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Scott A. Weiner
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Director

Don Heskett
KDF Inc.
P.O. Box 277
Konstantine, MI 49042

Dear Mr. Heskett:

In late 1990, a study was started to develop a treatment method for the removal of mercury from well water. During this study, seven different treatment techniques were evaluated at 5 test locations for approximately one year. After testing and identifying several effective systems, these systems were then used at other sites were mercury contamination was detected in drinking water. The extended evaluation period of these systems added to our understanding of how to implement these systems in such a way that they were both effective and economical for the removal of mercury.

Enclosed is a copy of the report which was based on the information gathered over the course of the past two years. I hope that this report will assist you in the remediation of mercury contaminated water supplies.

If you should have any questions please contact me at (609) 984-5862.

Sincerely,

Andrew Sites
Principal Environmental Engineer
Bureau of Wellfield Remediation

MERCURY POINT-OF-ENTRY TREATMENT STUDY

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NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION AND ENERGY
TRENTON, NEW JERSEY

SEPTEMBER 1992

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MERCURY POINT-OF-ENTRY TREATMENT STUDY

BACKGROUND

In the State of New Jersey more than 400,000 families rely on private wells as a source of potable water. Unfortunately in the last decade the contamination of many of these wells with volatile organics has become a common occurrence. However, it was not until early 1989 that mercury was considered a significant ground water contaminant. Prior to 1989, it was very rare that mercury was detected in ground water. Historically, less then 10 wells a year were discovered to be contaminated with mercury in New Jersey and most of these cases could be linked to a source such as a Superfund site.

In December of 1988, mercury was found in a private well in a residential area in Atlantic County. As part of the county health department's response, other wells in the area were sampled and these results indicated that some of these wells also exceeded the Maximum Contaminant Level (MCL) of 2 parts per billion (ppb) for mercury. An investigation was conducted during which 331 residential wells were sampled. Of the wells sampled, 64 wells exceeded the MCL and 187 indicated some level of mercury but were below the MCL.[1] As a result of the investigation, it was determined that 415 homes in the housing development were either impacted or threatened by the contamination and the residents should be using an alternate water supply. No source of the mercury was identified. As a result of this case, health departments in southern New Jersey began sampling for mercury in residential wells. Due to this sampling effort, more than 300 wells have been shown to have elevated concentrations of mercury. After analyzing the sampling data collected, it appears that the presence of the mercury is restricted to the Kirkwood Cohansey aquifer which is a coastal plain aquifer. The Kirkwood Cohansey is a unbuffered aquifer which has an average pH of 4.5. The location of the aquifer is shown in Attachment 1.

Mercury in drinking water is a serious health concern because it affects the central nervous system. Unlike many other contaminants, mercury poses an additional problem because it can enter the body by absorption through the skin, inhalation, or by ingestion[2]. For these reasons, the standard, conservative recommendation is that mercury contaminated water should not be used for either drinking, bathing or cooking.

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[1] John Montgomery, Pleasant Woods Ground Water Impact Area Report (NJDEPE Document, May 29, 1990) p.2.

[2] OSHA, MERCURY: Job Health Hazard Series (US Department of Labor, August 1975) p.5.

ACKNOWLEDGMENTS

The Department would like to thank the following companies for their participation in the Mercury POET Study. These companies and organizations made this study possible by volunteering their expertise, services and equipment.

Atlantic County Health Department
Century Water Inc.
Gloucester County Health Department
IET Inc.
New Jersey American Water Company
New Jersey Water Quality Association
ORC - KDF Inc.
Sybron Chemical Inc.
Shocky's Pure Water Inc.

* participants listed in alphabetical order

DISCLAIMER

The use of any trade names of products or materials in this report does not constitute an endorsement by the New Jersey Department of Environmental Protection and Energy.

In order to remove volatile organics for water, several proven point-of-entry treatment (POET) systems can be installed on a private well to produce potable water. Unlike volatile organic contamination, there was no proven POET system which could remove mercury from well water. Because of this, the only source of potable water for affected homeowners was to use bottled water until water lines could be extended to service them. Unfortunately, in many of the areas affected by mercury it was not likely that water lines would ever be extended to service the homes because they were miles from the nearest water line. In order to provide a source of interim potable water for cases like this the obvious solution was to develop a POET system which would remove mercury.

STUDY OBJECTIVE

The objective of this study was to identify a treatment media/system, which when implemented in/as a whole house point-of-entry water treatment system would remove mercury to a concentration below the MCL of 2 ppb. Upon identifying an effective treatment system this technology will be recommended by the NJDEPE for the removal of mercury from potable drinking water supplies.

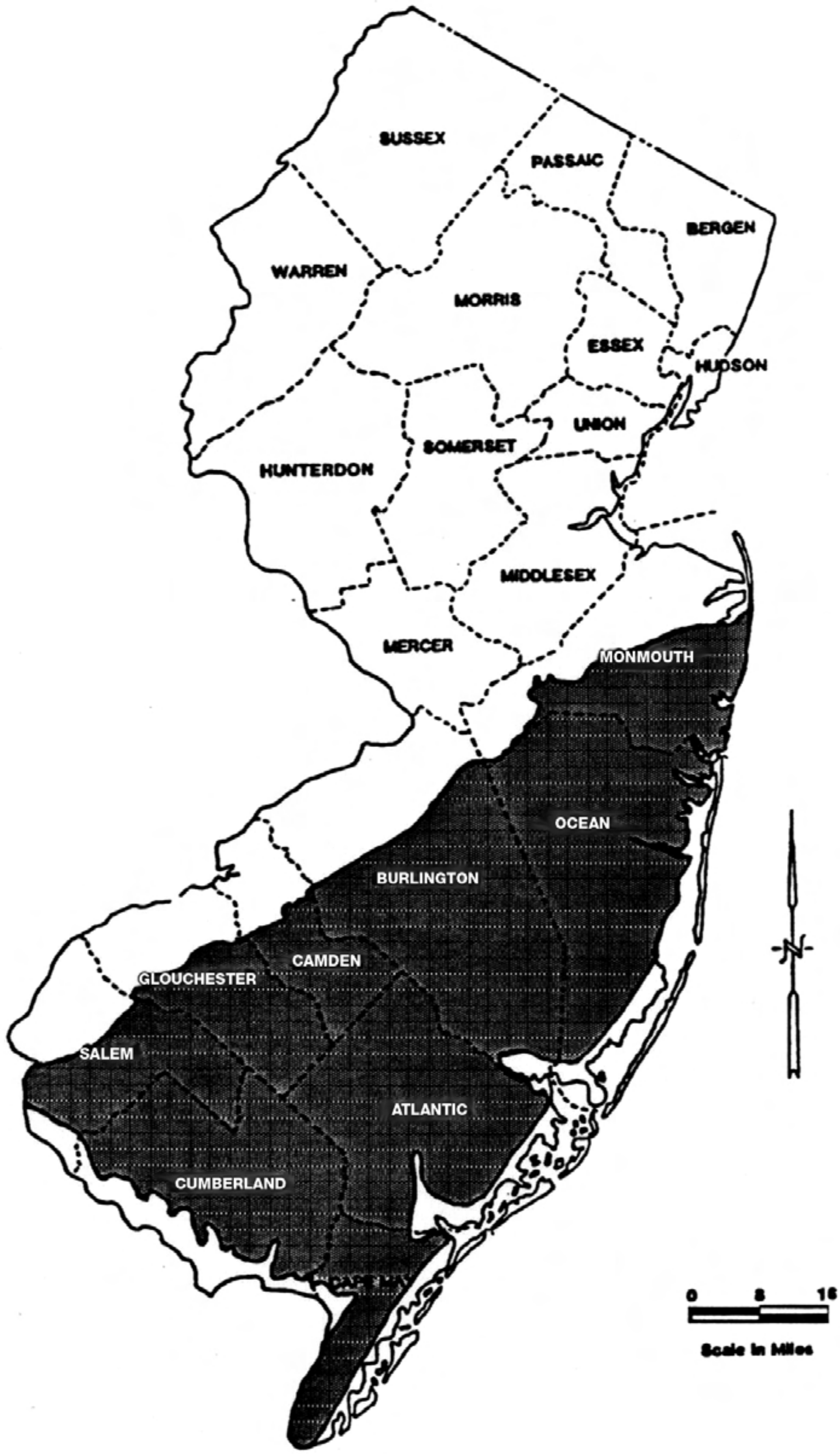
STUDY INTRODUCTION

In order to accomplish the objective of this study, four main questions needed to be answered and these questions evolved into the four phases of the study which were: **PHASE I** - determine both the form of the mercury and the potential for the mercury concentration to fluctuate in residential wells, **PHASE II** - select and test treatment media to determine their ability to remove mercury, **PHASE III** - evaluate data and select a treatment medium, **PHASE IV** - design a system and develop an operation & maintenance plan.

Five residential wells (A through E), were chosen and utilized as test locations because they consistently had elevated levels of mercury over the MCL. The residents involved were informed that the systems being tested may or may not remove the mercury and they were not to use the water for potable or direct contact purposes. Four of the test locations were in Atlantic County (locations A through D) and the fifth (location E) one was 28 miles to the east in Gloucester County. Location E was selected because there was a possibility that the form of the mercury might be different due to the distance between sites. If the form of the mercury was different it would be possible to determine how a different form of mercury would react to the treatment methods being tested.

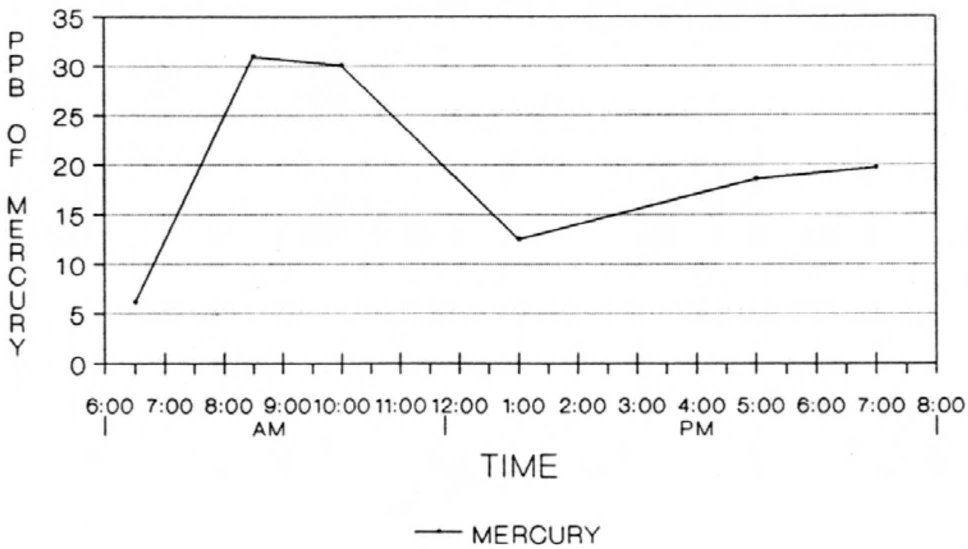
ATTACHMENT 1

KIRKWOOD-COHANSEY AQUIFER



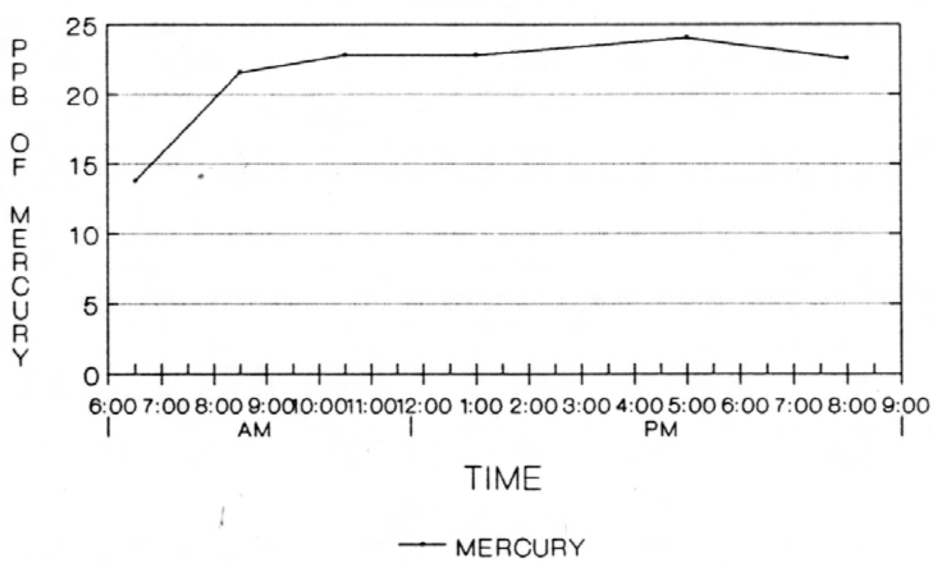
ATTACHMENT 2

TIME VARIANT SAMPLING
EVENT #1



LOCATION B; 10/10/90

TIME VARIANT SAMPLING
EVENT #2



LOCATION B; 12/11/90

PHASE I - SPECIATION AND TIME VARIANT SAMPLING

A. SPECIATION

In order to design an appropriate water treatment system, the form of the mercury must be known. Upon investigating the speciation of mercury, it was determined that there was no commonly available method for speciating mercury. The only widely available analysis for mercury in a dilute aqueous solution is for determining total mercury and the percentage of organic and inorganic mercury.

To determine if the mercury present was organic or inorganic, samples were taken from test location B in Atlantic County and also from location E in Gloucester County. These samples were analyzed by the New Jersey American Water Company's laboratory, and the results indicated that the mercury at both locations was comprised of 92 percent inorganic mercury. In addition 30 other samples taken as part of another study which also indicated that the mercury present in these wells was comprised of 8% methyl mercury and 92% inorganic mercury.

After consulting with geochemists and reviewing available literature, the consensus of opinion was that the predominant form that mercury may take in ground water would be a mercury salt. This hypothesis is based on the fact that mercury has a great affinity for chlorides. It is thought that if mercuric ions were to enter the aquifer system, the presence of chlorides in the soil could complex with the mercuric ions to form a mercury chloride compound ranging from $HgCl^{+}$ through $HgCl_4^{-2}$.[3]

B. TIME VARIANT SAMPLING

To address the issue of the consistency of the mercury concentrations in the well water, a set of samples were taken as part of a time variant test. The objective was to determine if the mercury concentration fluctuated during the day due to routine water usage. The time variant test was conducted on three occasions at location "B". The first two time variant tests were conducted using the same procedure which was to take samples at various times during the day with the intentions of sampling at maximum and minimum water usage periods. The samples were drawn from the closest faucet to the well pump which was prior to the pressure tank and the house plumbing. The results of the first and

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[3]Dr. Arthur Greenberg, STUDY OF MERCURY COMPOUNDS IN WATER OBTAINED FROM VARIOUS PRIVATE DOMESTIC WELLS IN ATLANTIC COUNTY (Rutgers University, NJ. 1990) p.1.

second events are shown in Attachment 2.

To better quantify the findings of the first two sampling events a third event was conducted where a greater number of samples were taken to more accurately define the rate of fluctuation of the mercury. During the third sampling event the water was run at approximately 3 gallons per minute for the duration of the sampling event. This was done to determine if stressing the aquifer would have an affect on the concentration of mercury in the well water. The results are shown in Attachment 3.

As a result of the time variant testing, it appears that the concentration of mercury can fluctuate substantially. It also appears that the fluctuation is correlated to the pumping of the system. During the first event, the water was being used very infrequently and it appears that if the system is allowed to sit idle, the first sample analyzed will indicate a lower level of mercury. Under sustained pumping conditions, such as in the third event, the concentration of mercury remained relatively constant within plus or minus 3 ppb of mercury. One theory is that the mercury may be present as a colloid and settles out when the well system is at rest.

Due to these findings in the time variant test, when samples were taken from the experimental units, the water was run in order to purge the pluming system and to stabilize the concentration of mercury.

PHASE II - SELECTION AND TESTING OF TREATMENT MEDIA

The following four steps were taken in this phase of the study to evaluate the mercury removal potential of different water treatment media.

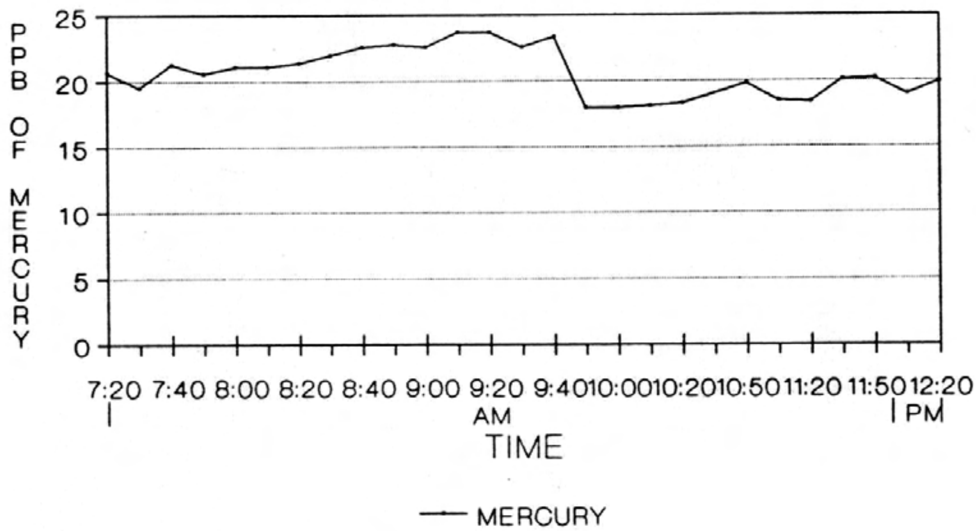
A. Selection of treatment media
B. Perform a bench test on representative media
C. Design experiment and sampling procedure
D. Perform full scale treatment tests
    1. Short-Term Testing
    2. Long-Term Testing

A. MEDIA SELECTION

To meet the objective of the study, the system must be capable of producing approximately 200 to 300 gallons per day (average water usage for a family of 4 to 6 people) at a minimum rate of 5 gallons per minute. For this reason, point-of-use reverse osmosis systems, which have been proven to be effective in removing metals

ATTACHMENT 3

TIME VARIANT SAMPLING
EVENT #3



LOCATION B; 6/13/91

such as mercury, were not included in this study because they only treat the water at one tap which would not provide any protection from dermal contact during activities such as showering. In addition, point-of-entry reverse osmosis systems were not included because they were not considered an economically feasible solution due to their capital cost of over $10,000 per unit and a substantial yearly maintenance expense.[4]

In researching the available literature, three main families of water treatment media have indicated some ability to remove metals. The three media types which were identified and used in this study were granular activated carbon, a granular bi-metallic compound and ion exchange resins. The specific media that were evaluated are shown in the following table.

MEDIA TYPE	MEDIA	SPECIFICS
Granular Activated Carbon	GAC-380	
Bi-Metallic Oxidation/Reduction Compound	KDF-55	finely ground alloy of 55% copper and 45% zinc
Ion Exchange Resin (IER)	C-249/ C-105E	strong acid cation resin
IER	SR-4	weak acid chelating resin
IER	S-920	mercury specific chelating resin
IER	ASB-2	strong base anion resin
IER	AFP-329	weak base anion resin

B. BENCH TEST

Before the full-scale testing of the media was conducted, a bench test was performed using four different media. The media evaluated were KDF, two types of cation resins (C-249 & C-105E), and an anion resin (A-300). The objective of the bench test was not to obtain

[4]Jay Montemarano, Point-Of-Entry Treatment Seminar Handbook (Rutgers University, 1991) Section 4, p.9.

"scientifically verifiable" information but to perform a cursory evaluation of the treatment media to determine what medium may or may not be effective. For this test, water was run through a common counter top point-of-use unit which consisted of a small column that was 3 inches in diameter and 10 inches in height. Approximately 45 cubic inches of the medium was place in the column then 1 gallon of water was run through the system before raw and treated water samples were taken. After sampling, the medium was removed from the system and a new medium was installed and the testing process was repeated.

The results of the bench tests are shown in Attachment 4. These results indicated that the anion resin, and the KDF were very effective and the cation resin was not effective in reducing the level of mercury. A second bench test was conducted and the result of the first test were confirmed. Based on this information more emphasis was placed on evaluating KDF and different types of anion resins.

C. EXPERIMENT DESIGN & SAMPLING PROCEDURE

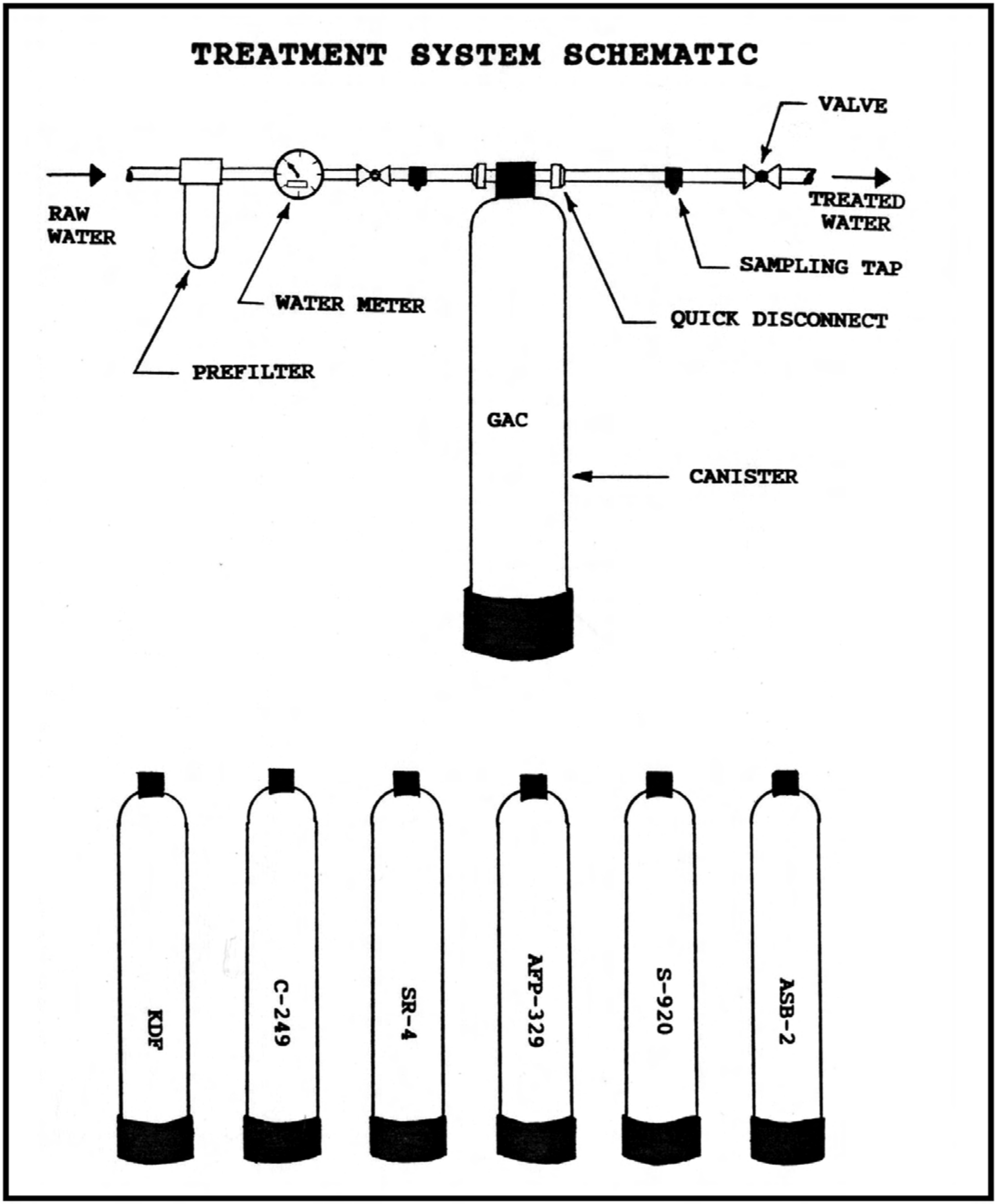
System Configuration

To evaluate each medium, a test system was designed which was comprised of a treatment medium, a tank, a water meter to monitor water usage, sampling taps for both raw and treated water, and a prefilter to remove any sand or sediment. The system schematic is shown in Attachment 5. The tanks used were selected to provide appropriate contact time between the water and the treatment medium and also to avoid a severe water pressure drop. The tanks were constructed of an ABS plastic liner with a spun fiberglass shell for rigidity. The flow of the water through the tank was down flow washing over the medium and then was collected in a manifold and was forced up through a riser pipe. For the KDF and the ion exchange resins, 0.33 cubic feet and 0.5 cubic feet, respectively, of the medium was placed in individual 7" (diameter) X 40 " (high) tanks. No back washing devices were used with any of these systems. A total of seven different types of treatment systems were constructed with each system using a different medium. The systems were installed after the pressures tank and treated all the water entering the test location.

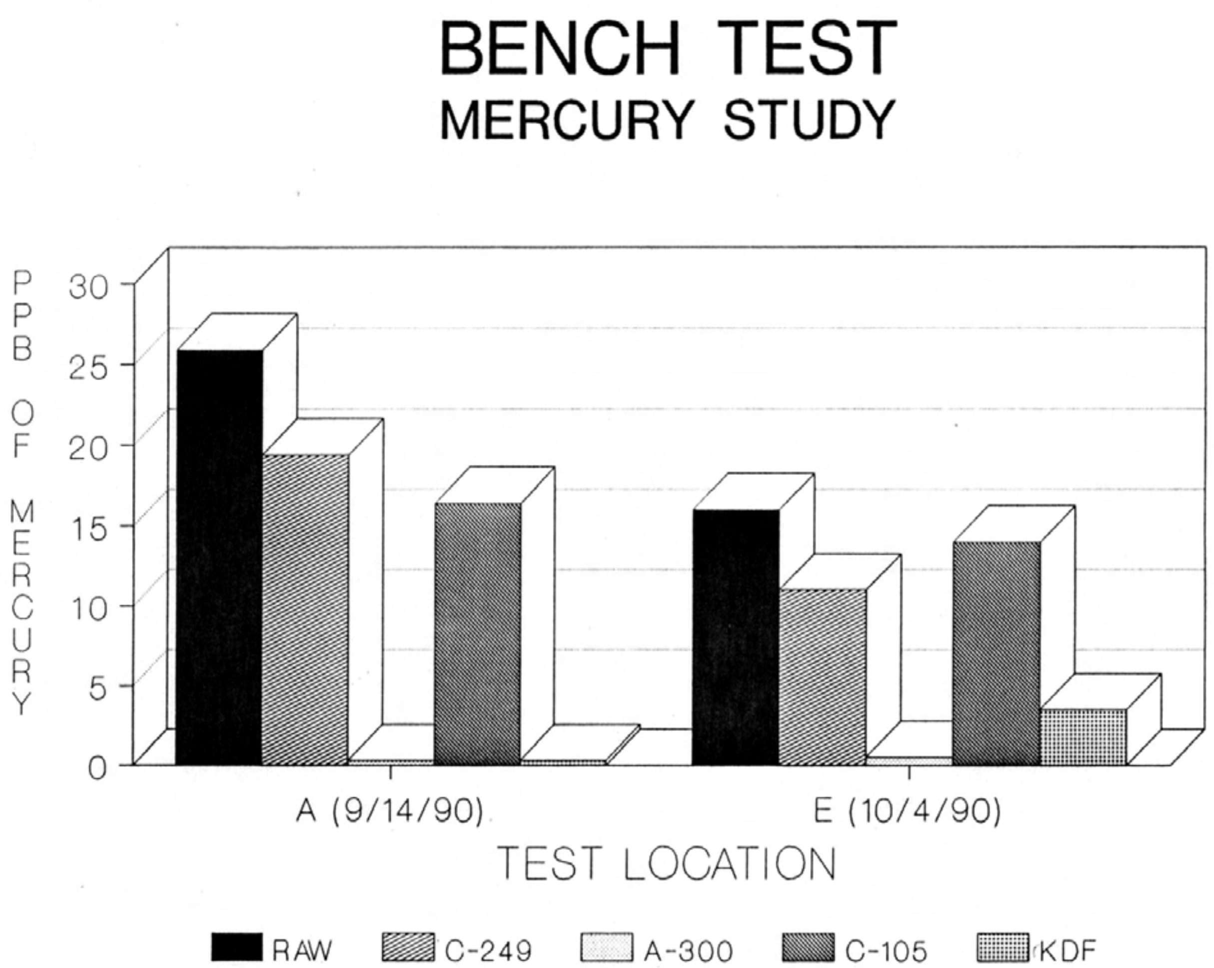
Testing Procedure

Due to limited space at the test locations, only one treatment system was put on line at a time at each site. At the start of the study, tanks containing granular activated carbon were installed at each of the five test locations. Once the testing of the GAC was completed the tanks were disconnected from the plumbing and the next set of tanks with a new treatment medium were installed. This

ATTACHMENT 5



ATTACHMENT 4



process was repeated until all the systems were tested.

Sampling Procedure

Each system was run for 1 to 2 weeks then samples were taken of the raw and treated water. The method used to analyze the water samples for the mercury was EPA method 245.1. This method is only capable of measuring total mercury. For quality assurance purposes, the samples taken from the units were split and analyzed by as many as three laboratories. The laboratories used were the Atlantic County Municipal Utilities Authorities Laboratory, the New Jersey Department of Health Laboratory, and the NJDEPE Division of Environmental Quality Analytical Services Laboratory. The samples were collected in plastic bottles and were preserved with hydrochloric acid to a pH of less than 2.

Prior to any samples being taken, water was run through the system in order to purge at least one tank volume of water (7 to 14 gallons) through the system. After purging the system and with the water continuing to flow, samples were taken of both the raw and treated water. Raw water samples were taken for every sampling event for comparison purposes because the raw water concentrations of the mercury were known to fluctuate considerably. The raw and treated sample results were used to accurately calculate the removal efficiency of the system.

D. FULL SCALE SYSTEM TESTING

The full scale treatment study consisted of two phases, 1)short-term and 2) long-term testing periods. The short-term testing was done as a preliminary evaluation of the systems. The medium that indicated promising efficiencies for mercury removal in the short-term phase were tested in the long-term phase. Any medium which was not effective in the short-term testing phase was not evaluated in the long-term testing.

Short-Term Testing

During the short-term testing phase, one system was installed at each test location and was run for approximately one week. At the end of the week, the systems were sampled and new systems with a different medium were substituted for the existing systems. This process was repeated until all the systems were tested.

In order to determine what effect the flow rate had on the efficiency of the systems, treated water samples were taken when the systems were operating at 3 and 5 gallons per minute (GPM). These two flow rates (contact times) can affect the removal efficiency because increased contact time generally results in an increase in contaminant removal.

The data generated indicated that all of the systems evaluated had a high removal rate of 94.5 percent or greater with the exception of the strong acid cation resin. The strong acid cation resin effectively had a zero removal efficiency. The test results from the six other systems that were sampled at flow rates of 3 and 5 GPM were compared and there appeared to be no difference in the removal efficiencies with respect to the flow rates. The results from the short-term testing are shown in Attachments 6 through 12.

Long-Term Testing

The intent of the long-term testing portion of the study was to further evaluate promising systems and to determine if the removal efficiencies would decline with use.

Since the strong acid cation resin was shown to be ineffective in the short-term testing, this system was not evaluated in the long-term testing. The other six systems which indicated an ability to remove mercury were individually sampled for a period of 6 to 10 weeks. The long-term evaluation followed the same procedure as the short term evaluation with the exception that the systems were run for 6 to 10 weeks and samples were taken once every 2 weeks. The following media were sampled as part of the long-term testing phase: GAC, KDF-55, AFP-329, SR-4, S-920, ASB-2.

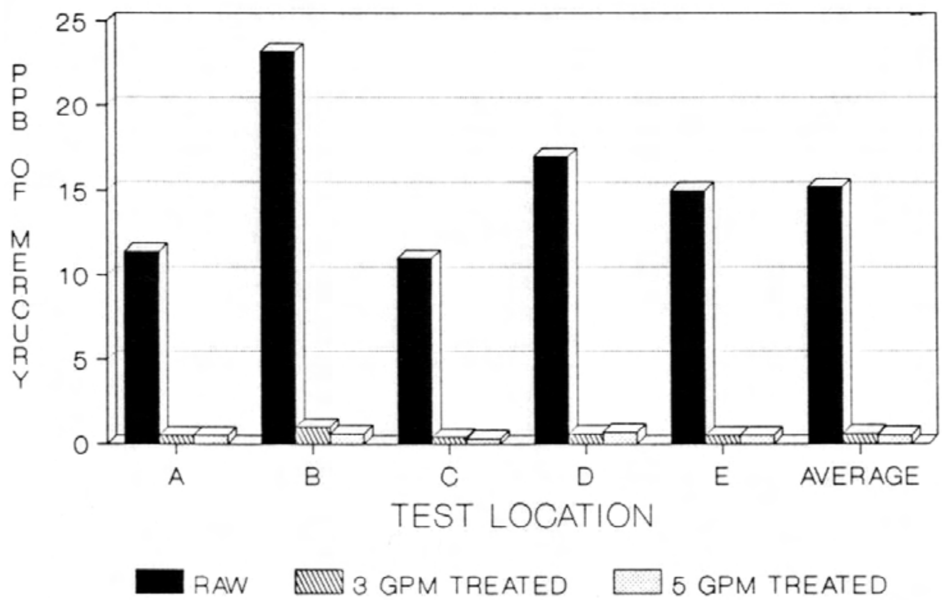
All of the results for the long-term testing are shown in Attachments 13 through 18. Attachment 19 shows the average efficiencies compiled from all test results taken during the study for each system. As can be seen from the results, all the systems evaluated in the long-term test performed at approximately the same levels as they did in the short-term testing period. No detectable degradation of any of the systems was observed.

During the study, some negative side effects were observed when several of the systems were on line. When the ASB-2 strong base anion resin was used it was observed that the resin would increase the acidity of the water by approximately 1 pH unit. The resin manufacturer indicated that this is a side effect that will continue with the use of the resin. This side effect could cause problems in many geographic regions where the raw water pH is already low. In these areas dropping the pH one unit will create a situation where pH adjustment will be necessary. If a pH adjustment system was required as part of the complete mercury removal system the cost of the system to the home owner would increase by approximately $400 to $1,000 (average cost of a pH adjustment system).

There were concerns about KDF adding excessive concentrations of zinc to the treated water since zinc is used as a sacrificial metal. Treated water from the KDF system at location "A" was sampled and it was found that the KDF introduced 2.9 parts per million (ppm) of zinc into the water. The levels of the zinc in the

ATTACHMENT 6

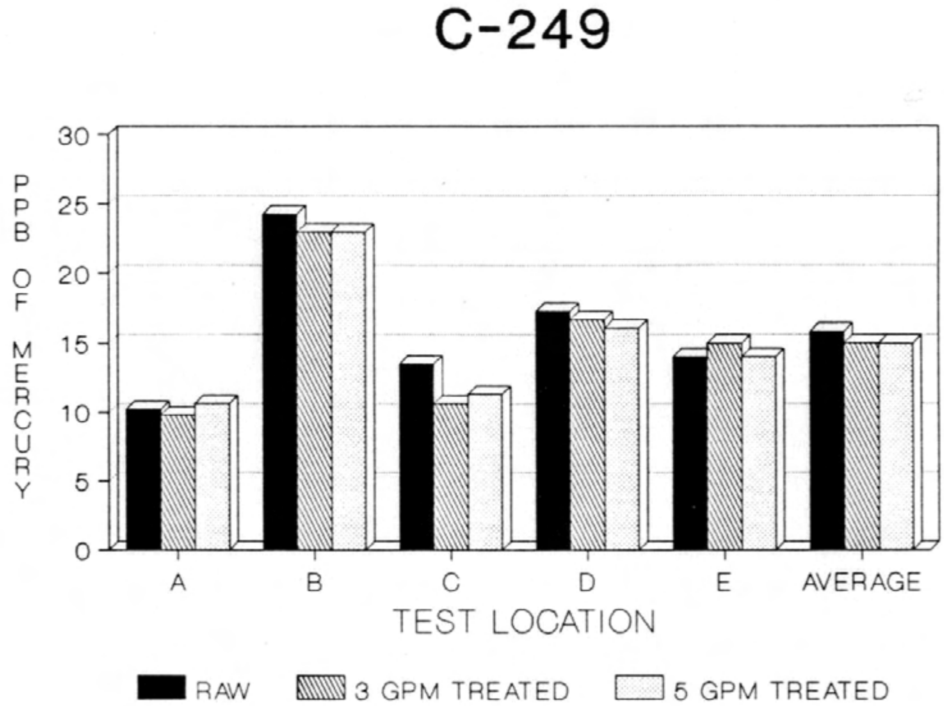
GRANULAR ACTIVATED CARBON



SHORT TERM TESTING

MEDIA	LOCATION	DATE	RAW	3 GPM	5 GPM	AVG. TRTED	% REDUCTION
GAC	A	11/15/90	11.40	0.50	0.50	0.50	95.61
GAC	B	11/15/90	23.20	1.00	0.60	0.80	96.55
GAC	C	11/15/90	11.00	0.40	0.30	0.35	96.82
GAC	D	11/15/90	17.00	0.60	0.68	0.64	96.24
GAC	E	11/15/90	15.00	0.50	0.50	0.50	96.67
GAC			AVG. RAW	AVG. 3GPM	AVG. 5GPM	AVG TRTED	AVG.%RED
			15.52	0.60	0.52	0.56	96.40

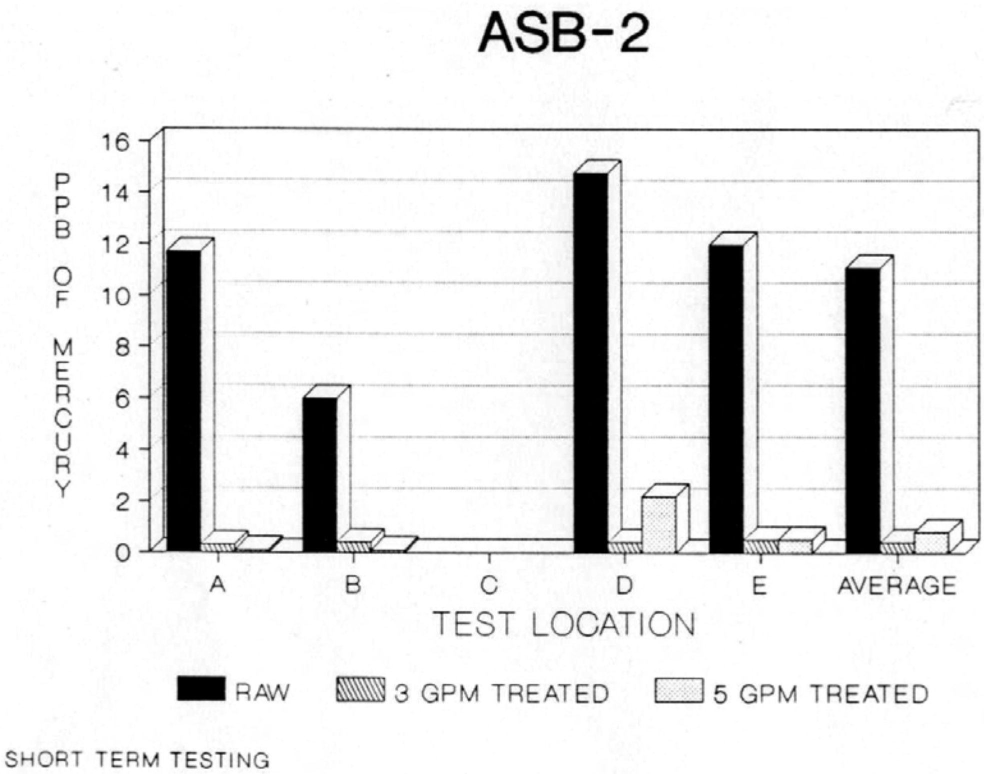
ATTACHMENT 7



SHORT TERM TESTING

MEDIA	LOCATION	DATE	RAW	3 GPM	5 GPM	AVG. TRTED	% REDUCTION
C-249	A	11/21/90	10.20	9.80	10.60	10.20	0.00
C-249	B	11/21/90	24.30	23.00	23.10	23.05	5.14
C-249	C	11/21/90	13.50	10.60	11.30	10.95	18.89
C-249	D	11/21/90	17.30	16.70	16.10	16.40	5.20
C-249	E	11/21/90	14.00	14.00	15.00	14.50	-3.57
C-249			AVG. RAW	AVG. 3GPM	AVG. 5GPM	AVG. TRTED	AVG.%RED
			15.86	14.82	15.22	15.02	5.30

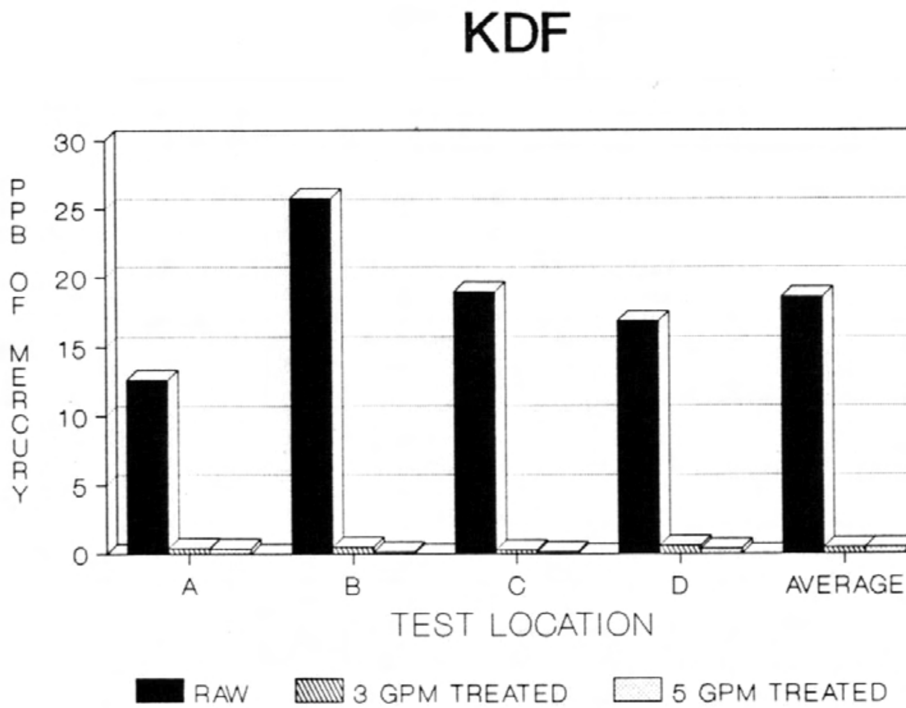
ATTACHMENT 8



MEDIA	LOCATION	DATE	RAW	3 GPM	5 GPM	AVG. TRTED	% REDUCTION
ASB-2	A	11/29/90	11.70	0.30	0.50	0.40	96.58
ASB-2	B	11/29/90	6.00	0.40	0.10	0.25	95.83
ASB-2	C	11/29/90					
ASB-2	D	11/29/90	14.80	0.40	2.20	1.30	91.22
ASB-2	E	11/29/90	12.00	0.50	0.50	0.50	95.83

	AVG. RAW	AVG. 3GPM	AVG. 5GPM	AVG. TRTED	AVG.%RED
ASB-2	11.13	0.40	0.83	0.61	94.49

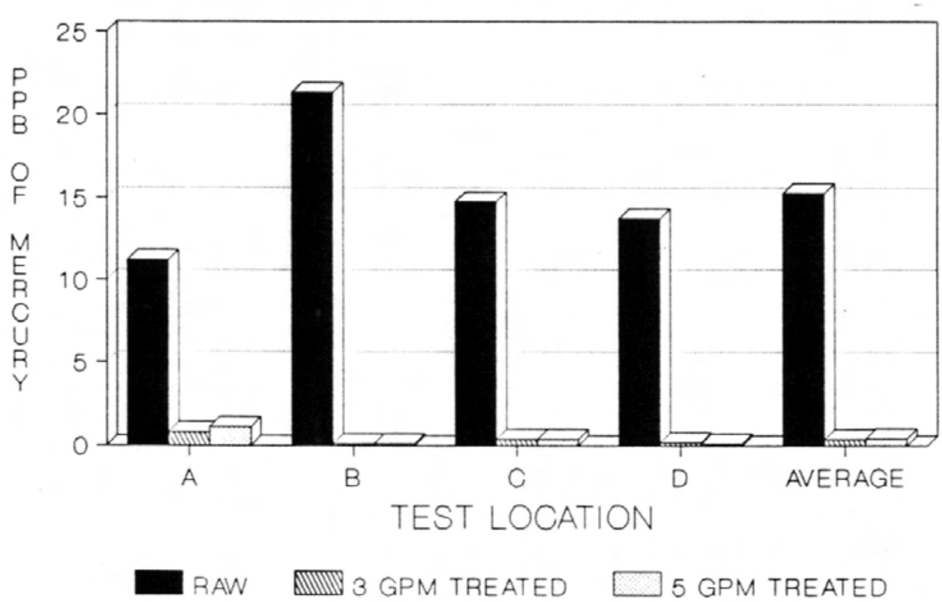
ATTACHMENT 9



SHORT TERM TESTING

MEDIA	LOCATION	DATE	RAW	3 GPM	5 GPM	AVG. TRTED	% REDUCTION
KDF	A	12/14/90	12.66	0.39	0.37	0.38	97.00
KDF	B	12/14/90	25.78	0.49	0.50	0.50	98.08
KDF	C	12/14/90	18.96	0.28	0.50	0.39	97.94
KDF	D	12/14/90	16.86	0.60	0.35	0.48	97.18
KDF			AVG. RAW	AVG. 3GPM	AVG. 5GPM	AVG. TRTED	AVG.%RED
			18.57	0.44	0.43	0.44	97.66

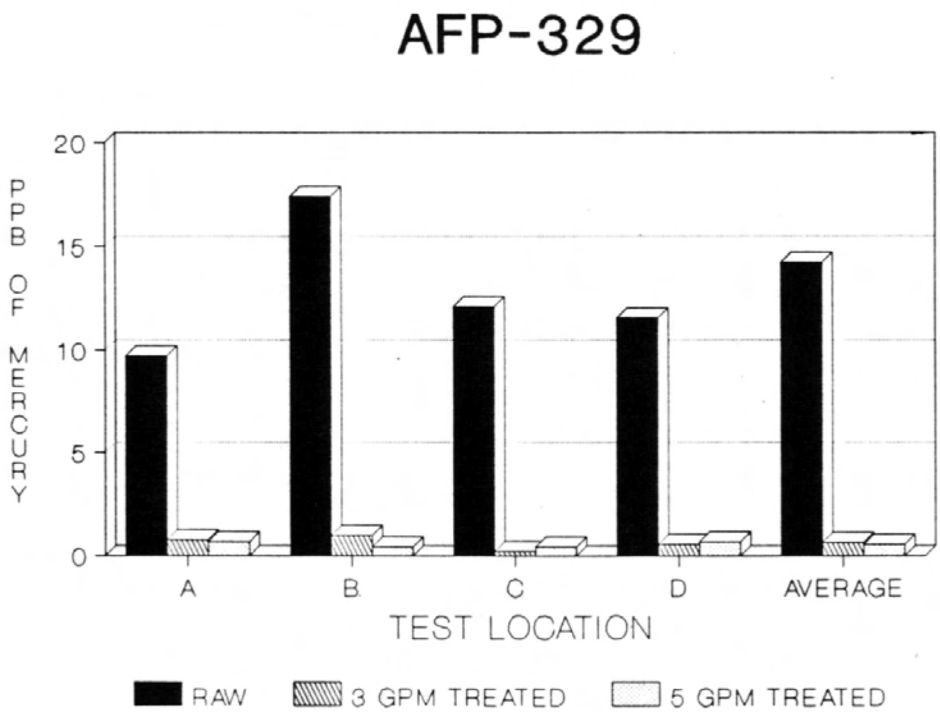
ATTACHMENT 10



SHORT TERM TESTING

MEDIA	LOCATION	DATE	RAW	3 GPM	5 GPM	AVG. TRTED	% REDUCTION
S-920	A	12/20/90	11.12	0.79	1.10	0.95	91.50
S-920	B	12/20/90	21.37	0.10	0.10	0.10	99.53
S-920	C	12/20/90	14.74	0.38	0.38	0.38	97.42
S-920	D	12/20/90	13.71	0.17	0.10	0.14	99.02
S-920			AVG. RAW	AVG. 3GPM	AVG. 5GPM	AVG. TRTED	AVG.%RED
			15.24	0.36	0.42	0.39	97.44

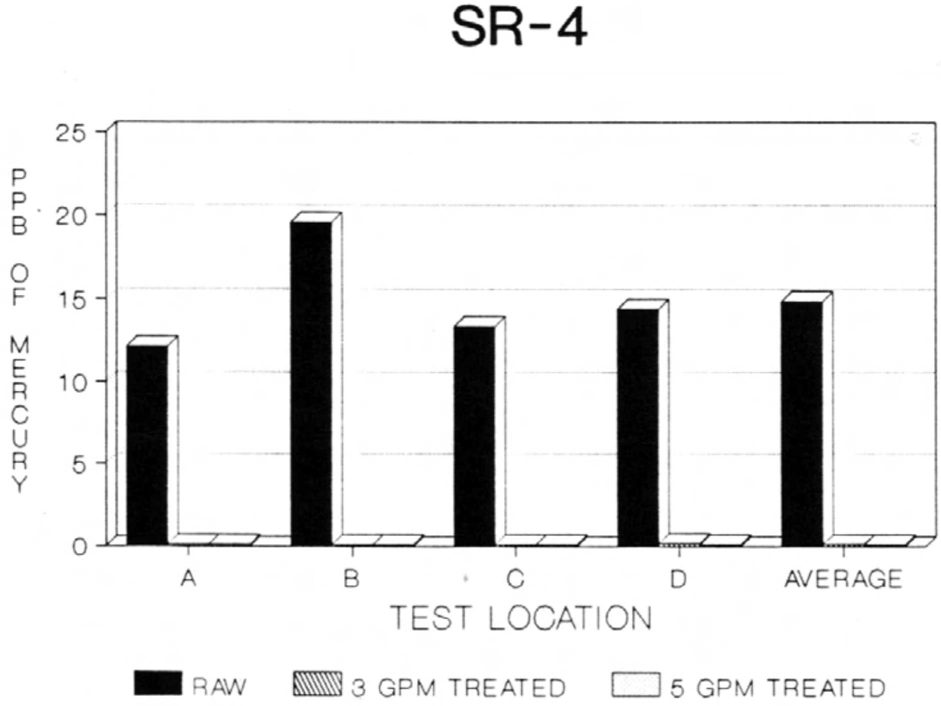
ATTACHMENT 11



SHORT TERM TESTING

MEDIA	LOCATION	DATE	RAW	3 GPM	5 GPM	AVG. TRTED	% REDUCTION
AFP-329	A	1/3/91	9.71	0.76	0.65	0.71	92.74
AFP-329	B	1/3/91	17.39	0.98	0.43	0.71	95.95
AFP-329	C	1/3/91	12.11	0.21	0.43	0.32	97.36
AFP-329	D	1/3/91	11.56	0.54	0.65	0.60	94.85
AFP-329			AVG. RAW	AVG. 3GPM	AVG. 5GPM	AVG. TRTED	AVG.%RED
			12.69	0.62	0.54	0.58	95.42

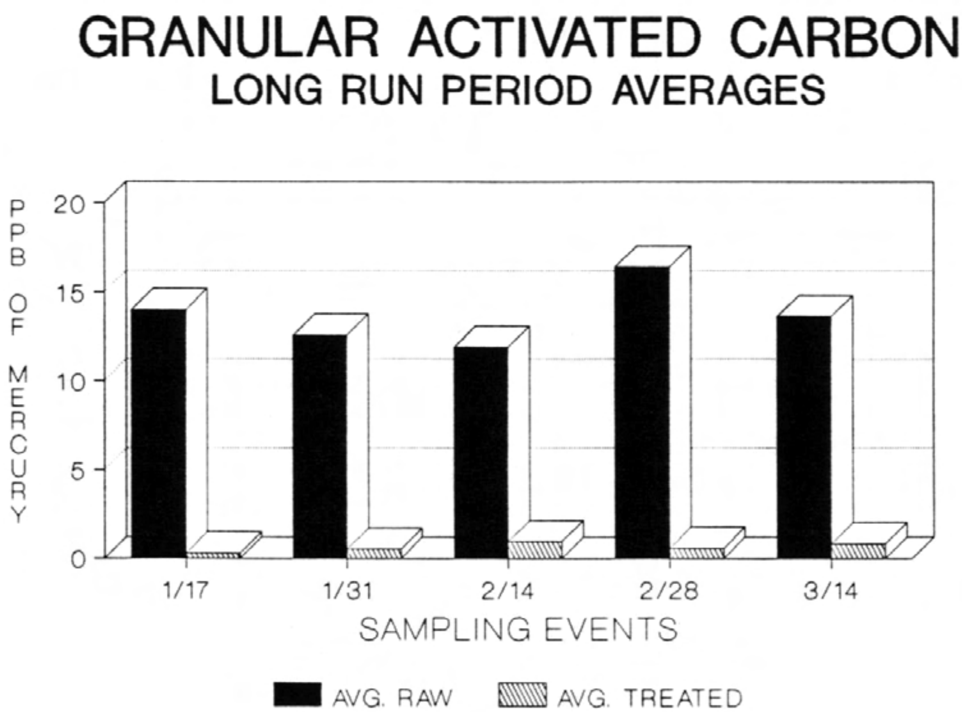
ATTACHMENT 12



SHORT TERM TESTING

MEDIA	LOCATION	DATE	RAW	3 GPM	5 GPM	AVG. TRTED	% REDUCTION
SR-4	A	1/10/91	12.16	0.10	0.10	0.10	99.18
SR-4	B	1/10/91	19.59	0.10	0.10	0.10	99.49
SR-4	C	1/10/91	13.38	0.10	0.10	0.10	99.25
SR-4	D	1/10/91	14.40	0.16	0.10	0.13	99.10
SR-4			AVG. RAW	AVG. 3GPM	AVG. 5GPM	AVG. TRTED	AVG.%RED
			14.88	0.12	0.10	0.11	99.28

ATTACHMENT 13

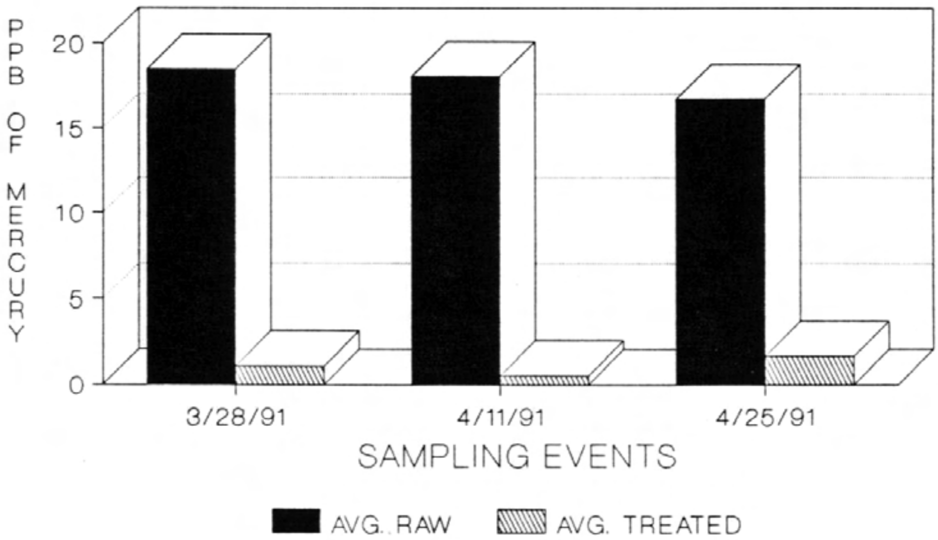


PERIOD: 1/10/91 - 3/14/91

MEDIA	PERIOD	DATE	AVG. RAW	AV.TRT	AVG % RED	LOCATION
GAC	1	1/17/91	14.00	0.28	98.00	A THRU D
GAC	2	1/31/91	12.56	0.51	95.94	A THRU D
GAC	3	2/14/91	11.90	0.94	92.10	A THRU D
GAC	4	2/28/91	16.14	0.57	96.47	A THRU D
GAC	5	3/14/91	13.53	0.82	93.94	A THRU D

ATTACHMENT 14

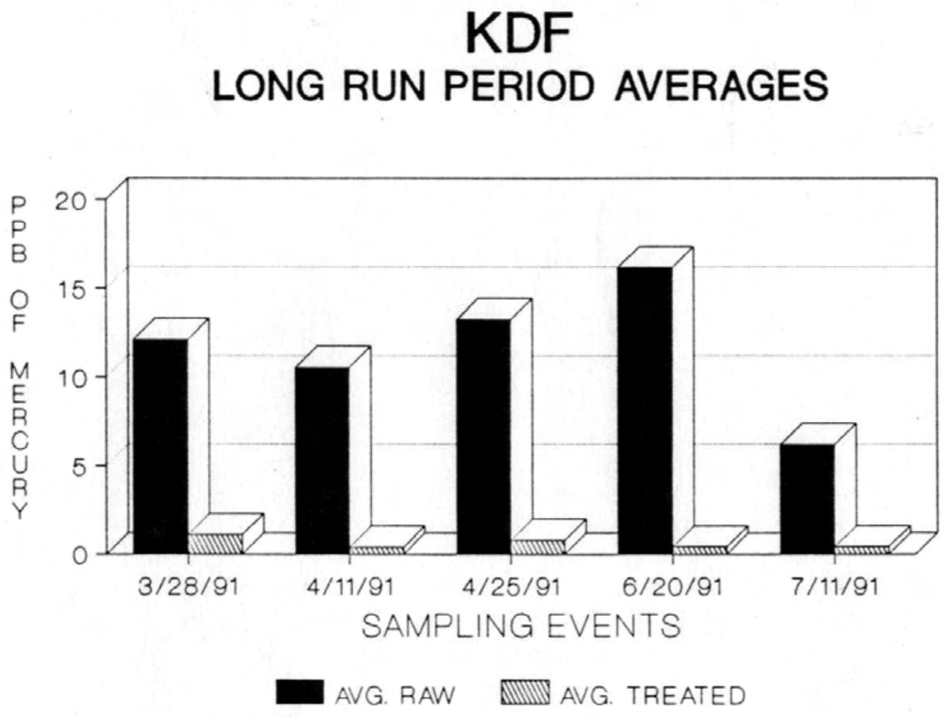
ASB-2
LONG RUN PERIOD AVERAGES



PERIOD: 3/14/91 - 4/25/91

MEDIA	PERIOD	DATE	AVG. RAW	AV.TRT	AVG % RED	LOCATION
ASB-2	1	3/28/91	18.50	1.08	94.16	B & D
ASB-2	2	4/11/91	18.09	0.52	97.15	B & D
ASB-2	3	4/25/91	16.74	1.66	90.08	B & D

ATTACHMENT 15

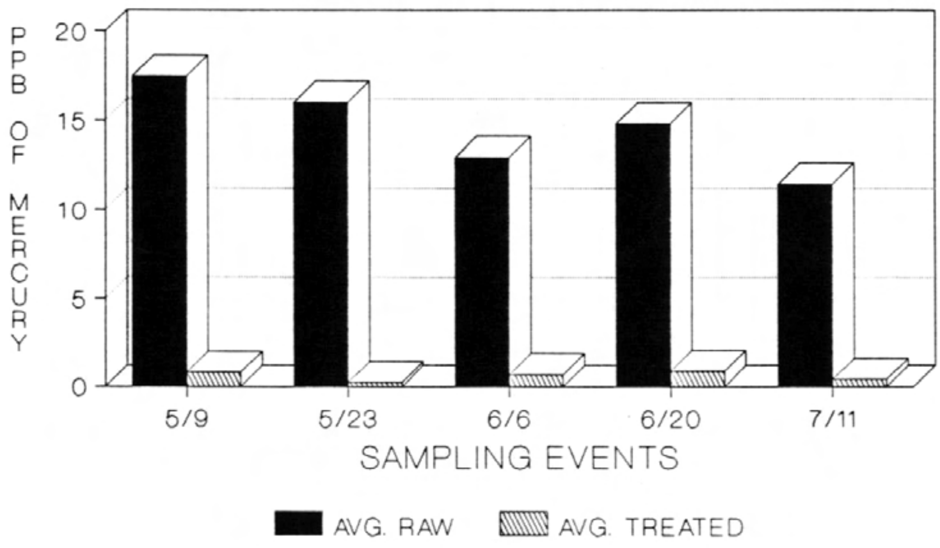


PERIOD: 3/14/91-4/25/91; 6/20/91-7/11/91

MEDIA	PERIOD	DATE	AVG. RAW	AV.TRT	AVG % RED	LOCATION
KDF	1	3/28/91	12.11	1.08	91.08	A & C
KDF	2	4/11/91	10.54	0.39	96.30	A & C
KDF	3	4/25/91	13.25	0.77	94.19	A & C
KDF	4	6/20/91	16.16	0.40	97.52	A
KDF	5	7/11/91	6.17	0.40	93.52	A

ATTACHMENT 16

SR-4
LONG RUN AVERAGES

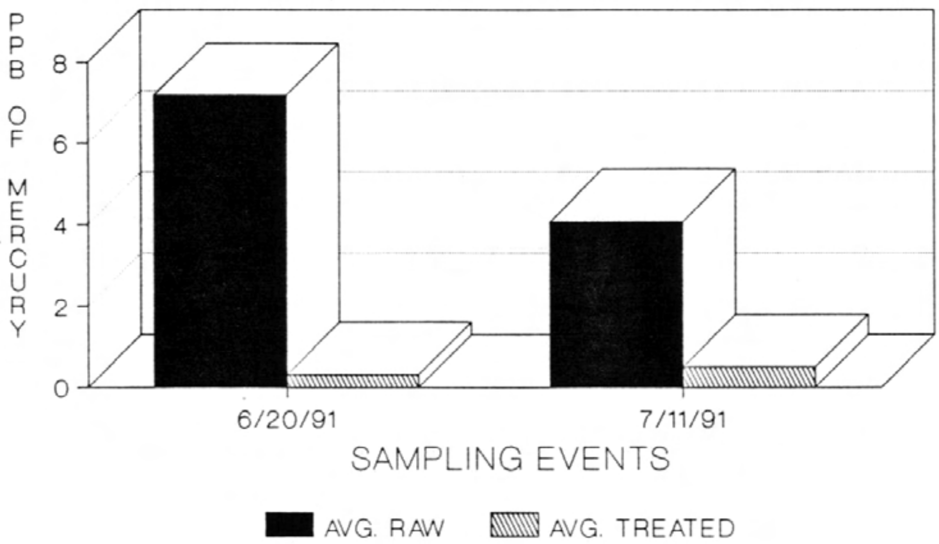


PERIOD: 5/9/91 - 7/11/91

MEDIA	PERIOD	DATE	AVG. RAW	AVG. TRTED	AVG % RED	LOCATION
SR-4	1	5/9/91	17.45	0.80	95.42	B & D
SR-4	2	5/23/91	16.01	0.23	98.56	B & D
SR-4	3	6/6/91	12.93	0.68	94.74	B & D
SR-4	4	6/20/91	14.80	0.87	94.12	B
SR-4	5	7/11/91	11.42	0.40	96.50	B

ATTACHMENT 17

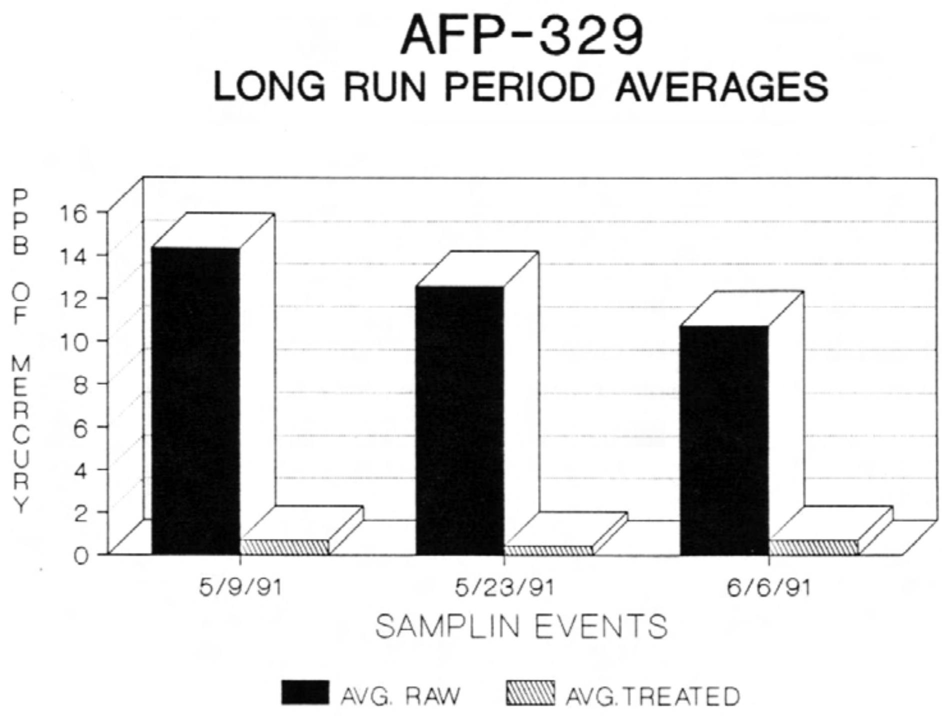
S-920
LONG RUN AVERAGES



PERIOD: 6/20/91 - 7/11/91

MEDIA	PERIOD	DATE	AVG. RAW	AV.TRT	AVG % RED	LOCATION
S-920	1	6/20/91	7.18	0.31	95.68	C & D
S-920	2	7/11/91	5.02	0.35	93.02	C & D

ATTACHMENT 18

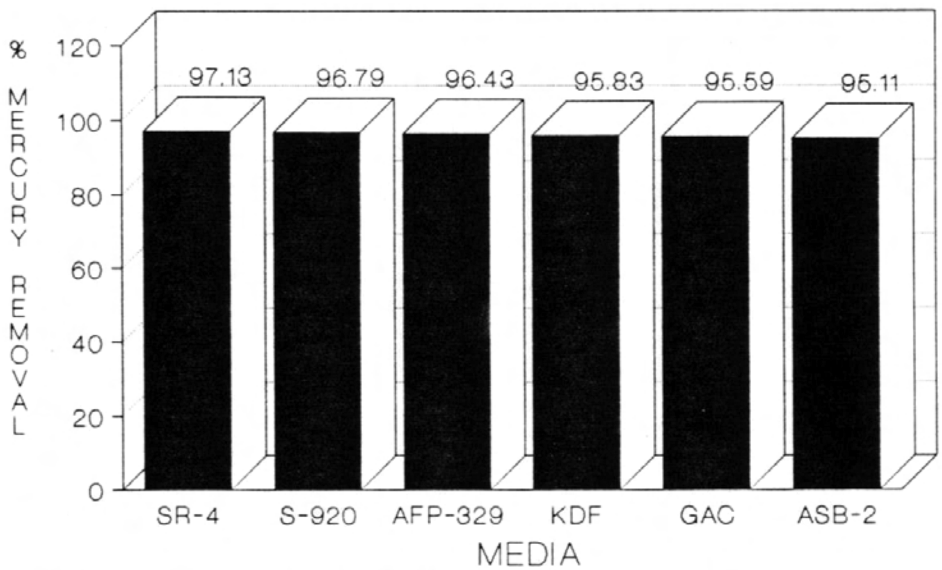


PERIOD 5/9/91 - 6/6/91

MEDIA	PERIOD	DATE	AVG. RAW	AV.TRT	AVG % RED	LOCATION
AFP-329	1	5/9/91	14.34	0.70	95.12	A & C
AFP-329	2	5/23/91	12.60	0.43	96.59	A & C
AFP-329	3	6/6/91	10.75	0.69	93.58	A & C

ATTACHMENT 19

OVERALL EFFICIENCIES
MERCURY STUDY



RESULTS COMPILED FROM ALL SAMPLES TAKEN

MEDIA	AVG. RAW (PPB)	AVG. TREATED (PPB)	% REDUCTION	WATER TREATED (GALLONS)
SR-4	14.88	0.43	97.13	55,615
S-920	10.67	0.34	96.79	44,397
AFP-329	12.21	0.44	96.43	78,083
KDF	14.03	0.59	95.53	41,156
GAC	14.00	0.62	95.59	65,391
ASB-2	14.31	0.70	95.11	31,430

treated water did not exceed the MCL which is 5 ppm. It should be noted that the pH of the raw water was acidic (5.1 pH).

PHASE III - EVALUATION & SELECTION OF MEDIA

A. EVALUATION OF MEDIA

The last portion of this study involved the determination of the best treatment system(s) which could be used for the reduction of mercury. Criteria used to evaluate the different systems included the following:

1. Removal Efficiency
2. Federal Drug Administration (FDA) Approval
3. Disposal of Spent Medium
4. Volume of Water Treatable per Cubic Foot of Medium
5. Cost
6. Operation and Maintenance
7. Side Effects

At the beginning of this study 7 media were to be analyzed to determine if any of them would have an acceptable efficiency to be used in a POET system for the removal of mercury. Upon reviewing the data, it was apparent that 6 of the media produced good results (>95.1% reduction) for mercury removal. Of these 6 media , 2 resins (SR-4 and S-920) have not yet been approved by the FDA for treating potable water.

One of the major concerns with all of the treatment systems is the disposal of the spent media. The worst case scenario would require that a leach test be performed to determine the media's waste classification. Based on the result of this test there is a potential that the waste will be classified as ID-27 which can be disposed of in a sanitary landfill. However, if it is not classified as ID-27 it will need to be sent to a hazardous waste landfill. The classification process would need to be followed when the spent media is being collected by a vendor for disposal. It should be noted that in New Jersey the resident generating the waste material can legally dispose of the media by placing it in the household trash.[5] However, it is recommended that the resident take the spent media to a hazardous waste drop off facility operated by their county so that the material will be disposed of properly. There is no charge for this service but it is restricted to residents, businesses are excluded.

More specifically, some of the media pose a greater disposal

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[5]NJDEPE, Hazardous Waste Regulations, NJAC 7:26-8.2

problem then others. GAC poses the largest disposal problem because GAC should be replaced once a year to avoid bacteria buildup. These frequent GAC replacements will create a disposal problem. Unlike the GAC used to treat volatile organic contaminates, the manufacturer of the carbon will not take back the GAC for regeneration. The only apparent option for the GAC would be to place it in a landfill. Other options for the disposal of KDF beside landfilling include recycling. The manufacturer, ORC Inc., indicated that the spent KDF is bought as a commodity by recyclers. Disposal options for the resins also include recycling the mercury by "retorting" the resin which will separate the mercury from the resin. The cost for retorting mercury bearing waste is approximately $300 per cubic foot.[6]

The following charts present the Pros and Cons that were identified for each of the media evaluated.

GRANULAR ACTIVATED CARBON
PROS: 1. Good average removal efficiency: 95.59% 2. Will also remove volatile organic contaminants 3. Relatively simple to implement 4. Installation cost: $500-$800/single tank
CONS: 1. Anticipated theoretical life is unknown 2. Removal mechanism is not completely understood 3. Will need to be disposed of in a landfill, regeneration is not an option 4. Carbon should be rebedded once a year due to bacterial growth; frequent rebedding may lead to disposal problems. 5. Potential for bed mixing if system is backwashed

[6]Barbara Sauer, Mercury Refining Co., Inc., Latham NY. Correspondence, January 3, 1991

KDF-55
PROS: 1. Good removal efficiency: 95.53% 2. Can potentially be recycled and the mercury recovered 3. Unit cost installed $500 to $800/unit
CONS: 1. Anticipated theoretical life is unknown 2. Will dissolve in acidic water 3. May add elevated levels of zinc to the water, depending upon the pH 4. Limited field experience with applications of KDF 5. Potential for bed mixing if system is backwashed

STRONG ACID CATION RESINS: C-249 & C-105
PROS: 1. NONE
CONS: 1. Not effective for removing mercury

WEAK ACID CATION RESIN: SR-4
PROS: 1. Good average removal efficiency: 97.13% 2. Theoretical life: 1 cubic foot could treat 2.9 million gallons 3. The mercury can potentially be recovered and recycled
CONS: 1. Is not yet approved by the FDA 2. Potential for bed mixing if system is backwashed 3. Would require pretreatment to remove hardness to prevent fouling

MERCURY SELECTIVE RESIN S-920
PROS: 1. Good average removal efficiency: 96.79% 2. Theoretical life: 1 cubic foot could treat 2.9 million gallons 3. The mercury can be recovered and recycled
CONS: 1. Is not yet approved by the FDA 2. Potential for bed mixing if system is backwashed

STRONG BASE ANION RESIN ASB-2
PROS: 1. Good average removal efficiency: 95.11% 2. Theoretical life: 1 cubic foot could treat 2.9 million gallons 3. The mercury can be recovered and recycled 4. Installation cost: $500 to $800/unit
CONS: 1. Will lower the pH by approximately one pH unit 2. A pH adjustment system will probably need to be installed 3. Potential for bed mixing if backwashed 4. Would require pretreatment to remove hardness to prevent fouling

WEAK BASE ANION RESIN AFP-329
PROS: 1. Good average removal efficiency: 96.43% 2. Commonly available 3. Theoretical life: 1 cubic foot could treat 2.9 million gallons 4. The mercury can be recovered and recycled 5. Will not reduce the pH of the treated water 6. Installation cost: $500 to $800/unit
CONS: 1. Potential for bed mixing if backwashed 2. Would require pretreatment to remove hardness to prevent fouling

See Attachment #20 for a summary of the media ratings in reference to the criteria used for evaluation.

ATTACHMENT 20

EVALUATION SUMMARY							
MEDIA FACTOR	GAC	KDF	C-105	SR-4	S-920	ASB-2	AFP-329
REMOVAL EFFICIENCY *	A	A	U	A	A	A	A
FDA APPROVED *	A	A	-	U	U	A	A
LONGEVITY *	UK	UK	-	A	A	A	A
DISPOSAL *	U	A	-	A	A	A	A
ENVIRONMENTAL IMPACT *	U	A	-	A	A	A	A
COST	A	A	-	A	A	A	A
O & M	U	A	-	A	A	A	A
SIDE EFFECTS	ND	D	-	ND	ND	D	ND
OVERALL	U	A	U	U	U	A	A

* - CRITICAL FACTORS
A - ACCEPTABLE
U - UNACCEPTABLE

UK - UNKNOWN
D - DETECTED
ND - NOT DETECTED

Based on the information presented, the following media were rejected.

GAC
C-105/C-249
SR-4
S-920

The media that were acceptable for removing mercury and did not present any major difficulty with their implementation were KDF, ASB-2 and AFP-329. Whoever, it should be noted that both KDF and ASB-2 did have some noncritical drawbacks. These draw backs are listed below.

KDF:
1. There is a potential that the KDF will dissolve in a low pH water and the mercury that was trapped on the KDF would be release into the water.
1. KDF adds zinc to the finished water.
2. Insufficient information is available to calculate the maximum theoretical amount of mercury that can be removed using KDF.

ASB-2:
1. The resin reduces the pH of the treated water, thus a post treatment pH adjustment system may be required which will increase the cost of the total system.

B. SELECTED MEDIA

Based on the conditions found at the test locations, the AFP-329 weak base anion resin appeared to be the best option for the removal of mercury. The manufacturer, Sybron Chemical Inc., indicated that one cubic foot of resin could theoretically treat 2,900,000 gallons of water assuming that the raw water concentration of mercury is 20 parts per billion.[7] Using this type of resin the cost for a mercury removal system for an average household would cost approximately 39 cents per day. The assumptions and calculations which were used to derive this figure are shown in Appendix 1.

It should be noted that under different ground water conditions the use of other treatment media such as KDF or ASB-2 may be more effective and cost efficient.

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[7]Michael Keller, Sybron Chemical Inc., Birmingham NJ. Correspondence, September 26, 1991

PHASE IV - MERCURY REMOVAL SYSTEM DESIGN

A. SITE SPECIFIC MEDIUM SELECTION

In order to select the appropriate medium, the form of the mercury present in the water must be determined. Since an analytical method does not currently exist to determine the form, an alternative method of selecting a medium must be used. Through this study it was demonstrated that several types of media will reduce the concentration of mercury, however, if the form of the mercury is different, then the use of another medium may be more appropriate.

A standard procedure used by the NJDEPE to determine the best medium for mercury removal is to perform a bench test at one of the impacted wells in the contaminated area. A procedure similar to the bench test used in the study is employed to test three to four medium. Each medium is tested by running water through a point-of-use system as raw and treated water samples are taken and analyzed. Based on the results of the bench test, a medium for the specific contamination problem is selected. The bench test is one way to confirm that the form of mercury present can be reduced by the treatment medium. The risk of installing a medium which may not be effective because a different form of mercury is present can be minimized by confirming the medium's efficiency before installing a full size system.

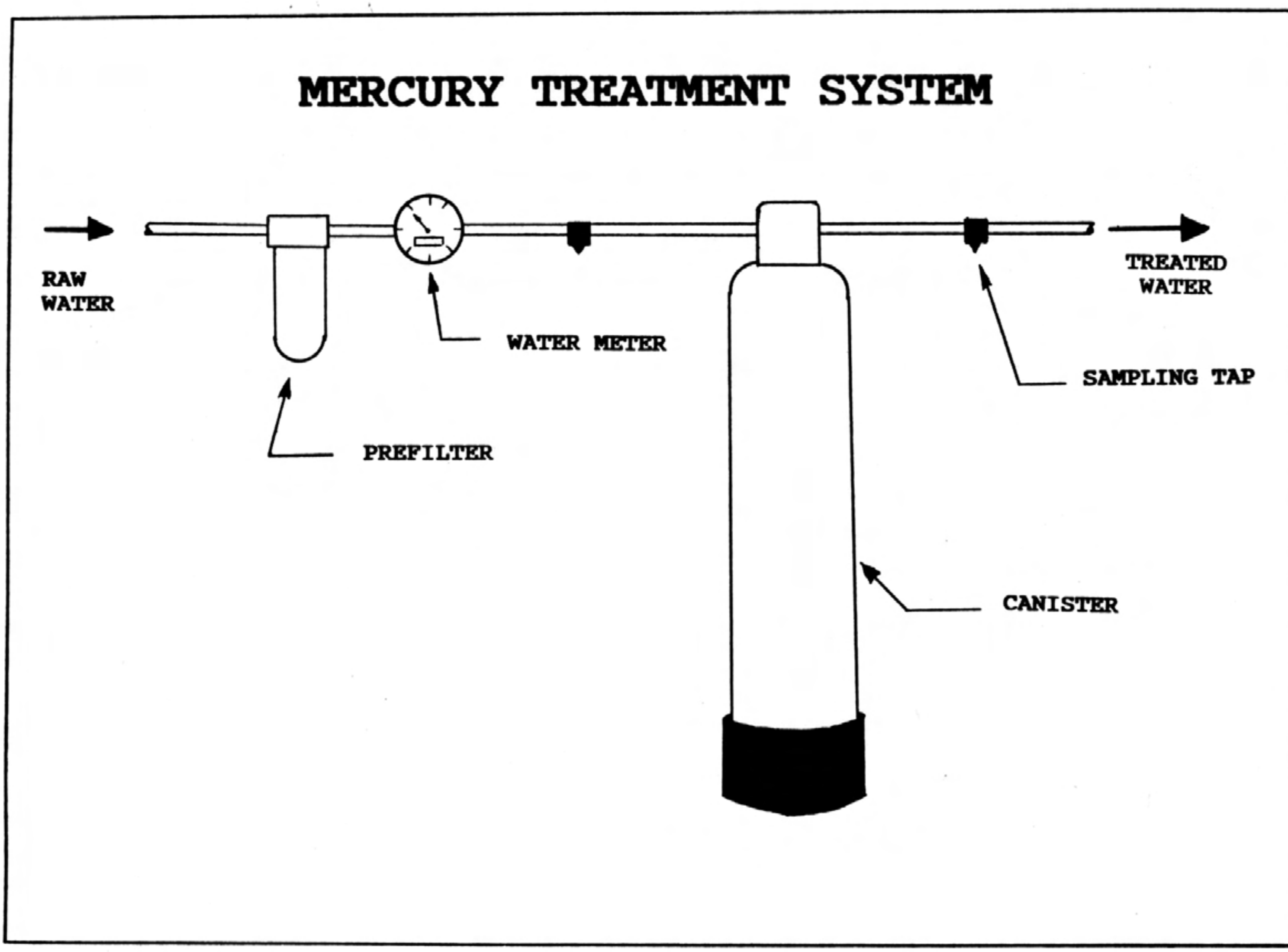
B. SYSTEM DESIGN AND SAMPLING PLAN

The system designed to remove mercury from a residential well would consist of a single tank media, a prefilter, and 2 sampling taps. If AFP-329, ASB-2, or KDF (or media with similar removal properties) is selected, the following specifications are suggested:

1. fiberglass tank 7" diameter X 40" high
2. prefilter (5 micron)
3. 1 water meter (to track water usage)
4. 2 sampling taps (for the raw and treated water)
5. 0.5 cubic feet of AFP-329 or ASB-2 or 0.33 cubic feet of KDF (or similar products)
6. water softener to prevent fouling by iron when using an anion resin
7. pH adjustment system if a strong base anion resin is used and the raw water pH is already acidic.

Attachment #21 is a schematic of a suggested mercury treatment system (optional pH adjustment system and water softener are not shown).

ATTACHMENT 21



SAMPLING PLAN

Once the unit is installed, a post installation sample should be analyzed prior to the water being used for potable purposes. The concentration of mercury in the treated water should be below the MCL of 2 ppb. When the unit is sampled, a sample should be taken from the raw water in addition to the treated water to determine the efficiency of the unit.

Regular sampling should be conducted periodically to assure that the unit is functioning properly. At a minimum, the unit should be sampled twice a year. In addition, it is suggested that more samples be taken during the first quarter of operation to closely monitor the systems operation.

OPERATION AND MAINTENANCE

Operating and maintaining the system requires that 3 tasks be performed. First, the prefilter cartridge should be replaced when a significant water pressure drop is noticed. Secondly, the unit needs to be sampled (the suggested sampling plan is presented above). The third task is to replace the media in the tank if mercury breakthrough occurs. This task should be done by a water treatment professional. In addition, if a pH adjustment system and or a water softener is installed these systems must also be maintained.

SUMMARY

The objective of the study was to identify a treatment system that could remove mercury from residential well water. Seven media were sampled and of the seven only one failed to perform. Of the remaining six media, 3 were eliminated due to a particular aspect which inhibited or prohibited their use. Of the 3 remaining media, AFP-329, ASB-2 and KDF were shown to be effective with no serious drawbacks.

This study has shown that mercury tainted water can be effectively treated by POETs. In addition, the implementation of the POETs is simple, effective and inexpensive. The cost for a mercury removal system for an average household including the purchase and maintenance would cost approximately 39 cents a day.

APPENDIX 1

POET SYSTEM ANALYSIS

ASSUMPTIONS

Number of gallons used per person	50 gpd/person
Number of people per household	4 people/house
Cost of treatment system - installed	$600
Cost of prefilters (assume 6/year)	$3.00 each
Cost of a mercury sample	$20/sample
2 mercury samples taken each year	$40/year
Safety factor (SF) for the media	2
Interest rate	8.0%

CALCULATIONS

1. Gallons treated/cubic foot of resin:
   2,900,000 gals/2 SF =1,450,000 gals/ft

2. Gallons treated by system (1/2 cubic foot):
   0.5 ft X 1,450,000 gals/ft = 725,000 gals

3. Gallons used per year per family:
   50 gpd/person X 4 people/family X 365 days/year = 73,000gals

4. Number of years the treatment system will work:
   725,000 gals/73,000 gals/year = 9.93 years

5. Present value (PV) cost of a system used for 10 years:

Item			PV Factor	Cost
system cost	$600	x	1.0	$600.00
prefilters	$18/yr	x	6.71	$120.78
water samples	$40/yr	x	6.71	$268.40
maintenance	$50/yr	x	6.71	$335.50
disposal	$200	x	0.46	$ 92.00
			TOTAL	$1,436.68

6. Cost per gallon $1,436.68/725,000 gals = 0.00198 cents/gal

7. Cost per day: ($1,436.68/10yrs) X (1 yr/365days) = 0.39 cents/day

NOTE: 1) Fouling of the resin will result in a decrease in the life expectancy of the resin.
2) If pre or post treatment is required the cost of the treatment alternatives will be higher.