EXHIBIT B

Task Force Study

FINAL REPORT

Pinhole Leaks in Copper Plumbing

Robert L. Ehrlich, Jr.
Governor

Michael S. Steele
Lt. Governor

Victor L. Hoskins
Secretary

Shawn S. Karimian
Deputy Secretary

DHCD
Maryland Department of Housing
and Community Development

100 Community Place
Crownsville, MD 21032-2032
www.dhcd.state.md.us

Executive Summary

The Task Force to Study Pinhole Leaks in Copper Plumbing was established under the auspices of Senate Bill 54, 2003, in order to help Marylanders understand the pinhole leak phenomenon, and thus deal with its consequences. Pinhole leaks pose problems for several reasons:

- They may cause water damage to plaster and sheetrock walls, electrical systems, flooring, ceilings or furniture;
- Undetected water leakage may result in mold growth;
- Repairing or replacing copper pipe, because of limited access, is generally costly;
- Water damage claims may result in homeowners' insurance premiums being raised, or non-renewal of policies.

Possible causes to the pinhole leak problem are offered in this report, although it is widely believed that there is no one cause; and there is no one solution. Rather, it is generally held that a number of circumstances may contribute to the problem, and a variety of remedies may be available for consideration.

In order to answer the charge set forth in Senate Bill 54, the Task Force established three subcommittees:

- **Water Treatment and Quality**, which dealt with water chemistry, water treatment practices, and water additives;
- **Materials and Installation**, which studied copper plumbing design, manufacturing and installation practices, and also researched other materials used in plumbing systems;
- **Insurance**, which investigated the effect of pinhole leak incidents on homeowners' insurance coverage.

This report examines the extent of the problem in major water suppliers' areas of the state and discusses the physical elements of the pinhole leak problem, including public water suppliers, sources of water, the water treatment process, copper piping, corrosion, and the effects of corrosion on copper pipe. The report then moves to regulatory issues, with emphasis on rules set forth by the U.S. Environmental Protection Agency, and the effects of those rules on water conditions. The Safe Drinking Water Act protects the public health by regulating the nation's public drinking water supplies. The Lead and Copper Rule protects the public by minimizing lead and copper levels in drinking water; and the Stage 1 Disinfectants and Disinfection Byproducts (D/DBP) Rule reduces health risks by regulating the allowable concentration of disinfection byproducts in the drinking water. This D/DBP Rule has been successful, for example, in reducing the overall risk of cancer. Unfortunately, the water treatment processes that reduce the concentration of disinfection byproducts *may* increase the incidence of corrosion in copper pipe and other piping materials based on recent water research.

In the section on Insurance, the report examines underwriting, since insurers have always used loss histories as a tool for rating eligibility of the prospective policy holder for coverage. This section describes the Comprehensive Loss Underwriting Exchange (CLUE) and A-Plus Reports and explains the effects of pinhole leaks on insurance coverage, including what options the consumer may consider when advised by their insurer that their policy may be cancelled or their premiums may increase. The options for consumers whose policies have been cancelled in the normal insurance market are explored as well.

Finally, the Task Force offers in this report a list of recommendations, sorted by category, for the reader's convenience. It should be emphasized that these are recommendations only and are the result of the group's study of the problem - by researching available written research, by interviewing various guests who appeared before the Task Force (expert scientific presentations by Dr. Marc Edwards of the Virginia Polytechnic Institute and State University (Virginia Tech) and Bob Buglass of Washington Suburban Sanitary Commission (WSSC), and others) as well as information gleaned from a poll of Maryland water suppliers.

The Task Force advises that, although specific causes have yet to be finitely determined, much research is underway; and options for prevention, as well as for mitigation of this problem, are available. Although the Task Force has now completed its charge, it is hoped that the water suppliers and the copper industry will sponsor further research and support these beginning efforts to solve the pinhole leak problem.

George C. Eaton, Chairman, Designee

Task Force to Study Pinhole Leaks in Copper Plumbing

December 2004

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Disclaimer

The report of this Task Force does not invoke any legal or regulatory authority of the State of Maryland, nor does it assign any legal culpability to any party mentioned in this report. Any information contained in this report should not be construed as legal or regulatory advice on any subject matter. No reader of this report should act or refrain from acting on the basis of any content included in, or accessible through, the report, without seeking the appropriate legal or other professional advice on the particular facts and circumstances at issue from professionals licensed in the recipient's state, country or other appropriate licensing jurisdiction.

The Task Force has made reasonable efforts to ensure that all information provided through this report is accurate at the time of inclusion. However, there may be inadvertent and occasional errors. It should not be taken as a definitive guide to every area of concern, nor should it be considered sufficiently full and accurate to cover every situation.

Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

I Introduction

A. The Problem of Pinhole Leaks

Pinhole leaks pose a problem to property owners for several reasons. They may cause water damage to walls, electrical systems, flooring, ceilings, or furniture. Undetected water caused by pinhole leaks may result in mold growth. Repairing or replacing pipe may be costly. Finally, water damage claims might result in homeowners' insurance premiums being raised or insurance companies not renewing homeowners' policies.

B. Senate Bill 54

The recent concerns about pinhole leaks in copper plumbing prompted the State of Maryland to establish a task force to examine the phenomenon and recommend possible solutions. This document summarizes the efforts of the Task Force in fulfilling Senate Bill 54.

The Bill states in part:

> "(f) The Task Force shall:
>
> (1) determine the extent, patterns, and trends of pinhole leaks in Maryland;
>
> (2) investigate the possible causes of pinhole leaks in copper plumbing, including: water chemistry requirements adopted by the EPA; water treatment practices; water additives; copper plumbing design, manufacturing, and installation practices; and copper plumbing cleaning and lining practices;
>
> (3) investigate the effect of pinhole leaks in copper plumbing on homeowners' insurance coverage; and
>
> (4) make recommendations regarding possible remedies for pinhole leaks in copper plumbing and possible steps for Maryland residents to take if they experience a problem with pinhole leaks.
>
> (g) The Task Force shall report its findings and recommendations to the General Assembly on or before December 31, 2004."

Because of the Task Force's mandate, this report covers pinhole leaks in water pipes made of copper, and their effects and not other types of problems that plumbers, homeowners, and insurers have encountered.

The primary focus of the report is on public water supply systems. Much of the State of Maryland is served by wells. There are risks to copper pipes from untreated well water, but this issue was not the basis for concerns that led to the formation of this Task Force.

The recommendations of this report are aimed at homeowners, water industry, plumbing industry, insurance industry, and state regulatory agencies.

Definition Used by the Task Force

The Task Force defines a *Copper Pinhole Leak* as the perforation of copper tube, pipe or fittings used for domestic water distribution as the result of pitting corrosion initiated on the interior/waterside surface with the subsequent leakage of water. Pinhole leaks in the sense of this report are limited to water supply systems employing copper piping. It does not cover leaks in drainage, waste, venting, comfort heating or cooling systems, or gas supply pipes.

Any other leaks reported are not pinhole leaks and have different causes.

A pinhole leak is a final breakthrough event of the progressive attack of pitting corrosion on copper water plumbing. A copper water plumbing system can be in a condition of having significant damage by pitting corrosion, but not have pinhole leaks. The challenge is how to discover pitting corrosion before pinhole leaks develop. Discovery of such latent damage would require removal and inspection of the internal surfaces of sample plumbing in the system.

Figure 1 shows a pinhole leak in a pipe that was sent to the Washington Suburban Sanitary Commission (WSSC).

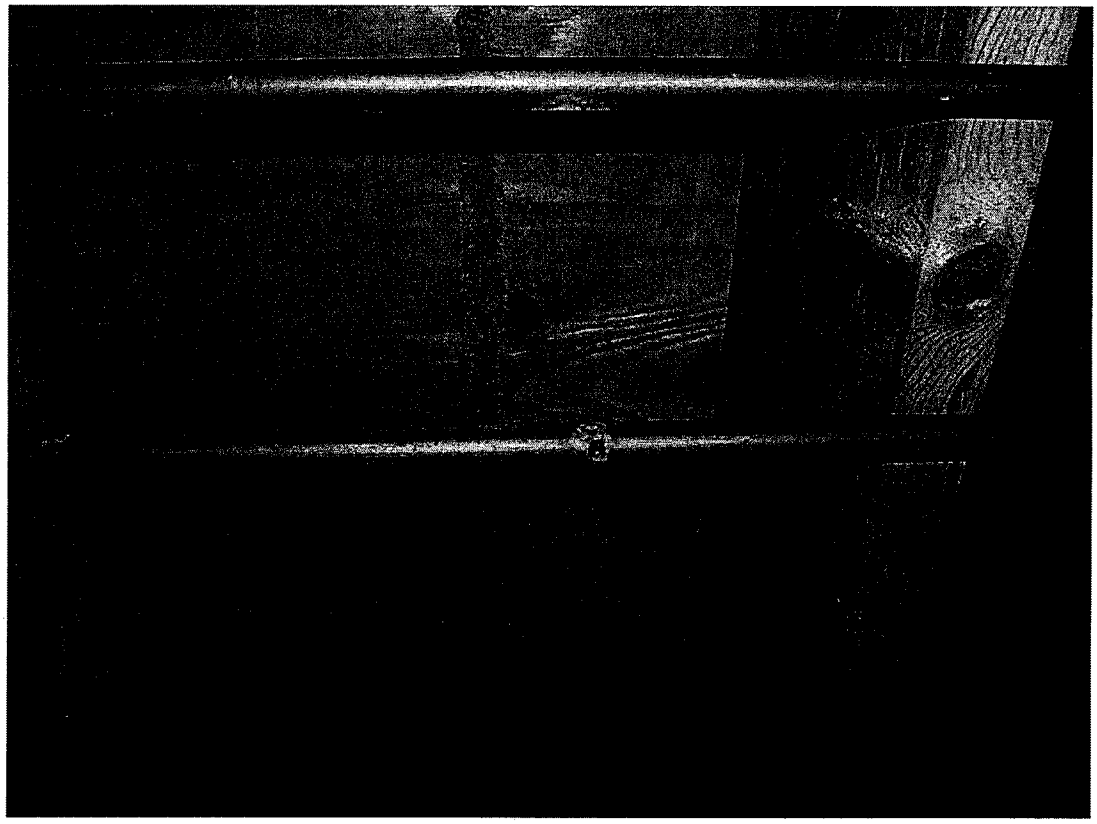

Figure 1: Pipe with Pinhole Leak (Courtesy of WSSC)

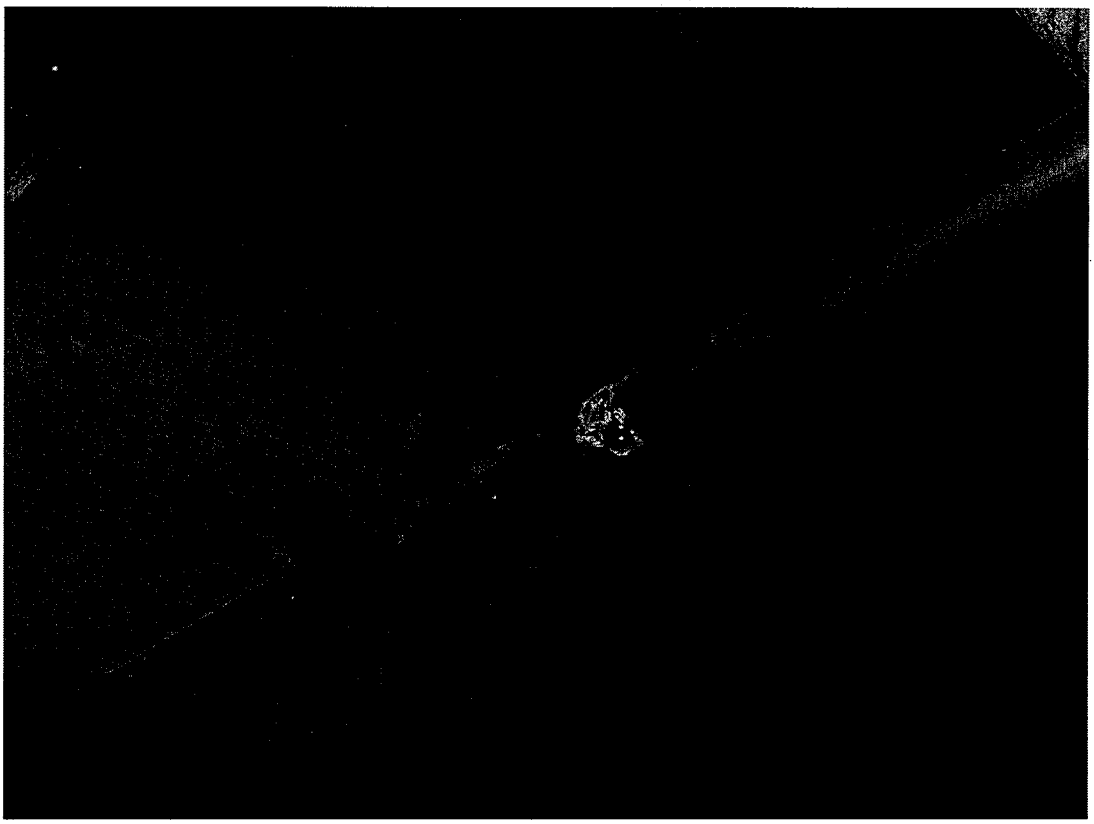

Figure 2: Shows Further Details of Pinhole Leak (Courtesy of WSSC)

C. The Task Force

Organization

The Maryland Department of Housing and Community Development, which is a Cabinet-level state agency, was given the responsibility to organize the Task Force, to host meetings, and to provide staffing support for the Task Force.

The Task Force was organized into three subcommittees:

1. **Water Treatment and Quality Subcommittee**, which dealt with water chemistry requirements adopted by the U.S. Environmental Protection Agency (EPA); water treatment practices; and water additives

2. **Materials and Installation Subcommittee**, which investigated copper plumbing design, manufacturing, and installation practices and copper plumbing cleaning and lining practices, as well as other materials such as plastic, epoxy, and other metals used in plumbing; and the

3. **Insurance Subcommittee**, which investigated the effect of pinhole leaks in copper plumbing on homeowners' insurance coverage.

Methodology

The Task Force followed this general methodology to fulfill the mandate of Senate Bill 54: ***investigating*** known cases of pinhole leaks and the frequency and possible causes of pinhole leaks, including a survey of public water suppliers in the state, as well as interviewing industry professionals and surveying literature; by ***determining*** possible causes for pinhole leaks; and by ***recommending*** possible steps for Marylanders, water suppliers, plumbing industry and insurance industry to take if they experience problems with pinhole leaks. These included recommendations on how to remediate current problems, what preventative measures could be taken, and how the State of Maryland can help. Finally, the Task Force concluded its mandate by ***issuing*** this report.

Early drafts of this report were distributed for comment among members of the Task Force and outside experts, including the U.S. Environmental Protection Agency. The Task Force wishes to thank those who took time to comment upon and, therefore, improve the report.

II. Background

A. Communities Affected and Timeframe

There is no comprehensive source of information on the occurrence of pinhole leaks. Washington Suburban Sanitary Commission (WSSC) has collected thousands of reports—although these reports are submitted voluntarily by residents who have pinhole leaks. This reporting increased after there were several media reports on pinhole leaks. Anecdotal information suggests that numerous homeowners consider pinhole leaks as a plumbing problem, and do not report them to their water utility. Plumbers in the metropolitan Washington area had also reported a rise in pinhole leak incidents. The WSSC started adding orthophosphates to water supplies on November 12, 2003. Plumbers in the WSSC service area have reported reductions in pinhole leaks since the introduction of orthophosphates. In a survey of the water utilities in Maryland undertaken by this Task Force, pinhole leaks in copper plumbing have been found to be concentrated in portions of Prince George's, Montgomery, and Carroll Counties.

One insurance company reports that the majority of pinhole leak claims come from Prince George's and Montgomery Counties. In addition, Carroll County has reported occurrences of pinhole leaks.

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B. Extent of Known Pinhole Leaks in Maryland

The Task Force conducted a survey, and used information gathered by the Washington Suburban Sanitary Commission (WSSC). The data from Maryland counties with known pinhole leaks is presented below. Other counties are listed in Appendix C.

Prince George's and Montgomery Counties

WSSC services a large portion of Prince George's and Montgomery Counties using surface water sources. WSSC is among the ten largest water and wastewater utilities in the nation, serving 1.6 million customers in Prince George's and Montgomery counties. The WSSC system consists of more than 5,000 miles of pipeline and 63 water storage facilities. According to the WSSC, through June 2004 approximately 5,400 customers out of about 417,000 accounts reported pinhole leaks.

WSSC maintains a Web site on which their customers can report pinhole leaks. (http://www.wsscwater.com/cfdocs/copperpipe/pinholescroll.cfm) This enables the WSSC to obtain the information without the cost or intrusion of surveys, but the data is limited to self-selecting households. Most reports come from older communities in southern Montgomery County such as Silver Spring and Bethesda, and northern Prince George's County such as Laurel and Beltsville, as shown in Figure 3:

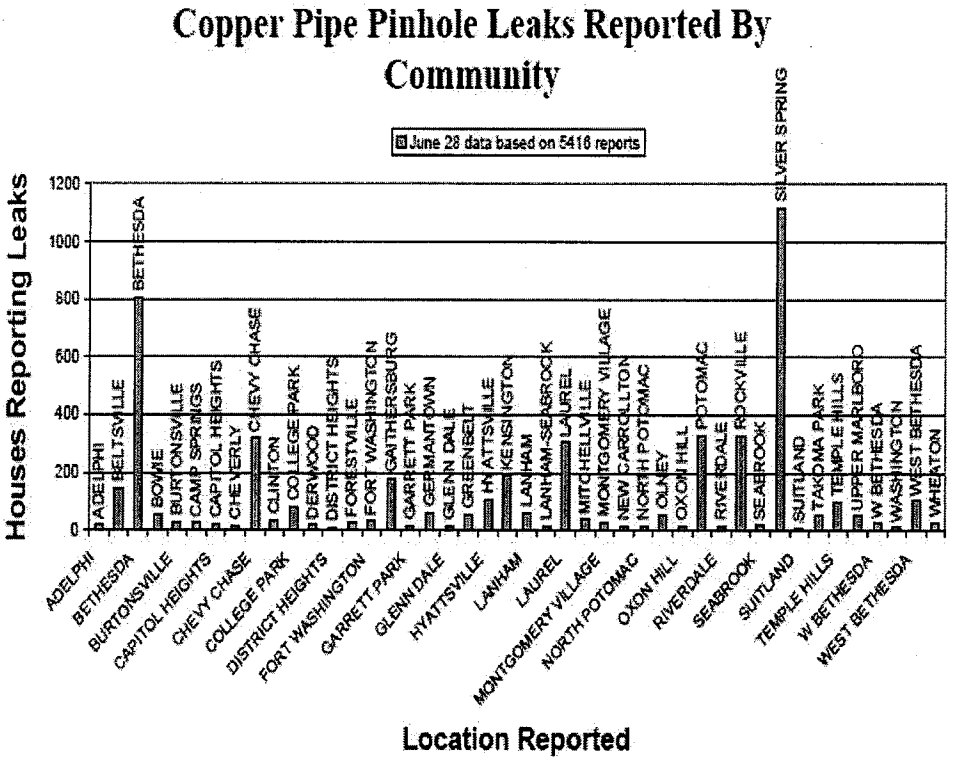

Figure 3: Pinhole Leaks by Community in WSSC Area, June 2004

Further breakdown by ZIP code, as shown in Figure 4, shows pinhole leaks are most widely reported in Montgomery County (ZIP codes starting with 208; Silver Spring ZIP codes start with 209) and Beltsville and Laurel in Prince George's County. ZIP codes of 20720 and 20723, are in Howard County.

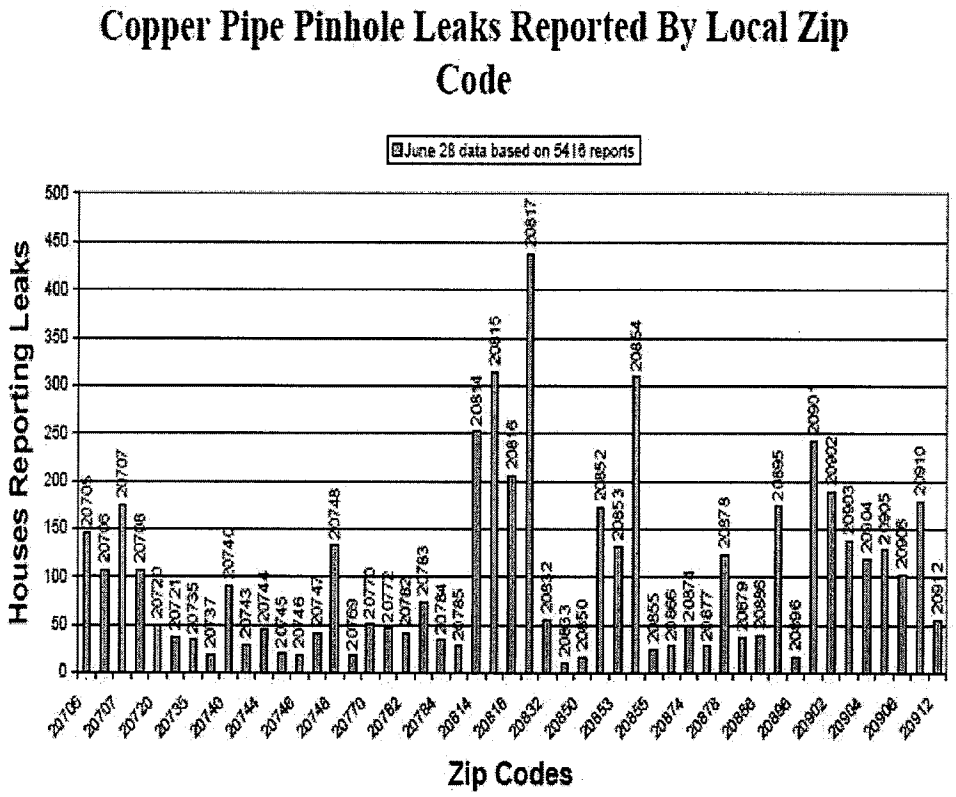

Figure 4: Pinhole Leaks by ZIP Code in WSSC Area, June 2004

(Data is not normalized to number of customers)

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The data presented in Figures 3 and 4 has not been normalized to frequency of complaints per 1,000 water service connections or billing customers. There may be more complaint reports in Silver Spring and Bethesda simply because there may be more customer connections in these communities. Furthermore, because these reports are self-selected, they may not reflect a true distribution of the problem. WSSC has normalized the collected data by the age of the house as shown in Figure 5*. The data shows that over 300 of every 1,000 houses built from 1930 – 1939 have reported leaks; about 75 of 1,000 houses built from 1940 – 1949 have reported leaks, approximately 40 per 1,000 in the decade 1950 to 1959, and fewer than 20 per 1,000 in subsequent decades.

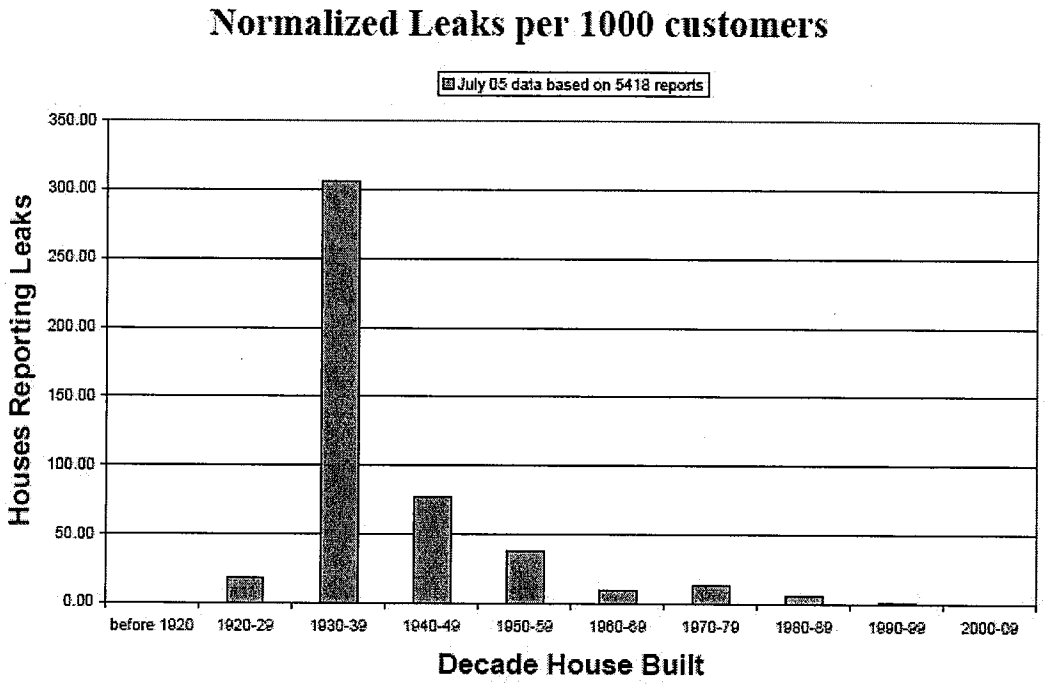

Figure 5: Pinhole Leaks per 1,000 Customers by Decade of Construction in WSSC Area, June 2004

*Definition of normalized is leak rate per 1,000 houses in each age group

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The WSSC reports that the majority of pinhole leaks that customers have reported are in cold water, horizontal copper piping, as shown in Figure 6. Most of the leaks are in the older areas of Montgomery and Prince George's Counties. Nearly 80% of the reports involve homes built prior to 1970.

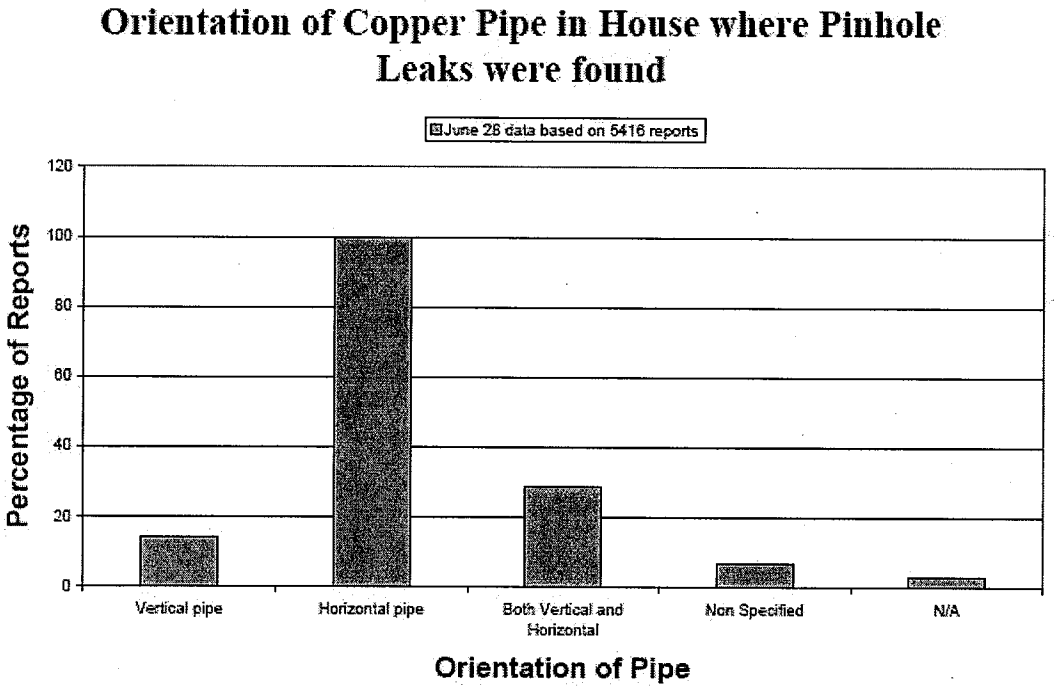

Figure 6: Pinhole Leaks by Pipe Orientation in WSSC Area, June 2004

Anne Arundel County

95% of all fresh water withdrawals in Anne Arundel County are from ground water sources. The Anne Arundel County Department of Public Works (DPW) Bureau of Utility of Operations uses groundwater supplies through 8 independent wells and 13 major water treatment plants, which obtain their water from 57 production wells. The county system is supplemented in the northern portion of the county by three connections to the City of Baltimore, from which the County purchases treated water. However, the Task Force received testimony from residents of Anne Arundel County who have experienced pinhole leaks.

As of the time of writing this report, there have not been any reported issues of increased occurrence or widespread distribution of pinhole leaks by the Annapolis DPW. Annapolis' public water supply is provided by a City-owned and operated treatment plant and distribution system. The U.S. Naval Academy has its own water system while the remainder of the Annapolis Peninsula is served by Anne Arundel County. The City's treatment plant handles groundwater extracted by wells from the Patapsco Aquifer. The plant's capacity was upgraded to 10 million gallons per day (MGD) from 6 million MGD in 1987. There are a number of other public water systems throughout Anne Arundel County that also utilize groundwater sources.

Baltimore City and County

The Baltimore City Bureau of Water and Wastewater, a Division of the Department of Public Works, provides water service to the City of Baltimore, 600,000 residents in Baltimore County, the eastern portion of Howard County, and the northern portions of Anne Arundel County. The sources of water, as shown in Figure 7 are the Liberty Reservoir, which is fed by the Patapsco River, the Loch Raven Reservoir, and the Susquehanna River.

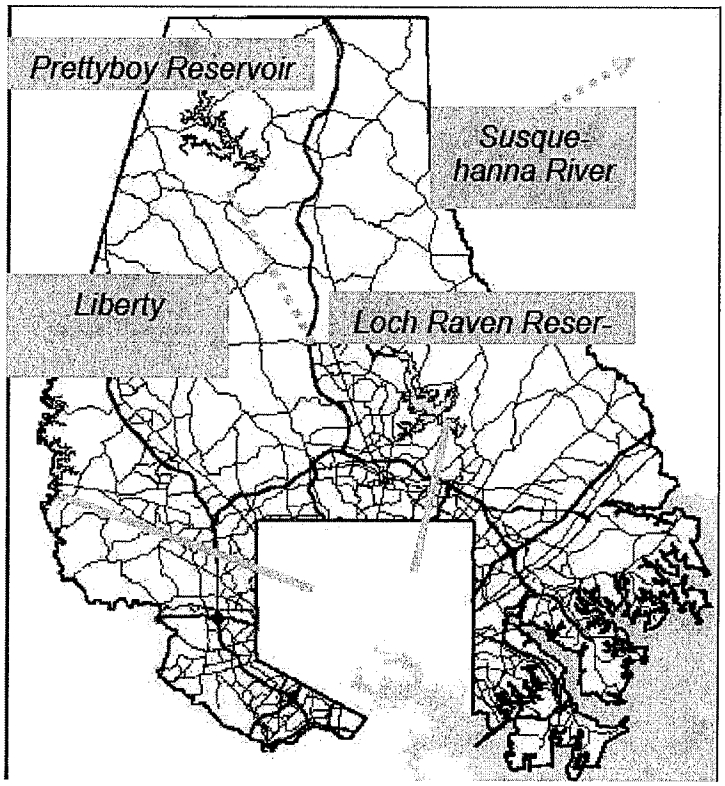

Figure 7: Baltimore County Water Sources (Courtesy of Baltimore DPW).

96% of all fresh water withdrawals in Baltimore County and City are from surface water sources. There are three treatment plants: Ashburton and two Montebello plants. Alum is used as a coagulant and sodium hypochlorite as a disinfectant. As of the time of writing this report, there have not been any reported issues or widespread distribution of pinhole leaks. However, the Task Force received testimony from residents of Baltimore City who have experienced pinhole leaks.

Carroll County

Groundwater is the principal source of both public and private potable water supplies in Carroll County. Approximately 72% of the County's population receives their water supply from wells (groundwater) only. With the exception of Westminster and the Sykesville- Freedom District, all the public water suppliers in Carroll County rely solely on groundwater from the aquifers in the County. The public water service areas provide an average daily volume of approximately 6.58 MGD of water to their service areas (including Westminster and Sykesville-Freedom), serving approximately 42% of the County's population. The Carroll County *Master Plan for Water and Sewerage* (http://www.carr.org/ccg/plan-d/w-splan/maps.htm) shows the ten Water Service Areas for the County. (Carroll County *Master Plan*)

Additionally, the Task Force received testimony and written documentation from residents of Carroll County who have experienced pinhole leaks.

Frederick County

Almost 79% of the County's water system customers receive treated water from surface water supplies, specifically the Potomac River and Lake Linganore. The remaining 21% of Fredrick County customers receive treated ground water from deep well sources.

Frederick County has established a telephone contact for users to report pinhole leaks: 301-631-3450, Monday through Friday from 7:00 a.m. to 3:30 p.m. (Frederick County)

Individual Water Sources

Individual water sources in Maryland are usually wells withdrawing water from groundwater supplies. Property owners that obtain their potable water from on-site private sources (wells, springs or lakes) and not municipal sources are personally responsible for the quality of their own potable water. These systems were not evaluated by the Task Force.

Outside Maryland

Research, motivated by failure of copper plumbing in service, has been undertaken through the years, beginning as early as the 1960s.

A nationwide telephone survey of plumbers conducted, on behalf of the WSSC, reported that plumbers throughout the United States were reporting an increase in pinhole leak activity. (Edwards, Rushing *et al*, 2001)

Dr. Marc Edwards of the Virginia Polytechnic Institute and State University (Virginia Tech) believes and has testified during hearings of the U.S. House of Representatives and at City Council Hearings of the District of Columbia government that pinhole leaks in copper tubing are a major national problem.

C. Insurance Issues

1. Insurance Underwriting and Rating

Insurers use loss histories as a primary underwriting and rating factor for homeowners' insurance policies. Insurers considering an application to write a new policy on an existing home obtain property loss histories in various ways. In addition to requesting information from the applicant, an insurance company may request a CLUE report.

Comprehensive Loss Underwriting Exchange (CLUE) and A-PLUS Reports

ChoicePoint, Inc., of Alpharetta, Georgia, provides underwriting tools to the insurance industry, which include resident information and fire loss history. Their Comprehensive Loss Underwriting Exchange (CLUE) database enables insurance companies to access consumer claims information when they are underwriting or rating an insurance policy. A CLUE report shows the history of losses for a specific property and property owner.

More than 600 or over 90% of the insurance companies in the United States report data to CLUE. There are approximately 47 million claims in CLUE. However, not all companies participate in CLUE, and insurers can withdraw their data from CLUE.

The source of the data is claim information provided by the insurance companies. It includes policy information, claim information such as the date of loss, type of loss, and the amounts paid, and the description of the property covered. This is the only data stored in CLUE. Insurers may not add information to the database.

Under the Federal Fair Credit Reporting Act, only the owner or insurer of the property can access CLUE reports. Policyholders can access only a report on themselves and their property. A prospective homeowner cannot access the CLUE report until he or she receives title to the property, unless it's provided by the seller. A policyholder can request a copy of the CLUE report either once every 12 months, or when he or she receives a cancellation or non-renewal notice.

CLUE reports are used almost without exception for new policies. Most insurers do not access CLUE at renewal, but rely on their own data.

CLUE does not track pinhole leaks specifically. The closest type of data would be reporting on pipe bursts ("frozen pipes") or water loss. One insurer is beginning to sort its own loss data to determine which water losses specifically come from pinhole leaks in copper plumbing.

One of the biggest issues with CLUE, and beyond CLUE to insurance policies is whether inquiries about an actual loss are counted as claims. Claim information in CLUE should be reported where there is a request from an insurer or claimant for payment because of a loss. In most cases, general questions about coverage are not recorded in the database. However, if a policyholder reports damage, even if ultimately no payment is made, the insurer is obligated to open a claim file, which would show up in the database. (CLUE; Wisconsin OCI)

A similar report is A-PLUS (Automated Property Loss Underwriting System), which is produced by the ISO Company of Jersey City, New Jersey.

Most insurance companies report claims to both CLUE and A-PLUS.

Both A-PLUS and CLUE comply with the Fair Credit Reporting Act. That law protects the consumer regarding the use of his or her credit information, including claims histories. Because of the nature of CLUE and A-PLUS, it cannot be used as a marketing or research database to determine the distribution of specific types of problems. (CLUE, A-PLUS)

2. Effects of Pinhole Leaks on Homeowners' Insurance

Policy Limitations and Eligibility for Insurance

Insurance policies typically cover the water damage resulting from a pinhole leak to the extent they cover water damage generally. They do not cover replacement of the affected pipe as they consider this to be a home maintenance issue.

Without more refined claims information, there is no way to determine the full impact of pinhole leaks on homeowners' insurance coverage. Each insurer has its own underwriting and rating criteria used to determine if a homeowner is eligible for coverage generally. In some companies, a home with two water damage claims might be placed in a high-risk pricing tier, or be denied insurance renewal. For the homeowner, this means higher premiums, or going to the unregulated insurance market to obtain a policy. The location of a home in an area with a number of water-damage claims may also lead to an increased premium or non-renewal of coverage.

Distinguishing Types of Damage

Nationwide, less than 40% of home insurance claims are for water damage. However, insurance companies do not distinguish between types of water damage. CLUE reports identify water damage as either a "freeze" (burst pipes, whether caused by cold weather or not) or water damage (water leaks through pipes, causing damage to sheet rock and other materials).

The insurance industry does not have a standard definition for pinhole leaks. As a result, the issue becomes whether pinhole leaks in copper plumbing qualify as sudden damage i.e. a "freeze", or are simply considered a maintenance issue.

Non-Renewal or Cancellation of a Policy

Insurers in most cases will renew an existing policy for homeowners who report pinhole leaks. However, some insurance companies will not renew a homeowner's policy based on prior pinhole leaks if the frequency of those leaks exceeds the threshold for claims that is established by the insurance company. The reason, according to insurers, is that actuarial science shows that if a policy has one claim, the likelihood of the second claim increases, and a second claim greatly increases the chance of a third claim. Any claim, regardless of the nature or magnitude, increases the risk of a subsequent claim, according to the actuarial science relied upon by insurers. The extent of the damage caused by a pinhole leak may affect rates and trending, but the most important factor for insurers is the presence of any prior claims. The threshold for non-renewal of a homeowner's insurance policy varies from company to company.

Based on the claims history, an insurance company might apply a surcharge to the homeowners' premium to cover the increased risk of damage, or increase the deductible on a policy. In addition, an insurance company may deny coverage for a prospective homebuyer, if the property has a history of prior water damage claims.

If an insurer takes an adverse action against a policyholder based on information in the CLUE database, they must notify the policyholder, through an Adverse Action Letter, that the source of the adverse action was information obtained in a CLUE report. The policyholder has the right to order a copy of the CLUE report. ChoicePoint serves as the point of contact in such a dispute. The insurance company must reply to ChoicePoint within 30 days with proof of the claim. If there is no proof, ChoicePoint removes the data from CLUE.

Obtaining Insurance Coverage when Adverse Action Occurs

The Maryland Joint Insurance Association (JIA) offers property insurance to Maryland residents who have had trouble finding coverage in the competitive marketplace. (MD MIA) The JIA will provide coverage for Maryland homeowners unable to obtain property insurance through the competitive property/casualty insurance marketplace. The JIA encourages applicants to seek coverage in the competitive marketplace first, and then to apply for coverage with the JIA through licensed property/casualty insurance agents. However, any applicant may apply directly to the JIA for coverage.

If one is unable to obtain insurance through JIA, unregulated insurance entities are the next step. Insurance companies often establish unregulated subsidiaries—so-called Lloyd's companies and reciprocal exchanges—to provide insurance in these cases. State insurance departments do not govern such subsidiaries. These companies may be self-underwritten or in some cases receive backing from a larger corporation. They are the insurers of last resort.

III. The Physical Elements of the Problem

A. Water

Public Water Suppliers

There are several types of public water suppliers in the State of Maryland:

- Public water systems (PWS), which can be community water systems (CWS) or non-community water systems (NCWS)
- Individual water systems

Title 40 of the Code of Federal Regulations, section 141.2 (40 CFR 141.2), defines a PWS as a system that provides 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."

A public water system is either a community water system (CWS) or a non-community water system (NCWS).

A community water system, as defined in 40 CFR 141.2 is "a public water system which serves at least fifteen service connections used by year-round residents or regularly serves at least twenty-five year-round residents." The definition in Sec. 141.2 for a non-transient non-community water system (NTNCWS) is "a public water system that is not a [CWS] and that regularly serves at least 25 of the same persons over 6 months per year."

Sources of Water

There are two categories of water sources used by public water suppliers: groundwater and surface water.

Groundwater

Groundwater originates from rain and snow that soaks into the ground, passing between particles of soil, sand, gravel or rock until it reaches a depth where the ground is filled, or saturated, with water. The area that is filled with water is called the saturated zone (aquifer) and the top of this zone is called the water table. Surface water provides more than 80% of the state's water supply; however, ground water supplies approximately 85% of the total water used in Southern Maryland and the Eastern Shore. Groundwater is generally more acidic than surface water, with pH values around 6.5, and there may be a significant amount of dissolved gases in groundwater. However, this varies throughout Maryland with the aquifer that is used by the water system.

Surface Water

Surface water is withdrawn from sources such as reservoirs, streams or rivers. Generally, surface water is soft to moderately hard depending on geology, and is generally higher in alkalinity.

Both groundwater and surface water are subject to biological contamination. There are thousands of sources of organic matter and bacteria. In the case of surface water, organic matter from sources such as decaying algae, vegetation, agricultural runoff, and sewage treatment discharge provide food for bacteria and provide the bacteria directly.

Impurities in Water

Public drinking water is highly regulated, and the water treatment processes are designed to remove harmful impurities from the source water. Impurities in water include, but are not limited to:

Microorganisms, such as bacteria, viruses and protozoa, are present in surface waters but their numbers depend on conditions in the drainage basin. These organisms can cause serious problems in treatment plant basins by the accumulation of growths on the walls, clogging of filters, and causing taste and odor problems. Untreated bacteria or other microorganisms in water can lead to serious illnesses.

Natural organic matter (NOM), which is organic matter originating from plants and animals present in natural (untreated or raw) waters, for example, in lakes, rivers and reservoirs.

Inorganic contaminants, such as salts and metals, which can be naturally occurring or result from urban storm water runoff, industrial or domestic wastewater discharges, oil and gas production, mining, or farming.

Pesticides and herbicides, which may come from a variety of sources such as agriculture, urban storm water runoff, and uses.

Organic chemical contaminants may include synthetic and volatile organic chemicals, which are byproducts of industrial processes and petroleum production. These can come from gas stations, urban storm water runoff, and septic systems.

Radioactive contaminants, which can be naturally occurring or be the result of oil and gas production and mining activities.

(WHO, 2001, Howard DPW 2003, O'Connor 2002, Rutz, 1996)

Disinfection Byproducts (DBPs) - According to the EPA, disinfectants used to treat water can react with naturally occurring materials in the water to form unintended byproducts that may pose health risks. Results from toxicology studies have shown several DBPs (e.g., bromodichloromethane, bromoform, chloroform, dichloroacetic acid, and bromate) to be carcinogenic in laboratory animals. Other DBPs (e.g., chlorite, bromodichloromethane, and certain haloacetic acids) have also been shown to cause adverse reproductive or developmental effects in laboratory animals (D/DBP Rule).

B. Water Treatment Process

Surface Water

Water undergoes several treatment processes after it arrives at the plant and before it is sent to the distribution system. A typical treatment plant using a surface water source, as shown in figure 8, includes:

1. Coagulation and flocculation, to cause small particles from the raw water to adhere to each other
2. Sedimentation, to remove those particles
3. Filtration, to remove the very smallest particles

4. Disinfection
5. Corrosion control (e.g. lime addition, to adjust pH. Note: some utilities use this practice to minimize the potential for dissolving lead solder used in the plumbing of older homes; others may use different corrosion control strategies such as the addition of a corrosion inhibitor.)

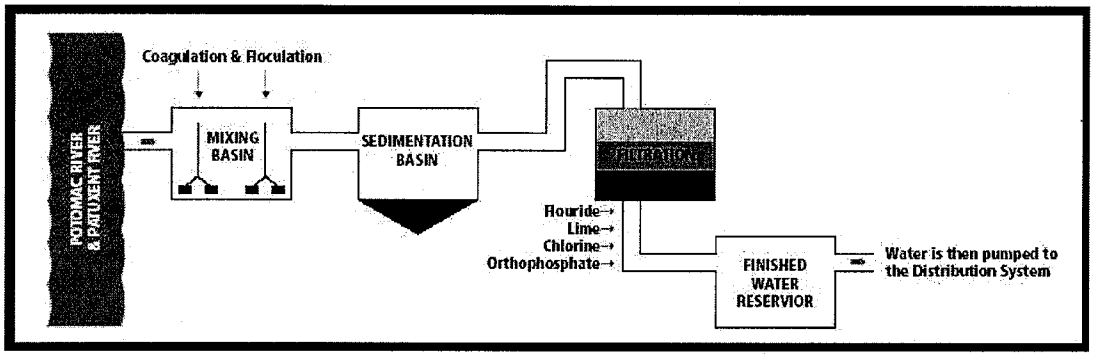

Figure 8: Typical Surface Water Treatment (Courtesy of WSSC)

Coagulation and Flocculation

The first step in water treatment is to remove small particles from the water. These particles, which include silt or microorganisms, make the water cloudy or turbid. Turbid water, besides being unsightly, also shields microorganisms from disinfectants. Smaller particles in suspension in turbid water stay in suspension because they hold a negative charge. Particles that might combine can repel each other because of these negative charges. Coagulation treats these particles with chemicals that remove the charge.

The most commonly used coagulant is alum, or aluminum sulfate ($Al_2(SO_4)_3$). Other coagulants are ferric sulfate ($Fe_2(SO_4)_3$), ferric chloride, ($FeCl_3$), or synthetic polymers. The WSSC uses polyaluminum chloride, Al(OH Cl (SO_4), at both plants. In most water treatment plants, coagulation occurs at acidic or neutral pH. For coagulation to be most efficient, however, there must be sufficient alkalinity in the water to allow the coagulant to react properly. (WHO, 2001)

The second step, flocculation, is related to the first. The water to be treated is mixed slowly and gently to promote clumping of particles into larger floc particles that may be removed by sedimentation or filtration.

The aluminum or ferric coagulant byproducts are aluminum or iron salts in the water.

Sedimentation

The third step is to allow the larger particles formed during coagulation and flocculation to settle at the bottom of a sedimentation basin.

The result after coagulation, flocculation, and sedimentation is the removal of larger molecular weight compounds, leaving only smaller organic chains (Rogers, 2004).

Filtration

The fourth step passes water through a series of filters. Filters for suspended particle removal can be made of garnet sand, silica sand, anthracite coal, activated carbon, or synthetics; the most widely used are rapid-sand filters in tanks. Gravity provides the driving force for the water and the flow is downwards. The filter is periodically cleaned by a reversal of flow and the discharge of back-flushed water into a drain.

Disinfection

The fifth step is disinfection. One of the most common methods is by adding chlorine, chloramines, or a solution of sodium hypochlorite (similar to household bleach but at a much lower concentration). However, other methods include adding ozone or irradiating the water with ultraviolet light, or using other chemicals.

pH Adjustment

Although pH adjustment occurs as part of the corrosion control process, pH control is also used for balancing other chemical reactions. Disinfection byproducts are more likely to form at a higher pH, while phosphate-based corrosion inhibitors such as orthophosphate, work best in a narrow pH range.

A common treatment is to inject alkaline chemicals such as calcium oxide or quicklime, (CaO) calcium bicarbonate ($Ca(HCO_3)_2$), hydrated lime $Ca(OH)_2$, or soda ash (Na_2CO_3) into the water to bring the pH above the chemically neutral level of 7.0 or higher. The results of chemical addition may include aluminum hydroxide (if residual aluminum remains in the water after filtration) and calcium sulfate.

Corrosion Control

Many water distributors practice corrosion control by adjusting the pH and/or alkalinity of the water and/or by addition of corrosion inhibitors (e.g. orthophosphate) to coat pipes.

Addition of Phosphates

Two types of phosphates may be added to water supplies:

> ***Orthophosphate*** is sometimes referred to as "reactive phosphorus." Orthophosphate is the most stable kind of phosphate, and is the form used by plants. Orthophosphates are produced by natural processes. Orthophosphate is used not only for lead and copper corrosion control, but also for corrosion control in iron pipes. Orthophosphate is also added to help minimize pinhole leaks in home plumbing. The WSSC started adding orthophosphates to water supplies on November 12, 2003. Plumbers in the WSSC service area have reported reductions in pinhole leaks since introduction of orthophosphates.
>
> ***Polyphosphates*** (also known as metaphosphates or condensed phosphates) are used to prevent the discoloration of water by preventing dissolved iron and manganese from reacting with oxygen. In water, polyphosphates are unstable and will eventually convert to orthophosphate.
>
> In addition, there are commercially available blends of orthophosphate and polyphosphate.
>
> Nationally, about half of all water utilities use some form of phosphate corrosion inhibitor. Phosphates used in water treatment are certified by the National Sanitation Foundation. (NSF)

Inorganic phosphates are added to the water for two reasons:

- Corrosion control: phosphates form low-solubility phosphate compounds on interior pipe surfaces. This process limits the release of lead, copper, and iron from water mains and domestic plumbing
- Prevention of water discoloration

Groundwater Treatment

Groundwater treatment systems are similar to surface water systems, but with less turbidity removal and more emphasis on iron and manganese removal. A typical groundwater treatment system would include but is not limited to:

1. Aeration
2. Filtering
3. Disinfection (with chlorine)
4. pH adjustment with alkaline chemicals to reduce acidity
5. Iron removal (when required)
6. Addition of corrosion inhibitor (when required).
7. Fluoridation (in some cases)

C. Copper Piping (Tubing)

Since 1963, the year Copper Development Association Inc. (CDA) was founded and began tracking consumption, more than 28 billion feet, or approximately 5.3 million miles of copper plumbing tube has been installed in about 80% of all U.S. buildings. (Veazey, 2002: 18)

In the United States, copper tubing, used for domestic water supply and distribution is manufactured to meet specification B88, *Standard Specification for Seamless Copper Water Tube*, established by the American Society for Testing and Materials (ASTM). According to the Copper Development Association Inc.'s *Copper Tube Handbook:*

> "All tube supplied to these ASTM standards is a minimum of 99.9% pure copper and silver combined. The copper customarily used for tube supplied to these specifications is deoxidized with phosphorus and referred to as C12200 (Copper No. 122) or DHP[1] Copper. Other coppers may also be used."

In addition to copper, there is a maximum of 0.04% phosphorus in copper tubing.

Each type represents a series of sizes with different wall thickness. Type K tube has thicker walls than Type L tube, and Type L walls are thicker than Type M, for any given diameter. All inside diameters depend on tube size and wall thickness. (*Copper Tube Handbook*, 2003)

Copper tube imported into the United States, if it is identified as ASTM B88, should meet the same standards as U.S. copper. In the State of Maryland, imported copper tubing is rarely used.

Types K and L copper tube are sold as "hard" (drawn temper) or "soft" (annealed temper) seamless copper tube. Type M is manufactured as "hard" piping only and is not sold in coils. Local building codes dictate to plumbers whether Type K, L or M piping will be used in housing. Type M is most common. Type K is often used for the underground water service from the water mains to the water meter.

The techniques for manufacturing copper piping are the same now as they have been for decades.

Copper has become the most widely used material for plumbing systems because of its ease of use, resistance to corrosion, and resistance to permeation by liquids and gases, which may be sources of corrosion and contamination.

Other Piping

Plastic piping is sometimes used as a substitute for copper piping, especially when the pH value of the water being supplied is below 6.5. Low pH waters, those at or below 6.5, are often found in private well water systems. Types of plastic piping include Polyvinyl Chloride (PVC), Chlorinated Polyvinyl Chloride (CPVC), and cross-linked polyethylene (PEX). Some plastic piping, such as PVC, is meant for cold water only. Local and State plumbing codes should be evaluated to determine if any of these plastic materials may be used.

Galvanized steel piping is made of steel that is covered with a zinc layer. The zinc serves as a protective barrier to the steel, corroding first.

Ductile iron pipe is used in water supply systems mains and for wastewater. Often these pipes are lined with cement, which might contain some aluminum.

D. Corrosion

Corrosion is the deterioration of a material due to its interaction with the environment. It is a natural process that may occur whenever metals meet water. The chemistry of corrosion involves many factors, such as:

- Whether the water is acidic (pH lower than 7.0) or alkaline or basic (pH higher than 7.0)
- Other elements.
- Dissolved carbon dioxide and oxygen in the water
- Concentration of sulfur-bearing compounds in the water
- Temperature of the water; there are different types of corrosion in hot and cold water
- Microorganisms in the water
- The velocity of water

Copper Corrosion

There are many forms of corrosion, but the Task Force, following its mandate, focused on pitting corrosion which is most likely to culminate in pinhole leaks in copper plumbing.

Pitting Corrosion

Pitting Corrosion is the non-uniform localized attack of the wall of copper tube, pipe or fittings initiated on the interior/waterside surface in the domestic water distribution system, in which only small areas of the metal surface are attacked, while the remainder is largely unaffected. Pitting corrosion starts on metal surfaces for unknown reasons, and some combinations of water chemistry factors allow the process to continue while some do not.

Pitting corrosion can be classified into three types (Ferguson *et al*, 1996: 240):

Type I pitting is associated with hard or moderately hard waters with a pH between 7 and 7.8, and it is most likely to occur in cold water. In many cases, a carbon film or silica scale forms with this type of pitting. The pitting is deep and narrow, and results in pipe failure. Factors that initiate this phenomena include stagnation early in pipe life; deposits within the pipe, including dirt or carbon films, high chlorine residuals, water softeners, or alum coagulation.

Type II pitting occurs only in certain soft waters, with a pH below 7.2 and occurs rarely in temperatures below 140 °F. The pitting that occurs is narrower than in Type I, but still results in pipe failure. Factors that initiate this phenomenon include higher temperatures, high chlorine residuals, or alum coagulation.

Type III pitting occurs in cold soft waters having a pH above 8.0. It is a more generalized form of pitting, which tends to be wide and shallow and results in blue water, byproduct releases, or pipe blockage. Factors that initiate Type III pitting include stagnation early in the pipe life, alkaline water, and alum coagulation. (Ferguson et al, 1996: 255; Laitsaari, 1999)

E. Effects of Pitting Corrosion

Pitting corrosion has two effects:

- Reduced life of pipes
- Increased probability of leaks, breaks, and contamination

IV. Regulatory Issues

A. Safe Drinking Water Act

The Safe Drinking Water Act (SDWA) was originally passed by Congress in 1974, and amended in 1986 and 1996. Its purpose is to protect public health by regulating the nation's public drinking water supply. The SDWA authorizes the United States Environmental Protection Agency (USEPA) to set national health-based standards for drinking water to protect against both naturally occurring and man-made contaminants that may be found in drinking water.

The Environmental Protection Agency's regulations are incorporated into the Code of Federal Regulations as Title 40, Parts 9, 141 and 142. Currently, the EPA regulates 91 separate parameters in drinking water, including the presence of microbiological, radiological, volatile organic and inorganic contaminants.

Public water suppliers serving community water systems are required to file an Annual Water Quality Report, in which they inform the public of the levels of contaminants measured in their systems and whether any of these levels are higher than the maximum contaminant level (MCL) allowed by the SDWA and other EPA regulations.

B. Lead and Copper Rule

Lead free piping and soldering has been required since the 1986 SDWA amendments. In addition, the EPA established the Lead and Copper Rule (LCR), (Volume 56, Federal Register, pp 26460-26564) (56 FR 26460) on June 7, 1991, to implement some requirements of the SDWA. It was modified on January 12, 2000 (65 FR 8, pp 1949-2015).

The purpose of the LCR is to protect public health by minimizing lead (Pb) and copper (Cu) levels in drinking water. The primary means that the LCR establishes to accomplish this is by reducing water corrosivity. The EPA established that lead and copper enter drinking water mainly from corrosion of plumbing materials.

The LCR establishes an action level (AL) of 0.015 milligrams per liter (mg/L) for lead and 1.3 mg/L for copper, based on the 90th percentile level of tap water samples. When these levels are exceeded, other requirements may be triggered, such as:

- Corrosion control treatment
- Source water monitoring/treatment
- Public education
- Lead service line replacement requirements

Water quality monitoring is required of all public water systems serving more than 50,000 persons to demonstrate compliance with the LCR.

C. Disinfectants and Disinfection Byproducts Rule

Studies in the 1990s showed that the disinfection process of water treatment reacted with natural organic materials (NOM) in water to form unintended byproducts that may pose health risks. Stage 1 of the Disinfectants and Disinfection Byproducts Rule (D/DBP Rule) (63 FR 241, 69389-69476), was finalized December 16, 1998 by EPA.

The Disinfectants and Disinfection Byproducts Rule applies to all public water systems that treat their water with a chemical disinfectant for either primary or residual treatment.

Water systems that use surface water or ground water under the direct influence of surface water and use conventional filtration treatment are required to remove *specified percentages* of organic materials, measured as total organic carbon (TOC) that may react with disinfectants to form DBPs. Enhanced coagulation or enhanced softening will be used to remove TOC, unless a system meets alternative criteria. Environmental Protection Agency's (EPA) goal is to reduce TOC in water by 35%, not to eliminate it. In the case of many nationwide water suppliers, changes in water treatment processes were minor. Other water suppliers increased coagulant doses which may have increased aluminum levels.

Large surface water systems that serve more than 10,000 persons (such as WSSC and the City of Baltimore) were required to comply with the Stage 1 Disinfectants and Disinfection Byproducts Rule and Interim Enhanced Surface Water Treatment Rule by January 2002. Ground water systems and small surface water systems were to begin complying with the Stage 1 D/DBP Rule by January 2004. (EPA D/DBP Rule)

Overall, Federal regulations such as the D/DBP Rule have been successful in reducing the overall risk of cancer.

Stage 2 of the D/DBP Rule was proposed in 2003; it is expected to lower the maximum contaminant level for trihalomethanes and haloacetic acids. The EPA received comments on the Stage 2 D/DBP Rule in January 2004. A final rule is expected in 2005.

D. Interim Enhanced and Long Term 1 Enhanced Surface Water Treatment Rule

In the past ten years, specific microbial pathogens, such as *Cryptosporidium*, which can cause illness, have been found to be resistant to traditional disinfection practices. Disinfectant resistant pathogens are covered under the Interim Enhanced and Long Term 1 Enhanced Surface Water Treatment Rule.

V. Possible Causes of Pinhole Leaks

There are several theories and some research as to the possible causes of pinhole leaks, but no definitive causes have been established. The following summarizes possible causes.

A. Research Related to the WSSC Water System

In response to increasing reports of pinhole leaks, WSSC launched a Pinhole Leak Investigation in 2000. A task force was formed and several experts in the field were contracted to study the phenomena. Additionally, WSSC started collecting data from its customers who had experienced pinhole leaks. With the result from the research, WSSC developed an outreach program with bill inserts and web page information on pinhole leaks, and implemented a pilot study to introduce orthophosphates into the drinking water.

As a result of numerous pinhole leak reports from customers, WSSC contracted research by Dr. Marc Edwards, who is Professor of Civil and Environmental Engineering at the Virginia Polytechnic Institute and State University in Blacksburg, Virginia. The research has examined the roles of aluminum and chlorine in possibly promoting copper pitting.

The study used off-the-shelf copper pipe (soft copper, hard copper and copper couplings) and water that contained approximately the same dissolved salts as water treated by the WSSC. The piping was polished to remove any surface contaminants. The water characteristics included aluminum, free chlorine, and a pH greater than 8.0, but included no NOM. (Rushing and Edwards, 2004) (Marshall, 2004).

During the above referenced study a one 1-foot section of Type M pipe produced eight pinholes. Figure 9 illustrates (rather dramatically) a section of pipe with clamps to stop leaks, although it should be noted that the tube shown in Figure 9 was not from the study nor was it from a location in Maryland.

Because the research from this study is relatively new, there have been questions about whether it has accounted for all possible causes.

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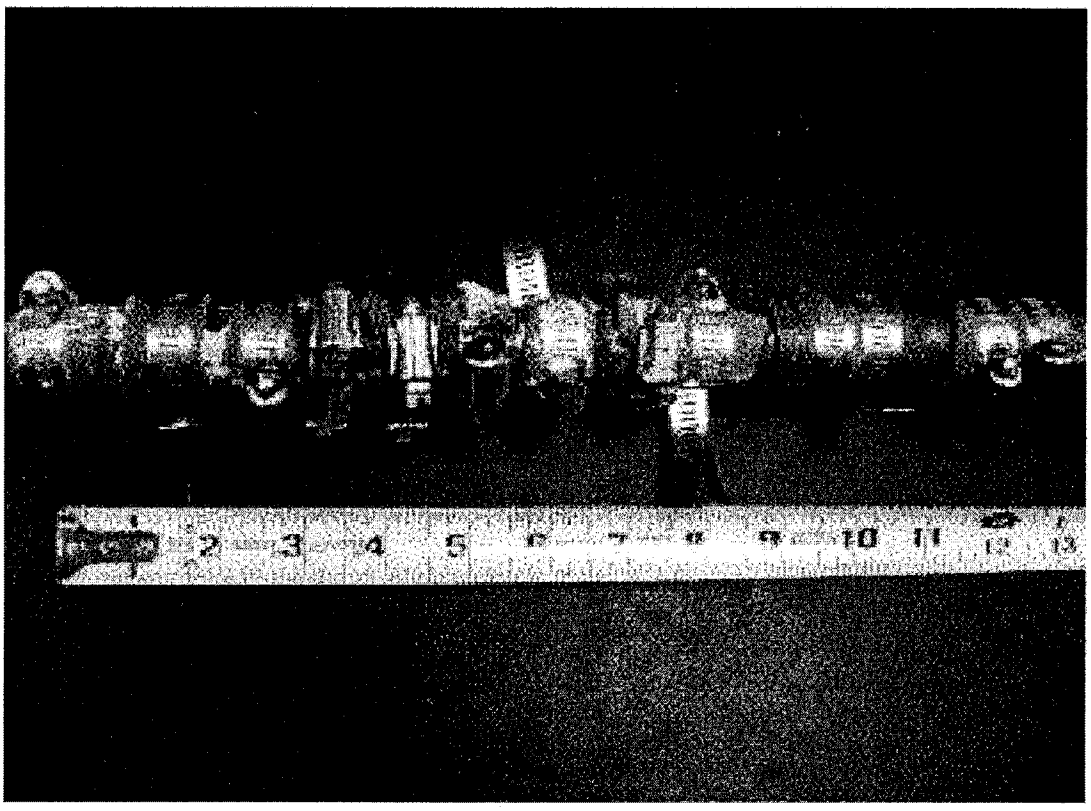

Figure 9: Pipe from Arlington, Virginia Water System with Clamps to Stop Pinhole Leaks (Courtesy Dr. Marc Edwards)

The research concludes that this combination of higher pH, low organic matter, aluminum solids, and free chlorine in water produces pinhole leaks. In addition, it appeared that aluminum solids catalyzed the cathodic reaction between copper and chlorine. A third-party study funded by the Copper Development Association Inc. of New York confirmed these findings. (Reiber, 2003a)

Dr. Edwards has recently completed experiments that use water collected from an actual distribution system instead of "synthetic" water, which has caused pitting corrosion in new type M copper tube. (Edwards, 2004b) Although the results from this experiment have not been published yet, Dr. Edwards, in association with Jason C. Rushing, has published his first peer-reviewed article. The abstract states in part:

> "Circumstantial evidence from one system with copper pitting problems suggested that high chlorine residuals and aluminum [sic] solids might be contributing factors. To test this hypothesis, a series of experiments were conducted to examine their effect on copper corrosion under stagnant and flow conditions. Although chlorine alone impacted copper corrosion, a synergistic reaction was discovered between chlorine and aluminum [sic] solids when exposed to copper. Evidence for this effect was seen in increased chlorine decay rates, increased non-uniform copper corrosion, and rising corrosion potentials

> during exposure. It is likely this reaction is involved in copper pit initiation." (Rushing and Edwards, 2004)

The findings of this were reported to the CDA, and were reported in a master's thesis by Ms. Becki Marshall of Virginia Tech. (Marshall, 2004).

Problems resulting in pitting corrosion in copper pipe were not anticipated by anyone in the copper industry, water utilities, or the EPA. Prior to Dr. Edwards recent work, there was no peer-reviewed scientific literature that suggested the combination used by Dr. Edwards would result in pitting corrosion. The WSSC advocates additional research and the American Water Works Research Foundation recently initiated a major project, in part funded by the U.S. EPA, to document the extent of the problem nationally and aid in discovering further causes and solutions.

Overall, the regulation of the EPA and the practices of public water suppliers have improved the quality of drinking water throughout the United States. The negative effects of lead solutes in drinking water have been known for decades, as well as the consequences in sickness from waterborne diseases from inadequate disinfection of drinking water.

It must be emphasized that though this combination of water chemistry causes pitting corrosion and pinhole leaks in copper plumbing, it is not the only possible combination of water chemistry that might result in pitting corrosion. As Rushing and Edwards report, "The synergistic interaction between aluminum and chlorine shown to occur in this work is of particular interest, and it would be worthwhile to see if other solids in water caused similar effects on copper." (Rushing and Edwards, 2004)

The Task Force recommends future research on the subject.

Another possible cause of pitting is chloramines, which are chemicals caused by combining chlorine and ammonia (NH_3). Chloramines are a weaker oxidant then pure chlorine, but more persistent.

Dr. Edwards believes that the pitting is caused by a combination of high pH, chlorine, trace aluminum in the water, and the absence of natural organic materials, which have been reduced in drinking water by direction of the EPA.

Figure 10 on the following page shows the effects of chlorine and aluminum corrosion on copper after 6 months.

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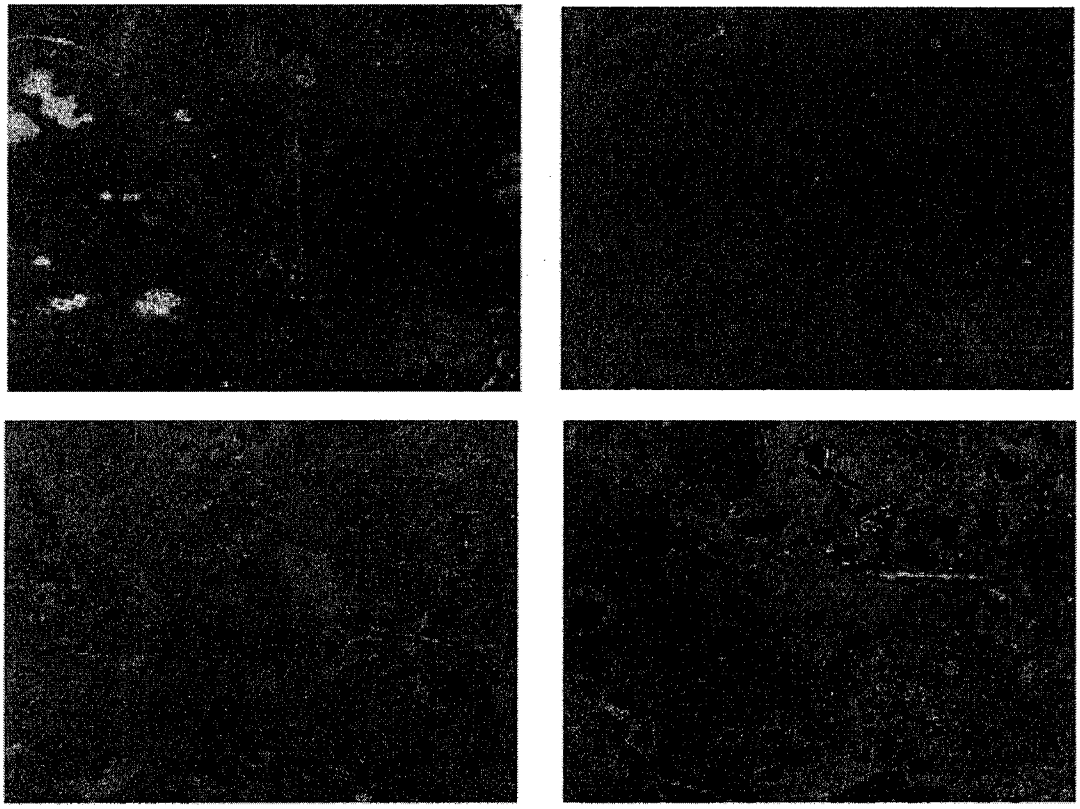

Figure 10: Dried Copper Surfaces After 6 months' Exposure to WSSC Water and Aluminum Solids

The top left picture is with water with 0 mg/L free chlorine. Top right: 1.2 mg/L free chlorine. Bottom left: 2.4 mg/L free chlorine. Bottom right: 3.6 mg/L free chlorine. All samples were exposed to 30 mg/L aluminum solids. Surface areas of each picture are approximately 100 cm^2, or 12 square inches. (Courtesy of Dr. Marc Edwards)

Figure 11 on the following page shows copper pipe samples at the end of the experiment. The patterns of corrosion are in straight lines, which are also how pinhole leaks are reported to appear.

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Figure 11: Copper Pipe Samples at the End of the Experiment.

From top to bottom: Control (no aluminum or chlorine), 1 mg/L Al, 3 mg/L Cl_2, 1 mg/L Al plus 3 mg/L Cl_2. (Courtesy of Dr. Marc Edwards)

His work indicates that EPA requirements—coupled with best industry practices including: NOM reduction, possibly cleaning/lining and installing new cement-lined pipes, traces of aluminum in water, and improved general corrosion control by raising pH—may promote copper pipe pinhole leaks. These laboratory findings suggest that further research should be conducted to follow up on this hypothesis, especially since the work done by Dr. Reiber for the CDA did independently verify Edwards' lab findings.

B. Other Reports

The University of Florida's School of Building Construction produced a survey of copper water tube corrosion in Florida. The University study, published in November 1997, surveyed existing peer-reviewed scientific and technical literature and surveyed plumbing contractors, building owners, building inspectors, and water providers.

The Florida report stated:

> "After analyzing the field data, the researchers concluded that this study by itself is inconclusive because they were not able to determine the solution or solutions to the corrosion problem(s) in Florida. The researchers, however, discovered that

> (1) copper corrosion failures were widespread by word of mouth and these failures did not follow any general pattern, and (2) the **suspected causes** of the corrosion included aggressive water, poor workmanship and addition of water softeners to water providers' water systems. The researchers did not obtain substantial data to determine how widespread and how extensive the corrosion problem was. Neither were they able to determine what the **actual cause(s)** of these corrosion problems were." (Rinker, 1997, p. 1-2) (Emphasis in the original text)

The American Water Works Association Research Foundation and DVGW-Technologiezentrum Wasser of Germany jointly publish a reference book, *Internal Corrosion of Water Distribution Systems,* which deals with copper corrosion in part. This text is aimed at engineers and scientists researching corrosion and provides many invaluable insights (Ferguson *et al*, 1996).

C. Copper Plumbing Materials

The Task Force determined that pitting corrosion and the resulting pinhole leaks in copper plumbing in Maryland is not believed to be the result of deficiencies in the manufacture of the copper plumbing materials.

D. Installation and Workmanship

The techniques of installing have not changed drastically since the 1930's.

Solder flux-induced corrosion occurs in isolated conditions, is easily identifiable, and can be corrected or avoided by using appropriate, code-approved soldering fluxes.

The main factor that can be clearly defined as faulty craftsmanship is in excessive use of fluxes. Fluxes are corrosive by their nature; they are used for soldering and brazing copper tubes. Brazing has not been an issue; however, if substantial amounts of flux are introduced into a tube and remain in the tube, then pitting may occur near the flux residues (Ferguson *et al*, 1996: 260).

Aside from flux-induced corrosion, pitting corrosion and the resulting pinhole leaks in domestic water systems in Maryland is not the result of improper installation and workmanship.

E. Design Issues

Even though data from the WSSC and the AWWA identifies the problem as happening mostly in horizontal, cold-water pipes in homes built before 1970, the Task Force does not consider design issues as potential contributing leak factors.

F. Reduced Natural Organic Matter (NOM)

In accordance with the SDWA of 1974, and the D/DBP Rule as passed on December 16, 1998, large water utilities had to begin compliance, including reducing the total organic carbon (TOC), by January 1, 2002. Some large water systems had begun complying with these new requirements earlier. Some water utilities had to make very little change in their treatment process or had to make none at all to meet the new requirements.

Stage 1 of the D/BPR required up to a 35% reduction in TOC, which would result in a decrease in NOM, but by no means did the regulation call for the complete removal of TOC/NOM, nor did water utilities remove all the TOC/NOM. However, the heaviest molecular materials tended to be removed from the water supply.

EPA states that NOM levels are believed to influence solubility of metals, including copper, lead and iron. NOM may possibly help contribute to an insoluble, stable mineral scale on pipe walls, which in turn insulates the pipe metal and fixes the mineral scale to the pipes more steadfastly. The decrease or disappearance of this biofilm layer may be related to the reduction of NOM and the disinfection practice changes made by utilities (switching to chloramines and/or increasing the chlorine dose) than the changes in natural organic matter making it through the treatment process.

The introduction of orthophosphates into drinking water was to serve as a substitute to provide coating for interior surfaces of the pipe, which would serve as a barrier to corrosion, without causing the byproducts that the EPA deemed were dangerous to human health. Further research is required to determine whether orthophosphate barriers are more or less effective than biofilm barriers.

G. Other Chemicals in Water

"Aggressive water" is a catchall term that deals with factors such as the pH content and presence of chlorides, metal ions, and dissolved gases in water. Once corrosion researchers determined that defective copper piping was not believed to be the cause of pinhole leaks, water chemistry became the next possible cause to be investigated.

The current literature indicates that dissolved carbon dioxide and hydrogen sulfide, and metals such as manganese, aluminum, and iron are associated with pinhole leaks, but association is not necessarily causation.

The Materials Subcommittee determined that aluminum-bearing compounds are the most probable corrosive agents involved in the outbreak of corrosion episodes in Maryland; however, the Task Force did not determine that aluminum-bearing compounds are the sole agents involved in corrosion. The source of the aluminum is yet to be determined. Aluminum could come from concrete distribution system pipe, or cement mortar lining of cast iron pipe, aluminum coagulant carryover from the treatment plant, or from the raw water.

H. Exterior Factors

The Task Force found no evidence to contribute pitting corrosion and the resulting pinhole leaks to any factors exterior to the plumbing. (e.g. electrolysis, lightning.)

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VI. Recommendations

The recommendations of the Task Force on Pinhole Leaks in Copper Plumbing do not carry legal or regulatory authority. In addition, the recommendations of the Task Force do not favor the purchase or use of any commercial product or service.

A. Home Purchaser's Role (When considering the purchase of a home)

1. **Request a home inspection when writing a contract for a home.**

   Be certain to discuss pinhole leaks issues with your inspector.

2. **Request a CLUE Report when to writing a contract or a condition to the contract.**

   Refer to the Insurance Section, page 10, of this report to see how a CLUE report can be ordered by the current homeowner, what the report contains, and how the insurance company uses this information. In addition, there is information on how to obtain homeowners' insurance and to look for disclaimers or exclusions in a policy.

3. **Review the Maryland Residential Property Disclosure and Disclaimer Statement that includes information about:**

   a) Any leaks or evidence of moisture

   b) Operating condition of plumbing system

   c) Any problems with water supply

4. **Read carefully your insurance policy for information about whether a pinhole leak is covered by the insurance company.**

5. **Ask for Warranty and Service Contracts that would cover pinhole leaks.**

   Although pinhole leaks may not be mentioned specifically, some home warranty plans cover pinhole leaks as part of their coverage for "plumbing systems". The consumer should check the home warranty contract carefully.

B. Home Owners with Pinhole Leaks Problems Should:

1. **Report their problem to their water supplier.** They may obtain the latest information and updates on problems in their service area.

2. **Determine if this is a recurring problem.**

3. **Seek assistance from a licensed and trained plumber in determining the most probable cause of the failure and on whether to:**

   a. Do a simple site -repair.

   b. Have leaking pipes replaced. If frequent leaks have occurred, consider re-piping with an alternative material approved by the local code.

c. Full system replacement. Evaluate the ramifications of re-piping with copper tube or alternate materials approved by the appropriate local plumbing code.

d. Consider pipe lining using an epoxy or similar material approved for use by the local plumbing code. The cost of this technique is approximately from $3,000 to $5,000 for a small house with 1 ½ baths, kitchen, and laundry area. Although the plumbing system is marked and identifiable as having an epoxy treatment, subsequent plumbing work that cuts through pipes may remove the protection of the epoxy coating. Coated pipes cannot be heated or soldered. Coating companies are required to leave stickers stating that the pipe has been treated. Consumers should be mindful that there is no guarantee that epoxy coating can protect against all levels of corrosion.

4. **Be aware of information on insurance company's procedures.**

   Refer to the Insurance Section, page 10, of this report to see how the homeowner can order a CLUE report, what the report contains and how the insurance company uses this information. There is information on how to challenge any inaccuracies contained in the report. In addition, there is information about what to do if the insurance policy is not renewed, or is cancelled.

C. Home Inspectors

Home Inspectors should be trained to identify pinhole leaks in copper plumbing and report any such leaks to the prospective homeowners.

D. Water Suppliers Should:

1. **Establish a method to collect information from their customers and from plumbers on pinholes leaks.**

2. **Develop information to inform the consumer about identifying pinhole leaks, such as:**

   - Mass mailings to customers in bill inserts
   - Regular and proactive updates to media outlets
   - Update letters to customers who have reported pinhole leaks
   - Update letters to local officials
   - Provide briefings to homeowners, community associations, home inspectors, real estate professionals, and government officials on the issue

3. **Monitor and participate in current and future research in order to be aware of industry changes that may positively affect the supply of their product to reduce pinhole leaks, but not compromise the quality and safety of their water.**

   Academic literature, until recently, did not provide an explanation for the causation of pitting corrosion in residential water copper plumbing, or methodologies to counter it. Continued funding for researchers is strongly recommended.

   Water utilities and national industry organizations, should promote continuing research on causation of pitting corrosion and prevention of pinhole leaks.

4. **Consider the research recently completed by the industry regarding the addition of orthophosphates and other additives.**

   Other water suppliers throughout the State have unique water chemistry, and the nature of that water chemistry, and the number of reported pinhole leaks, determines how they should adjust their water treatment. Water utilities whose customers are not having problems should be very cautious about changing their water chemistry.

   Consider the addition of orthophosphate into the treatment process if further research evaluation shows that the combination of factors suspected by the WSSC and researchers is beneficial to retarding pinhole leaks. The Copper Development Association Inc., the WSSC and the AWWA have sponsored research to determine how pinhole leaks occur.

5. **Strive to minimize the aluminum in the processed water and to keep the pH below the EPA recommended maximum of 8.5.**

   The presence of aluminum and high pH are factors that have been shown to increase the likelihood of pinhole corrosion in recent studies.

E. Plumbers and Home Improvement Contractors Should:

1. **Comply with applicable plumbing code**. This is not only for pipe repair and replacement, but where fluxes are used, they must meet the requirements of ASTM B813.
2. **Be encouraged to report pinhole leaks to the State Board of Plumbing, or the appropriate water supplier.** This should be a part of data gathering to determine the true scope and extent of pinhole leaks in copper plumbing.

F. Training and Information

Water suppliers, real estate professionals, plumbers, home inspectors, and governmental agencies should develop and implement public education and information programs. In addition, plumbers and water utilities should consider developing a central database on pinhole leaks.

1. **Real Estate agents/brokers** should be offered classes that include information on the existence and potential damage of pinhole leaks as part of their continuing education.

2. **Homeowners and prospective homeowners** should be offered information on pinhole leaks in adult education classes or be primed by their real estate representative.

3. **Plumbers** should be offered classes on information about pinhole leaks as part of their continuing education.

4. **Home Inspectors** should be trained to detect pinhole leaks in copper plumbing and report any such leaks to the prospective homeowners.

5. **Code Officials** should be offered classes on information about pinhole leaks as part of their continuing education.

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Conclusion

In the State of Maryland, pinhole leaks in copper plumbing from public water sources have been reported in Prince George's, Montgomery, and Carroll Counties. The Washington Suburban Sanitary Commission, which serves the former two counties, has been proactive and aggressive in obtaining reports from homeowners about pinhole leaks in copper plumbing. Also, the WSSC started adding orthophosphates to water supplies on November 12, 2003. Plumbers in the WSSC service area have reported reductions in pinhole leaks since the introduction of orthophosphates.

The chief risks to homeowners from pinhole leaks in copper plumbing are water damage to property caused by pinhole leaks and possible adverse action by insurance companies, including premium increases or non-renewal of homeowners' insurance. In the case of non-renewal, homeowners may be able to obtain coverage either through the Maryland Joint Insurance Association, or through non-regulated insurers. The Task Force believes the best course of action is to establish public awareness through a public information campaign.

Pinhole leaks in copper plumbing are an extreme type of pitting corrosion, which occur in water supply pipes. The manufacture of copper piping in the United States is uniform, and defects in workmanship appear to be limited to the improper placing of certain flux material used in soldering pipes. Most pipes reporting pinhole leaks are soldered correctly, which indicates that there are other issues causing the leaks.

The Safe Drinking Water Act of 1974 and the EPA's Lead and Copper Rule and Stage 1 Disinfectants and Disinfection Byproducts Rule mandated changes in water chemistry. The number of pinhole leaks reported nationwide is believed to have increased since the rules came into effect. Changes in water chemistry appear to be a possible stimulant to the increase of pitting in copper pipes, but water chemistry is a very complex issue.

The specific causes for pinhole leaks in copper plumbing have yet to be determined. Suspected causes exist, but until more systematically gathered information are collected, or until more peer-reviewed scientific research is conducted, it cannot be determined these are the causes for pinhole leaks in copper plumbing.

Marylanders can do several things to prevent or mitigate pinhole leaks in copper plumbing or the risk of increased premiums or non-renewal of insurance policies. The most cost effective practical measures involve visual inspection of pipes and fittings, and reporting suspected leaks to the local water supplier. If there are pinhole leaks, there are several options, depending on the severity of the leak and the potential cost, including replacing pipes and valves or relining pipes with epoxy. The Task Force recommends that Marylanders consult licensed professionals to determine if these measures are feasible. In addition to these measures, the Task Force also recommends that property owners obtain a copy of the CLUE or A-PLUS report for their properties to review the accuracy of the information in the report.

Water suppliers, real estate agents and plumbers should consider providing a program of public education so property owners will be aware of the issue of pinhole leaks in copper plumbing. The WSSC is already doing so; other utilities in the State should also initiate programs of public awareness. Mass mailings, websites, and press releases are some of the tools that may be utilized in providing this important information to Marylanders.

Water providers must balance many needs including water purity and corrosion control while supplying safe drinking water, and because they have different water supplies, the Task Force

cannot make a single recommendation to alter water chemistry. The health of the public comes first, as well as the preservation of the water supplier infrastructure. However, the Task Force urges water suppliers to continue trials to determine if water chemistry can be altered to reduce pinhole leaks, while maintaining public health and preserving the infrastructure.

The prevalence of pinhole leaks in copper plumbing, and the repercussions they present to property owners, are ongoing sources of debate. Although this Task Force has offered some plausible recommendations to this challenging situation, a definitive solution cannot be offered at this time. However, it is important to note that research continues on the local and national levels and currently, the AAWF is conducting a nationwide survey to gather more comprehensive data. Meanwhile, the WSSC, the AAWA, and Dr. Edwards, in conjunction with his colleagues at Virginia Institute of Technology, continue to work towards solutions for this problem.

APPENDIX A: FACT SHEET

TASK FORCE TO STUDY PINHOLE LEAKS IN COPPER PLUMBING

Maryland Department of Housing and Community Development

Robert L. Ehrlich, Jr., Governor ***Michael S. Steele, Lt. Governor***

Victor L. Hoskins, Secretary, DHCD ***Shawn S. Karimian, Deputy Secretary, DHCD***

The Task Force was established because extensive damage to homes, especially in certain areas of the state has been noted. The bill mandated that the Task Force shall: Determine the extent, patterns and trends of pinhole leaks in copper plumbing in Maryland; investigate the possible causes of pinhole leaks in copper plumbing; investigate the effects of pinhole leaks in copper plumbing on homeowners' insurance; and make recommendations regarding possible remedies and steps citizens can take if they experience pinhole leaks. Membership of the Task Force is comprised of recognized experts in the fields of water quality and treatment, piping materials and installation, and insurance practices, Maryland Consumer Representatives, and one Maryland Condominium Association Representative. The membership is complemented by a team of Department of Housing and Community Development staff dedicated to coordination of Task Force efforts in research, planning, meeting logistics, and final report implementation.

The Members

Victor L. Hoskins, Chairman, Secretary, Maryland Department of Housing and Community Development

George C. Eaton, Chairman Designee, Director, Division of Credit Assurance, DHCD

Jinhee Kim Wilde, Chairman, Washington Suburban Sanitary Commission

Designee, Robert Buglass, Principal Environmental Engineer, WSSC

Kendl P. Philbrick, Secretary, Maryland Department of the Environment

Designee, Christina Ardito, Public Health Engineer, MDE Water Supply Program

Alfred W. Redmer, Jr., Commissioner, Maryland Insurance Administration

Designee, Cathy Ruppel, Property and Casualty Insurance Analyst

Paivi Spoon, Policy Analyst, Prince George's Co. Department of Environmental Resources

David Lake, Montgomery Co. Special Assistant for Water & Wastewater Policy

Charles W. Carr, P.E., University of Maryland

George Cranford, Master Plumber & President of Washington Suburban Master Plumbers Association

Patrick J. Moran, Professor and Past Chairman, Mechanical Engineering, U.S. Naval Academy

Nicole M. Maddrey, Esq., Maryland Consumer Representative

Dale L. Powell, Representative of the Copper Development Association Inc.

Ruel Smith, Representative of the Maryland Condominium Association

Christopher Johnson, Maryland Consumer Representative

DHCD Task Force Operations Team

James Hanna, Director, Maryland Building Codes Administration (DHCD advisor, assigned to Water Treatment and Quality Subcommittee)

Mark Petrauskas, Office of the Attorney General (DHCD advisor, assigned to Insurance Subcommittee)

Eric Van De Verg, Office of Research (DHCD advisor, assigned to Materials and Installation Subcommittee)

Jean Peterson, Director, Administrative Services, DCA (DHCD advisor for planning, research, presentation, and final report implementation)

Cherri Becker, DHCD Administration, (DHCD advisor for I.T./website coordination, Blackboard Administrator, meeting logistics)

Kathleen Kotowski, DHCD Administration, recording/transcription, general administrative support

APPENDIX B: SENATE BILL 54

Senators Frosh and Ruben, in the 2003 Regular Session of the State Senate, introduced Senate Bill 54, which states:

Task Force to Study Pinhole Leaks in Copper Plumbing

FOR the purpose of establishing a Task Force to Study Pinhole Leaks in Copper Plumbing; specifying the membership and duties of the Task Force; providing for the appointment of the chairman of the Task Force; providing for the staffing of the Task Force; prohibiting a member of the Task Force from receiving compensation for serving on the Task Force; authorizing a member of the Task Force to receive reimbursement for certain expenses; requiring a certain report by a certain date; providing for the termination of the Task Force; and generally relating to the Task Force to Study Pinhole Leaks in Copper Plumbing.

WHEREAS, More than 80% of domestic and commercial water pipes are made of copper; and

WHEREAS, Pinhole leaks in copper water pipes can cause extensive, costly damage to the buildings in which the pipes are located; and

WHEREAS, The Washington Suburban Sanitary Commission has received more than 4,600 complaints from citizens in Montgomery and Prince George's counties about pinhole leaks in copper water pipes; and

WHEREAS, The incidence of pinhole leaks is higher in some areas than in other areas; and

WHEREAS, Claims for damages caused by pinhole leaks can contribute to increased premiums or cancellation of homeowners' insurance policies; now, therefore,

SECTION 1. BE IT ENACTED BY THE GENERAL ASSEMBLY OF MARYLAND, That:

(a) There is a Task Force to Study Pinhole Leaks in Copper Plumbing.

(1) The Task Force consists of the following members:

(i) the Chairman of the Washington Suburban Sanitary Commission, or the Chairman's designee;

(ii) the Secretary of Housing and Community Development, or the Secretary's designee;

(iii) the Secretary of the Environment, or the Secretary's designee;

(iv) the Commissioner of the Maryland Insurance Administration, or the Commissioner's designee;

(Powers) two representatives designated by the Maryland Association of Counties;

(vi) one faculty member from the University System of Maryland with expertise in the engineering and design of plumbing and piping, designated by the Chancellor; and

(vii) the following members appointed by the Governor:

1. one master plumber who is a resident of Maryland, is licensed by the State Board of Plumbing, and has expertise in the installation and replacement of copper plumbing;

2. one person with expertise in copper corrosion;

3. two consumer representatives from areas of the State served by different water suppliers;

4. one representative of a Maryland condominium association; and

5. one representative of the Copper Development Association Inc.

(2) The Task Force shall invite participation of a representative of the U.S. Environmental Protection Agency (EPA) with expertise in water chemistry, as designated by the EPA Administrator.

(c) The Governor shall designate the chairman of the Task Force.

(d) The Department of Housing and Community Development shall staff the Task Force.

(e) A member of the Task Force:

(1) may not receive compensation; but

(2) is entitled to reimbursement for expenses under the Standard State Travel Regulations, as provided in the State budget.

(f) The Task Force shall:

(1) determine the extent, patterns, and trends of pinhole leaks in Maryland;

(2) investigate the possible causes of pinhole leaks in copper plumbing, including: water chemistry requirements adopted by the EPA; water treatment practices; water additives; copper plumbing design, manufacturing, and installation practices; and copper plumbing cleaning and lining practices;

(3) investigate the effect of pinhole leaks in copper plumbing on homeowners' insurance coverage; and

(4) make recommendations regarding possible remedies for pinhole leaks in copper plumbing and possible steps for Maryland residents to take if they experience a problem with pinhole leaks.

(g) The Task Force shall report its findings and recommendations to the General Assembly on or before December 31, 2004.

SECTION 2. AND BE IT FURTHER ENACTED, That this Act shall take effect June 1, 2003. It shall remain effective for a period of 1 year and 8 months and, at the end of January 31, 2005, with no further action required by the General Assembly, this Act shall be abrogated and of no further force and effect.

APPENDIX C: AREAS REPORTING LOW INCIDENCE OF PINHOLE LEAKS

Allegheny County	97% of all fresh water withdrawals in Allegheny County are from surface water sources.
City of Cumberland	The City of Cumberland obtains all of its water from the Lake Koon and Gordon reservoirs located in the Cumberland Valley Township, Bedford County Pennsylvania.
City of Frostburg	The City of Frostburg obtains its water from the Piney Creek reservoir.
Calvert and St. Mary's Counties	99.7% of all fresh water withdrawals in Calvert County and 97% in St. Mary's County are from groundwater sources. Calvert and St. Mary's Counties draw water from groundwater sources, including the Piney Point-Nanjemoy, Aquia, and Magothy aquifers. The Piney Point-Nanjemoy aquifer is primarily used for small water users, such as self-supplied domestic users and small businesses. The Aquia aquifer is the primary source of public water supply within Calvert County.
Cecil County	Cecil County withdraws 29% of its fresh water by volume from surface water sources and 71% from groundwater sources. Cecil County contains a portion of two watersheds: Chester-Sassafras and Lower Susquehanna. As of the time of writing this report, there have not been any reported issues of increased occurrence or widespread distribution of pinhole leaks in Cecil County.
Charles County	Charles County withdraws 9% of its fresh water by volume from surface water sources and 91% from groundwater sources. Although both the Patuxent and Potomac River systems border Charles County, their use as surface water supply sources is constrained because of their salinity concentrations. The County also has a large number of smaller rivers and streams that are incapable of any large-scale water supply. The major groundwater resources of Charles County are the Magothy and Patapsco aquifers. Groundwater provides the vast majority of the drinking water in Charles County. In a few places, it is available from springs; but in most locations, water is drawn from drilled or dug wells tapping into underlying water-bearing aquifers. Charles County has 30 private and 23 municipal public systems within Charles County, which provide potable water service to approximately 66% of the County's population. The public systems are owned and operated by either Charles County (21 systems), the Town of Indian Head, and the Town of La Plata. (Charles County, 2003: 3-16).
Dorchester County	**Cambridge -** The city of Cambridge's water is supplied from nine production wells withdrawing from three separate aquifers. The city has six wells

withdrawing water from the Piney Point aquifer, which is approximately 500' below the surface, one well in the Magothy aquifer, which is approximately 900' below the surface and two wells withdrawing from the Raritan aquifer, which is approximately 1,400' deep. As of the time of writing this report, there have not been any reported issues or widespread distribution of pinhole leaks in the city of Cambridge.

Frederick County

Frederick County withdraws 64% of its fresh water by volume from surface water sources and 36% from groundwater sources.

Almost 79% of the County's water system customers receive treated water from surface water supplies, specifically the Potomac River and Lake Linganore. The remaining 21% of Fredrick County customers receive treated ground water from deep well sources.

Frederick County has established a telephone contact for users to report pinhole leaks: 301-631-3450, Monday through Friday from 7:00 a.m. to 3:30 p.m. (Frederick County)

Garrett County

Garrett County withdraws 63% of its fresh water by volume from surface water sources and 37% from groundwater sources.

Garrett County receives its water supplies from surface water from Deep Creek Lake and from groundwater sources, including wells. As of the time of writing this report, there have not been any reported issues or widespread distribution of pinhole leaks in Garrett County.

Harford County

Harford County withdraws 38% of its fresh water by volume from surface water sources and 64% from groundwater sources.

Harford County's Department of Water and Sewer is responsible for the county's over 540 miles of water mains with twelve storage tanks holding more than ten million gallons of water. There are three water treatment plants: one plant treats surface water from either the Loch Raven Reservoir or the Susquehanna River, another plant treats surface water from the Susquehanna River, and the third plant treats ground water from seven wells. In 2003, the DWS provided 4 billion gallons of water to 100,000 consumers for an average of 11 MGD. The DWS treated 2.2 billion gallons of surface water from the Loch Raven Reservoir, 700 million gallons from the Susquehanna River, and 1.1 billion gallons of groundwater from wells tapping the Potomac Group Aquifer.

Howard County

Howard County receives its water from three sources: North Laurel east of Interstate 95 and south of Patuxent Range Road, receives water from the WSSC's Patuxent plant. The eastern part of the county receives its water from Baltimore. The rest of the county does not have public water supply.

As of the time of writing this report, there have not been any reports or widespread distribution of pinhole leaks by the Howard County DPW.

Kent County

Kent County's Water and Wastewater Services operate four groundwater treatment plants (Edesville, Fairlee, Kennedyville, and Worton). Water from these plants is treated for high concentrations of iron and for acidity). (Kent County) As of the time of writing this report, there have not been any reported

issues or widespread distribution of pinhole leaks in Kent County.

Wicomico County

Salisbury - The city of Salisbury has two water treatment plants, drawing from the Manokin and Paleo Channel Aquifers. The City's water treatment process includes aeration, pre-chlorination, filtration, iron removal, disinfection, and corrosion control and fluoride addition. As of the time of writing this report, there have not been any reported issues or widespread distribution of pinhole leaks in the city of Salisbury.

Worchester County

Ocean City - Ocean City's water supply is currently contained in two underground aquifers, the Ocean City and the Manokin, the Manokin Aquifer being deeper and more difficult to treat. Water from these aquifers is withdrawn through a series of 23 wells. These wells vary in depth from 200 to 400 feet. Raw water transmission lines carry this water to one of three treatment plants for disinfection and iron removal. As of the time of writing this report, there have not been any reported issues or widespread distribution of pinhole leaks in Ocean City.

Mixed Groundwater and Surface Water Sources

Table 2 shows the remaining counties of Maryland and their water sources by percentage of volume withdrawn:

County	Surface Water	Ground Water
Caroline	27%	73%
Dorchester	5%	95%
Queen Anne's	16%	84%
Somerset	0.4%	99.6%
Talbot	7%	93%
Washington	87%	13%
Wicomico	4%	96%
Worchester	3%	97%

Table 1: Other Counties of Maryland

As of the time of writing this report, there have not been any reported issues or widespread distribution of pinhole leaks in these counties.

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APPENDIX E: ABBREVIATIONS AND GLOSSARY

Term	Definition
Aggressive Water	A catchall term referring to water with a high acidity content, dissolved gases, or other conditions that promote copper pipe corrosion.
Chloramines	An alternative disinfectant formed by combining chlorine and ammonia (NH_3).
CLUE	Comprehensive Loss Underwriting Exchange: a claims history database created by ChoicePoint that enables insurance companies to access consumer claims information when they are underwriting or rating an insurance policy
Coagulation	The process of destabilizing small suspended particles in water by means of removing their negative chemical charges so they can be removed by sedimentation and/or filtration
Corrosion	The deterioration of a material due to its interaction with its environment
Current	The flow of electrons through a medium
D/DBP	Disinfection and Disinfection Byproducts Rule
DBP	Disinfection Byproduct: Where disinfection is used in the treatment of drinking water, disinfectants combine with naturally occurring matter in the water to form chemicals called disinfection byproduct, some of which can be harmful to health.
DPW	Department of Public Works
DWS	Division of Water and Sewer
Electrolyte	A fluid that can conduct electricity, usually through the addition of salts, acids, or bases that provide ions in solution
Flocculation	The process of gently mixing water to allow coagulated charges to become larger
Ionization	The process of adding electrons to or removing electrons from atoms or molecules, which creates ions
Ions	Atoms or molecules that have lost electrons, resulting in a positive charge, or gained electrons, resulting in a negative charge
LCR	Lead and Copper Rule
MCL	Maximum contaminant level: The highest level of a contaminant that is allowed in drinking water. MCLs are set as close to the MCLGs as feasible using the best available treatment technology and considering cost. MCLs are enforceable standards
MCLG	Maximum Contaminant Level Goal: The level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety and are non-enforceable public health goals.
MGD	Million gallons per day
NOM	Natural organic matter
Oxidation	The process that occurs when a substance loses electrons, such as the production of copper ions in the presence of water

pH	The measure of the acidity or alkalinity of a solution. A solution with a pH of 7 is neutral. The formal definition of pH (hydrogen ion potential) of a solution is pH = -log10 (H+), where (H+) is the hydrogen ion concentration. The pH scale can range between about -1 and +15; a neutral solution has pH 7.0.
Reduction	The process that occurs when a substance gains electrons, such as the production of a hydrogen atom and water when a hydronium ion (H30+) gains an electron
SDWA	Safe Drinking Water Act
TOC	Total organic carbon

APPENDIX F: USEFUL WEB SITES AND PHONE NUMBERS

Washington Suburban Sanitary Commission—Pinhole Leaks

http://www.wssc.dst.md.us/cfdocs/copperpipe/pinholescroll.cfm

Washington Suburban Sanitary Commission—Reporting Leaks

http://www.wsscwater.com/cfdocs/copperpipe/pinholescroll.cfm

Telephone: 301-206-4001

Maryland Insurance Administration Consumer Information

http://www.mdinsurance.state.md.us/jsp/consumer/Consumer.jsp10?divisionName=Consumer+Information&pageName=/jsp/consumer/Consumer.jsp10

Frederick County Division of Utilities & Solid Waste Management

301-631-3450, (Monday through Friday from 7:00 a.m. to 3:30 p.m.)

Maryland Joint Insurance Association

http://www.mdjia.org/
410-539-6808 or 800-492-5670

CLUE Reports (ChoiceTrust, Inc.)

http://www.choicetrust.com/

A-PLUS (ISO, Inc.)

1-800-888-4476

APPENDIX G: MARYLAND RESIDENTIAL PROPERTY DISCLOSURE AND DISCLAIMER STATEMENT

Property Address: _____

Legal Description: _____

NOTICE TO SELLER AND PURCHASER

Section 10-702 of the Real Property Article, *Annotated Code of Maryland*, requires the owner of certain residential real property to furnish to the purchaser either (a) a RESIDENTIAL PROPERTY DISCLAIMER STATEMENT stating that the owner is selling the property "as is" and makes no representations or warranties as to the condition of the property or any improvements on the real property, except as otherwise provided in the contract of sale, or (b) a RESIDENTIAL PROPERTY DISCLOSURE STATEMENT disclosing defects or other information about the condition of the real property actually known by the owner. Certain transfers of residential property are excluded from this requirement (see the exemptions listed below).

10-702. EXEMPTIONS. The following are specifically excluded from the provisions of §10-702:

1. The initial sale of single family residential real property:
   A. that has never been occupied; or
   B. for which a certificate of occupancy has been issued within 1 year before the seller and buyer enter into a contract of sale;
2. A transfer that is exempt from the transfer tax under §13-207 of the Tax-Property Article, except land installment contracts of sales under §13-207(a) (11) of the Tax-Property Article and options to purchase real property under §13-207(a)(12) of the Tax-Property Article;
3. A sale by a lender or an affiliate or subsidiary of a lender that acquired the real property by foreclosure or deed in lieu of foreclosure;
4. A sheriff's sale, tax sale, or sale by foreclosure, partition, or by court appointed trustee;
5. A transfer by a fiduciary in the course of the administration of a decedent's estate, guardianship, conservatorship, or trust;
6. A transfer of single family residential real property to be converted by the buyer into use other than residential use or to be demolished; or
7. A sale of unimproved real property.

MARYLAND RESIDENTIAL PROPERTY DISCLOSURE STATEMENT

NOTICE TO OWNERS: Complete and sign this statement only if you elect to disclose defects or other information about the condition of the property actually known by you; otherwise, sign the Residential Property Disclaimer Statement. You may wish to obtain professional advice or inspections of the property; however, you are not required to undertake or provide any independent investigation or inspection of the property in order to make the disclosure set forth below. The disclosure is based on your personal knowledge of the condition of the property at the time of the signing of this statement.

NOTICE TO PURCHASERS: The information provided is the representation of the Owners and is based upon the actual knowledge of Owners as of the date noted. Disclosure by the Owners is not a substitute for an inspection by an independent

home inspection company, and you may wish to obtain such an inspection. The information contained in this statement is not a warranty by the Owners as to the condition of the property of which the Owners have no knowledge or other conditions of which the Owners have no actual knowledge.

How long have you owned the property? _____

Property System: Water, Sewage, Heating & Air Conditioning (Answer all that apply)

Water Supply	☐ Public	☐ Well	☐ Other _____			
Sewage Disposal	☐ Public	☐ Septic System approved for _____(# bedrooms)				
Garbage Disposal	☐ Yes	☐ No				
Dishwasher	☐ Yes	☐ No				
Heating	☐ Oil	☐ Natural Gas	☐ Electric	☐ Heat Pump	Age ____	☐ Other _____
Air Conditioning	☐ Oil	☐ Natural Gas	☐ Electric	☐ Heat Pump	Age ____	☐ Other _____
Hot Water	☐ Oil	☐ Natural Gas	☐ Electric	Capacity ___	Age ____	☐ Other _____

Please indicate your actual knowledge with respect to the following:

1. Foundation: Any settlement or other problems? ☐ Yes ☐ No ☐ Unknown
COMMENTS:_____

2. Basement: Any leaks or evidence of moisture? ☐ Yes ☐ No ☐ Unknown ☐ Does Not Apply
COMMENTS:_____

3. Roof: Any leaks or evidence of moisture? ☐ Yes ☐ No ☐ Unknown
Type of Roof:_____ Age_____
COMMENTS:_____
Is there any existing fire retardant treated plywood? ☐ Yes ☐ No ☐ Unknown
COMMENTS:_____

4. Other Structural Systems, including exterior walls and floors:
COMMENTS:_____
Any defects (structural or otherwise)? ☐ Yes ☐ No ☐ Unknown
COMMENTS:_____

5. Plumbing system: Is the system in operating condition? ☐ Yes ☐ No ☐ Unknown
COMMENTS:_____

6. Heating Systems: Is heat supplied to all finished rooms? ☐ Yes ☐ No ☐ Unknown

COMMENTS:_____

Is the system in operating condition? ☐ Yes ☐ No ☐ Unknown

COMMENTS:_____

7. Air Conditioning System: Is cooling supplied to all finished rooms? ☐ Yes ☐ No ☐ Unknown ☐ Does Not Apply

COMMENTS:_____

Is the system in operating condition? ☐ Yes ☐ No ☐ Unknown ☐ Does Not Apply

Comments:_____

8. Electric Systems: Are there any problems with electrical fuses, circuit breakers, outlets or wiring?

☐ Yes ☐ No ☐ Unknown

COMMENTS:_____

Will the smoke detectors provide an alarm in the event of a power outage? ☐Yes ☐ No ☐ Does Not Apply

COMMENTS:_____

9. Septic Systems: Is the septic system functioning properly? ☐ Yes ☐ No ☐ Unknown ☐ Does Not Apply

When was the system last pumped? Date_____ ☐ Unknown

COMMENTS:_____

10. Water Supply: Any problem with water supply? ☐ Yes ☐ No ☐ Unknown

COMMENTS:_____

Home water treatment system: ☐ Yes ☐ No ☐ Unknown

COMMENTS:_____

Fire sprinkler system: ☐ Yes ☐ No ☐ Unknown ☐ Does Not Apply

COMMENTS:_____

Are the systems in operating condition? ☐ Yes ☐ No ☐ Unknown

COMMENTS:_____

11. Insulation:

In exterior walls? ☐ Yes ☐ No ☐Unknown

In ceiling/attic? ☐ Yes ☐ No ☐ Unknown

In any other areas? ☐ Yes ☐ No Where? _____

COMMENTS:_____

12. Exterior Drainage: Does water stand on the property for more than 24 hours after a heavy rain?

☐ Yes ☐ No ☐ Unknown

COMMENTS:_____

Are gutters and downspouts in good repair? ☐ Yes ☐ No ☐Unknown

COMMENTS:_____

13. Wood-destroying inspects: Any infestation and/or prior damage? ☐ Yes ☐ No ☐ Unknown

COMMENTS:_____

Any treatments or repairs? ☐ Yes ☐ No ☐ Unknown

Any warranties? ☐ Yes ☐ No ☐ Unknown

COMMENTS:_____

14. Are there any hazardous or regulated materials (including, but not limited to, licensed landfills, asbestos, radon gas, lead-based paint, underground storage tanks, or other contamination) on the property?

☐ Yes ☐ No ☐ Unknown

If yes, specify below

COMMENTS:_____

15. Are there any zoning violations, nonconforming uses, violation of building restrictions or setback requirements or any recorded or unrecorded easement, except for utilities, on or affecting the property?

☐ Yes ☐ No ☐ Unknown

If yes, specify below

COMMENTS:_____

16. Is the property located in a flood zone, conservation area, wetland area, Chesapeake Bay critical area or Designated Historic District? ☐ Yes ☐ No ☐ Unknown

If yes, specify below

COMMENTS:_____

17. Is the property subject to any restriction imposed by a Home Owners Association or any other type of community association? ☐ Yes ☐ No ☐ Unknown

If yes, specify below

COMMENTS:_____

18. Are there any other material defects affecting the physical condition of the property?

☐ Yes ☐ No ☐ Unknown

COMMENTS:_____

NOTE: Owner(s) may wish to disclose the condition of other buildings on the property on a separate RESIDENTIAL PROPERTY DISCLOSURE STATEMENT.

The owner(s) acknowledge having carefully examined this statement, including any comments, and verify that it is complete and accurate as of the date signed. The owner(s) further acknowledge that they have been informed of their rights and obligations under §10-702 of the Maryland Real Property Article.

Owner _____ Date _____

Owner _____ Date _____

The purchaser(s) acknowledge receipt of a copy of this disclosure statement and further acknowledge that they have been informed of their rights and obligations under §10-702 of the Maryland Real Property Article.

Purchaser _____ Date _____

Purchaser _____ Date _____

MARYLAND RESIDENTIAL PROPERTY DISCLAIMER STATEMENT

NOTICE TO OWNER(S): Sign this statement only if you elect to sell the property without representation and warranties as to its condition, except as otherwise provided in the contract of sale; otherwise, complete and sign the RESIDENTIAL PROPERTY DISCLOSURE STATEMENT.

The undersigned owner(s) of the real property described above make no representations or warranties as to the condition of the real property or any improvements thereon, and the purchaser will be receiving the real property "as is" with all defects which may exist, except as otherwise provided in the real estate contract of sale. The owner(s) acknowledge having carefully examined this statement and further acknowledge that they have been informed of their rights and obligations under §10-702 of the Maryland Real Property Article.

Owner _____ Date _____

Owner _____ Date _____

The purchaser(s) acknowledge receipt of a copy of this disclaimer statement and further acknowledge that they have been informed of their rights and obligations under §10-702 of the Maryland Real Property Article.

Purchaser _____ Date _____

Purchaser _____ Date _____

(This space is left intentionally blank.)