if any further reassessment of the site is necessary.

6.1.3 Don's Disposal

EPA HSCD will be reviewing (PA) available site information in Summer 2000 to determine if any further reassessment of the site is necessary.

6.1.4 DuPont Belle Plant

EPA's Hazardous Site Cleanup Division's Site Assessment Program will review the current conditions at this property to determine whether it is a possible source or contributor of dioxin to the Kanawha River, Armour Creek or the Pocatalico River. This review will be based on EPA's existing information and new data collected in September 1999.

6.1.5 Fike Chemical Co.

EPA HSCD will be conducting a sampling assessment of stormwater sewers of the Nitro WV area in Summer 2000. Sampling will include collection of sediment and surface water from drainages used by the old CST.

6.1.6 Fleming Landfill

EPA HSCD will be reviewing (PA) available site information in Fall 2000 to determine if any further reassessment of the site is necessary.

6.1.7 George's Creek Landfill

EPA HSCD will be reviewing (PA) available site information in Fall 2000 to determine if any further reassessment of the site is necessary.

6.1.8 Heizer Creek Landfill

EPA HSCD conducted a CERCLA site inspection at the site in May 2000 and is currently awaiting the results of the sampling event. EPA HSCD will determine future remedial actions at the site pending receipt of the SI data.

6.1.9 Kanawha Western Landfill

EPA's Hazardous Site Cleanup Division's Site Assessment Program will review the current conditions at this property to determine whether it is a possible source or contributor of dioxin to the Kanawha River, Armour Creek or the Pocatalico River. This review will be based on EPA's existing information, which had earlier resulted in a Superfund "No Further Response Action Planned" (NFRAP) classification, plus additional information as needed.

6.1.10 Landfill adjacent to Midwest Steel

EPA HSCD will be conducting a sampling assessment (SI) at the site in Fall 2000 to further characterize potential migration of dioxin from the site to Armour Creek.

6.1.11 Manila Creek Landfill

EPA HSCD conducted an Expanded Site Investigation (ESI) at the site in May 2000 which included the installation of four off-site groundwater monitoring wells and collection of samples to determine if dioxin and other contaminates are migrating off site. EPA will determine what actions, if any are necessary upon receipt of the data.

6.1.12 Flexsys Plant Property

EPA HSCD is currently in the process of negotiating a consent order with Solutia to address the removal of drums and dioxin contamination at the part of the facility, formerly owned by AES.

6.1.13 Old Nitro Landfill

EPA HSCD will be conducting a PA of the site in Summer 2000 to determine if any further assessment of the site is necessary.

6.1.14 Poca Strip Mines/Poca Drum Dump

EPA HSCD will be reviewing (PA) available site file information in the Fall 2000 to determine if any further reassessment of the site is necessary.

6.1.15 South Charleston Landfill

EPA HSCD is currently awaiting a health consultation by ATSDR on data collected at the site in September 1999, before determining what future actions if any are necessary at the site.

6.1.16 Union Carbide (Rhone Poulanc) Institute Plant

EPA HSCD will be reviewing (PA) available site file information in the Fall 2000 to determine if any further reassessment of the site is necessary

6.2 CONTROL OF IN-PLACE SEDIMENTS

Resuspension of contaminated in-place sediments has been identified as contributing to violations of water quality standards for dioxin during high flow events. The primary implementation options under consideration are natural attenuation and physical removal of contaminated sediments (e.g. dredging). Natural attenuation processes can include burial of contaminated sediments as cleaner sediments are deposited upon them, and/or the flushing of contaminated sediments out of the system during high flows. Since the data to adequately characterize the site contamination, and dioxin fate and transport pathways in the river, is inadequate the preferred course of action to control in-place sediments is not evident.

Additional monitoring activities are needed to better define the benefits of natural attenuation compared to physical removal of contaminated sediments. These are discussed below.

6.3 ADDITIONAL MONITORING

The EPA and W.Va. will continue to support monitoring, as funds allow, to further identify sources and conditions contributing to dioxin impairments in the Kanawha River, Pocatalico River, and Armour Creek. Monitoring can support further identification of sources or inappropriate discharges, improved understanding of the delivery and transport of dioxin in the area of concern, and tracking of the changes in frequency of violations and degree of impairment. If monitoring information suggests that the TMDL requires revision, the West Virginia and EPA Region III may choose to revise the TMDL analysis or allocation as appropriate.

EPA Superfund Program conducted sediment and water sampling in the Kanawha River in May/June 2000 to further identify hot spots of contamination and to indicate potential source areas of dioxin. EPA anticipates sampling of storm water and industrial discharge outfalls to the Kanawha River in Fall 2000 in an attempt to identify current loading sources of dioxin to the Kanawha River.

Additional data are recommended in three areas to allow implementation of the TMDL and verification that water quality standards are being achieved in response to the TMDL. These areas are: watershed sources, upstream boundary loads, and instream conditions. Monitoring activities intended to identify and quantify watershed sources were discussed previously in the section on control of watershed sources. The remainder of this section discusses monitoring needs for upstream boundary loads and instream conditions.

6.3.1 Upstream Boundary Loads

The existing TMDL is based upon only a single data value describing dioxin concentrations at the upstream boundary of the Kanawha River study area. This data value indicated the presence of dioxin contamination, but provided no information on boundary concentrations in the Pocatalico River, Armour Creek, or the sources or variability in dioxin at the Kanawha upstream boundary. High volume dioxin sampling results in the Coal River, Armour Creek, Bill's Creek, and above Coal River are not yet available for incorporation into this TMDL report.

Additional monitoring could be conducted on a seasonal (e.g. quarterly) basis, and should be structured to include at least one high flow and one low flow period. This will better characterize the magnitude and seasonal variability of boundary concentrations.

With respect to identification of upstream sources, EPA's Removal Program collected a sediment sample in the Coal River for dioxin analysis in the Spring of 1999. EPA's Hazardous Site Cleanup Division's Site Assessment Program will search EPA's CERCLIS data base for any sites in this sub-basin. Based upon the sample results and data base review, EPA will determine whether any additional assessment work or cleanup is necessary.

6.3.2 Instream Conditions

Future data collection in the Pocatalico River, Armour Creek, and Kanawha River systems will be useful in order to monitor trends in dioxin concentration and verify that implementation of controls is leading to compliance with water quality standards. This monitoring could be conducted on a seasonal (e.g. quarterly) basis, and should be structured to include at least one high flow and one low flow period.

Additional monitoring efforts will also be useful in order to perform an assessment of the relative benefits of natural attenuation versus physical removal of contaminated sediments. Components of this monitoring include:

- Characterization of stream hydrology and geomorphology
- Sediment grain size analysis of suspended and bedded sediments
- Sediment core profiles of dioxins and moisture content
- Periodic sampling of dioxin and suspended sediment throughout the system
- High flow event monitoring
- Flume studies to evaluate sediment resuspension
- Sediment core dating

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REFERENCES

"Dioxin Data Summary", September 1999.

ecology and environment, inc., 1981. Field Investigations of Uncontrolled Hazardous Waste Sites. TDD F3-8011-07.

Fike/Artel Superfund Site, Fike WWTP Analytical Data with Attachments, May 1999.
ATSDR Health Consultation-Sampling Plan, November 1999.

EPA Region III, 1980. Trip Report-RCRA Inspection of the Holmes and Madden Landfill. Philadelphia, PA .

EPA, 1986. EPA Environmental News, "EPA Announces Consent Agreements with Monsanto on Two West Virginia Dump Sites." West Virginia Department of Natural Resources Public Information Office, Charleston, WV.

EPA, 1991a. Technical Support for Water Quality-based Toxics Control. EPA/505/2-90-001, PB91-127415, Office of Water (EN-336), Washington, D.C.

EPA, 1991b. Guidance for Water Quality-based Decisions: The TMDL Process. EPA 440/4-91-001, Office of Water (WH-553), Washington, D.C.

EPA, 1995. Great Lakes Water Quality Initiative Technical Support Document for the Procedure to Determine Bioaccumulation Factors. EPA-820-B-95-005, Office of Water (4301), Washington, D.C.

EPA, May 11, 2000. "EPA Superfund Kanawha Valley (Dioxin) Site Assessments."

EPA, May 25, 2000. "Kanawha River Valley Dioxin Assessment Project-March 2000 Site Information Update." Brownfield & Site Assessment Section (3HS34), Wheeling, WV.

Halliburton NUS Corporation, 1993. Final Report, Site Inspection Prioritization, Monsanto Chemical. EPA Region III, Philadelphia, PA.

Halliburton NUS Corporation, 1995. Final Report, Site Inspection Prioritization (SIP) No. 2, Clark Property. EPA Region III, Charleston, WV.

Kanetsky, 1986. A Study of Dioxin Contamination in Sediments in the Kanawha River Basin. EPS-QA87-004, EPA Region III, Philadelphia, PA.

Limno-Tech, Inc., 1992. Phase II Screening Model Application to Dioxin (2,3,7,8 TCDD) in the Columbia River. Prepared for U. S. EPA Region X, Seattle, WA.

Monsanto Corporation, ca. 1977. Hazardous Waste Survey Certification (aka, Eckhardt Survey). West Virginia Division of Natural Resources, Hazardous Waste Ground Water Branch, Nitro, WV.

NUS Corporation, 1983. A Field Trip for Union Carbide Corporation Institute Plant. TDD No. F3-8306-27, EPA Hazardous Site Control Division, Philadelphia, PA.

NUS Corporation, 1985a. A Site Inspection for the Heizer Creek. TDD No. F3-8308-29, EPA Hazardous Site Control Division, Philadelphia, PA.

NUS Corporation, 1985b. A Field Trip Report for Monsanto Site. TDD No. F3-8407-45, EPA Hazardous Site Control Division, Philadelphia, PA.

NUS Corporation, 1986. Site Inspection of Manila Creek Dump. TDD No. F3-8211-48, EPA Hazardous Site Control Division, Philadelphia, PA.

NUS Corporation, 1986. Non-Sampling Site Reconnaissance Summary Report, Holmes and Madden Landfill. TDD No. F3-8412-08, EPA Hazardous Site Control Division, Philadelphia, PA.

NUS Corporation, 1987. Site Inspection of DuPont Belle Plant. TDD Nos. F3-8405-38/F3-8702-21, EPA Hazardous Site Control Division, Philadelphia, PA.

ORSANCO, 1999. Dioxin Modeling for the Development of an Ohio River TMDL. Interim Draft Report. Ohio River Valley Water Sanitation Commission, Cincinnati, Ohio.

Paradigm Analytical Laboratories, Inc. 1998. Polychlorinated Dibenzo-*p*-Dioxins and Dibenzofurans Measurements. Wilmington, NC.

SATA, 1998. Site Summary Report-Heizer Creek Site, Poca, Putnam County, WV. CERCLIS No. WVD980538656, EPA Region III, CEPP and Site Assessment Section, Philadelphia, PA.

SATA, 1998. PREscore Summary Report-Heizer Creek Site, Poca, Putnam County, WV. CERCLIS No. WVD980538656, EPA Region III, CEPP and Site Assessment Section, Philadelphia, PA.

SATA, 1999. Trip Report, Kanawha Valley-Dioxin Site, Nitro, Putnam County, WV. TDD No. 9901-04, EPA Region III Removal Response Section, Philadelphia, PA.

Smith and Ruggero, 1986. Concentrations of 2,3,7,8-Tetrachlorodibenzo-p-dioxin in Sediments in the Kanawha River, West Virginia and Proposal for Further Sediment Sampling. EPA Region III, Philadelphia, PA.

St. John, 1986. Gazette-Mail, “Chemicals oozing from old Poca dump.” West Virginia Department of Natural Resources Public Information Office, Charleston, WV.

Tetra-tech, 1993. Level 1 Site Inspection Prioritization Report of South Charleston Municipal Landfill, South Charleston, WV. CERCLIS No. WVD980538243, EPA Region III, Hazardous Waste Management Division, Philadelphia, PA.

Tetra-Tech, date unknown. Nitro Landfill Sites, Level 1-Site Inspection Prioritization. Work Assignment Number 92-31-3JZZ, EPA Region III, Philadelphia, PA.

US Department of Health and Human Services, 2000. Health Consultation: Dioxins in Soil at the Former Midwest Steel Site. Atlanta, GA.

WVDEP, 1998. 303(d) List

West Virginia Division of Water Resources, 1984. Preliminary Assessment, Putnam County Drum Dump. Hazardous Waste/Ground Water Branch, West Virginia Department of Water Resources, (location unknown).

WESTON, 1998. "Site Summary Report, Heizer Creek Site, Poca, Putnam County, WV." Prepared for EPA Region III, Philadelphia, PA.

WESTON, 1999. Trip Report Former Midwest Steel Site Dioxin Assessment, Nitro, Putnam County WV. Prepared for EPA Region III, Philadelphia, PA.

WESTON, 2000. Manilla Creek Landfill Site-PREscore Summary Report. TDD No. 0001-69, EPA Hazardous Site Control Division, Philadelphia, PA.

Wischmeier and Smith, 1978. Predicting rainfall erosion losses – a guide to conservation planning. Agricultural Handbook 537, U.S. Department of Agriculture, Washington D.C.

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APPENDIX A

Estimates of Water Column Dioxin Concentrations from Fish Tissue

Only a limited number of water column dioxin concentration measurements are available for the Kanawha River, Pocatalico River, and Armour Creek. A much larger data base of fish tissue dioxin measurements are available. Instream dioxin concentrations were estimated from the available fish tissue dioxin data using the following equation based on the Great Lakes Water Quality Initiative Technical Support Document for the Procedure to Determine Bioaccumulation Factors (EPA, 1995):

$$C_{total}\ pg/L = (10^9) \times (C_{fish\ tissue}\ ug/g) / f_{lipid} / BAF / f_{fd} \qquad (A-1)$$

Where

$$f_{fd} = 1 / [1 + (POC \times K_{ow} \times 10^{-6}) + (DOC \times K_{ow} / 10 \times 10^{-6})]$$

$POC = 0.35$ mg/L

$DOC = 2.43$ mg/L

$\log_{10}(K_{ow}\ L/kg) = 7.02$

$BAF = 9360000$ L/kg

Fish tissue dioxin concentrations were available for 148 samples in the TMDL site. However, many of the other inputs to Equation A-1 were not available for individual samples and needed to be estimated. An average lipid fraction was calculated by specie and substituted where necessary. When the fish specie was not identified for the dioxin tissue concentration, an overall average lipid concentration was used. Average particulate and dissolved organic carbon values were calculated and used throughout the calculations.

The resulting back-calculated water column concentrations (i.e. an estimate of the water column concentration that would lead to the observed fish tissue dioxin concentration) are shown in Figures A-1 through A-3, and compared to the water quality standard. It is recognized that the calculation procedure requires many simplifying assumptions, and each estimate has a high degree of uncertainty associated with it. Nonetheless, the extent to which these back-calculated concentrations exceed the water quality standard strongly imply that the water column water quality standards for dioxin have been routinely exceeded in all three systems.

Figure A-1. Kanawha River Water Column Concentrations from Fish Tissue by Date

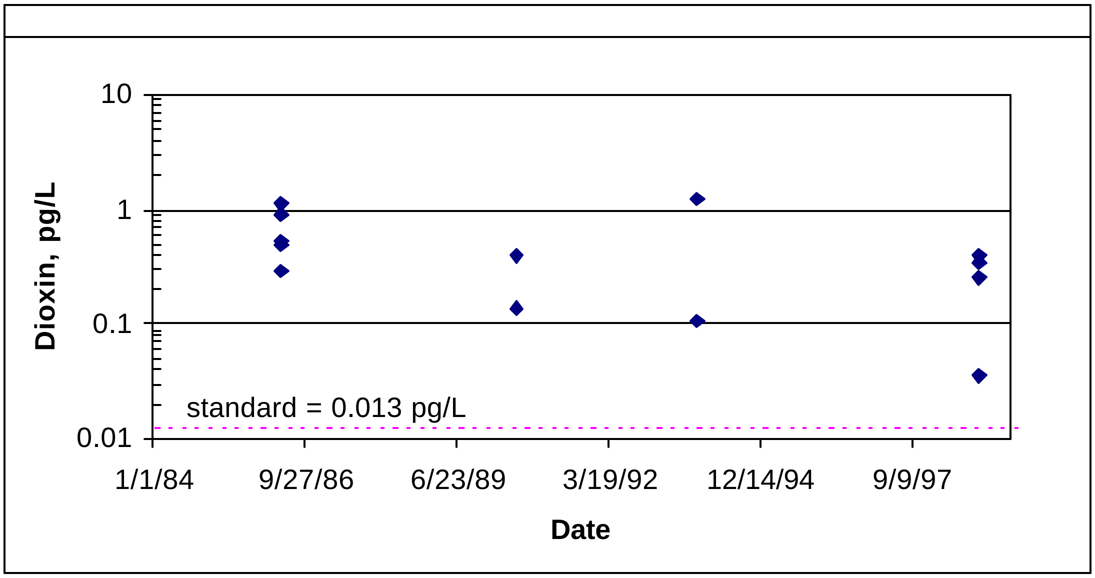

Figure A-2. Pocatalico River

Water Column Concentrations from Fish Tissue by Date

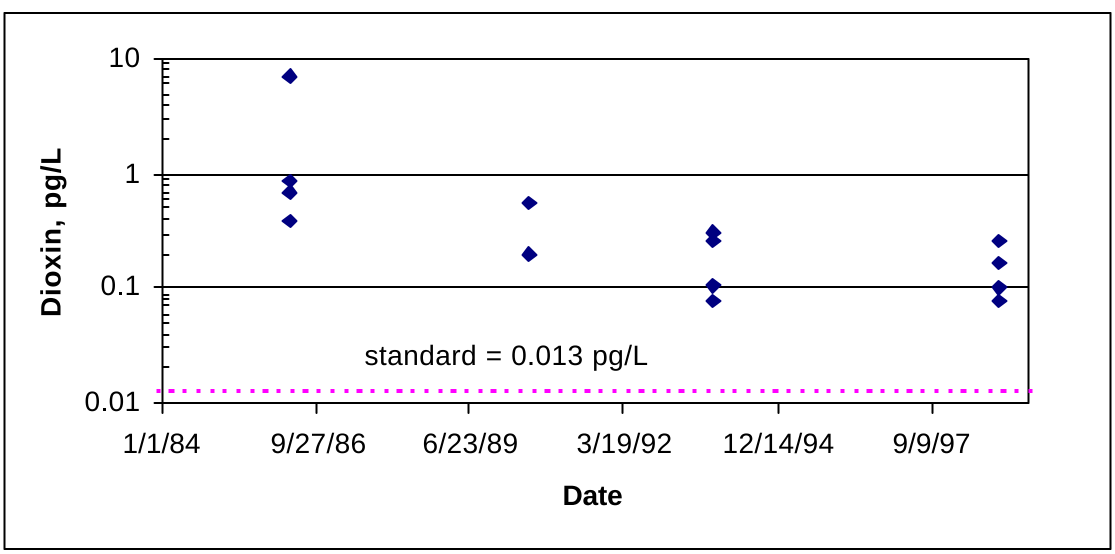

Figure A-3. Armour Creek Water Column Concentrations from Fish Tissue by Date

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APPENDIX B

CONTAMINATED GROUNDWATER

The primary source of dioxin to the Kanawha River at low flows has been preliminarily attributed in this report to contaminated groundwater. No direct data exist quantifying contaminated groundwater loading; rather, this source was selected through the process of elimination of other potential sources. The possibility exists that atmospheric deposition or upstream sources are significant contributors of dioxin. Additional data are required to better define the exact sources of dioxin. These additional data will not significantly change the TMDL, but will be used to better define the implementation plan required to reduce existing sources.

This addendum explains the decision process for selecting contaminated groundwater as a significant source, and potential impacts on the TMDL.

Decision Process

The facts leading to selection of contaminated groundwater are as follows:

1) A large increase in water dioxin concentration is observed at RM 41.3, relative to the upstream boundary at RM 45.5. A mass balance calculation shows that the magnitude of this load ranges from 2700 to 4400 ug/day.

2) Potential sources contributing to this increase include: direct point source discharge; runoff of contaminated soils; atmospheric deposition, diffusion from in-place contaminated sediments; upstream sources; and contaminated groundwater.

3) Direct point sources were eliminated from consideration because no known point sources of dioxin occur in this area.

4) Runoff of contaminated soils was eliminated from consideration because the increases in dioxin were observed during low flow, dry weather periods.

5) Atmospheric deposition was eliminated because the dioxin increase occurred over a localized area, while atmospheric deposition would be expected to have a more diffuse impact. Chapter 6 of this report calls for the need of monitoring studies to better quantify atmospheric deposition.

6) Preliminary mass balance calculations shown in Chapter 3 indicate that diffusion from in-place contaminated sediments could only account for a very small fraction of the observed increase in dioxin.

7) The one available dioxin measurement at the upstream boundary (River Mile 45.5) indicated dioxin concentrations significantly lower that those observed at River Mile 41.3. Because this one measurement may not be representative of overall Kanawha River conditions, Chapter 6 of this report calls for monitoring studies to better quantify upstream sources.

8) Contaminated groundwater was selected as the loading category via the process of elimination. It is recognized that, in the absence of organic solvents, dioxin has very low solubility in water and would not normally be expected to be present in significant quantities in groundwater. Given the heavily industrialized nature of the area and past presence of groundwater contamination, it is quite plausible that dioxin is in solution with contaminated groundwater moving as base flow.

Potential Impact on TMDL

The final TMDL will not be greatly affected whether contaminated groundwater is a major loading category or not. The implementation activities necessary to achieve the TMDL, however, will be highly dependent on the nature of the source.

Groundwater loading of dioxin must be maintained at a level less than or equal to that stated in the load allocation in order for water quality standards to be maintained at low river flows. If contaminated groundwater is not a source of water quality standards violations at low flow, its current magnitude will be less than the load allocation.

Additional data better defining the source of dioxin will directly impact the implementation measures necessary to achieve the TMDL. Source control activities must focus on those sources that are causing the water quality standards violations. Chapter 6 of this report, Ongoing Activities and Future Monitoring, lays out plans for collecting additional data to better define the sources and to guide future implementation activities.