HEALTH AND CORROSION IMPACT OF SOFT WATER

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*Copies of the complete report are available, upon request, from the A/C Pipe Producers Association.

1. EXECUTIVE SUMMARY

1.1 INTRODUCTION

Certain chemical constituents released into public drinking water systems by corrosive action can pose potential health hazards. Further, extensive epidemiological research has strongly suggested that consumption of soft and sometimes aggressive drinking water may be related to increased incidence of cardiovascular disease. It has also been recognized that aggressive water in distribution systems rapidly increases corrosion rates and thereby increases the rate of pipe replacement and the costs associated with it. The purpose of this report is:

- to delineate the health issues involved in consumption of soft and/or corrosive water
- to elucidate mechanisms by which soft water is implicated in cardiovascular disease
- to quantify health and corrosion costs of aggressive water
- to examine corrosion treatment options in terms of cost-effectiveness and health benefits.

1.2 SUMMARY OF FINDINGS

Health Impacts

- Medical studies have shown a high statistical correlation between soft water and cardiovascular heart disease (CVD).
- All known risk factors account for only 50 percent of the incidence of cardiovascular disease, excluding the risk from the consumption of drinking water. Drinking water may account for a significant fraction of the remaining 50 percent.
- As shown in Table 1-1, the cause and effect mechanisms of this relationship can be hypothesized into three classes.

TABLE 1.1

CLASSIFICATION OF RELATIONSHIPS OF DRINKING WATER TO CARDIOVASCULAR DISEASE

Class I	One or more of the major components of hard water are protective. These beneficial elements are lacking in soft water. o Magnesium o Calcium
Class 2	One or more of the minor components ("trace" elements) that tend to be present in hard water, but absent or deficient in soft water, are protective. o Lithium o Chromium o Vanadium o Selenium o Manganese o Strontium
Class 3	One or more components in soft water are harmful -- this includes metal ions that are leached from the distribution system. o Cadmium o Copper o Lead o Beryllium

- As shown in Table 1-2, water treatment techniques may reduce the incidence of CVD.

- Over 55 million people are exposed to soft water (less than 60 ppm hardness $CaCO_3$ equivalents) in the United States (see Figure 1-1 and Table 1-3).

- The death rate from CVD can potentially be decreased in soft water areas by 0.65 deaths per 100,000 population for each increase of 1 ppm of hardness ($CaCO_3$).

- By increasing the hardness (greater than 60 ppm) through pH adjustment, 13,825 lives could be saved annually in soft water areas. This amounts to a minimum annual health savings of $3.5 billion per year.

- Health benefits from hardening soft water exceed treatment costs by about 300 times.

Corrosion Related Impacts

- Soft water may be corrosive to water distribution systems, leading to significant damage of pipes, pumps, meters, and storage equipment, as well as household plumbing appliances.

- Past studies have shown an increase in certain toxic trace metals from corrosion due to leaching of pipes. These elements, particularily lead and cadmium, can represent a potential health hazard.

- Costs for replacement of water-related pipe corrosion in distribution systems with aggressive water can range up to $20.16 per capita annually, with an average of $2.67 per capita annually.

- Water loss from leakage of pipes in distribution systems can amount to as much as 50 percent. A nationwide water loss average is 15 percent. Of these water losses, 38 percent (equivalent to six percent of distributed water) may be due to corrosion as a result of aggressive water areas.

- Power requirements are higher in many aggressive water areas because of decrease flow capacity in corroded pipes.

Corrosion Control Techniques

- There are two major corrosion control techniques: pH adjustment and addition of corrosion inhibitors.

TABLE 1-2

WATER TREATMENT EFFECTS ON CVD MECHANISMS

	Theory	Treatment Type I	II	III	IV
1a	Calcium lowers CVD.	B	NE	PB	NE
1b	Magnesium lowers CVD.	PB	NE	NE	NE
2a	Lithium beneficial.	NE	PB	PA	PA
2b	Strontium beneficial.	PA	PA	PA	PA
3a	Cadmium related to CVD.	B	B	B	B
3b	Lead related to CVD.	B	B	B	B

NE - No Effect - Treatment will not lower or increase incident of CVD.

B - Beneficial - Treatment will lower incident of CVD.

PB - Potentially Beneficial - Treatment may lower incident of CVD.

A - Adverse - Treatment will increase incident of CVD.

PA - Potentially Adverse - Treatment may increase incident of CVD.

Treatment Types

I - pH adjustment using lime.

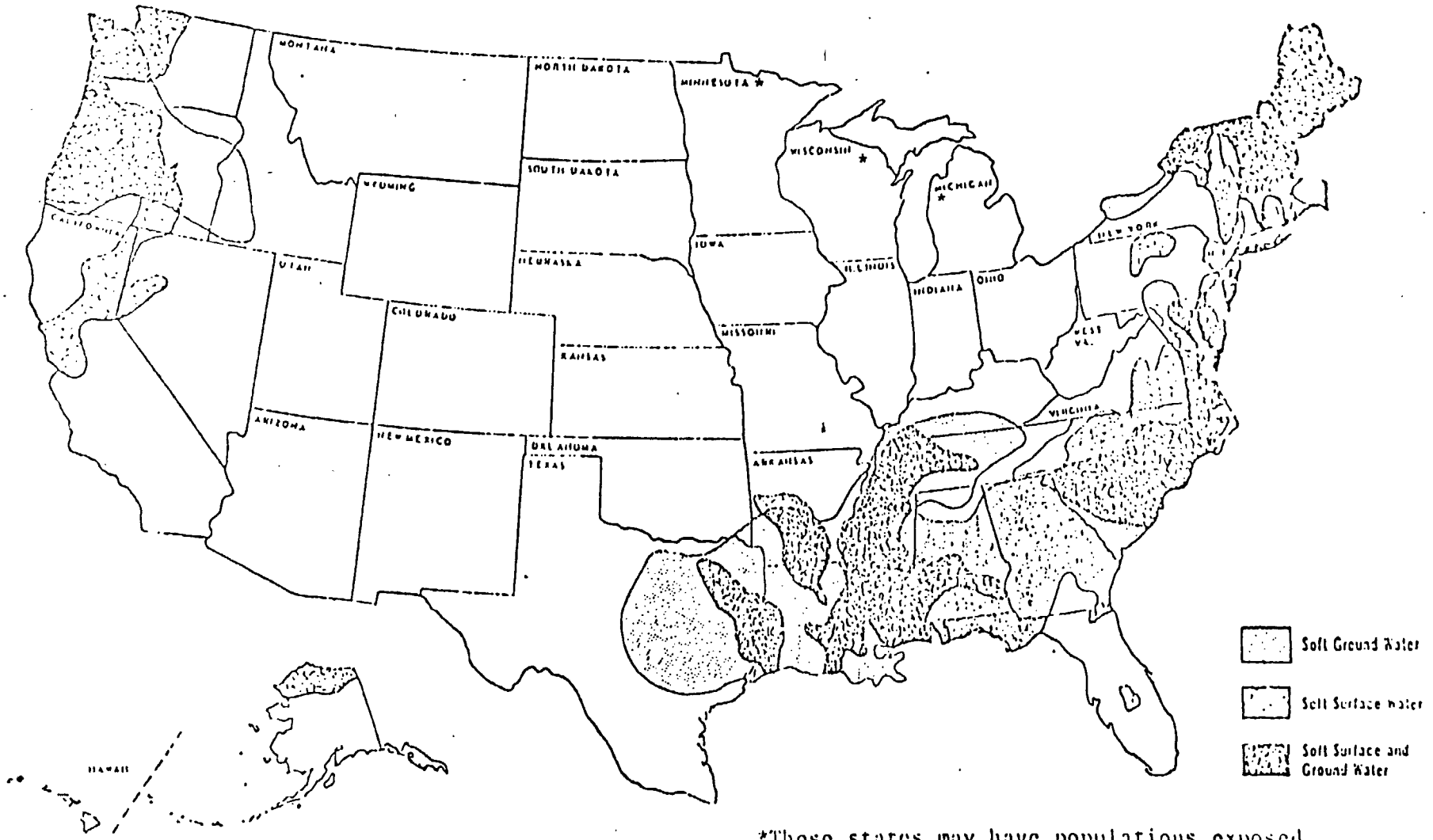
II - pH adjustment using sodium hydroxide or soda ash.

III - addition of corrosion inhibitors - polyphosphates.

IV - addition of corrosion inhibitors - silicates.

FIGURE 1-1

SOFT WATER AREAS IN THE UNITED STATES



*These states may have populations exposed to soft water.

SOURCE: EEA

CTD001969

TABLE 1-5

NUMBER OF PERSONS IN THE UNITED STATES
EXPOSED TO SOFT WATER IN 1970

	Population Exposed (in millions)	Percentage of Population Exposed
Eastern States	30.9	55%
Connecticut	2.9	96%
Delaware	0.5	100%
District of Columbia	0.7	100%
Maine	1.0	100%
Maryland	3.0	78%
Massachusetts	5.7	100%
New Hampshire	0.8	100%
New Jersey	4.5	63%
New York	5.6	31%
Pennsylvania	0.9	7%
Rhode Island	0.9	100%
Vermont	0.4	91%
Virginia	4.0	89%
Southern States	21.4	38%
Alabama	1.0	31%
Arkansas	0.3	17%
Florida	0.1	1%
Georgia	2.7	59%
Kentucky	0.3	10%
Louisana	0.3	8%
Mississippi	2.2	100%
North Carolina	4.4	86%
South Carolina	2.2	83%
Tennessee	2.0	52%
Texas	5.9	53%
Western States	3.7	7%
California	1.0	5%
Hawaii	0.8	100%
Idaho	0.2	25%
Nevada	0.003	0.6%
Oregon	1.5	74%
Washington	0.2	5%
United States	56.0	27%

SOURCE: EEA

- o pH adjustment using lime has beneficial health effects.
- o Corrosion control by deposition of $CaCO_3$ films on the interior surfaces of the water conveyors provides the broadest and most general protection to water systems and plumbing materials.
- o Any of the stability indices, Langlier Saturation Index (LSI), Aggressive Index (AI), or Ryznar Saturation Index (RSI), can be used interchangeably to measure the stability and corrosion potential of water.
- o Annual treatment costs to control corrosion range from $0.185 to $0.47 per capita.
- o The benefit to cost ratio of using corrosion control to reduce pipe damage ranges from 1.2:1 to 15.4:1.

Regulatory Findings

- o EPA has the authority under the Safe Drinking Water Act to regulate soft corrosive water.

1.3 CONCLUSIONS

Soft and/or corrosive water represents a substantial health risk to those dependent on it for drinking water. Several different water treatment methods can lessen the potential adverse health impacts. Technology to decrease water corrosivity is readily available and economically feasible. Not only could the use of this technology result in significant public health benefits, but it could also have the additional benefit of lowering corrosion in public water distribution systems.

EPA has the authority, in the Safe Drinking Water Act, to include a minimum hardness requirement and to establish an MCL based on corrosion indices. This authority should be exercised to protect public health, considering the potential adverse health effects of increased cardiovascular disease in soft water areas and increased toxic contaminants in corrosive water areas. Given the large percentage of the United States population exposed to soft or corrosive water, a minimum hardness requirement and a maximum contaminant level based on any one of the corrosion indices should be implemented nationwide.