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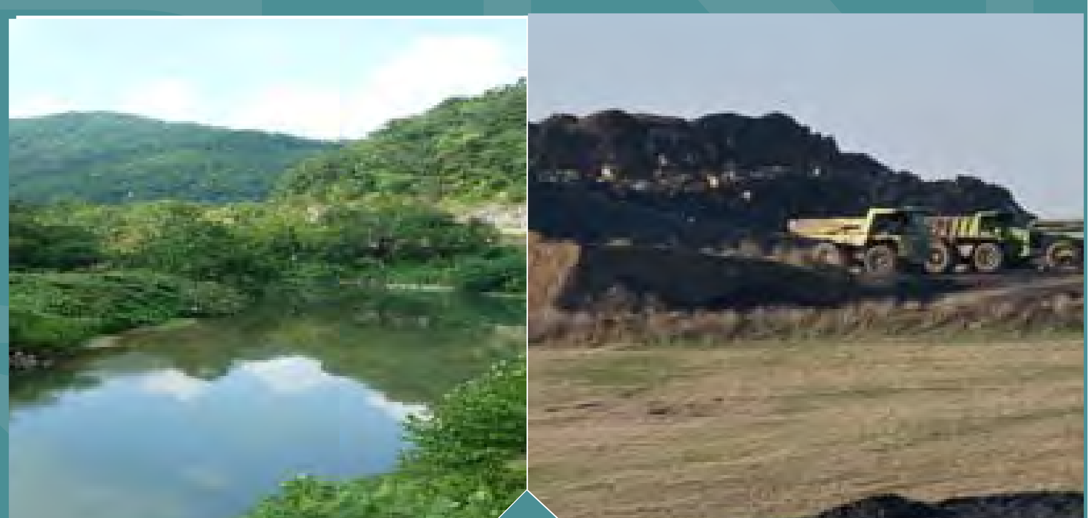
Economic Impact of Surface Mining on Drinking Water: Cost Analysis of Contaminated Household Drinking Water Supplies



Office of Research and Development
Water Supply and Water Resources Division

Economic Impacts of Surface Mining on Household Drinking Water Supplies

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Notice

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Abstract

This report provides information on the economic and social impacts of contaminated surface and ground water supplies on residents and households near surface mining operations. The focus is on coal slurry contamination of water supplies in Mingo County, West Virginia, and describes community health problems and costs over time. According to public records, 1.4 billion gallons of toxic slurry were pumped into underground mine shafts contaminating streams and well water of 769 residents in Rawl, Lick Creek, Merrimac and Sprigg, WV in the mid-1980s. Additional information on household water treatment and alternative sources of drinking water are provided to help communities solve drinking water contamination problems near mining operations.

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Acronyms and Abbreviations

AMD	Acid Mine Drainage
EPA	U.S. Environmental Protection Agency
Esq.	Esquire
KY	Kentucky
KY DEP	Kentucky Department of Environmental Protection
MCL	Maximum Contaminant Level
NRMRL	National Risk Management Research Laboratory
NPDWR	National Primary Drinking Water Regulations
NSDWR	National Secondary Drinking Water Regulations
N/A	not applicable
OVEC	Ohio Valley Environmental Coalition
PLLC	Professional Limited Liability Company
ppm	parts per million
PSD	Public Service District
PWS	Public Water System
QA	quality assurance
SDWA	Safe Drinking Water Act
SMCL	Secondary Maximum Contaminant Level
TDS	total dissolved solids
USDA	United States Department of Agriculture
USDA WEP	Water and Environmental Programs (Rural Development)
WSWRD	Water Supply and Water Resources Division
WV	West Virginia
WV DEP	West Virginia Department of Environmental Protection
WV DHHR	West Virginia Department of Health and Human Resources

1.0 Introduction

In Mingo County, West Virginia (WV), chemicals used in coal slurry operations have entered surface and ground water sources via surface impoundment injection wells. According to public records, 1.4 billion gallons of coal slurry were pumped into underground mine shafts contaminating streams and well water of 769 residents in Rawl, Lick Creek, Merrimac and Sprigg, WV, beginning in the mid-1980s (Nyden 2010a).

Coal slurry is a waste stream produced during the washing of coal with water and chemicals. Coal slurry generally consists of heavy metals including aluminum, arsenic, barium, beryllium, cadmium, chromium, copper, iron, lead, manganese, selenium, sodium and zinc. Liver cells that are exposed to coal slurry contaminated water have a higher mortality rate than liver cells that are exposed to clean drinking water (Bunnell 2008). Table 1.1 lists additional organic compounds found in coal slurry.

Table 1.1 - Additional chemicals found in coal slurry (KY DEP 2007)

Aniline	Dibenzofuran	Pyrene
Acenaphthene	Dibutyl phthalate	1,2,4-trichlorobenzen
Acrylamide	Diethyl phthalate	1,2-Dichlorobenzene
Anthracene	Dimethyl phthalate	1,3-Dichlorobenzene
Benzidine	Dioctyl phthalate	1,4- Dichlorobenzene
Benzo(a)anthracene	Fluoranthene	2.4-Dinitrotoluene
Benzo(a)pyrene	Fluorene	2.6- Dinitrotoluene
Benzo(b)fluoranthene	Hexachloro – 1, 3	2-Chloronaphtalene
Benzo(ghi)perylene	Hexachloroethane	2-Methylnapthalene
Benzo(k)fluoroanthene	Hexa – Cl-1,3-Cyclope	2-Nitroaniline
Benzyl alcohol	Indeno(1,2,3-c,d)pyrene	3-3’-Dichlorobenzidin
bis(2-ethylhexyl)phthalate	Isophorone	3-Nitroaniline
bis(2-chloroethoxy)-methane	N-Nitrosodi-n-propylamine	4-Bromophenyl
bis(2-chloroethyl)ether	N-Nitrosodiphenylamine	4-Chloroaniline
bis(2- chloroisopropyl)ether	Naphthaline	4-Chlorophenyl
Butyl benzylphthalate	Naphthalene	4-Nitroaniline
Chrysene	Nitrobenzene	
Dibenzo(a,h) anthracene	Phenanthrene	

Acid mine drainage and naturally occurring contaminants found in local geologic formations also contaminate well water. Acid Mine Drainage (AMD) is metal-rich acidic runoff formed from chemical reactions between water and exposed rocks containing sulfur-bearing pyrite and other minerals that frequently come from areas with metal ore or coal mining activities. AMD often contaminates groundwater supplies near abandoned and active metal and coal mines. Table 1.2 lists limits for parameters above which drinking water may be affected by acid mine drainage.

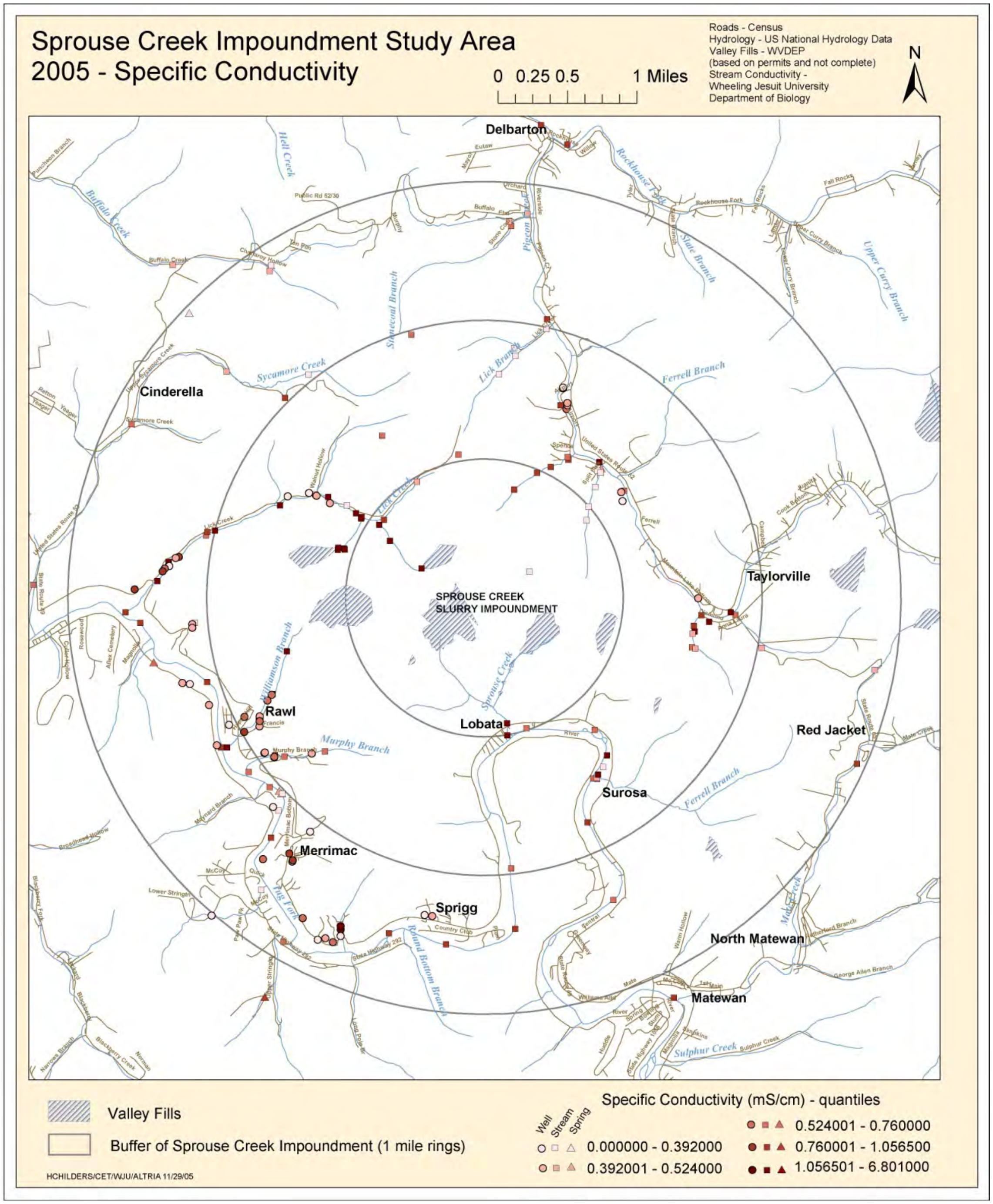
Table 1.2 - Threshold concentrations of AMD contaminants

(McCament, Bowman et al. 2003)

Parameter	Limit
Iron	0.5 mg/L
Manganese	0.5 mg/L
Aluminum	0.3 mg/L
Specific Conductance	800 µS/cm
Sulfate	74 mg/L
Alkalinity	20 mg/L (upper limit)
pH	pH 6 s.u. (upper limit)

Slurry that was not stored above ground was pumped, or "injected", into abandoned underground mines. Once underground, it migrated into the groundwater contaminating local well water, especially when blasting from surface mining occurred in the area (OVEC 2012). Slurry injections in Mingo County are thought to have first begun in February of 1977 in abandoned underground mines. As the roofs of these inactive mines subside, the rock strata above are fractured allowing greater infiltration of ground water in the mines which recharge the aquifer supplying wells located in the valleys. The water quality from abandoned mines can vary greatly depending on which coal seam was mined (WV DEP 2002a). Figure 1.1 shows the location of coal slurry impoundments and the extent of elevated specific conductivity readings in the waters of the Sprouse Creek Impoundment Study Area in Mingo County, WV.

Figure 1.1 – Impact of coal slurry impoundment contamination in Mingo County, WV



The U.S. Environmental Protection Agency (EPA) has established National Primary Drinking Water Regulations (NPDWRs or primary standards) that set mandatory water quality standards for drinking water contaminants. These enforceable standards protect the public against consumption of drinking water contaminants that present a risk to human health. EPA has also established National Secondary Drinking Water Regulations (NSDWRs or secondary standards) that set non-mandatory water quality standards for 15 contaminants. NSDWRs are non-enforceable Federal guidelines regarding cosmetic effects (such as tooth or skin discoloration) or aesthetic effects (such as taste, odor, or color) of drinking water.

A study completed in Mingo County in 2004 (Stout 2004) focused on 7 regulated NPDWR metals and 5 unregulated NSDWR metals. Primary standards for the 7 regulated metals tested were exceeded 13 times in samples collected from 15 different wells. Maximum Contaminant Levels (MCLs) were exceeded for lead (8), arsenic (2), barium (1), beryllium (1), and selenium (1), but not for cadmium or chromium. An MCL is the maximum permissible level of a contaminant in water delivered to any user of a public water system. Secondary standards for the 5 metals tested were exceeded 36 times in samples collected from 15 different wells. Secondary Maximum Contaminant Levels (SMCLs) were exceeded for iron (17), manganese (17), aluminum (1), and zinc (1), but not for copper. Information on metal contaminants and their health effects in drinking water is available in U.S. EPA's National Primary and Secondary Drinking Water Regulations (US EPA 2012).

The West Virginia Department of Environmental Protection (WV DEP), Office of Abandoned Mine Lands and Reclamation found similar levels of contamination in Mingo County drinking water wells. Primary standards were exceeded in 16 of 133 samples (12%), while one or more secondary standards (primarily iron and manganese) were exceeded in 111 of 133 samples (83%) (WV DEP 2002a).

Contaminant concentrations found in Mingo County exceeded Safe Drinking Water Act limits for aluminum, arsenic, barium, beryllium, iron, lead, manganese, selenium and zinc. Consumer Confidence Reports indicate that Mingo County Public Service District (PSD) Naugatuck and the Williamson Utility Board rank 39th out of 39 in the state of WV and 2,366th out of 2,379 for water quality nationally (Water Delivery 2012). The main risks from ingestion and exposure based on contaminants found in Mingo County are liver damage, cancer, kidney problems, blood issues, reproductive disorders and problems with the nervous system.

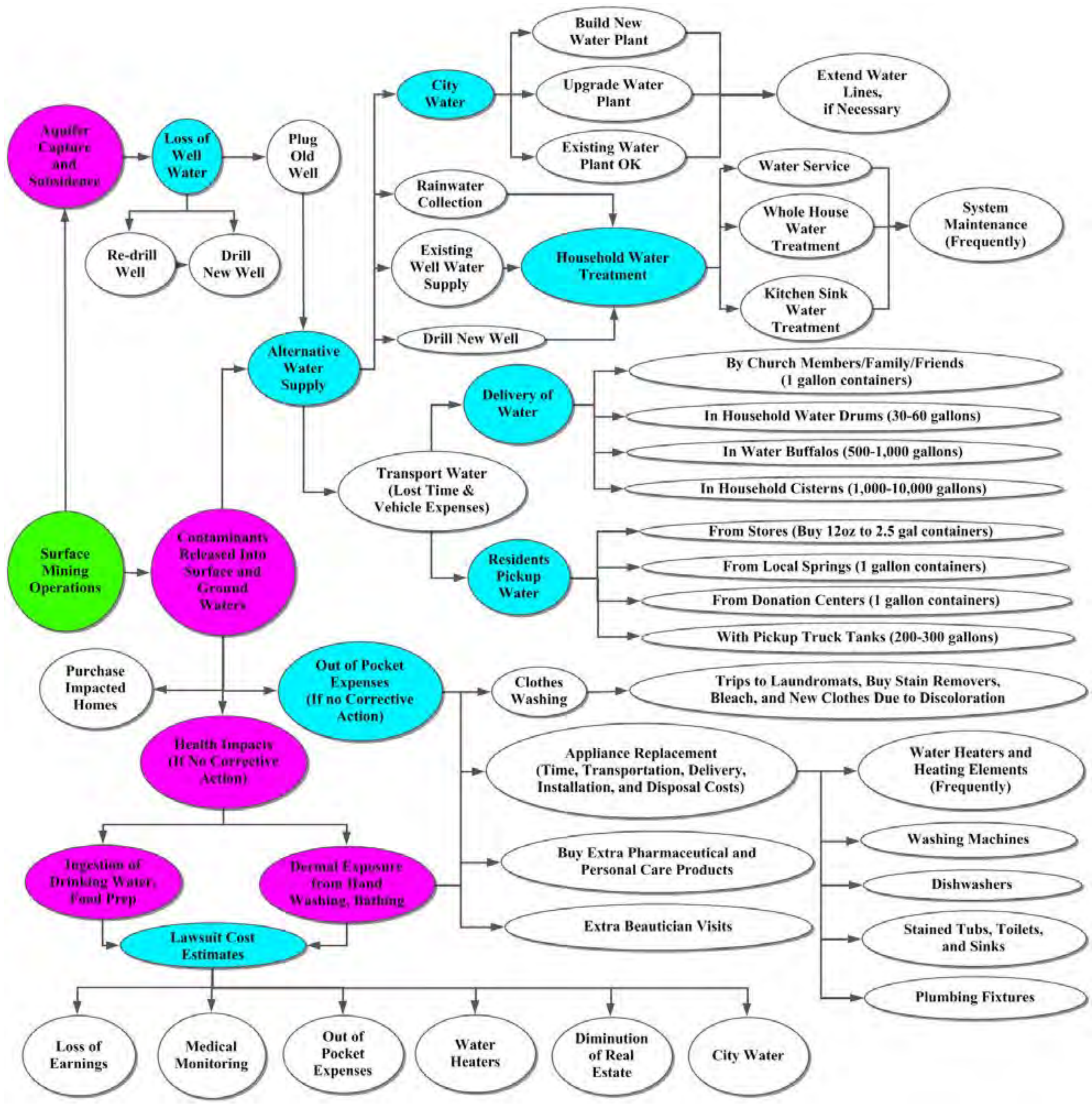
This paper evaluates the impacts of surface mining activities on both public and private drinking water systems and evaluates the costs associated with all aspects of drinking water treatment and distribution before and after the loss of clean and safe drinking water sources. A public water system (PWS) as defined under the Safe Drinking Water Act is a system for the provision of water to the public for human consumption through pipes or other constructed conveyances, if such system has at least fifteen service connections or regularly serves an average of at least twenty-five individuals daily at least 60 days out of the year (40 C.F.R. Section 141.2). Private drinking water wells for individual households are not regulated by the Safe Drinking Water Act.

Public information and cost estimates were obtained from Mingo County Coal Slurry litigation, Mingo County residents, water treatment utilities and vendors, government agencies and water quality studies. The study summarizes and compares costs associated with alternative water supply decisions to provide options for communities facing contamination of their drinking water sources.

2.0 Summary of Impacts

The flow chart in Figure 2.1 describes the impact of surface mining on clean and safe drinking water. Temporary and permanent “alternative water supplies” are included as well as a description of the impacts associated with resident exposure to mining contaminants in drinking water, if no corrective action is taken. Historic information on access to city water was compiled to document recent plans for municipal water plant upgrades and water extensions in Mingo County, WV. Many of the out-of-pocket costs and costs for delivery and pickup of water were obtained during meetings and phone conversations with Mingo County employees and residents. To provide a range of costs for appliance replacement and household water treatment systems, three prices were obtained for basic models of appliances and water treatment systems using internet searches. The appliance cost estimates do not include more expensive energy and water saving appliances or high-cost kitchen and bath products (e.g., hot tubs). Applicable water treatment systems were selected based on their ability to remove typical contaminants found in coal slurry. Lawsuit cost estimates were compiled by Thompson Barney, PLLC, of Williamson, WV (Thompson 2012). Costs associated with the loss of well water and alternative water sources, out-of-pocket expenses and lawsuit cost estimates are discussed in more detail in the following section.

Figure 2.1 - Flow chart of the impacts of mining contaminants on drinking water



3.0 Results and Discussion

3.1 Lawsuit Cost Estimates

3.1.1 Loss of Earnings

In areas near the coal slurry injection wells in Mingo County, residents developed health issues from ingestion and exposure to contaminated water. Loss of earnings had the largest impact on Mingo County residents. A cost estimate for total loss of earnings for the 769 residents was $60,612,448 (Thompson 2012).

3.1.2 Medical Monitoring

The main medical issues for the 769 Mingo County residents were recurring kidney stones, diarrhea, boils, cysts, skin rashes, and in some cases, various cancers. Residents experienced mouth and dental issues, liver and gall bladder disorders, kidney and urinary tract disorders, digestive disorders, cancers, skin disorders, eye disorders, and children's health issues (Thompson 2012).

A major medical cost associated with contaminated drinking water is medical monitoring. In 2007, economist Dr. Harvey S. Rosen estimated future medical monitoring costs to be approximately $11,052,487 for residents of Rawl, WV located below the coal slurry injection wells (Rosen 2007a). This cost estimate was based on 286 residents over a 30-year period or average life expectancy. The cost estimate is based on medical, professional, testing and psychiatric services. There are other factors like mouth and dental issues that were not included in this cost estimate. However, dentists in WV report mouth and dental issues are prevalent in areas with contaminated drinking water (Hendryx, Ducatman et al. 2012). Cancer screening was estimated to be $70,114. One resident itemized medical monitoring costs of $41,332 from 1984 to 2009 (Thompson 2012).

To take care of their health issues, residents drove to a clinic in Williamson, WV for treatment. Ointments and other prescribed medicines were purchased to remedy resident ailments. However, when the ingredients found in some treatment products such as ointments or antibiotics were mixed with the contaminated drinking water, the effectiveness of medications was neutralized, and in some cases, caused health issues to worsen (Blankenship 2012).

Residents reported that hand washing and bathing caused cysts, rashes and other skin disorders that were resistant to treatment with medications (Blankenship 2012, Brown and Brown 2012). Hair color and make-up were purchased to hide cosmetic stains and damage to hair and skin caused by corrosive well water. Extra money was spent on cosmetologist visits to cover up discoloration and skin disorders from bathing or showering in contaminated well water (Jones 2011).

3.1.3 Out-of-Pocket Expenses

Residents in rural areas of Mingo County without municipal drinking water service reported a multitude of compounding problems and household costs associated with coal slurry contamination of their drinking water source. Any product that water flowed through, especially water heaters, dishwashers, washing machines, coffee makers, toilets and sinks were purchased and replaced on a more frequent basis resulting in out-of-pocket expenses. One household reported out-of-pocket costs of $44,780 that included $12,200 in water treatment and transport costs from 1984 to 2009. One resident replaced five water pumps ($1,000), five water heaters ($350 each), four washing machines ($300 each), new pressure tanks every three years ($200 each), bathtubs, toilets and sinks ($1260), toilet parts ($15 each) and three faucet traps ($20 each) after coal slurry contamination of their well water. The lawsuit cost estimate for out-of-pocket expenses for the 769 residents in Mingo County was $1,336,061 (Thompson 2012).

For households with drinking water wells closest to coal slurry contamination, homeowners had out-of-pocket expenses associated with corrosive indoor air quality. One household had high levels of hydrogen sulfide gas in their well water that caused permanent sinus problems (Brown and Brown 2012).

Because of the contaminated and corrosive quality of their well water, appliances and products were destroyed or "wore out" at an accelerated rate (Blankenship 2012, Brown and Brown 2012). The great distances between the mining communities in Mingo County and stores resulted in lost time and travel expenses for purchase of replacement appliances, products and parts. The range of costs for basic models of appliances and fixtures that required frequent replacement is listed in Table 3.1.

Table 3.1 - Range of costs for appliances and fixtures requiring frequent replacement

Appliance	**Range of Costs***
Electric water heaters	$269-$297
Gas water heaters	$389-$558
Dishwashers	$289-$370
Washing machines	$399-$450
Bathtubs	$149-$349
Toilets	$100-$130
Sinks	$30-$58
Faucets	$16-$18

*On-line costs at (Lowes Sears and Home Depot 2012)

Because of the potency and rust in the water and the deterioration of washing machines, families replaced ruined clothing frequently. Residents chose to wash clothes at laundromats ($3/load) with city water compared to using their home washer ($1/load) because their well water quality was contaminated (Simple Dollar 2011). Stain removers and bleach were purchased to remove discoloration. Iron removal products were used with every load of wash. Cologne and perfume were used to mask the smell of contaminated clothing (Brown and Brown 2012).

Sinks, toilets and bathtub fixtures deteriorated every 1 to 2 years due to rust stains and precipitation of iron in the well water. For comparison with a household with clean drinking water, toilets should last a lifetime except for replacement of small parts (Keating 2011, Tonearely 2011, Love to Know Corporation 2012).

3.1.4 Water Heaters

The water heater replacement frequencies in Mingo County were much higher than manufacturer expectations. Gas water heaters are designed to last at least 11 years, and electric water heaters are designed to last at least 13 years (Demesne 2010, Mr Appliance 2010, Apartment Therapy 2012). In Mingo County, heating elements for hot water heaters were replaced twice a year, while hot water heaters were replaced every other year. The lawsuit cost estimate for replacement of 115 water heaters was $500 per water heater per household (Thompson 2012).

3.1.5 Diminution of Real Estate

The estimated total cost for diminution of real estate in Rawl, WV, was $1,174,343 for 769 residents (Thompson 2012). In Mingo County, one homeowner claimed real estate losses of over $150,000. After spending over $10,000 in repairs related to contamination, a second homeowner was forced to abandon his house by the local health department resulting in a real estate loss of $45,000 (Sammons 2012).

3.1.6 City Water

Because of their contaminated private well water supplies, rural homeowners lobbied for municipal drinking water. If a water utility does not have enough capacity to service additional residents, existing water plants may need to be retrofitted or new water plants may need to be designed, constructed and built to meet the water demands of new customers. For instance, Mingo County PSD currently has about 2,000 customers including 1,200 customers that were added in the last 3 to 4 years (Heflin 2012). The costs for procuring city water over a 30 year period from 2007 to 2037 were estimated to be $14,963 per household in Mingo County (Rosen 2007b). United States Department of Agriculture (USDA) funding for loans and grants for Mingo County water projects are listed in Table 3.2. USDA's Rural Development Water and Environmental Program (WEP) provides loans, grants and loan guarantees for drinking water facilities in rural areas and cities and towns of 10,000 or less.

Table 3.2 - USDA Rural Development - Mingo County Water Projects (Rowan 2012)

Applicant	Date of Obligation	Loan Amount	Grant Amount	Number of Users
Mingo County PSD	8/10/2004	$0	$550,000	2,540
Gilbert, Town of	4/19/2007	$472,000	$328,000	172
Gilbert, Town of	8/13/2008	$1,200,000	$476,000	229
Mingo County PSD	12/30/2008	$1,450,000	$1,167,500	456
Gilbert, Town of	7/22/2009	$0	$589,478	N/A*
Mingo County PSD	8/20/2009	$222,000	$0	2,982
Mingo County PSD	9/30/2009	$1,986,000	$0	96
Gilbert, Town of	5/8/2009	$662,000	$824,000	170
Mingo County PSD	12/2/2009	$0	$1,168,000	450
Mingo County PSD	2/11/2010	$1,429,000	$2,926,000	148
Mingo County PSD	3/31/2010	$763,000	$900,000	86
Gilbert, Town of	7/13/2012	$0	$350,000	N/A*
Total Project Costs		**$8,184,000**	**$9,278,978**	**7,329**

*Subsequent funding - users already counted

West Virginia Department of Health and Human Resources (WV DHHR) provided requests for water extensions and water facilities in Mingo County, WV between 2003 and 2012 as shown in Table 3.3. Based on an average of 7 waterline extension project requests, an estimate of $3 million was needed to extend water to an average of 212 new customers with an average rate increase of $30.74/month. An estimate of $5 million was needed to upgrade a treatment plant for 286 new customers with a rate increase of $31.82/month. The cost estimate to design and build a new water treatment plant for 2318 new customers was $20 million with a rate increase of $24/month. However, no Intended Use Plan project requests in Mingo County were selected for funding between 2003 and 2012.

Table 3.3 – Intended Use Plan Requests for Mingo County (2003-2012) (WV DHHR 2012)

System / Project (Plan Year 2003-20012)	Potential DWTRF Total	Total Project Cost	New Customers	Proposed Rates/Month
Water Extensions (Average of 7 Projects)	$924,053	$3,014,617	212	$30.74
Gilbert Water System (Plant Upgrade**)**	$2,292,000	$5,225,000	286	$31.82
New R.D. Bailey Regional WTP – Gilbert (New Plant)	$1,000,000	$20,000,000	2318	$24.00

3.2 Alternative Water Supplies

Mingo County residents found ways to reduce their exposure to mining contaminants in their drinking water by locating alternative sources of water for drinking and household use. Families collected and acquired drinking water from local springs (Blankenship 2012), water utility pay stations (Heflin 2012), donation centers and stores (Brown 2012). Many installed whole house water treatment systems (Brown and Brown 2012, Sammons 2012). In rare cases, residents paid to have water delivered (Brown and Brown 2012).

3.2.1 Residents Pick Up Water

Mingo County residents picked up drinking water for their own households and for others (Brown 2012). Due to a court injunction in 2006 (Nyden 2010b), residents received six one-gallon containers (case) of drinking water per person per week for several years. Many of the residents impacted by the court order retrieved their water from distribution centers (e.g., church outbuildings/stores). Truck loads (150 to 200 cases) of drinking water ($4.19/case in 2006) were distributed to residents identified in the court injunction. As many as 400 people per month retrieved drinking water from the food pantry at a local church. Church members, family members and friends delivered water to residents with no means of transportation. There were no dedicated water delivery trucks available in sparsely populated Mingo County. As a result, volunteers in the community used their own vehicles to transport drinking water to distribution centers and to families with no means of transportation on a regular basis. The constant delivery of drinking water by volunteers resulted in vehicle maintenance and fuel costs (Brown 2012).

Water tanks were purchased to retrieve drinking water from municipal and commercial locations. Water tanks for pickup trucks cost from \$300 to \$400, depending on the size and store of purchase (Rural King 2012, Tank Depot 2012a, Tractor Supply Co 2012a). The pickup truck tanks generally hold 200 to 300 gallons of water. To provide water for his family, a homeowner retrieved 750 gallons of treated water from Williamson, WV, using a pickup truck with a trailer and storage tank from 2004 to 2007. This resulted in an estimated cost of \$35 to \$40 per month (Sammons 2012). However, this cost estimate does not include costs for vehicle maintenance and the lost time required to fill, transport and deliver the drinking water.

Similarly, the purchase and transport of drinking water from stores resulted in vehicle costs for transport and lost time. In Mingo County, stores selling bottled drinking water are typically a substantial distance from people's homes. The small volume of drinking water sold at stores, \$1 to \$3 for 12 ounce bottles to 2.5 gallon containers, required frequent trips and out-of-pocket costs for residents each month.

Bottled water is considered a "long shelf life" item because the water will not sell as quickly as other products with expiration dates. As a result, water tends to stay on the shelf longer than other items resulting in less space reserved for drinking water within stores. When the demand for water is high in areas with contaminated drinking water, more space is required for drinking water products (Jones 2011).

Residents continue to purchase drinking water at the store, while using the public water for other needs such as bathing and washing clothes. As a result of the legacy of contaminated water in Mingo County, there is still concern over the safety and risk associated with the city tap water (Brown 2012).

Many residents bought bottled drinking water from local stores, while others filled water tanks (water buffalos) for storage and use (Brown and Brown 2012). The cost per load of city water at the Mingo County PSD was $1.75 for 500 gallons of water (Heflin 2012). Many residents also drove to Williamson, WV to retrieve municipal drinking water. There were also charitable donations of drinking water from stores like Walmart that provided free gallon containers of drinking water to the community. Buying water was an economic burden. The added household costs took money away from other necessities such as food, clothing, and ordinary monthly bills (Brown 2012).

3.2.2 Delivery of Water

In counties with commercial water delivery services, vendors typically transport and deliver water to households in trucks and charge by the gallon. Dispenser bottles (3 and 5 gallon containers) for water coolers range in price from $3 to $5 for bottle deliveries of five bottles (Dean's Water Service 2013, Jemika Bottled Spring Water 2013). Bulk delivery of drinking water in WV costs from $70 to $150 for 1000 gallons depending on the distance from the water supply (Dean's Water Service 2013, Mark's Water Hauling 2013, Puddle Maker 2013). Residents can purchase and use water drums, tanks and cisterns for water collection and storage of the delivered water. Household drinking water collection and storage tank options include 30 to 55 gallon drums that cost $50 to $80 per drum (Bayte Containers 2012, Be Prepared 2012, Simpler Life 2012) and larger water tanks (water buffalos) that range in size from 500 to 1,000 gallons and cost $350 to $1,500 (Go-To Tanks 2012, National Tank Outlet 2012, Tank Depot 2012b). Rain barrels (Hayneedle 2013) range in size from 40 to 300 gallons and cost $70 to $700 and can also be used to collect rainwater from the roof of the home to supplement the household water supply. Large water cisterns constructed of plastic, concrete and steel are another option that are generally priced based on the gallons of water that the cistern can hold. For instance, concrete cisterns cost $1.66 per gallon, plastic cisterns cost $1.43 per gallon, and steel cisterns cost around $2.51 per gallon (Sarasota County Florida 2012). Cisterns used in residential areas typically hold anywhere from 1,000 gallons to 10,000 gallons. Small cisterns are typically prefabricated and delivered by truck while large cisterns are typically constructed on-site.

Collection and transport of drinking water from a potable water source is a temporary alternative. The cost of constructing numerous water tanks and the labor-intensive delivery costs are not economically feasible as a long-term solution (WV DEP 2002b).

3.2.3 Household Water Treatment

In Mingo County, homeowners installed water softening and filtration systems to treat their contaminated well water. One homeowner estimated the cost of water tanks, filter housings and replacement filters to be $12,200 over a 29-year period (Thompson 2012). Household water treatment systems are capable of removing a wide variety of surface mining and naturally occurring contaminants

Many residents hired water service companies to avoid high purchase and maintenance costs that included the replacement of fouled media, filters and bags of salt on a regular basis (e.g., weekly or bi-weekly). Monthly expenses for water softening and filtration systems cost households between $7 and $100 per month, with an average of $51 (WV DEP 2002b). In Mingo County, local water service company agreements became too costly for providers and residents. Constant damage to the household systems from contaminated water required maintenance every few days (Brown and Brown 2012). Whole house water softeners were purchased to remove iron and manganese to improve the taste and remove odors from well water contaminated with mine wastes. When operated and maintained properly, water softening systems reduce stains on kitchen and bathroom fixtures and prevent discoloration during clothes washing. Water softening systems also improve household water flow due to less buildup of mineral deposits and corrosion in plumbing and water heaters.

In a household close to the coal slurry injection wells, water softener media was replaced once a year ($60). However, to prevent clogging, the homeowner disassembled the water softener one to two times per month to remove particles and disinfect media with bleach to reduce the frequency of media replacement (Brown and Brown 2012).

According to the 2010 U.S. Census, Mingo County had an average household population of 2.45 people (US Census Bureau 2012). The United States Geological Service (USGS) estimates household water usage of 80-100 gallons per person per day (USGS 2012). Therefore, the average Mingo County household uses 196-245 gallons of water per day. A 30,000- or 40,000- grain water softener is needed for families of 4 ($400) to 6 ($500) people (Budget Water 2012). The replacement cost for water softening media varies from $90 to $200 depending on the water quality (Water Value 2012a). An appropriately sized (15 gallons per minute) water softening system costs between $1,198 and $1,616 (Clean Water Systems Inc 2012, Rain Dance Water Systems 2012b, Water Value 2012b) with media replacements every 5-15 years (Clean Water Systems Inc 2012).

At a second household close to the coal slurry injection wells, a water treatment system was purchased that included a 1500 gallon storage tank, pumps, pressure tanks, and 11-inch cartridge filters ($50 each) for particulate removal. Twelve submersible well pumps were purchased to replace existing pumps due to the corrosive water quality (Sammons 2012).

For kitchen sink systems, adsorptive filters or reverse osmosis systems can remove mining contaminants from tap water. Reverse Osmosis (RO) is a membrane separation process in which feed water flows along the membrane surface under pressure. Purified water permeates the membrane and is collected, while the concentrated water, containing dissolved and un-dissolved material that does not flow through the membrane, is discharged to the drain (Applied Membranes Inc 2010). With adequate pretreatment, RO systems remove a wide variety of contaminants. However, many homeowners have issues with the low flow rates produced by the RO system and maintenance that includes replacing multiple cartridges and sterilizing and replacing tubing annually (Patterson, Smith et al. 2012). Multi-stage RO kitchen sink systems normally range in price between $283 and $750, depending on the gallons of water produced per day and their treatment capabilities (Excel Water Technologies Inc 2012, Patterson, Smith et al. 2012, Rain Dance Water Systems 2012a). RO systems are capable of removing 90% of total dissolved solids, 99% of all organics and 99% of all bacteria (Excel Water Technologies Inc 2012). However, RO systems are designed to treat water with less than 1,500 ppm dissolved solids, 0.3 ppm iron and 0.5 ppm manganese. Based on the contaminated well water quality in Mingo County, pretreatment systems were required to make RO systems technically feasible. The main contaminants that are reduced/treated by RO are arsenic, barium, cadmium, chromium III & VI, copper, lead, nitrate, nitrite, selenium, radium 226 and 228, fluoride, turbidity, cysts, and total dissolved solids (TDS). Multi-stage filter replacement normally costs between $50 and

$150 per year, while membrane replacement typically costs about $150 every 2-5 years (Rain Dance Water Systems 2012a).

3.3 Loss of Well Water

Blasting and subsidence during surface mining operations can disrupt drinking water aquifers resulting in the loss of resident well water (Petty 2011). Many homeowners chose to re-drill their existing well ($900) or drill new wells ($1,800 to $3,000) in search of reliable or clean sources of well water (Thompson 2012).

3.4 Summary of Cost Estimates

Based on the above discussion, estimated costs from residents and public records in Mingo County, WV are summarized in Table 3.4.

Table 3.4 - Cost estimates from residents and public records in Mingo County, WV

I. Water Supply Costs			
Drinking Water Alternatives	**Item**	**Range of Costs**	
A. Existing Well with Household Water Treatment	(1) Water Service ($51/month Avg.)	$ 7	$ 100
B. Water Transport (Lost Time and Vehicle Expenses Not Included)	(1) Residents Pick up Water		
	a. Natural Springs	$ -	
	b. Donation Centers ($/6 gal)	$ 4	
	c. Water Plant Pickup ($/1000 gal)	$ 3.50	
	(2) Water Delivery (Lost Time/Vehicle Expenses Not Included)		
	a. Charitable Deliveries	$ -	
C. Loss of Existing Well Water	(1) Re-drill Existing Well	$ 900	
	(2) Drill New Well ($2400 Avg.)	$ 1,800	$ 3,000
D. City Water	(1) Existing Plant OK	$ -	
	(2) Waterline Extensions (Avg. of 7)	$ 3,000,000	
	(3) Upgrade Plant	$ 5,000,000	
	(4) New Plant	$ 20,000,000	
II. Lawsuit Cost Estimates			
Lawsuit Cost Basis	**Item**	**Range of Costs**	
A. Based on 769 Residents	(1) Loss of Earnings	$ 61,000,000	
	(2) Medical Monitoring	$ 70,000	
	(3) Out of Pocket Expenses	$ 1,300,000	
	(4) Diminution of Real Estate	$ 1,100,000	
B. Based on 115 Instances	(1) City Water per Household	$ 15,000	
	(2) Water Heaters per Household	$ 500	
C. Based on 2 Instances	(1) Purchase of Homes	$ 45,000	$ 150,000

Estimated costs from internet searches are summarized in Table 3.5. Vendors were contacted in the West Virginia, Ohio and Kentucky area to obtain representative costs for Mingo County residents. However, shipping costs were not included in the cost estimates found on the internet.

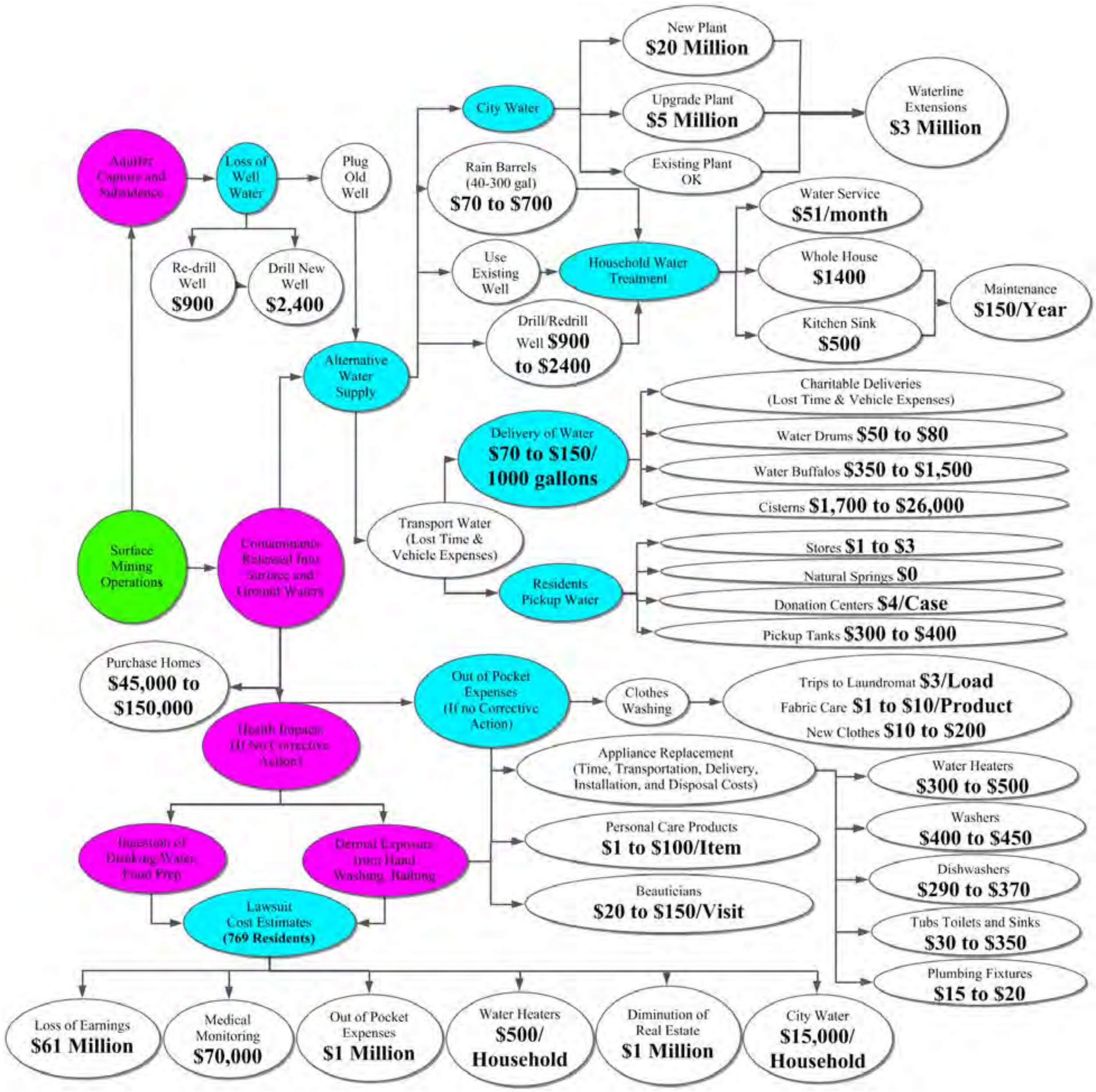
Table 3.5 - Cost estimates from internet searches for Mingo County, WV

I. Water Supply Costs			
Drinking Water Alternatives	**Item**	**Range of Costs**	
A. Existing Well with Household Water Treatment	(1) Cost to Purchase Water System		
	a. Rain Barrels (40-300 gal)	$ 70	$ 700
	b. Kitchen Sink Treatment (RO)	$ 283	$ 750
	c. Whole House Treatment (Water Softener)	$ 1,198	$ 1,616
	(2) Cost of System Maintenance ($150/Year)		
B. Water Transport (Lost Time and Vehicle Expenses Not Included)	(1) Residents Pickup Water		
	a. Stores (12 ounce-2.5 gal)	$ 1	$ 3
	b. Pickup Truck Tanks (200-300 gal)	$ 300	$ 400
	(2) Water Delivery (Lost Time & Vehicle Expenses Not Included)		
	a. Actual Delivery Cost/1000 gallons	$ 70	$ 150
	b. Cost to Purchase Containers		
	1. Water Drums (30-60 gal)	$ 50	$ 80
	2. Water Buffalos (500-1,000 gal)	$ 350	$ 1,500
	3. Cisterns (1,000-10,000 gal)	$ 1,700	$ 26,000
III. Out of Pocket Expenses			
Expenses	**Item**	**Range of Costs**	
A. Clothes Washing	(1) Trips to Laundromat ($/load)	$ 3	
	(2) Fabric Care ($/product)	$ 1	$ 10
	(3) New Clothes ($/item)	$ 10	$ 200
B. Appliance Replacement (Time, Transportation, Delivery, Installation, and Disposal Costs Not Included)	(1) Washers	$ 399	$ 450
	(2) Water Heaters	$ 269	$ 558
	(3) Bathtubs	$ 149	$ 349
	(4) Toilets	$ 100	$ 130
	(5) Sinks	$ 30	$ 58
	(6) Dishwashers	$ 290	$ 370
	(7) Plumbing Fixtures	$ 16	$ 18
C. Personal Care Services and Products	(1) Cosmetologists/Visit	$ 20	$ 150
	(2) Personal Care Products/Item	$ 1	$ 100

4.0 Conclusions

This study was designed and implemented to review and document the options and alternatives available in remote communities impacted by contamination from surface mining operations. Contaminated water from coal slurry, abandoned mine drainage, and natural occurring contaminants can incur a huge economic burden to residents without city water. Water-related costs include medical monitoring, loss in real estate values, well installation and maintenance fees, replacement of appliances, water collection and storage costs, water delivery fees, water treatment service fees, household water treatment system costs, municipal water bills and bottled water purchases. The flow diagram in Figure 4.1 documents the costs associated with these alternatives and provides options for communities facing similar contamination of their drinking water sources.

Figure 4.1 - Flow chart showing summary of cost estimates



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