Underground Water Service Lines

Material Usage Trends 1965 - 2009

Based on a Meta Analysis of Studies Conducted for Copper Development Association

July 27, 2010

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Study Goals

The multiple objectives of this research were to:

- Identify trends in water utility requirements for water service line materials used over the past 50 years and understand why specific materials have been selected. This meta analysis compiled data based on seven research studies conducted for the Copper Development Association (CDA) from 1965 through 2009.*
- 2. Understand why specific water service line materials are selected for both new and replacement services; and by utility companies, developers and contractors.
- 3. Identify (i.e. 'map') municipalities/water systems with significant number of lead water services; and assess expected actions with regard to lead service line replacement programs—both for the utility and non-utility (i.e. homeowner/business/contractor) portion of the water service line.

Scope and Methodology

The study was conducted through a combination of resources, including:

- Research studies based on interviews with municipal water utilities, builders, developers and contractors responsible for installing or specifying water service tube materials.
- A review of literature and published industry, government and trade reports and databases from the organizations such as the U.S. Census Bureau, Environmental Protection Agency (EPA), American Water Works Association (AWWA), National Association of Home Builders, Plastic Pipe Institute, CDA, and F.W. Dodge Div. McGraw-Hill Information Systems.)
- Review of information from key firms knowledgeable and active in area of lead service line issues and replacement programs.

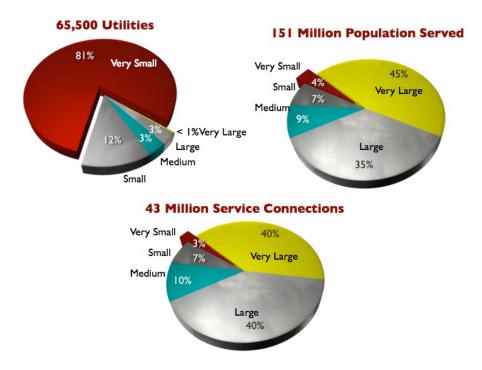
Municipal Water Service Infrastructure:

The EPA monitors public water system compliance to the Safe Water Drinking Act, and compiles information on more than 155,000 public water systems in the SDWIS (Safe Drinking Water Information System) database. Approximately 35,000 of these are designated as Community Water Systems (CWS) -- public water systems that supply water to the same population year round with at least 15 water service connections and at least 25 customers. These CWS serve an estimated 165 million customers through 52 million service connections.

The largest (250) utilities, represent 0.7 percent of the total, serve almost 50 percent of the US population. And the top 2,000 utilities (in EPA's 'large' and 'very large' categories) represent about 5 percent of the total and account for about 80 percent of the service connections and population served in this database. On the other end of the spectrum, the very small utilities (representing 81 percent of the total number of utilities) account for only three percent of the service connections and population.

*See Appendix I Page 27

The most recent survey of municipal utilities' programs and practices in 2009, concentrated on the large and very large utilities.



In all, as part of the research, we conducted interviews with 155 municipal water utility authorities in 45 states. A complete list is included in the Appendix II.

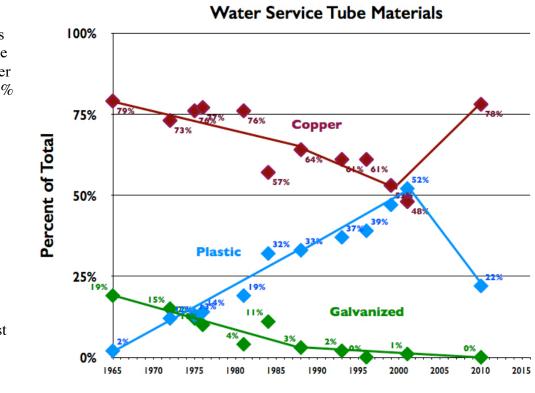
Titles/Responsibilities Survey Respondents:

Respondent Title	% of Respondents
Engineer (Chief, Deputy Director, Senior, Water, Head, Lead Design,	47%
Technical Supervisor, Manager of System, Civil, Coordinator,)	
Superintendent (also Manager, Director, Supervisor, Assistant	26%
Director) of Utility, Public Works, Water Service, Water Division	
Director (Manager, Superintendent) of Operations, Distribution, Field	24%
Operations, Maintenance and Repairs, Field Services, Transmission and	
Distribution, Collection, Line Maintenance	
Materials Management/Purchasing (include Materials Managers,	15%
Planners, Coordinators, Administrators; Senior Buyers, Contracts	
Administrators, Director Capital Planning, Purchasing Manager, Senior	
Strategic Buyer)	
Construction Supervisor (Manager, Coordinator, Chief of Design)	10%
Other (includes Deputy General Counsel of Lead Program; IT	12%
Manager, Design Division Director, Account Executive, Supervisor	
Systems Design and development, Supervisor Water and Service	
Design, Public Information Coordinator, Manager of Plans Approval,	
Tech Services Manager, Plumbing Supervisors and Inspectors)	

Summary and Conclusions

Trend in Water Service Tube.—For the past 50 years, copper tubing has endured as the mainstay water service tube material from the utility main to the residential property line. In 1964,

when the Copper Development Association commissioned its first water service tube study, copper accounted for 79% of installations, followed by galvanized steel (13%), cast iron (6%) and plastic (2%). Plastic usage steadily increased increased to approximately about half of all utility installations--first as a replacement for cast iron and galvanized steel



and then starting in the mid 1980's, also at the expense of copper. Among eingineers and specifiers, copper has always been the prefered material for its reliability, durability and longevity. Plastics have gained market penetration because of their generally lower cost per foot. Since 2000 more and more utilities—especially those in large northeastern, midwest and southwest cities have returned to copper water service tube as their standard because of the reasons cited above, along with specific operational concerns with plastic water service that had been installed.

Background—2009 Study.--Almost 90 percent of MWUA's have responsibility for water service line s from main to property line, with only about 5 percent specifying the type of water service tube materials used all the way to the building. This is the building owners' responsibility, and it is strongly influenced by the contractor.

Water Service Materials.—For the water service tube from the main to the property lines, utilities install copper in more than 85 percent of their connections. Copper is the preferred material for its longevity, durability and easy traceability. Fewer than 20 percent of utility company respondents indicate that they have ever had problems with copper service tube, while 66 percent of the utilities (that use or are familiar with plastic) told us that they have (or have had) problems with their plastic water service installations.

Lead replacement.—While 38 percent of the utilities report at least some lead service lines remain in their systems, *scheduled replacement programs* triggered by the 1991 Lead and Copper Rule seem to be few and far between. This is because utilities with high lead levels in their water system have either already replaced the majority of their lead service lines, or have taken other measures to control corrosion and reduce lead in their water systems. Where lead lines are being replaced—primarily in situations where leaks have developed or where utilities come across lead lines in other maintenance work, copper is the preferred material by utilities.

Water Service replacement prospects beyond lead replacement.—In addition to lead service lines, approximately 20 percent of the utilities regularly replace service lines other than lead—either on a scheduled basis, or when they come across specific type of materials. Many of these lines are plastic lines that were installed 20 to 40 years ago.

Detail of Findings

Number of Service Lines installed.

The 154 utilities covered in the 2009 survey represent 44 percent of the service connections and population covered in the EPA SDWIS database.

The municipal water utilities covered in our survey account for 19 million service connections, and serve a population of about 67 million. According to survey respondents, these utilities accounted for approximately 105,000 (new and replacement) water services over the last year.

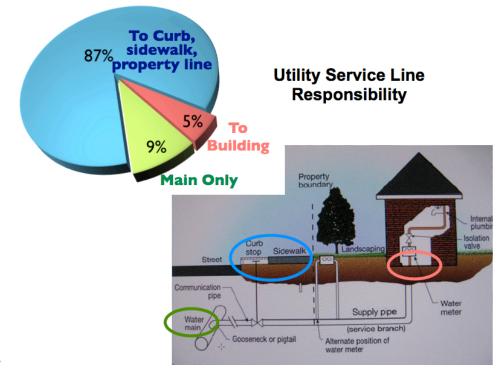
It is important to note, however, that because of the nation-wide housing slump and municipality budget reductions, water service line installations among the MWUA's in this survey have been significantly diminished compared to previous year installations and/or what they consider 'typical' years. In all, reported water service installations among participating water utilities were down by 75 percent.

Responsibility for Service Lines: Utility vs. Customer

According to a major water utility engineering/design firm, approximately 70 percent of water utilities have only partial jurisdiction over the service lines that carry water from the main into the property. The typical service line consists of a communication pipe (usually owned by the utility)

extending from the water main to the curb stop or property boundary, and a supply pipe (usually owned by the property owner) from the curb stop to the building.

Nine percent of the water utilities covered in our research take no accountability for water service lines beyond their service mains. Eightyseven percent take responsibility to the curb stop, sidewalk or customers' property line. These two scenarios comprise what are identified in the diagram as 'communication pipe.'



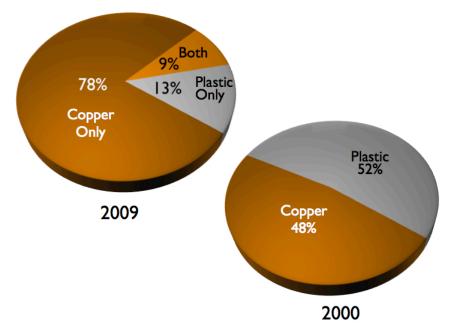
The service line from this property line/curb stop area to the building itself—indicated as 'service branch supply pipe' in the diagram, is the responsibility of the (home- or business-) owner for 95% of the service line installations among the utilities covered in the research.

Type of Water Service Line Materials

In 2009, seventy-eight percent of the water utilities install only copper service lines, and an additional nine percent install both copper and plastic. This represents a thirty-percentage-point increase in copper (only) usage compared to water service research conducted conducted in 2000.

Only 13 percent of the utilities are not installing any copper for their (new or replacement) water service lines.

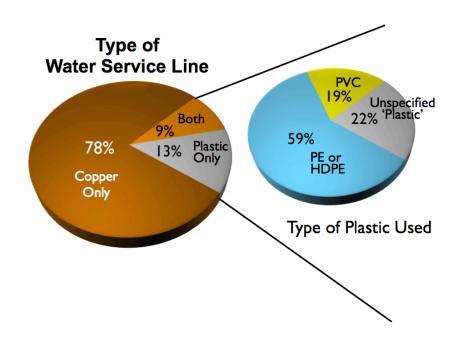
And in two out of three of the utilities that use both plastic and copper for water service tube, they report that copper accounts for over 90 percent of their installations. Among these utilities, plastics are often used when soil is known to be corrosive to copper, and where very long runs are involved. According to one utility with subsidiaries in MA and CT,



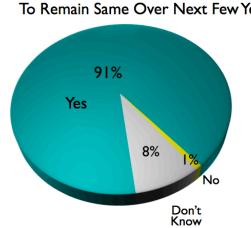
Type of Water Service Line Material Installed

"We use plastic if we know the soil in the area is corrosive, or if we have a plastic line now and need to repair it. About 1-2% of our new installations are PE; about 5% of our total system."

Among the municipal utilities where plastic tube is being installed, polyethylene is identified most frequently, followed unspecified 'plastic' and PVC.



Anticipated Trend.--Over the next few years, utilities do not expect that the types of materials that they are using for water service tube will be much different than those they are currently installing.



Expect Service Tube Materials To Remain Same Over Next Few Years?

"We're going from PVC back to copper." (EPA Region 5; 94,000 Connections)

"Copper is all we've allowed since the 1930's, in sizes from 3/4 to 1 1/2 or 2 inches). It has proven longevity." (EPA Region 5; 99,000 Connections)

"We had older services that were galvanized, PVC and PB. Most have been replaced in the last 15 years. We used copper before that and have had no problems with it. Some of the copper is 60 years old." (EPA Region 9; 26,000 Connections)

"When the price of copper went from \$1/ft. to \$3/ft., we were talking about switching to HDPE. Then the price came down again, so we stayed with copper. We will continue to use copper unless economic conditions force us to change." (EPA Region 10; 131,000 Connections)

"We're always looking for something better, but we've had fairly good success with copper." (EPA Region 4; 246,000 Connections)

"I would like to use HDPE, because of its flexibility. The water utility wants to stay with copper." (EPA Region 6; 135,000 Connections)

"Only copper is allowed, since galvanized was replaced." (EPA Region 10; 180,000 Connections)

"We used copper from the late '50's until recently, when the prices went through the roof. We switched to PVC because of the price. Now that the price of copper has gone back down, we're deciding whether to go back to it." (EPA Region 5; 52,000 Connections)

"Materials are decided on a project basis. It depends a lot on soil type (if corrosive, we would use plastic)." (EPA Region 9; 220,000 Connections)

*To maintain respondent anonymity throughout this report, utilities are identified by EPA region (see Appendix II Page 27) and relative utility size (number of connections)

Average length of Water Line Services:

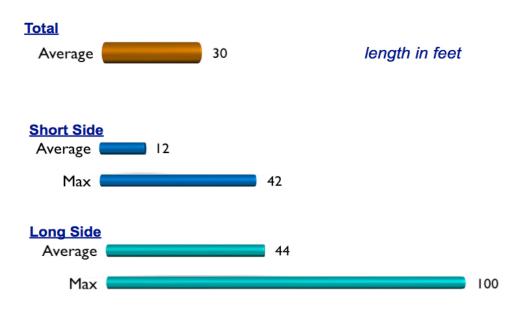
According to a 2008 AWWA Research Foundation report¹, the average length of the utility portion of water service lines (25-27 feet) represents about 43 percent of the average length of the total service line from the main to the structure.

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	Average Length Utility	Average Total Length of
	Portion, FT	Service Line, FT
Urban	25 (3-60)	55
Suburban	27 (0-60)	68

Average service line lengths from survey¹

Among the MWUA's included in our survey, their portion of water services averaged about 30 feet as summarized in the following chart.

Utility Portion of Water Service Line



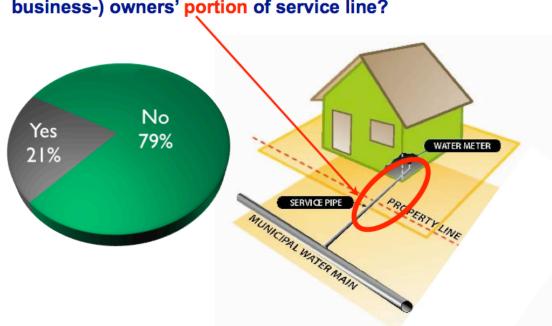
¹Contribution of Service Line and Plumbing Fixtures to Lead and Copper Rule Compliance Issues. Anne Sandvig, HDR Engineering 500 108th Ave N.E. Bellevue, WA 98004. Sponsored jointly by AWWA Research Foundtion, Denver, CO and US Environmental Protection Agency, Washington, DC

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Utility Influence on Non-Utility Portion

Survey respondents were asked whether their utility specifies (or influences) the type of materials used for remainder (i.e. customer side) of water service line? Nearly 80 percent do not.

In fact, as several of the comments below show, even where utilities indicate a material preference, the contractors (and cost) often have significant influence, and ultimately the homeowners choose the materials.



Does utility specify type of materials for (homebusiness-) owners' portion of service line?

According to the AWWA report¹, when utilities are required to replace lead services, they are only required to replace that section of the service line they own. The utilities must offer to replace the owner's portion of the line, however they are not required to pay the cost of replacing the homeowner's portion.

Replacing an entire service line is important, because according to engineering/design firms, partial lead service line replacement may elevate lead levels at the tap because of physical disruption to the portion of the lead service line remaining and subsequent release of lead.

Galvanic corrosion may also contribute to elevated lead levels, where a copper pipe is joined directly to the remaining partial lead service line. This temporary elevation in lead levels may take from several days to several months to stabilize to below the Action Level. The LCR requires utilities to notify property owners and residents at least 45 days before they implement partial lead service line replacement to inform them that lead levels may rise temporarily.

Cost, system pressure, length of line, corrosion concerns and contractor influence appear to be the main factors why specific materials are used—as seen in the following comments.

"If it's a change-out, most use copper. Plastic is more common for new construction because it's cheaper." (EPA Region 4; 72,000 Connections)

"We have a '100 ft. Rule', because copper comes in hundred-foot rolls. If the distance from the meter to the building is over 100 ft, they may use plastic, but we don't encourage it. We have a 'dual check' after the meter, which protects us from getting contaminants in the system [that could come through the plastic]; the customer takes the risk for his side." (EPA Region 3; 118,000 Connections)

"There's a lot of plastic, some copper...it's usually a cost issue. Copper is used on shorter services, plastic on longer ones. Another factor is whether it's straight or there are a lot of bends and turns. The plumber decides." (EPA Region 4; 246,000 Connections)

"...Poly (which breaks the most) is being used. Often, people hire plumbers to put in copper service, and the plumber puts in poly instead. Plumbers will do anything to save a buck." (EPA Region 10; 35,000 Connections)

"We require contractors to use K copper, because we're afraid they'll buy cheap plastic, if they're allowed to use plastic." (EPA Region 6; 67,000 Connections)

"All the contractors use copper...DK if it's a written regulation." (EPA Region 1; 19,000 Connections)

"Our system is relatively high pressure., so contractors probably use copper, but we don't specify what to use." (EPA Region 9; 26,000 Connections)

"Copper is used in the city (because it's easier to thaw it, and trace it). Plastics are allowed when there is a meter pit, and the house is a long distance (over 100 ft.) from the road (because copper coils aren't long enough and we don't want joints)." (Syracuse, NY EPA Region 2; 46,000 Connections)

"In some jurisdictions, or in rural areas, there may be plastic mains. They break, because they weren't the right pressure rating...put in the wrong schedule PVC..." (EPA Region 4; 198,000 Connections)

"Copper and PE are allowed, but we're re-evaluating the PE. There has been a problem with failures." (EPA Region 5; 272,000 Connections)

"Plumbing Code determines...but most are PVC or other plastic that meets the pressure rating." (EPA Region 5; 52,000 Connections)

"We have allowed HDPE in the last two years, for small services, as long as it can handle the pressure. (We grant latitude to developers, to keep constructions costs down)." (EPA Region 8; 41,000 Connections)

"The property owner decides...usually relies on the plumber's recommendations. There is a lot of PVC, because plumbers like to use it." (EPA Region 4; 100,000 Connections)

"We can't specify because the Plumbing Code is responsible for that part, but we strongly encourage K copper for smaller services and ductile iron for larger. Outside the Right of Way, however, a lot of plastic is used." (EPA Region 5; 79,000 Connections)

"We encourage copper, but people use mostly PVC. Most houses are rated for 80 pound minimum pressure (i.e. not very high). Not much copper is used." (EPA Region 4; 128,000 Connections)

Why Copper?

The main reasons that copper is the material used most often for the utility portion of water service relate to utilities' good

experience that they have had with copper over the years. Copper tube is described as durable, reliable, easy to locate, easy to thaw, long lasting etc.

Several utilities report having tried plastics over the years including PE, PVC and PB—but having problems with it. See the summary chart and comments below.



Here are some specific comments regarding why copper tube is used for water service applications.

"In the early 80's we used plastic, but it was not a good product. We had to replace it all, at great expense, less than 10 years later. We went back to using copper, and decided we would only use copper from then on." (EPA Region 10; 66,000 Connections)

"We have used copper since the mid 60's, and have had very good success with it." (EPA Region 5; 90,000 Connections)

"Under state law, we are required to use copper under major thoroughfares. We have very hot soil, which corrodes ductile iron (but not copper)." (EPA Region 7; 80,000 Connections)

"We allow HDPE as a cost concession to developers. We use copper for everything the Utility installs (new and replacements) because the Maintenance Division insists on it. We would much prefer to have only copper used." (EPA Region 4; 244,000 Connections)

"We have looked at plastic, but see no reason to change away from copper." (EPA Region 5; 90,000 Connections)

"We use HDPE within 200 feet of the railroad line (because of electrolysis). There are very few [HDPE services] – only about 100 in the system." (EPA Region 2; 75,000 Connections)

"PVC breaks more (none in our system.) Copper is sturdier." (EPA Region 6; 66,000 Connections)

"Galvanized didn't last (and was replaced). Plastic failed (decades ago)." (EPA Region 9; 26,000 Connections)

"[Copper] because we had an instance where gasoline migrated through PE pipe." (EPA Region 2; 83,000 Connections)

"We allowed HDPE for around 10 years; we recently stopped allowing it because of our history of failures with it. Whole subdivisions have had to be torn up (to remove it). There have been lawsuits between homeowners' associations and builders..."

"Engineers specify copper. Plastic is not good in our climate...lots of freezing and thawing..." (EPA Region 5; 52,000 Connections)

"Historically, copper has been the best material. When we used PE and PB, we had problems." (EPA Region 6; 113,000 Connections)

"We moved to copper in the 1940's. It has been a good material...material of choice. We don't have aggressive soils; no problems with corrosion. In the 1980's, we used HDPE, which regularly developed leaks. We stopped using it, and are replacing it now with copper." (EPA Region 3; 91,000 Connections)

"Copper has history...written into city ordinance eons ago. It would be a major undertaking to change the ordinance." (EPA Region 7; 96,000 Connections)

"The South Carolina DOT requires copper in the road right-of-way." (EPA Region 4; 150,000 Connections)

"When we used copper, we had no problems with it. It was easy to locate and more durable than PE (which some of our neighbors use)." (EPA Region 5; 52,000 Connections)

"We used PE for a couple of years (from 1980-81). The pipe was very brittle, and snapped. We investigated and found that the pipe was manufactured by one company, Yardley. It was during the petroleum crunch, and they had left out a petroleum product, which caused it to get brittle. We have since replaced most of that pipe." (EPA Region 10; 141,000 Connections)

"Copper because winters are cold. We pass current through the services, to thaw..." (EPA Region 8; 41,000 Connections)

"Copper is more durable in our soil conditions." (EPA Region 6; 184,000 Connections)

"We tried plastic, but had problems with it. It was also hard to locate." (EPA Region 4; 100,000 Connections)

"Copper holds up better than anything else." (EPA Region 4; 100,000 Connections)

"Copper is used because it's stronger. It goes under pavement, and we don't want to dig it up." (EPA Region 4; 80,000 Connections)

"Copper because interior plumbing is copper. Also, plastic is easily damaged, by digging." (EPA Region 1; 87,000 Connections)

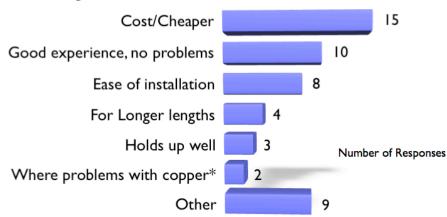
"Copper is proven. We've looked at PEX and PE, and we're not comfortable with them. We've looked for large utilities that use plastic, and couldn't find any." (EPA Region 7; 68,000 Connections)

"Copper is not permeable to pollutants, which is a big issue with plastic. We're an industrial area, and there are contaminants in the ground." (EPA Region 3; 52,000 Connections)

"Copper is less maintenance. Our goal is to have no plastic in the system. (There may be some that developers snuck in.)" (EPA Region 9; 344,000 Connections)

Why Plastic

As with distribution tube, cost appears to be the main incentive for using plastic water service line. Long service lines—especially in rural areas are another reason why utilities have gone to plastics for certain installations to avoid te need for extra connections.



Why Plastic?

Here are some specific reasons why respondents prefer plastic water service lines:

"Like that PE comes in long lengths; doesn't require fittings." (EPA Region 4; 25,000 Connections)

"PE used because of cost (contractors want it)." (EPA Region 6; 218,000 Connections)

"...plastic-lined copper, because it's corrosion-resistant...works for us." (EPA Region 9; 27,000 Connections)

"We use HDPE where the runs are longer, or in areas where there have been corrosion issues." (EPA Region 7; 48,000 Connections)

"PE is less expensive than copper, better than galvanized (it doesn't deteriorate)." (EPA Region 4; 90,000 Connections)

"Our mains are PVC and HDPE because the ground is corrosive. It bothers ductile iron (in mains), but copper is okay." (EPA Region 8; 100,000 Connections)

"The utility is using HDPE because of the cost, and it's a good material. We're trying it...will monitor it and see if it works. If it holds up, we may allow it for all services." (EPA Region 6; 67,000 Connections)

"We use PE because it's more durable than PB. We used PB in the 80's and it broke. There were lawsuits. Then we went to PE." (EPA Region 9; 128,000 Connections)

"(HDPE) We did extensive studies, and research on it. We have made it our standard (have used for 5 or 10 years)." (EPA Region 4; 146,000 Connections)

Reasons for Selecting Copper vs. Plastic Water Service Over Time

In research conducted for CDA in 1985, plumbing contractors and builders were asked to rate their general level satisfaction with copper and plastic water service tubing materials for:

- Ease of Installation
- Reliability
- Economy of use.

The following table summarizes findings from research conducted 25 years ago, and shows that similar to to the 2009 study, specifiers and installers rated their overall level of satisfaction with copper tubing higher than plastic for reliability; and similar to plastic for ease of installation and overall economy of use.

ſ				
	Copper	Copper	Plastic	Plastic
Level of Satisfaction	Mean	Percent of	Mean	Percent of
	Rating*	Respondents	Rating*	Respondents
Reliability in Service	3.53		2.95	
Excellent		58%		28%
Good		37%		45%
Fair		4%		21%
Poor		1%		6%
Ease of Installation	3.37		3.26	
Excellent		43%		42%
Good		51%		45%
Fair		6%		10%
Poor		0%		3%
Economy of Service	3.04		3.19	
Excellent		30%		41%
Good		48%		41%
Fair		20%		13%
Poor		3%		5%

Level of Satisfaction with Copper vs. Plastic Pipe (1985 Study)

*Rating Scale – Excellent (4) Good (3) Fair (2) Poor (1)

Ever had problems (With Copper or Plastic?)

In the 2009 research, utilities were asked whether they have any specific problems with copper or plastic water service tume.

Among those who use (or **Any Problems With:** are familiar with) copper, 80 percent say that they Copper? have had no problems with it. Plastic? Among those familiar with 80% plastic water service, Yes however, only 33 percent say have not had problems 66% with the plastic. Some Some

Problems with Copper.-- Virtually all of the comments relating to problems with copper revolve around developing corrosion, pinholes, leaks over time—generally attributed to aggressive soil or electrolysis.

"Problems are rare. Our system gets about 90 to 100 leaks per year; and less than 6 are in copper pipes. We have been using copper for over 50 years." (EPA Region 3; 32,000 Connections)

"Copper sometimes develops pinholes. Not often. No real problems." (EPA Region 9; 19,000 Connections)

"Some parts of town have 'hot' soil, which corroded the copper (as well as iron flange fittings used with ductile iron)." (EPA Region 9; 30,000 Connections)

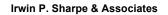
"After 30 years in the ground, it leaks (gets holes in it). We repair it, or replace it with poly." (EPA Region 6; 49,000 Connections)

"...external corrosion, from soil. Newer copper is more susceptible...probably inferior material. If you compare them to the old ones, for example, if you hit them, the new ones sound different. [He says they're made in USA]." (EPA Region 4; 43,000 Connections)

"Recently we've had a few instances where copper that has been in for under 10 years has developed holes (1/8 to ¼ inches in diameter); we don't know why yet." (EPA Region 3; 32,000 Connections)

"With copper, we've only had a failure (leaky pipe) once every 2 years or so." (EPA Region 7; 96,000 Connections)

"We do soil samples first. Where the soil is corrosive, the copper is taped or bagged." (EPA Region 9; 220,000 Connections)



"Most damage is from people hitting it. Rarely from natural causes (around 1 per month)." (EPA Region 4; 90,000 Connections)

"We haven't had problems with the material. Problems come from improper installation, or from corrosive soil (but we know about that ahead of time, and use PE in those areas)." (EPA Region 1; 21,000 Connections)

"Electrolysis, when people ground their electricity to the plumbing." (EPA Region 5; 296,000 Connections)

"We have some plastic in limited areas (where there are corrosive soils or stray currents causing electrolysis) to isolate the main from electrolysis—but consultants have found ways to avoid electrolysis without plastic." (EPA Region 3; 475,000 Connections

"We have electric streetcars and light rail. They are insulated to prevent current from corroding the copper pipes." (EPA Region 10; 180,000 Connections)

"Electrolysis from the railroad line causes pinholes. We use HDPE within 200 feet of RR tracks." (EPA Region 4; 128,000 Connections)

"We had one corrosion problem because it was near a gas main. (The corrosion inhibitor near the gas line was causing copper to corrode)." (EPA Region 4; 100,000 Connections)

"I don't know if we've had problems, but if we find copper services we replace them with HDPE," (EPA Region 4; 146,000 Connections)

"Very few problems...only from poor installation." (EPA Region 10; 180,000 Connections)

Problems with Plastic.—Utilities cite cracks (e,g, from brittleness, high pressure, kinks, damages, chlorine) and difficulties in locating plastic pipe as their major concerns with the materials.

"We used PE and HDPE until a few years ago; it's no longer allowed. It got crunched and cut from the bedding (because of the way it was installed)." (EPA Region 9; 78,000 Connections)

"A lot of blue and black poly was used in the 70's. There were three leaks in one year on one street; all were blue poly. They had to pay to fix it. It lasted less than 30 years, which is almost nothing, compared to the expected life of copper." (EPA Region 5; 79,000 Connections)

"HDPE fails...not sure why...maybe an installation problem. It often fails at the connections. It also fails in the middle of the line from nicks...and it splits...There is a lot of thermal variation in our soil, and we don't know if that's the cause." (EPA Region 9; 191,000 Connections)

"PVC installed in the 70's and early 80's didn't hold up...developed leaks...pipe split, or cracked at the connections." (EPA Region 9; 79,000 Connections)

"We installed plastic in the early 80's. It was an inferior product, and it failed (leaked, cracked). We had to remove it all less than 10 years later. There was 100% failure. We have replaced it all." (EPA Region 10; 66,000 Connections)

"The old plastic (cold rolled poly) got brittle...connections broke...if it got a kink, it would break and split...flattened out at the main..." (EPA Region 6; 67,000 Connections)

"We used to have PB, but the chlorine ate it up." (EPA Region 9; 17,000 Connections)

"...gets fragile and breaks, with age (30 years)." (EPA Region 4; 43,000 Connections)

"PVC – usually the fittings break." (EPA Region 9; 26,000 Connections)

"...breakage do to high pressure." (EPA Region 2; 83.000 Connections)

"[PE] occasionally, the older ones crack and split." (EPA Region 4; 90,000 Connections)

"Problems come from people digging around the lines, not bedding them properly, or kinking them." (EPA Region 7; 48,000 Connections)

"We have used plastic during a few periods within the last 20 years, and it has only caused us problems....problems with going from metal to plastic, problems with the earth shifting and plastic breaking because it's not very malleable."

"PE and PB split. We stopped installing them about 15 years ago." (EPA Region 6; 113,000 Connections)

"We have clay soil, and it gets very dry. That causes PVC pipe to break, and leak (mostly at the connections). Most of the PVC pipe in the system was probably installed in the 1970's, by private developers." (EPA Region 6; 1,120,000 Connections)

"We allowed PE for a short period, discontinued because there were problems...failures. I heard that it split at connections, ...de-lamination problem, ...lots of leaks..." (EPA Region 5; 272,000 Connections)

"We can't locate the plastic pipes, so we put in a tracer wire. Sometimes they get cut, and we can't locate the pipe." (EPA Region 5; 52,000 Connections)

"In neighboring cities they had a problem with PE in industrial areas – petroleum intrusion through the pipe." (EPA Region 10; 131,000 Connections)

"In the 70's we installed 10,000 PE services. The soil was rocky, and there were numerous leaks." (EPA Region 4; 100,000 Connections)

There are several utilities that indicated that they are quite OK with plastic service line...

"We've used HDPE for over 20 years, and we love it. It's supposed to last forever. The only inconvenience is you need a copper tracer wire, to locate it." (EPA Region 9; 220,000 Connections)

"Our system is 35 years old. PE is all we've ever used." (EPA Region 5; 40,000 Connections)

"The old poly pipe cracks and breaks. We have had no problem with HDPE. It depends on the supplier..." (EPA Region 10; 29,000 Connections)

"[Poly installed in '70's and '80's] ...gets brittle and breaks. The Poly they have now is thicker...different type. It's better...fewer problems." (EPA Region 6; 41,000 Connections)

Lead Water Replacement Programs

The EPA instituted the Lead and Copper Rule (LCR) in 1991. This required municipal water utilities to take some action to reduce lead in their systems if the lead exceeds 0.015 mg/L (based on a sampling of system tap water at the 90th percentile). Exceeding action levels is not an EPA violation per se, but triggers mandatory water quality parameter monitoring, corrosion control treatment, source water monitoring and treatment, and/or lead service line replacement (LSLR).

Most utilities have been able to successfully meet allowable lead levels by adjusting water chemistry to reduce corrosion. Others have instituted LSLR programs. Once implemented, utilities are allowed to discontinue their lead service line replacement program if their systems are at, or below, the action level in two consecutive rounds of regulatory monitoring.

Lead Service Line Inventory

Among the MWUA's covered in our survey, 38 percent (56 utilities) report at least some lead service lines in their system. As several of the comments below indicate, a number of these utilities have replaced the lead services they are aware of, but not all utilities have complete inventory records on the types of services in their system.

Utilities With Lead Service Lines in System



Based on 148 utilities

"If we have a record of a lead line, we'll try

to replace it. We have replaced all that we know about, but sometimes we'll stumble across one. If that happens, we'll look for others in the area." (EPA Region 9; 191,000 Connections)

"We think we don't have lead, but every once in a while one shows up, and we replace it immediately. We have no idea how many are left." (EPA Region 2; 83.000 Connections)

"There are no records from the time period when they were installed, so we have no idea how many are in the system." (EPA Region 7; 46,000 Connections)

"We had a lead replacement program, but almost all have been replaced. We were doing 1000/yr. There are only a few hundred left to do." (EPA Region 5; 74,000 Connections)

"Our system is relatively new (mostly from the 1940's). I think lead was popular before that. If we find any lead, we replace it, but we haven't found any in several years." (EPA Region 3; 91,000 Connections)

"We've replaced all that we know of." (EPA Region 9; 686,000 Connections)

"There's not much lead left. It was mostly taken care of a few years ago, so it's not a big issue anymore. It's being replaced systematically, sometimes by the utility, sometimes by the homeowner. Sometimes it's just decommissioned, if it's on a vacant property." (EPA Region 3; 140,000 Connections) "We've almost finished replacing the lead lines. If we find one, we'll replace it. If we find a customer line that's lead, we notify them. There are no incentives for them to replace it, other than their health." (EPA Region 7; 137,000 Connections)

"We switched from lead to copper before 1942, so most of our main replacement is being done in the old parts of town, within city limits. Outside the city, 95% is not lead." (EPA Region 5; 79,000 Connections)

"Twenty to thirty years ago we had 25,000 known lead lines. We aggressively replaced most of them. Whenever we paved a street, we changed all the lead services...replaced 200-300 per year. We have stopped in recent years, because budgets and manpower have been extremely tight. Now we're replacing 30-50 per year, when they are leaking. When budgets are back to normal, we'll probably go back to replacing the remaining ones. (EPA Region 5; 90,000 Connections)

Lead Service Line Replacement Programs

The EPA monitors lead in systems and reports status in their Safe Drinking Water Information System (SDWIS) database. According to EPA, at all of these utilities, the systematic lead line replacement programs have ended as of January 1, 2009. When we asked EPA why only 14 (of the more than 65,500) utilities included in their database have LSLR programs, they pointed out that it is likely that a lot of older systems took preventative measures to replace lead service lines and were not required to report it. This list covers systems that exceeded the action level and thus were required to report LSLR.

In addition to MWUA's listed in the EPA database, we identified an additional 13 utilities with lead water service line replacement programs. The table below provides some additional detail on these programs.

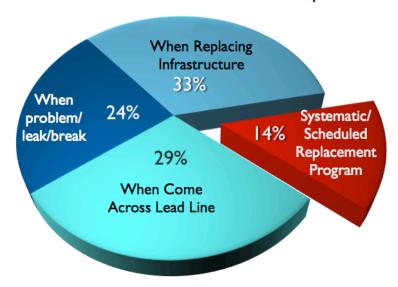
Utility EPA Region 1 87,000 connections,	How Dealing With Lead in System Has a lead Replacement incentive program for private (homeowner) service lines
EPA Region 5 52,000 connections	Will replace all lead water service pipe by 2014 at cost of \$35 million
EPA Region 1 105,000 connections	Under federal law, this treatment was required by 1997. The CWD has had treatment in place since the Fall of 1995 and meets the federal requirements The Water Department "encourages homeowners to replace the lead water service pipe which they own," and will replace any lead services for a nominal fee.
EPA Region 1 59,000 connections	Have to replace 200 services/year starting 2014 until lead levels safe
EPA Region 1 76,000 connections	They are replacing about 200 lead service or connections per year, with funds from MWRA; residents encouraged to replace service line from street to house.
EPA Region 5 4,000 connections	Village obliged to replace the part of lead service line that they own, if requested by customer. Provides customer information on "How to protect yourself, how to test for lead.
EPA Region 5 246,000 connections	Uses calcium carbonate in water as buffer against lead. Testing shows that lead levels are safe. But they have program to replace lead service lines by 2015.

Utility EPA Region 5 74,000 connections	How Dealing With Lead in System All lead water lines in city have to be replaced (including mairs and service lines) by January 2011 according to city ordinance. When utility replaces the service line, property owners are required to replace their portion of the line.
EPA Region 5 26,000 connections	They use chemicals to coat pipes, so they don't leach lead. They suggest alternative and less expensive means (than replacing plumbing and service lines), such as installing water filter, letting water run, etc. They estimate 3,500 homes have lead pipes. No mention of plans to replace water service lines
EPA Region 2 727,000 connections	Under the State Sanitary Code, New York City has had a program in place to minimize lead in your drinking water since 1992. New York City is adding food grade phosphoric acid to the water supply and maintaining a targeted pH to keep lead from dissolving in the water. This program also includes public education. The City is also required to replace any lead service line it controls if the line contributes lead concentrations of more than 15 parts per billion
EPA Region 2 273,000 connections	March 2009 "Stimulus Watch" reports "shovel ready projects" for Replacement of Lead Water Services from the Street Water Main to the Water Meter. There are some 12,000 existing lead water service pipes in the City. These services have the potential of having lead leach into the served facilities. Est. \$12,000,000 and 50 jobs.
EPA Region 3 475,000 connections	Provides consumer pamphlet about testing, and how homeowners can protect themselves. Nothing about replacing water service. Says: their treatment processes are reducing lead levels.
EPA Region 5 94,000 connections	If water tests high for lead, customer encouraged to replace service pipe on his property. City will replace lead pipe belonging to city, at no charge. Phone Engineering Dept.
EPA Region 2 46,000 connections	Will replace seven percent of lead pipe (1,325) annually between the main and curb shut-off starting 2005. Homeowners are responsible for replacement of service on their own property.
EPA Region 5 35,000 connections	The utility's main focus right now is on lead replacement. They are eplacing 2,300 a year. We are not installing new services. If a customer wants a new service installed (e.g. a new subdivision) and doesn't want to wait for the city to do it, they can use a city-approved contractor.
EPA Region 3 632,000 connections	If customer replaces private part of service, they'll replace public part on request; will replace lead as part of street paving, only if customer agrees to replace private part. Financial assistance available. According to WASA website, Bryant Associates are the engineers responsible for replacement.

Type of LSLR Programs

Lead Service Lines

Fewer than 15 percent of the MWUA's with lead service lines have *systematic, scheduled* replacement programs for their lead pipe. Rather, for the most part, service lines are replaced when there is a problem (i.e. a leak or a break in the line), the utility "comes across" a lead line, or during regular system maintenance of the water service mains or road infrastructure.



When Lead Service Lines Are Replaced

Based on 56 utilities Reporting Replacing Lead Lines

"There were 18,000 lead services in the system. We had a lead service replacement program (that replaced 1,325/year, but is currently inactive. We'll probably start again when funding becomes available. There are 14,500 services left in the system." (EPA Region 2; 46,000 Connections)

"All the lines belong to the customers. There are probably about 60,000 lead lines in the system, but they are replaced only if they leak, or is someone wants to replace it." (EPA Region 5; 99,000 Connections)

"Some iron services are connected with lead at the end. If we come across a lead connector, we always replace it with copper." (EPA Region 1; 19,000 Connections)

"Our lead replacement program has been ongoing for years. We hope we don't have any lead lines left. The program is to replace lead if we encounter it, and to notify customers if we find that their services are lead." (EPA Region 6; 184,000 Connections)

"A lot of the lead and galvanized lines installed 40-50 years ago are starting to go bad, and customers are replacing them with copper. If the customer replaces a service, the city will replace its side with copper. The demand comes from the customer end, so there is no way to predict how many we will replace. The actual work is done by a contractor, but the city allows only copper." (EPA Region 79; 47,000 Connections)

"When we do service main replacement, we also replace any lead or galvanized service pipe connected to it." (EPA Region 4; 25,000 Connections)

"If we find a customer line that is lead, we replace it for free for a certain number of feet—often paying for all of it. Customer has the option, but most accept because it seldom costs them more than a couple hundred dollars. In the case of a longer service where the customer share is higher, they can pay the balance up front, or over 24 months with no interest. In 2005 there were 4,500 lead customer lines. There are 3,800 still left to do." (EPA Region 1; 87,000 Connections)

"We'll replace lead services on our side, if the customer replaces his lead lines. We'll also replace our lead services if there's a leak." (EPA Region 2; 49,000 Connections)

"We replace lead when we're doing street reconstruction projects. We notify the customers in advance, offer them a 'payoff interest program'. If they choose to replace their part, we hire a plumber to replace it up to and including the meter set. They can pay it off over 10 years, with interest. The typical cost is \$2,000-\$3,000. Less than five percent of customers take advantage of the program, because most are in poorer neighborhoods." (EPA Region 5; 79,000 Connections)

"If a customer has a lead service between the house and the curb, and he replaces it with copper (rather than just repairing it), then we will replace the utility's part for free. (EPA Region 5; 90,000 Connections)

"The State of Massachusetts had a requirement that we replace a certain percentage of lead every year. They no longer have that requirement, but if there is a leak or other problem with a lead line, we replace it." (EPA Region 1; 23,000 Connections)

"Our system is old, and we don't have records of what is used where. If we find lead, we notify the customers. It's up to them to replace it if they want to." (EPA Region 4; 72,000 Connections)

"Galvanized and lead are often mixed and matched. Sometimes we replace a galvanized line and find that it's galvanized at the ends and lead in the middle. Sometimes we replace a main, and half the services attached to it are galvanized, and half lead. There's no consistency." (EPA Region 4; 198,000 Connections)

"We used to have a \$4 million budget for lead service replacement. It went down to \$2 million for 2009 and 2010. We used to replace lead services on the public side whether or not the customer wanted to participate. Now we only do it if they change their sides." (EPA Region 3; 140,000 Connections)

"There's no 'program' because our water quality is within allowances. We replace it if it's damaged. But when we replace it, it's to the property line." (EPA Region 7; 96,000 Connections)

"If we're repairing a pipe, and it's lead, we'll usually replace it." (EPA Region 5; 27,000 Connections)

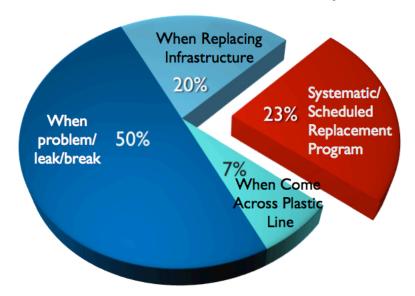
"We don't go out looking for lead pipes to replace; we replace them when a street has been dug up for some project and we find lead pipes." (EPA Region 5; 94,000 Connections)

"Lead is mostly being replaced with copper. We tried lining lead services with a plastic insert that is inflated to line the pipe. It was an experiment (for cost reduction). Some worked fine, but there were problems with others." (EPA Region 4; 246,000 Connections)

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Plastic Service Line Replacements

Non-Lead Service Lines.—In addition to the lead lines discussed above, approximately 30 MUWA's report replacing plastic (PE, HDPE, 'Poly,' PVC, PB), galvanized, iron and/or copper water service lines. Similar to lead lines, fewer than 25 percent of these are replaced on a systematic basis. Rather when repairs (breaks, leaks) are needed, new (service line or street infrastructure) or utilities "come across" materials that they have targeted for replacement.



When Plastic Service Lines Are Replaced

Based on 30 utilities Reporting Replacing Plastic Lines

The types of materials being replaced—polyethylene, polybutylene, PVC, galvanized and iron were discussed earlier in the section on problems with current materials. Here are some comments about the when services are replaced.

"Older generation PE (installed in the 70's and 80's) was thin-walled., got brittle, and failed around the brass fittings. When I started here in the late 70's, we spent 75 percent of our time repairing service lines. We thought we had around 8,000 PB and PE lines, but when we went in and looked, it was more like 10-11,000. We are systematically replacing everything that is not copper. We have done more than 6,000 so far, and will work through the rest of the system. We have been using only copper since 1990. Currently, one third of the system is copper." (EPA Region 9; 24,000 Connections)

"Over time they wear out. It's usually 20-30 years before we have problems. Currently, we have other capital projects, so we are only replacing services when there are problems. But replacing plastic pipe is our biggest concern. There are about 10,000 services left in the system (PB and PE). We replace them pre-emptively where the cost of failure would be relatively high, and the cost to replace them relatively low." (EPA Region 10; 180,000 Connections)

"We have an aggressive program to change out PVC from the 70's and early 80's." (EPA Region 9; 80,000 Connections)

"We're replacing poly pipe on a regular basis." (EPA Region 10; 52,000 Connections)

"We inherited a system that allowed plastic; DK type (black, comes (in rolls). We replace it whenever we encounter it, or when there is a problem. Not many left." (EPA Region 4; 150,000 Connections)

"We had a lot of problems with PE in the 1990's into the early 2000's. It didn't hold up...leaked. We removed all we knew about, and if we encounter any now, we replace it. All we allow now is copper." (EPA Region 6; 138,000 Connections)

"Plastic ones failed (probably was PVC). We don't have many left, but we replace them (to the meter) whenever we find one (about 3-4 services per year)." (EPA Region 9; 26,000 Connections)

"Polybutylene is being replaced, on a schedule (200 – 250 per year). We have had standard PB problems – they crap out on you." (EPA Region 6; 27,000 Connections)

"We have replaced most of the plastic installed in the 1980's. Anywhere there was a bend, it split open. We have a handful left, and replace them whenever there is a problem." (EPA Region 9; 19,000 Connections)

Appendix I

Meta study compiled from the following research reports.

1965 *Water Service, Distribution and DWV Market Study* 1964-1975. Robert Heller Associates, Inc. NY; and Ferber Company Mangement Consulting.

1975 Plumbing Applications 1974-1980. Ferber Company Management Consulting, NY.

1993 *Residential Plumbing Materials Study*—A Market and Perception Study. Irwin P. Sharpe & Associates, West Orange, NJ

1996 Residetnial Plumbing Tube Benchmark Study—A National Survey of Plumbing Contractors. Irwin P. Sharpe & Associates, West Orange, NJ

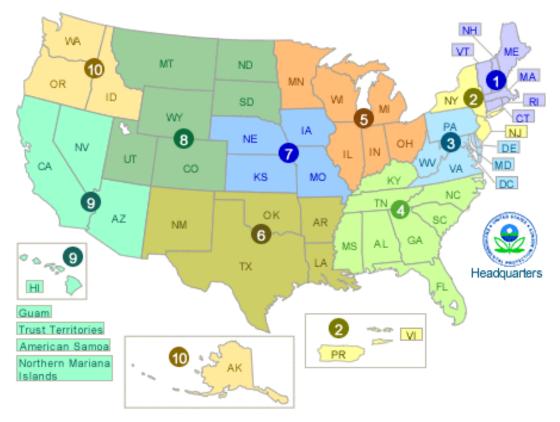
1998 Residential Plumbing Tube II—A survey of Plumbing Contractors and Wholesalesrs. Irwin P. Sharpe & Associates, West Orange, NJ

2000 Copper Tube Model—Evaluation of Residential and Non-Residential U.S. Construction Markets. Irwin P. Sharpe & Associates, West Orange, NJ

2009 Underground Water Service Lines. Irwin P. Sharpe & Associates, West Orange, NJ

Appendix II

EPA Regions



Appendix III

List of Public Water Utilities Included in 2009 Research

PWS Name	State	PWS Name	State
AKRON CITY PWS	ОН	CITY OF JACKSON	MS
ALBUQUERQUE WATER SYSTEM	NM	CITY OF KILLEEN	ТХ
ALDERWOOD WATER DISTRICT	WA	City of Redding	CA
ALLENTOWN CITY BUREAU OF WATER	PA	CITY OF TAMPA-WATER DEPARTMENT	FL
AQUA OHIO, INC. PWS	ОН	City of Vallejo	CA
AQUARION WATER CO OF CT-GREENWICH	СТ	CITY OF WACO	ТХ
SYSTEM	~~	- CLEVELAND PUBLIC WATER SYSTEM	ОН
AQUARION WATER CO OF CT-MAIN SYSTEM	СТ	- CLINTON TOWNSHIP	MI
AQUARION WATER CO OF CT-STAMFORD	СТ	- CLOVIS, CITY OF	СА
ARTESIAN WATER COMPANY	DE	- COBB COUNTY	GA
ARVADA CITY OF	CO	- COLORADO SPRINGS UTILITIES	CO
ASHEVILLE CITY OF	NC		
AURORA CITY OF	СО	- COLUMBIA	MO
BALTIMORE CITY	MD	- COLUMBIA CITY OF (4010001)	SC
BATON ROUGE WATER COMPANY	LA	- COLUMBUS PUBLIC WATER SYSTEM	ОН
BELLEVUE, CITY OF	WA	- CONSOLIDATED U D OF RUTHERFORD	TN
BILLINGS CITY OF	MT	D.C. WATER AND SEWER AUTHORITY	DC
BIRMINGHAM WATER WORKS & SEWER BOARD	AL	- DALLAS WATER UTILITY	ТХ
BOSTON WATER & SEWER COMMISSION (MWRA)	MA	- DE KALB	IL
BOULDER CITY OF	CO	DEARBORN	MI
		DEL-CO WATER COMPANY, INC.	ОН
BURBANK-CITY, WATER DEPT.	CA	- DENVER WATER BOARD	СО
CEDAR RAPIDS WATER DEPARTMENT	IA	- DETROIT CITY OF	MI
CENTRAL ARKANSAS WATER	AR	- DOUGLASVILLE-DOUGLAS CO. AUTH.	GA
CHARLESTON WATER SYSTEM (1010001)	SC	- DURHAM, CITY OF	NC
CHARLOTTE-MECKLENBURG UTILITY	NC	- East Bay MUD	CA
CINCINNATI PUBLIC WATER SYSTEM	ОН		
City of Antioch	CA	- East orange County WD - WZ	CA
CITY OF AUSTIN WATER & WASTEWATER	ТХ	- ELGIN	IL
CITY OF BEAUMONT WATER UTILITY DEPT	ТХ	- ERIE CITY WATER AUTHORITY	PA
CITY OF BETHLEHEM	PA	- ERIE COUNTY WATER AUTHORITY	NY
CITY OF FORT WORTH	ТХ	- FAIRFAX COUNTY WATER AUTHORITY	VA
CITY OF FRISCO	ТХ	FORSYTH CO. WATER & SEWER	GA
CITY OF HAGERSTOWN	MD	- FRESNO, CITY OF	CA
	TX	- FT COLLINS CITY OF	СО

PWS Name	State	PWS Name	State
GRAND RAPIDS	MI	NEW BEDFORD DEPT. OF PUB. INFRASTRUCTURE	MA
GREENSBORO, CITY OF	NC	NEW JERSEY AMERICAN - ELIZABETHTOWN	NJ
GREENVILLE WATER SYSTEM (2310001)	SC	NEW YORK CITY-CATSKILL/DELAWARE SYSTEM	NY
HENDERSON CITY OF	NV	NORFOLK, CITY OF	VA
HENRICO COUNTY WATER SYSTEM	VA	NORTH LAS VEGAS UTILITIES	NV
HILLSBORO, CITY OF	OR	NORTHERN KENTUCKY WATER SERVICE	KY
HINGHAM/HULL AQUARION WATER CO	MA	OKLAHOMA CITY	OK
INDIANAPOLIS WATER	IN	ORLANDO UTILITIES COMMISSION (8 WPS)	FL
JERSEY CITY MUA	NJ	PASSAIC VALLEY WATER COMMISSION	NJ
KALAMAZOO	MI	PHILADELPHIA WATER DEPARTMENT	PA
KANSAS CITY	MO	PHOENIX, CITY OF	AZ
KANSAS CITY BOARD OF PUBLIC UTILITIES	KS	PORTLAND BUREAU OF WATER WORKS	OR
KENTUCKY-AMERICAN WATER CO	КҮ	PROVIDENCE-CITY OF	RI
KINGSPORT WATER DEPT	TN	QUINCY WATER DEPT. (MWRA)	MA
LAKEHAVEN UTILITY DISTRICT	WA	RACINE WATERWORKS	WI
LAKELAND, CITY OF	FL	REGIONAL WATER AUTHORITY	СТ
LANSING BOARD OF WATER & LIGHT	MI	ROCHESTER CITY	NY
LEES SUMMIT	MO	Saint Paul Regional Water Services	MN
LINCOLN, CITY OF	NE	SALEM PUBLIC WORKS	OR
LONG ISLAND AMERICAN WATER CORP	NY	SALT LAKE CITY WATER SYSTEM	UT
LOS ANGELES-CITY, DEPT. OF WATER & POWER	CA	SAN ANTONIO WATER SYSTEM	ТΧ
LOUISVILLE WATER COMPANY	KY	San Jose Water Company	CA
LYNN WATER & SEWER COMM	MA	SANDY CITY WATER SYSTEM	UT
MADISON WATER UTILITY	WI	Santa Cruz Water Department	CA
MALDEN DPW WATER DEPT. (MWRA)	MA	SAVANNAH-MAIN	GA
MANCHESTER WATER WORKS	NH	SEATTLE PUBLIC UTILITIES	WA
MCWA SHOREMONT WTP	NY	SHREVEPORT WATER SYSTEM	LA
MCWA UPLAND SYSTEM	NY	SIOUX FALLS	SD
MEDFORD WATER COMMISSION	OR	SOUTH GATE-CITY, WATER DEPT.	CA
METROPOLITAN DISTRICT COMMISSION	СТ	SPARTANBURG WATER SYSTEM (4210001)	SC
METROPOLITAN UTILITIES DISTRICT	NE	SPRINGFIELD	MO
MIDDLESEX WATER COMPANY	NJ	SPRINGFIELD	IL
Minneapolis	MN	SPRINGFIELD WATER & SEWER COMMISSION	MA
MONTGOMERY WATER WORKS	AL	-	
NASHVILLE WATER DEPT #1	TN	-	

PWS Name	State	PWS Name	State
ST LOUIS CITY	MO	VALENCIA WATER CO.	CA
ST PETERSBURG, CITY OF	FL	VANCOUVER, CITY OF	WA
SUFFOLK COUNTY WATER AUTHORITY	NY	VIRGINIA BEACH, CITY OF	VA
SYRACUSE CITY	NY	WALNUT VALLEY WATER DISTRICT	CA
TACOMA WATER DIVISION, CITY OF	WA	WASHINGTON SUBURBAN SANITARY COMMISSION	MD
TOHO WATER AUTHORITY EASTERN	FL	WATER DISTRICT 1 OF JOHNSON CO	KS
TRUCKEE MEADOWS WATER AUTHORITY	NV	WEST VIEW BORO MUNI AUTH	PA
TUCSON, CITY OF	AZ	WICHITA, CITY OF	KS
TULSA	ОК	YONKERS CITY	NY
UNITED WATER IDAHO INC	ID	YOUNGSTOWN CITY PWS	ОН