

Well water quality in the vicinity of a coal slurry impoundment near Williamson, West Virginia.

Prepared in response to:

Questions from citizens attending the January 15, 2004 training session of the Coal Impoundment Location and Warning System, Delbarton, West Virginia

Prepared by:

Ben M. Stout III, Ph.D. and Jomana Papillo, Research Assistant
Wheeling Jesuit University
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Executive summary

Fifteen wells were sampled within 2 air miles of the Sprouse Creek Slurry Impoundment at the request of citizens attending the January 15, 2004 training session of the Coal Slurry Impoundment Location and Warning System. Wells in the area of Sprigg, Merrimac, Rawl, and Lick Creek near Williamson, West Virginia, reportedly had good quality water approximately 10-15 years prior to this study. More recently, households consistently reported periodic “blackwater” events in their well water, fixtures that corroded within 2 years, red and black stains on their porcelain, walls, clothing and dishes, and health problems including cancer and kidney stones. This study focused on 7 heavy metals regulated by Environmental Protection Agency primary drinking water standards, and 5 metals regulated by secondary standards. An experimental design was implemented to capture spatial (geographic) and temporal (low flow versus high flow) variation in well water quality conditions. We hypothesized that if coal slurry was impacting wells, then well water would reflect the elemental constituents of coal slurry.

Primary drinking water standards for the 7 metals tested were exceeded 13 times in samples collected from 15 different wells. Standards were exceeded for lead (8), arsenic (2), barium (1), beryllium (1), and selenium (1), but not for cadmium or chromium. Lead was detected in 6 of 12 wells during low flow conditions with concentrations ranging from 6 to 23 ppb, and 5 of 12 wells exceeded the standard. Lead was detected in 7 of 8 wells during high flow conditions with concentrations ranging from 9 to 110 ppb, and 3 wells exceeding the primary standard. Arsenic was detected in 1 of 12 wells sampled during low flow conditions, and no wells exceeded the primary water quality standard. Arsenic was detected in 6 of 8 wells during high flow conditions with concentrations ranging from 4.2 to 340.0 ppb and 2 wells exceeding the 10 ppb standard.

Secondary drinking water standards for the 5 metals tested were exceeded a total of 36 times in samples collected from 15 different wells. Standards were exceeded for iron (17), manganese (17), aluminum (1), and zinc (1), but not for copper. During low flow conditions 10 of 12 wells exceeded the 300 ppb secondary drinking water standard for iron. Iron exceeded the standard in all 8 wells sampled during high flow conditions, with

concentrations ranging from 371 to 57,588 ppb. Manganese concentrations during low flow conditions ranged from not detected in a spring and in a 26 foot deep dug well, to 2,999 ppb in a 76 foot deep drilled well (Table 1). Manganese exceeded the 50 ppb standard in 9 of 12 wells during low flow. Under high flow conditions manganese exceeded the secondary standard in all 8 wells sampled with concentrations ranging from 82 to 4,063 ppb.

One sample was collected by decanting water off the sludge from a hot water heater. The sludge was dark red, as was the liquid. The sample contained exceptionally high concentrations of 4 metals that exceeded primary standards including arsenic (150 ppb), barium (3,000 ppb), lead (188 ppb), and selenium (646 ppb). Most interesting, arsenic and selenium were not detected in the source well from which the hot water heater was supplied. For those elements detected in both the source well and the hot water heater, concentrations were 30 times greater for barium, 7 times greater for chromium, and 12 times greater for lead in the hot water heater versus the source well. Hot water heaters appear to represent a significant water supply concentrating mechanism for heavy metals regulated by primary standards. The dark red color of the sludge was due to 557,700 ppb of iron and 27,260 ppb of manganese.

A comparison of water quality during low flow (base flow) versus high flow (event flow) was conducted by re-sampling 5 wells in response to citizen concerns regarding “blackwater” in their wells following rainfall events. Arsenic was detected in 1 well during low flow, but in 4 of the 5 wells during high flow. Barium was detected consistently in all wells under all conditions. Beryllium and cadmium were not detected in the 5 wells under any flow condition. Chromium was detected in 3 wells during low flow and all 5 wells during high flow. Lead was detected in 3 wells during low flow and 4 wells during high flow. Selenium was detected in 1 well during low flow, but was not detected during high flow. Among the non-regulated chemicals tested, vanadium was detected in 3 of 5 wells during low flow, but was not detected during high flow. Flow condition causes significant differences in the elemental composition of well water in the study area.

A comparison of Williamson area well water with the available data from domestic wells in neighboring counties of southern West Virginia and Eastern Kentucky indicated that Williamson area wells had the poorest water quality in the coalfield region. Poor water quality in these communities had been indicated by some past studies, but refuted more recently in a study by the Agency for Toxic Substances and Disease Registry. The information presented here indicates significant metals contamination at concentrations well beyond what should be used as a water supply source. Additional studies are required to determine the exact source of contamination.

Based on the results of this study a thorough and comprehensive assessment of the relationship between well water quality and human health is warranted in the area of Sprigg, Merrimac, Rawl, and Lick Creek near Williamson, West Virginia.

Introduction

A study of drinking water quality was conducted in response to the requests of citizens at a meeting of the Coal Impoundment Study in Delbarton, West Virginia. Citizens were primarily concerned with potential health effects due to heavy metals in their well water, which they felt was related to the Sprouse Creek Slurry Impoundment (MSHA identification number: 1211-WV04-40516-02, WV DEP permit number: O-41-84) and an underground injection system. Prior to field sampling, a phone conversation with Dr. Diane Schafer, an orthopedic surgeon in Williamson, WV revealed her opinion that “there is no question about illnesses [in Mingo County] caused by poor water quality (personal communication, Feb.3, 2004).” She said that there are definitely some water quality problems and that Rawl is the worst of the communities. Among the citizens of Rawl, Sprigg, Merrimac, and Lick Creek, there are high incidences of Alzheimer’s disease, blood problems, cancers not related to smoking, diseases of the environment, and Attention Deficit Disorder. According to Dr. Schafer, the water is “brackish.” Illnesses that citizens have complained of also include: kidney stones and kidney failure, environmental toxic poisoning, arsenic poisoning, dementia, birth defects, cancer, thyroid problems, and gastrointestinal problems that appear to be related to *H. pylori* bacteria.

In response to their concerns, the investigators made arrangements with the Water Quality Laboratory at Heidelberg College to analyze 23 samples of water from wells used by citizens. The Water Quality Laboratory was chosen based on cost comparisons and because of their well-established well water sampling program including over 30,000 wells nationwide. Heavy metals were analyzed because this was of main concern to the citizens.

There are 2 categories that the metals standards fall into: regulated and non-regulated. Regulated metals are broken down into 3 categories: primary standards, secondary standards, and lifetime health advisories. The US Environmental Protection Agency (EPA) describes a National Primary Drinking Water Regulation (primary standard) as “a legally-enforceable standard that applies to public water systems. Primary standards protect drinking water quality by limiting the levels of specific contaminants that can adversely affect public health and are known or anticipated to occur in water” (EPA, 2004b). The National Secondary Drinking Water Regulation (secondary standard) is a “non-enforceable guideline regarding contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water. The EPA recommends secondary standards to water systems but does not require systems to comply. However, states may choose to adopt them as enforceable standards.” This means that although the chemical may make the water smell, look, or taste peculiar, that does not necessarily mean it will harm your health (US EPA, 2004a). “Health Advisories are guidance values based on non-cancer health effects for different durations of exposure (e.g., one-day, ten-day, longer-term, and lifetime). Health Advisories provide technical guidance to EPA Regional Offices, State governments, and other public health officials on health effects, analytical methodologies, and treatment technologies associated with drinking water contamination” (US EPA, 2004b).

Metals tested in this study and regulated by primary standards are: arsenic, barium, beryllium, cadmium, chromium, lead, and selenium. Metals regulated by secondary standards included: aluminum, copper, iron, manganese, and nickel. Metals regulated by lifetime advisories are sodium and zinc. Non-regulated chemicals tested in this study include calcium, strontium, cobalt, magnesium, potassium, silica, and vanadium. For non-regulated chemicals, health effects are either minimal or are not well known. It should also be known that standards referred to in this study are for the purpose of comparison because standards apply to public water systems, not private wells.

Hypothesis:

We hypothesized that if coal slurry was impacting wells, then well water would reflect the elemental constituents of coal slurry, particularly high levels of arsenic, barium, cadmium, chromium, lead, and selenium because these metals were observed in excess of primary standards in a coal slurry sample collected March 20, 1985, approximately 4 miles south of Williamson (EPA, 1985). It was also noted that copper, iron, and manganese exceeded secondary standards in the coal slurry sample.

Materials and Methods

Sample collection and analysis

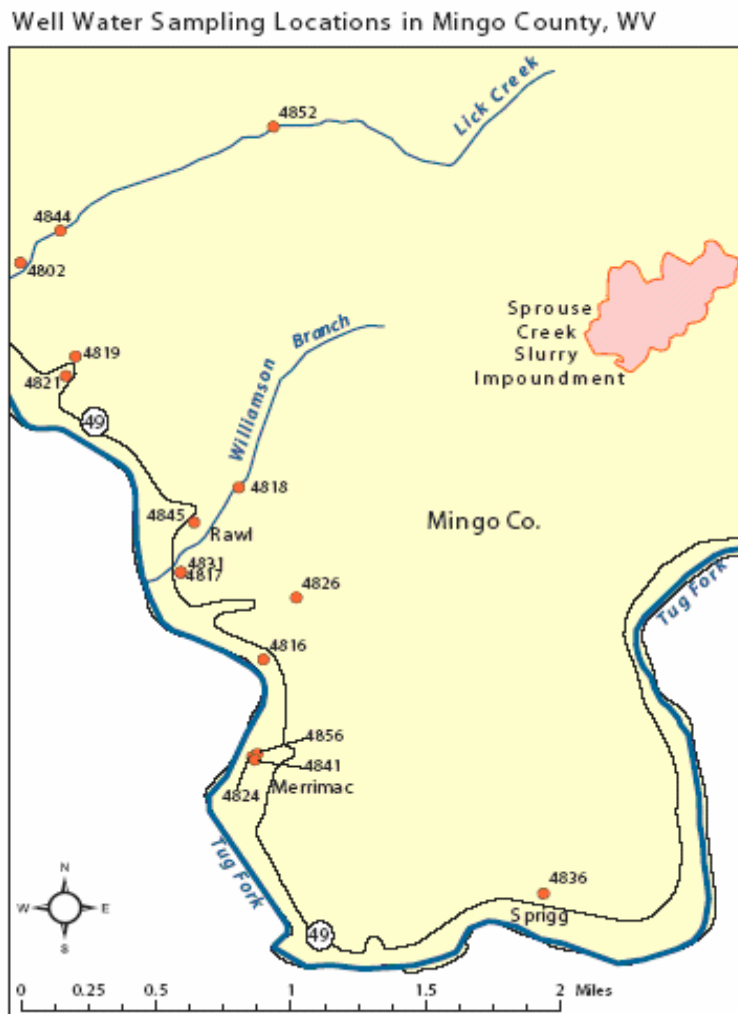
Water quality sampling followed the protocol for well water sampling as mandated by the Water Quality Laboratory at Heidelberg College. For each well, 3 plastic bottles were filled with water. One bottle was used for the analysis of arsenic, and the remaining 2 bottles were used for analysis of barium, beryllium, cadmium, chromium, lead, selenium, aluminum, copper, iron, manganese, nickel, sodium, zinc, calcium, strontium, cobalt, magnesium, potassium, silica, and vanadium. A "Cooperative Private Water Supply Testing Program Participant Information Sheet" was filled out for each well. A number was assigned to each well, and a bar code for each sample was placed on all 3 bottles and on the accompanying information sheet. Samples were analyzed in the Water Quality Laboratory using Standard Methods (Clesceri, *et al* 1999).

Water from wells 4819, 4844, 4802, and 4852 was taken from the kitchen tap. The cold water tap was allowed to run into the sink for approximately 1 minute. Each of the 3 bottles was filled in this stream of water and then labeled. The remaining well samples were taken directly from the well by first disconnecting the household system (typically located in the basement, crawlspace, or nearby shed) and then flushing for 1 minute before filling bottles as described above. Three samples were taken from sources that were not wells, including: a spring on the east side of the Norfolk Southern railroad tracks that is used as a water supply source by many area residents (4816), a municipal source originating from the Williamson water treatment plant and taken directly from the tap in a local business (4824), and a hot water heater (4831) from which supernatant water was decanted from the sludge that accumulated in the bottom of the heater. The sludge had been removed from the hot water heater and placed into a clean 5 gallon

bucket prior to decanting. The well (4826) that feeds the hot water heater (4831) was also sampled after disconnecting it from the household system as described above.

Study area

Sampling locations were chosen geospatially to obtain representative wells in the 4 sub-watersheds of Lick Creek, Rawl, Merrimac, and Sprigg, WV. The investigators sampled at the head, middle, and bottom of the hollow in these watersheds (Map 1). Latitude and longitude were obtained using a global positioning system. Five wells were re-sampled during high flow conditions (described below) and thus have well numbers corresponding to previous sampling points. Three wells sampled during high water conditions were described by street addresses, but latitude and longitude were not acquired.

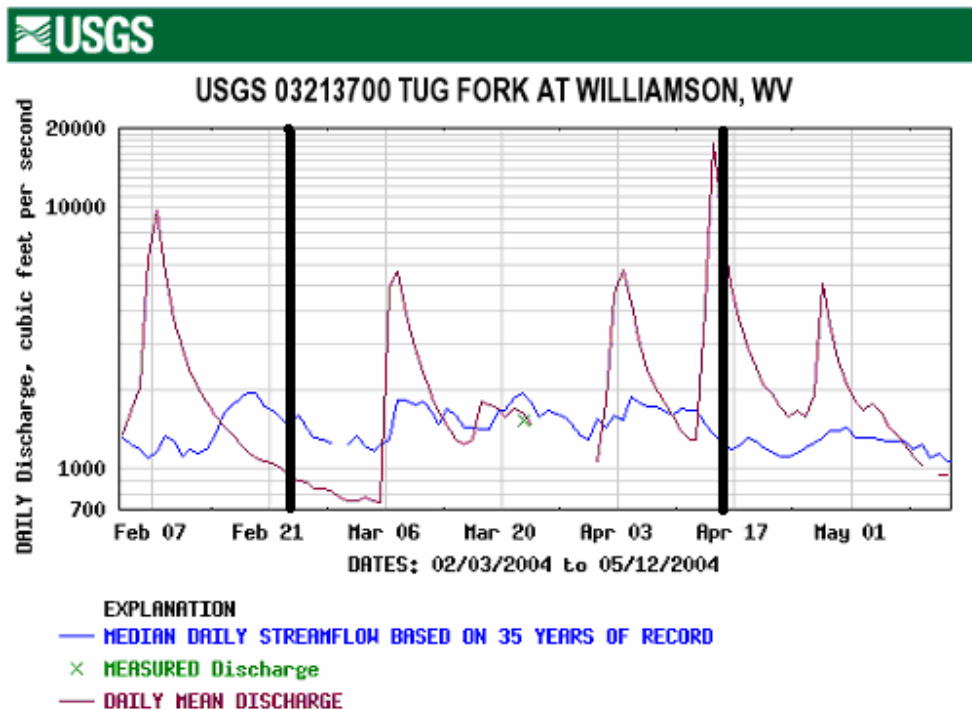


Map 1. Williamson area well water sampling locations, Mingo County, WV.

Sampling during low flow and high flow conditions

Fifteen samples were taken during a low flow period on February 25 and 26, 2004 when mean daily stream flow was between 882 and 841 cubic feet per second at the Tug Fork River gauging station at Williamson (Hydrograph 1). During low flow sampling discharge in the Tug Fork River was approximately 38% of the 35 year median flow condition for those dates.

Eight samples were taken during a high flow period on April 16, 2004 when mean daily stream flow was 5,120 cubic feet per second in the Tug Fork River, or 270% the 35 year median flow condition for that date (Hydrograph 1). The 8 high flow samples were collected by citizens who had been trained by the investigators on how to take samples, label them, fill out data sheets, and mail them according to the Water Quality Lab protocol. The samples were labeled and mailed to Wheeling Jesuit University where sample data sheets were photocopied prior to mailing the samples to the Water Quality Laboratory.



Provisional Data Subject to Revision

Hydrograph 1. Stream discharge ($\text{ft}^3/\text{second}$) at the US Geological Survey Tug Fork recording station near Williamson, West Virginia showing discharge in relation to median flow on February 25-26, and April 16, 2004 well water sampling dates (indicated by vertical black lines).

Results

Water chemistry in Williamson area wells

Well water was tested for 7 metals regulated by primary standards, 5 metals regulated by secondary standards, 2 metals regulated by lifetime health advisories, and 7 non-regulated chemicals.

Metals regulated by primary standards in Williamson area well water

Six of 7 metals that were tested for and that are regulated by primary standards were detected in at least one Williamson area well (Tables 1 & 2). Cadmium was not detected in any well sample. Arsenic was detected in 6 of the 15 different wells, twice in excess the primary standard. Barium was detected in 12 of the 15 wells, once in excess of the standard. Beryllium was detected in 2 of the 15 wells, once in excess of the standard. Chromium was detected in 11 of 15 wells and did not exceed the standard. Lead was detected in 14 of the 15 wells, exceeding the standard in 7 different wells including twice in 1 of the 5 wells that was re-sampled during high flow conditions. Selenium was detected in 1 well and that sample exceeded the primary standard. Primary drinking water standards for the 7 metals tested were exceeded 13 times in samples collected from 15 different wells. Standards were exceeded for lead (8), arsenic (2), barium (1), beryllium (1), and selenium (1), but not for cadmium or chromium.

A sample from a spring used by many families as their drinking water source yielded 1 chemical, chromium, regulated by primary standards. The spring sample had 7 ppb chromium, and was well below the standard of 10 ppb. A sample from the Williamson area municipal supply yielded 2 metals, chromium (3 ppb) and lead (16 ppb) that were tested for and are regulated by primary drinking water standards. In the municipal sample only lead exceeded the 15 ppb standard. In contrast, a sample of the supernatant water decanted from sludge that had collected in the bottom of a hot water heater (source identity 4831) yielded 6 of the 7 tested metals of primary concern, with only cadmium not detected. Four of the 7 metals tested in the hot water heater exceeded primary drinking water standards by factors of 15X for arsenic (150 ppb), 1.5X for barium (3,000 ppb), 12.5X for lead (188 ppb), and 129.2X for selenium (646 ppb). Most interesting, arsenic and selenium were not detected in the sample from the source well (4826) from which the hot water heater (4831) was supplied. Of the 7 metals tested only lead exceeded the primary standard in the source well. When concentration factors for metals of primary concern are calculated by dividing the concentration in the hot water heater by the concentration in the source well (for those elements detected in the source well) the multiplication factor for barium is 30X, chromium 7.3X, and lead 11.8X.

Whereas no households with drilled wells had used their well water as a drinking source for some time, all households actively used their well water as a source for bathing and washing. Therefore, concentration of metals in hot water heaters followed by vaporization during bathing (most used showers) indicates that inhalation, ingestion, and absorption may be significant human exposure pathways. Many households complained

of difficulty in keeping the walls of their bathrooms clean due to buildup of black and red precipitates. Additionally, all households had to use plastic, not metal, fixtures in their bathrooms and kitchen sinks because metal fixtures corroded and dissolved “within 2 years.” Most households had replaced their hot water heater within the past 2 years because of corrosion leading to failure of their hot water heater. One additional observation was that when well samples were collected by disengaging the well supply from the household plumbing, as was done in 10 of the 15 different wells sampled (5 samples were collected from the tap as stated and identified specifically in the Methods Section), derelict hot water heaters were observed alongside new hot water heaters in most of the basements and sheds that were visited.

Arsenic was detected in 1 of 12 wells sampled during low flow conditions, with a concentration of 3.2 ppb being below the 10 ppb primary water quality standard (Table 1). Arsenic was 150 ppb in the sample collected from the hot water heater. Arsenic was detected in 6 of 8 wells during high flow conditions with concentrations ranging from 4.2 to 340.0 ppb where detected, and 2 wells exceeding the 10 ppb standard (Table 2).

Barium was detected in 10 of 12 wells sampled at base flow, and one well yielding 2,400 ppb exceeded the 2,000 ppb standard (Table 1). Barium was not detected in the spring or the municipal supply. Barium was 3,000 ppb in the sample from the hot water heater. Barium was detected in 7 of 8 wells tested during high flow conditions with concentrations ranging from 200 to 500 ppb (Table 2).

Beryllium was not detected in wells at low flow, the municipal water sample, or the sample from the spring (Table 1). Beryllium was detected at 1 ppb in the hot water heater sample. Under high flow conditions beryllium was detected in 2 of 8 wells with concentrations of 1 and 7 ppb, therefore one sample exceeded the standard of 4 ppb at high flow (Table 2).

Cadmium was the only metal out of 7 metals tested that are regulated by primary drinking water standards that was not detected in any samples under any condition in Williamson area wells (Tables 1 & 2). Cadmium was also the only metal regulated by primary drinking water standards that was not detected in the sample from the hot water heater.

Chromium was detected in 6 of 12 wells under low flow conditions, with concentrations of 3 to 9 ppb being well below the standard of 100 ppb (Table 1). Chromium was detected in the spring (7 ppb), the municipal water sample (3 ppb), and the hot water heater (29 ppb). Under high flow conditions chromium was detected in all 8 wells with concentrations ranging from 2 to 24 ppb (Table 2). Chromium did not exceed primary drinking water standard of 100 ppb in any of the wells tested.

Lead was detected in 6 of 12 wells during low flow conditions with concentrations ranging from 6 to 23 ppb (Table 1). Five of 12 wells exceeded the 15 ppb primary standard. Lead was not detected in the spring, but exceeded the primary standard in the municipal water sample (16 ppb) and was 188 ppb in the hot water heater sample.

Lead was detected in 7 of 8 wells under high flow conditions with concentrations ranging from 9 to 110 ppb, and 3 wells exceeded the primary standard (Table 2).

Selenium was detected in only 1 of 12 wells under low flow conditions with a concentration of 65 ppb in excess of the 50 ppb standard (Table 1). Selenium was not detected in the spring or the municipal water sample. The selenium concentration was 646 ppb in the sample from the hot water heater. Selenium was not detected in any well under high flow conditions (Table 2).

Metals regulated by secondary standards in Williamson area well water

All 5 of the metals tested that are regulated by secondary drinking water standards were detected in Williamson area wells (Tables 1 & 2). Aluminum was detected in 12 of the 15 different wells tested, and the aluminum secondary standard was exceeded in 1 well. Copper was detected in 3 of 15 different wells and did not exceed the secondary standard in any well. Iron was detected in all 15 wells and exceeded the secondary standard in 13 of the wells, including twice in 4 of the 5 wells that were re-sampled during high flow conditions. Manganese was detected in 14 of the 15 different wells tested. Manganese exceeded the secondary standard in 13 of the 15 wells, including twice in 4 of the 5 wells re-sampled during high flow conditions. Zinc was detected in 14 of the 15 different wells tested. Zinc exceeded the secondary drinking water standard in 1 of the 15 wells. Secondary drinking water standards for the 5 metals tested were exceeded a total of 36 times in samples collected from 15 different wells. Standards were exceeded for iron (17), manganese (17), aluminum (1), and zinc (1), but not for copper.

A spring water sample contained only 1 of 5 metals tested and regulated by secondary standards: iron at 14 ppb. The sample from the Williamson municipal supply contained aluminum at 30 ppb and manganese at 35 ppb. In contrast, a sample of supernatant water decanted from the sludge which had collected in the bottom of a hot water heater (source identity 4831) yielded all 5 of the tested metals of secondary concern. Two of the 5 metals tested in the hot water heater exceeded secondary drinking water standards by factors of 1,859X for iron, and 5,452X for manganese. Most interesting, iron was 1.6X above standard and manganese 1.1X above standard in the sample from the source well (4826) from which the hot water heater (4831) was supplied. Here again, the hot water heater acts as a concentrating mechanism from which vaporization and subsequent inhalation, as well as ingestion and absorption exposure during bathing may be a significant human exposure pathway as described previously for metals of primary concern. Neither copper nor aluminum were detected in the source well, but both were detected in the hot water heater. Zinc was concentrated by a factor of 81.5X in the hot water heater (4831) compared to the source well (4826), iron was concentrated by 1,179.1X, and manganese 485.6X.

Aluminum was detected in 8 of 12 wells tested during base flow condition with concentrations ranging from 10 to 60 ppb (Table 1). Aluminum was not detected in the spring and was 30 ppb in the municipal water sample. Aluminum was 200 ppb in the hot

water heater sample, equal to the 200 ppb secondary standard. Aluminum concentrations ranged from 30 to 170 ppb during high flow with one exception: one well tested during high flow had a concentration of 8,030 ppb, well in excess of the 200 ppb secondary standard (Table 2).

Copper was detected in only 1 well at base flow with a concentration of 53 ppb, well below the 1,300 ppb secondary standard (Table 1). Copper was not detected in the spring or the municipal supply and was below the standard with a concentration of 390 ppb in the hot water heater. Copper was detected in 2 of 8 wells sampled during high flow conditions with concentrations of 131 and 758 ppb being below the secondary standard (Table 2).

Iron was the predominant metal regulated by secondary standards that was detected in study wells, with concentrations ranging from 39 ppb to 25,280 ppb (Table 1). Iron was not detected in the sample from the municipal water supply, and 14 ppb were found in the spring water sample. Ten of 12 wells exceeded the drinking water standard of 300ppb during base flow. Iron was 557,700 ppb in the sample from the hot water heater. Iron exceeded the 300 ppb standard in all wells under high flow conditions, with concentrations ranging from 371 to 57,588 ppb (Table 2).

Manganese concentrations under low flow conditions ranged from not detected in the spring and a 26 foot deep dug well to 2,999 ppb in a 76-foot-deep drilled well (Table 1). Manganese was 35 ppb in the municipal water sample. Manganese exceeded the 50 ppb standard in 9 of 12 wells. Manganese was 27,260 ppb in the sample from the hot water heater. Under high flow conditions manganese exceeded the secondary standard in all 8 wells sampled with concentrations ranging from 82 to 4,063 ppb (Table 2).

Zinc was detected in 9 of 12 wells sampled during low flow conditions with concentrations ranging from 12 to 239 ppb, and no samples in excess of the 5,000 ppb secondary standard (Table 1). Zinc was not detected in the spring or the municipal supply. The hot water heater had a zinc concentration of 2,118 ppb. Zinc was detected in all 8 wells tested during high flow conditions and one well exceeded the secondary standard with a concentration of 5,658 ppb (Table 2).

Regulated chemicals with lifetime health advisories in Williamson area well water

Two metals tested and regulated by lifetime health advisories included nickel and sodium. Nickel was detected in only one for the 15 wells tested; a concentration of 285 ppb in excess of the 10 ppb standard (Tables 1 & 2). Nickel was not detected in the spring, the municipal supply, or the hot water heater (Table 1). Nickel was detected in only one well, and that sample was collected during high flow conditions (Table 2).

Sodium was detected in all samples ranging in concentration from 7,600 to 184,400 ppb during low flow conditions (Table 1), and 8,300 to 189,100 ppb during high flow conditions (Table 2). In wells sodium exceeded the 20,000 ppb standard in 13 of the 15 different wells tested (Tables 1 & 2). The sodium standard was exceeded in 10 of 12

wells tested during low flow (Table 1), and 6 of 8 wells tested during high flow, including twice in 4 of the 5 wells re-tested during high flow (Table 2). In total, sodium standards were exceeded 16 times (Tables 1 & 2). Sodium was 2.1X the standard in the sample from the spring, and 2.1X the standard in the sample from the municipal water supply (Table 1). Interestingly, sodium was only 1.6X the sodium standard in the hot water heater, and had a concentration factor of only 3.3X compared to the source well (source identity 4826) from which the hot water heater (source identity 4831) was supplied. Therefore, sodium had the lowest concentration factor of any of the regulated chemicals that were detected in the source well.

Non-regulated chemicals in Williamson area well water

Calcium, magnesium, potassium, and silica were present in all wells, springs, the municipal water sample, and the hot water heater tested under both low and high flow conditions (Tables 1 & 2). Calcium and magnesium were the most abundant non-regulated chemicals tested. Potassium and silica were also present in high concentrations relative to other elements.

Strontium was present in 8 of 12 wells tested during low flow conditions (Table 1), and 4 of 8 wells tested under high flow conditions (Table 2). Cobalt was detected in one well during low flow conditions (Table 1), and one well tested during high flow conditions (Table 2). Vanadium was detected in 5 wells tested during low flow conditions, in the municipal water sample, and in the hot water heater sample (Table 1). Vanadium was not detected in any of the 8 wells tested during high flow conditions (Table 2).

Of the 7 non-regulated chemicals tested, strontium and vanadium were not detected in the source well (4826) but were detected in the hot water heater (4831). Multiplication factors from source to hot water heater for the other 5 non-regulated chemicals indicated the following rates of increase: calcium=1.9X, magnesium=1.1X, potassium=1X, and silica=13.2X. Cobalt was not detected in either the source or the hot water heater. Of the non-regulated chemicals, only silica multiplied to the extent witnessed for many of the regulated chemicals.

Table 1. Summary of well water chemistry ($\mu\text{g/l}$) during low flow conditions within 3 miles of a coal slurry impoundment in Mingo County, WV, February 25 & 26, 2004 (n.d.=non-detect, values shown in bold with borders exceed EPA limits).

Source information (12 household wells, a spring used by many households, the municipal water supply, and a hot water heater)

source	spring	well	well	well	well	muncpl.	well	well	well	well	well	well	well	well	heater
well depth (feet)	0	26	158	55	220		100	85	100	79	150	78	189	100	100
location in hollow	bottom	middle	head	head	middle	tap	bottom	bottom	bottom	head	bottom	bottom	middle	bottom	bottom
source water hardness	207	130	89	70	120	240	158	207	229	90	403	185	301	240	151
source identity (Map 1).	4816	4821	4818	4852	4819	4824	4802	4856	4817	4826	4844	4836	4845	4841	4831

Regulated Chemicals (all values in $\mu\text{g/l}$, micrograms per liter, or parts per billion)

	EPA stndrd.	<i>Primary (enforceable) standards</i>															
		spring	well	well	well	well	muncpl	well	well	well	well	well	well	well	heater		
Arsenic	10	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	3	n.d.	150
Barium	2000	n.d.	n.d.	700	500	400	n.d.	200	900	300	100	n.d.	100	100	2400	3000	
Beryllium	4	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	1
Cadmium	5	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Chromium	100	7	n.d.	n.d.	n.d.	n.d.	3	6	3	n.d.	4	7	9	7	n.d.	29	
Lead	15	n.d.	n.d.	n.d.	n.d.	n.d.	16	6	n.d.	n.d.	16	19	20	23	16	188	
Selenium	50	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	65	n.d.	n.d.	646	

Secondary (recommended) standards

Aluminum	200	n.d.	10	60	n.d.	50	30	60	50	60	n.d.	n.d.	60	50	n.d.	200
Copper	1300	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	53	n.d.	n.d.	n.d.	n.d.	n.d.	390
Iron	300	14	271	120	364	39	n.d.	1257	5339	10553	473	1015	1569	25280	1221	557700
Manganese	50	n.d.	n.d.	23	29	52	35	67	269	308	55	57	2999	435	157	27260
Zinc	5000	n.d.	64	n.d.	25	n.d.	n.d.	137	15	49	26	48	239	67	61	2118

Lifetime health advisory

Nickel	100	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Sodium	20000	41300	25500	83700	23900	106700	42300	26300	29300	30400	9500	101000	7600	41100	184400	31200

Summary statistics

exceedence of standards	1	1	1	2	2	2	3	3	3	3	4	4	4	5	7
best-to-worst ranking	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

Non-regulated (N.R.) chemicals

Calcium	N.R.	42000	25000	22400	17100	31500	48400	36900	53500	58000	24200	85000	52600	70700	65500	46700
Strontium	N.R.	1500	n.d.	930	n.d.	720	700	650	840	760	n.d.	2210	n.d.	660	2580	1210
Cobalt	N.R.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	12	n.d.	n.d.	n.d.	n.d.
Magnesium	N.R.	24800	16400	8100	6600	10000	28800	15900	17800	20500	7200	46400	13000	30100	18500	8200
Potassium	N.R.	7600	4100	3400	3400	3500	3400	3300	3900	3500	4300	8900	4000	3700	4200	4200
Silica	N.R.	3940	5120	7040	8000	7820	3150	7800	12020	10600	7480	4240	11150	9050	10520	98590
Vanadium	N.R.	n.d.	10	n.d.	35	n.d.	10	n.d.	n.d.	13	n.d.	n.d.	16	22	n.d.	91

Table 2. Summary of well water chemistry ($\mu\text{g/l}$) during high flow conditions within 3 miles of a coal slurry impoundment in Mingo County, WV, April 16, 2004 (n.d.=non-detect, values shown in bold with borders exceed EPA limits)

source	well	well	well	well	well	well	well	well
well depth (feet)	78	85	100	189	55	220	120	n/a
location in hollow	bottom	bottom	bottom	middle	head	middle	middle	n/a
source water hardness	163.6	90.2	136.4	246.9	68.1	72	186	757.9
source identity (Map 1).	4836	n/a	4802	4845	4852	4819	n/a	n/a

Regulated Chemicals (all values in $\mu\text{g/l}$, micrograms per liter, or parts per billion)

	EPA standard	<i>Primary (enforceable) standards</i>							
		<u>well</u>	<u>well</u>	<u>well</u>	<u>well</u>	<u>well</u>	<u>well</u>	<u>well</u>	<u>well</u>
Arsenic	10	n.d.	8	4	8	44	340	5	n.d.
Barium	2000	200	500	200	400	500	500	400	n.d.
Beryllium	4	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	1	7
Cadmium	5	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Chromium	100	6	17	4	8	2	4	18	24
Lead	15	10	12	10	22	9	n.d.	110	30
Selenium	50	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
<i>Secondary (recommended) standards</i>									
Aluminum	200	170	70	70	70	30	40	50	8030
Copper	1300	n.d.	n.d.	n.d.	131	n.d.	n.d.	758	n.d.
Iron	300	7586	57588	2203	27327	4214	9701	25059	371
Manganese	50	2890	511	171	387	82	452	2953	4063
Zinc	5000	1000	419	74	388	62	70	5658	712
<i>Lifetime health advisory</i>									
Nickel	100	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	285
Sodium	20000	8300	15700	35300	43200	30900	189100	61500	55800
<i>Summary statistics</i>									
exceedence of standards		2	2	3	4	4	4	5	7
best-to-worst ranking		1	2	3	4	5	6	7	8

Non-regulated (N.R.) chemicals

Calcium	N.R.	47300	20700	33100	60800	17300	19000	48600	99500
Strontium	N.R.	n.d.	n.d.	640	680	510	600	n.d.	n.d.
Cobalt	N.R.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	179
Magnesium	N.R.	11100	9400	13000	23100	6000	6000	15700	123700
Potassium	N.R.	2200	2400	2300	2300	2400	3800	2300	18300
Silica	N.R.	9720	11910	7050	9670	6510	5710	9440	13560
Vanadium	N.R.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.

A comparison of 5 wells tested during low flow versus high flow conditions

Five wells sampled during low flow conditions were re-sampled during high flow conditions (Table 3). The comparison included wells that ranged from 55-220 feet in depth and included sites in the head, middle, and bottom of the hollows. The comparison also included some of the better wells in terms of water quality (4852, 4819, and 4802) and some of the worst (4836 and 4845). The compared wells had consistently lower hardness during high flow events than during low flow; an apparent dilution effect. Lower hardness was the result of reduced calcium and magnesium concentrations. Iron and manganese, however, were typically greater during high flow and consistently exceeded water quality standards.

Regulated chemicals were detected 2.25X more frequently during high versus low flow events in 4 of the 5 wells compared. In the other well the detection of regulated chemicals decreased by 1, specifically selenium. The number of metals in excess of water quality standards declined by 2 in well 4836, stayed the same in 2 wells, and increased by 2 in the 2 other wells that were re-sampled. Many of the chemical concentrations measured at low flow were similar at high flow. For instance, wells with relatively low hardness at low flow also had low hardness at high flow compared to other wells. Likewise, high hardness wells had relatively high hardness under high or low flow conditions.

However, the composition of some specific elements in well water changed considerably due to flow conditions. For instance, vanadium was detected in 3 of 5 wells during low flow, but was not detected during high flow. The reverse was also apparent, for instance, with arsenic detected in only one of the 5 re-sampled wells at low flow, but 4 of 5 wells during high flow. Copper was detected only once in wells, during high flow. Selenium was detected only once in wells, during low flow.

Arsenic was not detected in well 4836 under any flow condition. Arsenic was detected in well 4845 under both flow conditions. In 3 other wells arsenic was detected only during the high flow event. In 2 of those wells, arsenic exceeded the 10 ppb standard with values of 44 and 340 ppb. Arsenic at 340 ppb was the highest level observed during this study.

Chromium was detected in 3 wells at both high and low flow, but 2 other wells only at high flow. High flow conditions resulted in lead being detected in one well where it had not previously been detected. Otherwise, chromium was consistently detected in (3 wells) or not detected (one well), regardless of flow conditions. Selenium had been detected in well 4836 during low flow, but was not detected in that well or any other well during high flow.

Table 3. Comparison of well water chemistry (ug/l) during low flow (base flow, February 25 & 26, 2004) versus high flow (blackwater, April 16, 2004) conditions (n.d.=non-detect, values shown in bold with borders exceed EPA limits).

source identity (Map 1).	well 4819		well 4852		well 4836		well 4845		well 4802	
well depth (feet)	220		55		78		189		100	
location in hollow	middle		head		bottom		middle		bottom	
source water hardness	120	72	70	68	185	164	301	247	158	136
flow condition	low	high	low	high	low	high	low	high	low	high

Regulated Chemicals (all values in ug/l, micrograms per liter, or parts per billion)

	EPA standard	<i>Primary (enforceable) standards</i>											
		low		high		low		high		low		high	
Arsenic	10	n.d.	340	n.d.	44	n.d.	n.d.	n.d.	n.d.	3	8	n.d.	4
Barium	2000	400	500	500	500	100	200	100	400	200	200	200	200
Beryllium	4	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Cadmium	5	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Chromium	100	n.d.	4	n.d.	2	9	6	7	8	6	4	6	4
Lead	15	n.d.	n.d.	n.d.	9	20	10	23	22	6	10	6	10
Selenium	50	n.d.	n.d.	n.d.	n.d.	65	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
<i>Secondary (recommended) standards</i>													
Aluminum	200	50	40	n.d.	30	60	170	50	70	60	70	60	70
Copper	1300	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	131	n.d.	n.d.	n.d.	n.d.
Iron	300	39	9704	364	4214	1569	7586	25280	27327	1257	2203	1257	2203
Manganese	50	52	452	29	82	2999	2890	435	387	67	171	67	171
Zinc	5000	n.d.	70	25	62	239	1000	67	388	137	74	137	74
<i>Lifetime health advisory</i>													
Nickel	100	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Sodium	20000	106700	189100	23900	30900	7600	8300	41100	43200	26300	35300	26300	35300
<i>Summary statistics</i>													
exceedence of standards		2	4	2	4	4	2	4	4	3	3	3	3
number of detects		5	8	5	9	9	8	9	10	8	9	8	9

Non-regulated (N.R.) chemicals

Calcium	N.R.	31500	19000	17100	17300	52600	47300	70700	60800	36900	33100	36900	33100
Strontium	N.R.	720	600	n.d.	510	n.d.	n.d.	660	680	650	640	650	640
Cobalt	N.R.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Magnesium	N.R.	10000	6000	6600	6000	13000	11100	30100	23100	15900	13000	15900	13000
Potassium	N.R.	3500	3800	3400	2400	4000	2200	3700	2300	3300	2300	3300	2300
Silica	N.R.	7820	5710	8000	6510	11150	9720	9050	9670	7800	7050	7800	7050
Vanadium	N.R.	n.d.	n.d.	35	n.d.	16	n.d.	22	n.d.	n.d.	n.d.	n.d.	n.d.

A comparison of Williamson wells with regional domestic water wells

The results of well water sampling in the Williamson area were compared to results available from nearby domestic well water samples from southern West Virginia and Eastern Kentucky (Figures 1-5, Table 4). Two metals of greatest concern include arsenic (Figure 1) and lead (Figure 2). 2 additional metals that are of secondary concern, iron (Figure 2) and manganese (Figure 3) were also plotted because they are important indicators of coal related contamination. Sodium was also compared because it often exceeded lifetime health advisories in Williamson area wells (Figure 5). Summary statistics including sample size, percent of wells where elements were detected, and percent of samples collected that exceeded standards are shown in Table 4.

Samples for comparison in West Virginia counties were collected in 1997-1999 by the Division of Water Resources Groundwater Program and can be found in Appendix B of the Department of Environmental Protection's Biennial Report to the Legislature (WV DEP, 2002). Sample data for comparison in Kentucky counties were downloaded from the Kentucky Groundwater Data Repository (Kentucky Geological Survey, 2003). For Kentucky counties samples were selected for wells sampled 1) from 1994-2003, 2) in domestic water use designation wells only, and 3) by Kentucky Division of Water Resources or the Natural Resources Environmental Protection Council.

Arsenic concentrations in Williamson wells exceeded the primary drinking water standard in 2 of 8 wells (25%) during high flow conditions (Figure 1, Table 4). The 340 ppb in one well was the highest arsenic concentration in any of the regional wells. The next highest arsenic value was a Williamson well under high flow conditions at 44 ppb. Arsenic was detected in 75% of the Williamson wells during high flow conditions, and 8% of Williamson wells under low flow. Arsenic was not detected in any of the 12 wells sampled by WV DEP in Wyoming, McDowell, and Mingo Counties, West Virginia. Arsenic was detected in 14 of the 79 wells tested in Kentucky counties, including 13% of Pike County wells and 22% of Martin county wells. The highest concentration in Pike County wells was <2 ppb. Four Martin County wells exceeded the primary standard with values of 11-14ppb. Arsenic was not detected in any of the 11 Floyd County wells, however, we did locate a pollution monitoring well in Floyd County with an arsenic level of 172 ppb (data not included), approximately one-half the level witnessed in the exceptionally high arsenic concentration in one Williamson well.

Lead is abundant in Williamson area wells compared to other domestic wells (Figure 2, Table 4). One sample contained 110 ppb lead, the highest lead concentration in regional samples, and from a different well than the one that had the extraordinarily high concentration of arsenic. Lead was detected in 50% of low flow and 88% of high flow samples in the Williamson area. Lead was not detected in the 12 samples from the DEP Water Resources groundwater study. Lead was detected in 28% of Pike County samples, 18% of Martin County samples, and 45% of samples from Floyd County.

Lead exceeded the standard in 42% of Williamson low flow samples and 38% of Williamson high flow samples. Lead exceeded drinking water standards in 4% of Pike County, 4% of Martin County, and 9% of Floyd County domestic well water samples. Average lead concentrations in Williamson area samples greatly exceed average lead concentrations in other regional wells.

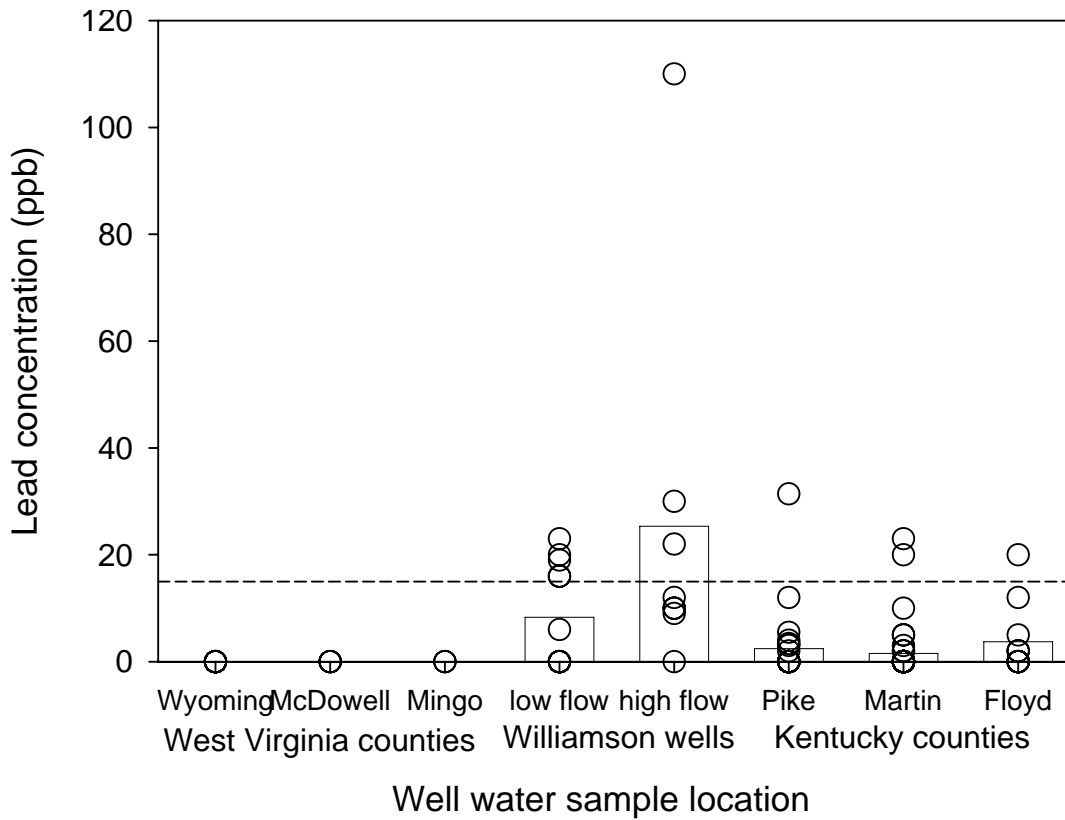
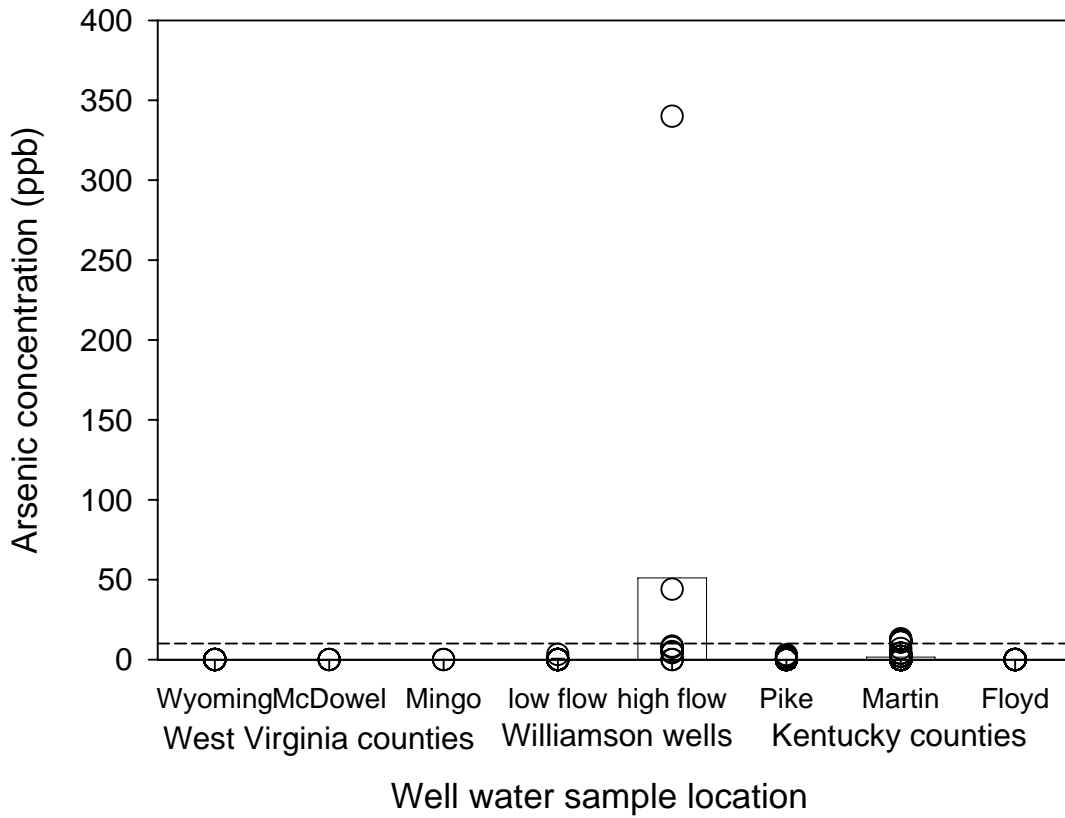
Iron (Figure 3) and manganese (Figure 4) concentrations followed patterns similar to those of arsenic and lead when comparing regional wells. Both peak and average concentrations of these elements were greater in Williamson area wells during high flow than in any other wells. During low flow, average iron concentrations in Williamson area wells were marginally less than in Pike County wells, as were peak iron concentrations. Average manganese concentrations in Williamson area wells during low flow were similar to those of Pike County and McDowell County. Both iron and manganese were detected in the vast majority of the wells in the region (Table 4).

Williamson wells at high flow and the 3 McDowell County wells exceeded standards for iron and manganese 10% of the time. One Williamson area well that was sampled at both low and high flow, 2 Williamson area wells sampled only during high flow, 4 wells in Pike County, and 1 Martin County well had extremely high concentrations of iron and manganese. These values were nearly 10-times the standard.

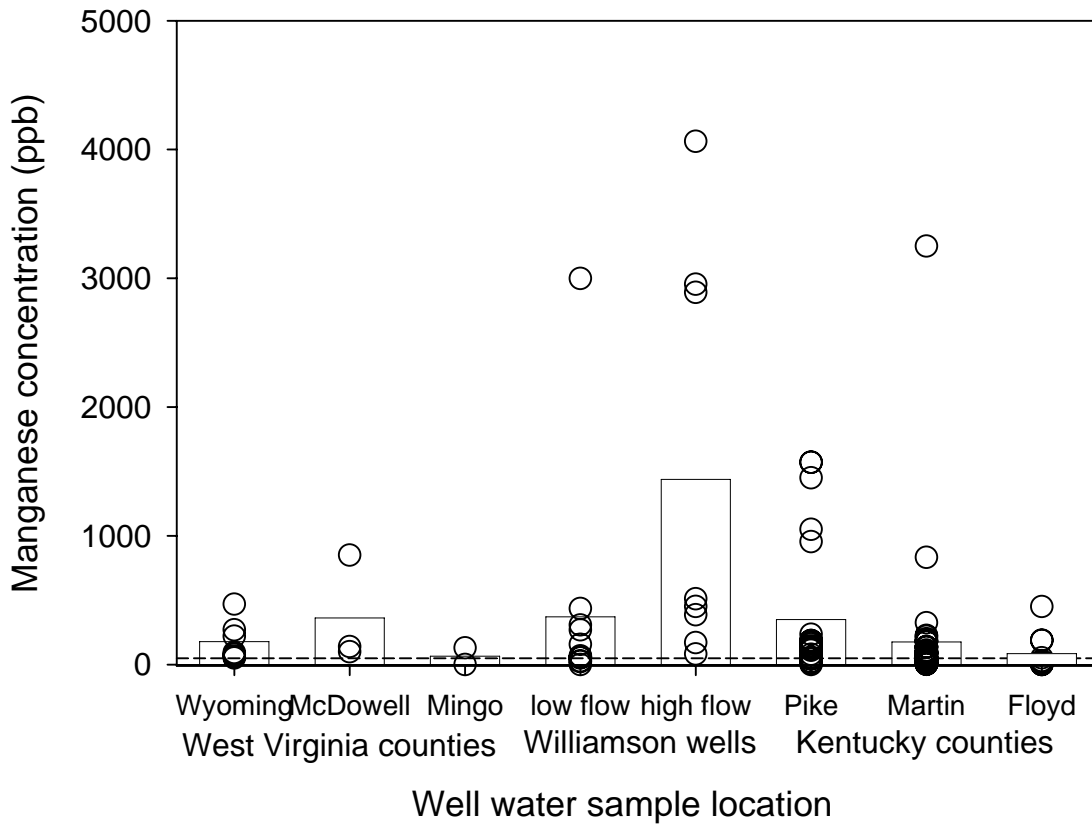
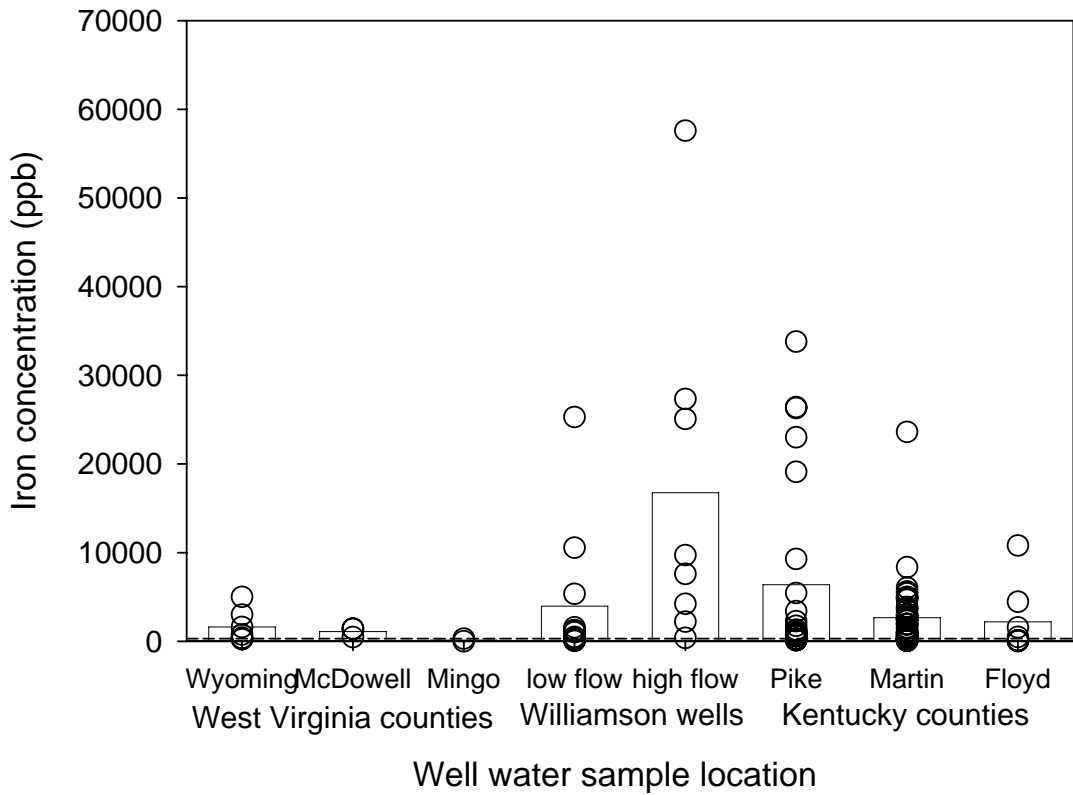
Average sodium concentrations, while way above recommended standards, show an opposite pattern to the aforementioned metals. Sodium concentrations are lower in Williamson wells than in other regional wells. This may reflect cation exchange in the presence of metals. Regardless, sodium is consistently above standard in the majority of Williamson wells. High sodium levels in the presence of high metals concentrations is an additional health effects concern for Williamson area wells.

Table 4. Summary statistics for Williamson well samples compared to other regional well samples.

	<u>West Virginia counties</u>			<u>Williamson wells</u>		<u>Kentucky counties</u>		
	<u>Wyoming</u>	<u>McDowell</u>	<u>Mingo</u>	<u>low flow</u>	<u>high flow</u>	<u>Pike</u>	<u>Martin</u>	<u>Floyd</u>
<u>Arsenic</u>								
<u>samples</u>	7	3	2	12	8	23	45	11
<u>%detect</u>	0	0	0	8	75	13	22	0
<u>%exceed</u>	0	0	0	0	25	0	9	0
<u>Lead</u>								
<u>samples</u>	7	3	2	12	8	25	45	11
<u>%detect</u>	0	0	0	50	88	28	18	45
<u>%exceed</u>	0	0	0	42	38	4	4	9
<u>Iron</u>								
<u>samples</u>	7	3	2	12	8	25	45	8
<u>%detect</u>	10	10	50	10	10	10	10	10
<u>%exceed</u>	86	10	0	75	10	80	80	50
<u>Manganese</u>								
<u>samples</u>	7	3	2	12	8	25	45	11
<u>%detect</u>	10	10	50	92	10	96	10	82
<u>%exceed</u>	10	10	50	75	10	76	67	36
<u>Sodium</u>								
<u>samples</u>	7	3	2	12	8	23	45	15
<u>%detect</u>	10	10	10	10	10	10	10	10
<u>%exceed</u>	10	10	10	83	75	91	82	10



Figures 1 & 2. Arsenic and lead concentrations in Williamson area well water in relation to other regional well water samples. Concentrations below detection limits are shown as zero. Bars indicate average concentration in each group. Dashed line indicates drinking water standards. Samples sizes shown in Table 4.



Figures 3 & 4. Iron and manganese concentrations in Williamson area well water in relation to other regional well water samples. Concentrations below detection limits are shown as zero. Bars indicate average concentration in each group. Dashed line indicates drinking water standards. Samples sizes shown in Table 4.

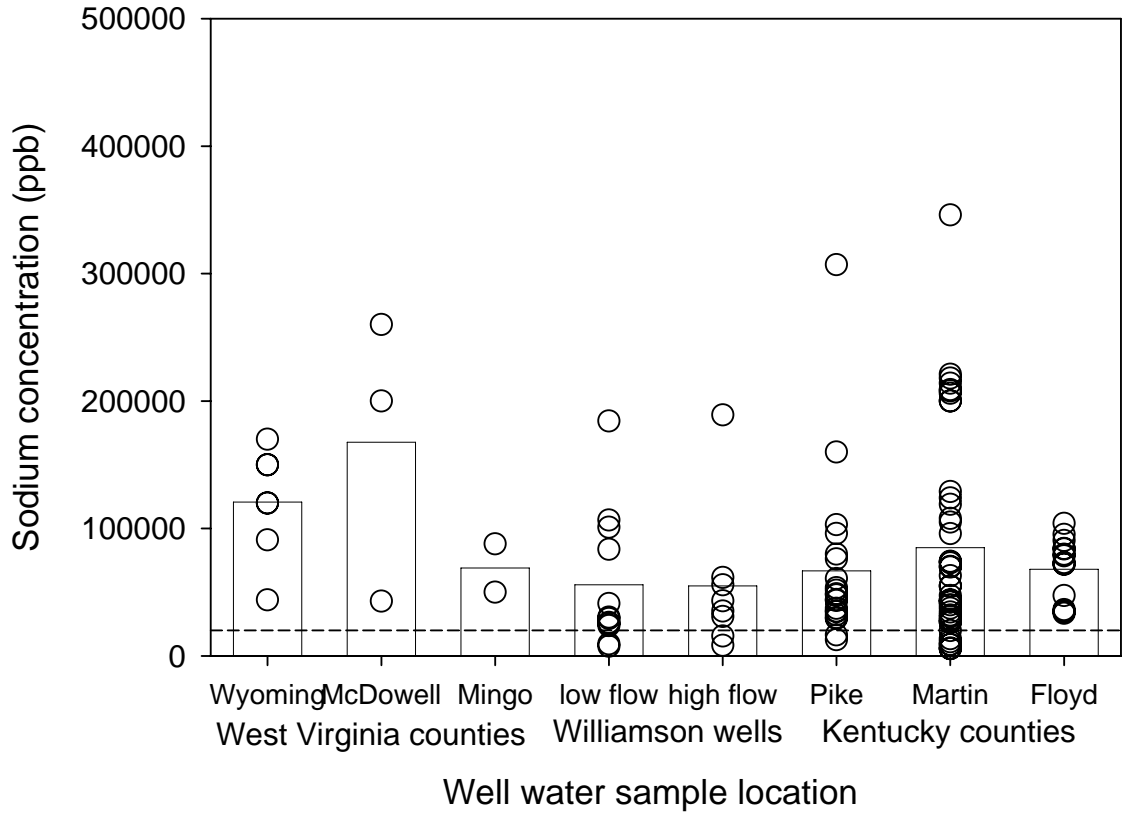


Figure 5. Sodium concentrations in Williamson area well water in relation to other regional well water samples. Concentrations below detection limits are shown as zero. Bars indicate average concentration in each group. Dashed line indicates drinking water standards. Samples sizes shown in Table 4.

Discussion

Water supply concerns

The results of this study indicate that well water quality in the area of Sprigg, Merrimac, Rawl, and Lick Creek near Williamson, West Virginia is unquestionably poor. Excessive levels of heavy metals, particularly lead and arsenic, may present a chronic health hazard to those families exposed to wells. Exposure may occur from inhalation and ingestion during bathing, using tap water in icemakers, and from contact with well water during washing in sinks, dishwashers and washing machines; particularly when hot water is used. Hot water heaters act to concentrate metals prior to delivery to the household system.

The metals found in Williamson area wells are commonly associated with coal mining activities, and these levels may be confounded by historic mining practices or exacerbated by recent drilling activities. However, iron at levels up to 57,588 ppb and manganese at levels up to 4,063 ppb indicates that Williamson area wells may be subjected to coal slurry contamination. Samples of coal slurry liquids collected in 1985 from the Pond Fork coal slurry impoundment yielded 3,833,000 ppb of iron and 20,000 ppb of manganese (US EPA, 1985). Likewise, slurry samples from the Big Branch Impoundment in Martin County, KY, had 10,700,000 ppb iron and 53,500 ppb manganese (US EPA, 2001).

Arsenic is common in coal and associated shale, and is adsorbed onto iron oxides and oxyhydroxides (Fisher, 2002). Iron hydroxide ($\text{Fe}(\text{OH})_3$), commonly referred to as “yellow boy,” is the most common form of iron in oxygenated water (Wetzel, 1975) and appears to be the primary cause of red staining on clothes and porcelain in the households visited during this study. The reddish sludge collected from the bottom of the hot water heater had 557,700 ppb iron and 150 ppb arsenic. The non-detects of arsenic under low flow conditions followed by detects in 3 of 5 wells during high flow may be related to the arsenic-iron flocculent complex in the study wells.

The levels of metals found in Williamson area wells are greater than metals found in water supply wells in neighboring counties in southern West Virginia and eastern Kentucky. Although there is very little domestic well data available in this region, several of the few wells that have been tested in Pike and Martin Counties, Kentucky are also of serious concern. Nonetheless, metals were detected and standards exceeded in a greater percentage of Williamson area wells than in other coalfield region wells. Arsenic concentrations greater than 10 ppb are rare in Kentucky groundwater (Fisher & Goodmann, 2002). The Williamson area wells studied rank among the poorest in the nation in terms of arsenic (Welch, *et al*, 2000).

Metal concentrations in Williamson area well water repeatedly violated US EPA standards developed for public water supply sources. While most of our samples were from private wells, only the spring, a dug well, and 5 of the 14 drilled wells tested appear to be reasonable sources of drinking water. Seven of 14 drilled wells exceeded primary drinking water standards. Thirteen of the 14 drilled wells exceeded secondary drinking water standards. Although secondary standards are considered to impart taste and odor

concerns more so than health concerns, the concentrations witnessed in these wells was extraordinary. For instance, in one well iron was 192 times greater than the secondary standard. Another well had manganese at 81 times greater than the secondary standard.

Sources of contamination

A considerable amount of effort has been directed at assessing source water quality in the area. Well water quality analyses done by the E.L. Robinson Engineering Company for the West Virginia Department of Environmental Protection (WVDEP, 2001) concluded that “the only feasible and permanent solution to the water quality problem of the study area is an extension of the Mingo County PSD’s water system.” The study also concluded that “the interview and water analysis phases of this study indicated severe problems with ground water sources within the study area.”

Nonetheless, the Agency for Toxic Substances and Disease Registry (ATSDR) in conducting a Public Health Consultation in the Lick Creek area concluded that sites studied, including the Rawl Sales and Processing mine site, are not a public health hazard (ATSDR, 2004). Concurrently, ATSDR recommended that a) persons drinking groundwater from this area should consult with a doctor to see if they should restrict manganese in their diets or from other sources, such as multivitamins or mineral supplements b) persons with liver or gastrointestinal disease should consult a doctor to see if they should avoid ingestion of water in this area, water that is high in manganese, and c) infants should not be fed dry formula mixed with groundwater that is high in manganese and/or sulfates. Interestingly, within that same report it is stated that “coal mining activities can add many minerals to the groundwater such as iron, manganese, and sulfur.” High iron, manganese and sulfate levels have long been considered indicators of water pollution from mining; however, other metals regulated by primary drinking water standards are also associated with mining and drilling. No such heavy metal data was available for ATSDR review.

Coal slurry has been injected into deep mines in this area since the 1980s (ATSDR, 2004). A study conducted by the West Virginia Department of Environmental Protection indicated that some of the wells along lower Lick Creek may have residue from slurry injection (WV DEP, 1995). The ATSDR (2004) study stated that chemicals in the mine would be “diluted with mine water, and the longer the sludge is in the mine, the greater the potential for dilution.” This may be so, but the “dilution effect”, as evidenced by the new data presented herein, is still not enough to achieve water quality standards.

In their report ATSDR (2004) stated that “the nature of chemicals, if any, in the sludge that spilled into Lick Creek is unknown.” While the chemical constituents of coal slurry certainly require further study (National Academy of Sciences, 2002), some data were available to ATSDR regarding the chemical composition of slurry. For instance, ATSDR was involved in a study regarding a 309 million gallon coal slurry spill at Martin County Coal Corporations Big Branch Impoundment near Inez, Kentucky in October, 2000. The ATSDR’s final report, dated April 22, 2003, included data indicating that coal slurry solids contained arsenic at up to 8,000 ppb and lead at up to 21,000 ppb (ATSDR, 2003a). Moreover, a stream water sample collected in Coldwater Creek a week after the spill had 86 ppb arsenic and 430 ppb lead (US EPA, 2000). The administrative record

(US EPA, 2001) also contained slurry chemistry data that was collected by Eastern Coal Corporation as part of a consent order on a Superfund site near McAndrews, Kentucky, approximately 4 air miles south of Williamson (US EPA, 1985). Eastern Coal Corporation began underground injection of coal slurry into an abandoned mine in January, 1984. In November, 1984 citizens in the surrounding area complained of possible contamination of their water supply. In February, 1985 EPA ordered Eastern Coal Corporation to cease injecting slurry until it received an Underground Injection Control permit because “the slurry being injected by Eastern contained contaminants which were likely to enter a public water supply and may present an imminent and substantial endangerment to human health.” The water from the coal slurry sample collected by Eastern contained, among other contaminants, 1,820 ppb arsenic and 3,890 ppb lead. In March, 1985 Eastern provided citizens with a connection to the water system to the Williamson, West Virginia water supply and Eastern was allowed to resume slurry injection (EPA, 1985).

Prior to the current study no arsenic testing had been done in the communities of Sprigg, Merrimac, Rawl, and Lick Creek. Although arsenic was mentioned in the ATSDR report in response to a claim of a poisoned child, the agency stated that no data could be obtained to assess this claim and that the child had moved away from the area. The ATSDR maintained that the exposure pathway no longer exists because 2 households that had used spring water are now supplied with well water. The conclusions of the report state that there is no apparent public health hazard with regard to possible contamination from 3 sites including the Rawl Sales and Processing strip mine (ATSDR, 2004). The results of the current study conflict with those findings. The ATSDR ranks arsenic and lead as the top 2 substances on their 2003 priority list (ATSDR, 2003). The priority list is a list of 275 substances commonly found at Superfund sites “which are determined to pose the most significant potential threat to human health due to their known or suspected toxicity and potential for human exposure” at Superfund sites on the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) national priority list.

We recommend that ATSDR revisit the concerns of citizens regarding well water and health in the Williamson area. Additional well water testing should be conducted either by WV DEP or US EPA in support of a ATSDR health effects study. In addition to metals, a through analysis of volatile organic compounds, such as acrylamides and other additives used in the coal preparation process should be tested in order to identify source(s) of contamination. Should evidence of coal preparation residues mount, tracer dye, stable isotopes, or volatile organic chemicals unique to coal preparation plants could be measured to help identify the source(s) of contamination.

Conclusion

This study supports the claims of citizens that their well water is contaminated and subject to “blackwater” events. Well water often contained black particles and yielded metal concentrations in excess of drinking water standards. This confirms that the well water being utilized by citizens in the area is polluted. Additional studies are required to determine the exact source of contamination; however, our data suggest that

coal-related activities may contribute to the pollution. Most of the households visited during the study reported health concerns related to water quality including kidney stones, cancers, and developmental issues regarding the young. Given the two-decade history of contaminated well water and associated health problems in the communities of Sprigg, Merrimac, Rawl, and Lick Creek, it is the opinion of the authors that a detailed, professionally administered study of the relationship between illness and well water quality should be conducted.

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