

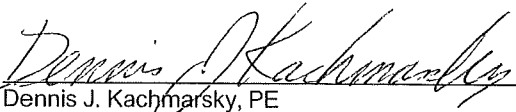
# Mount Vernon

Mount Vernon, Ohio

**Laundry Color Wash Study: Phase I**

12 March 2008

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**Laundry Color Wash  
Study: Phase I**

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## **I. Introduction**

Customers of the Mount Vernon water system have registered complaints of spotting on clothing after performing laundry for over 15 years. The first recorded complaint of this nature was June 12, 1990. Beginning in 1995, the City began collecting chlorine dioxide levels (initially speculating a connection) whenever a report was made at the residence. This spotting has been generally characterized as “splotching” and typically occurs on dark clothing.

The City has invested significant resources through a number of studies conducted to determine the cause of these incidences. There is yet to be a satisfactory resolution to this problem.

This Phase I Laundry Color Wash Study is designed to provide a technical review of the previous efforts to resolve this problem. A summary of the results of these efforts was reviewed and then compiled to develop a matrix of possible sources of this spotting. The matrix illustrates whether the analysis used to determine the spotting disproved or left unanswered a theory for the color spotting. In addition, some general observations are made from the summary results that assess the need for additional testing or identify gaps in the data. Finally, additional recommendations are made outlining a systematic approach with the goal of bringing this issue to a resolution if possible.

## **II. Summary of Previous Studies**

A brief discussion and summary of the previous studies is outlined in the following subsections in chronological sequence. Copies of the detailed information are included in the Appendices to provide a comprehensive documentation of the efforts to resolve this problem.

In order to gain a perspective of the prevalence of the spotting incidents, the City has recorded incidents of color spotting graphically on a map. This map is included in Appendix 1, and indicates that there have been isolated occurrences at extremities of the system, but the majority of spotting occurrences are clustered around the central and eastern portion of the downtown neighborhoods. This may be generally characterized as the “older” part of the water distribution system. The complete summary of the “Splotching Complaints” (color spotting) compiled by the City is included in Appendix 1.

Observations about the locations of the complaints could indicate that age of the system and associated piping materials may be contributory factors. But this is not conclusive as there are many other “older” system areas with few complaints.

**Oxidizable Substances Analyses** – Samples at five city locations including the Water Treatment Plant Tap were analyzed by the Belmonte Park Environmental Laboratories in July 2000. The results are shown in Appendix 2 and indicate that no oxidizable substances were detected in any of the samples.

**Drinking Water Research Group Study** – A Canadian study was performed on the effects of various concentrations of ClO<sub>2</sub> (chlorine dioxide) on clothing, was published in August 2000 and is included in Appendix 3. Dark clothing was used and no discoloration of clothing occurred through ClO<sub>2</sub> concentrations from 0.06-0.66 mg/L. However, at concentrations between 0.8-1.0 mg/L, two out of eight clothing samples showed evidence of splotching. As shown in Appendix 3, concentrations of ClO<sub>2</sub> do not exceed 0.60 mg/L at the Water Treatment Plant Tap and are typically much less in concentration in the distribution system.

**Burgess & Niple Study – Part 1 and Part 2**–Burgess & Niple (B&N) reported that it took concentrations at levels of nearly twenty times the Plant Tap strength of ClO<sub>2</sub> to produce bleaching on fabrics they tested in September 2000. This confirmed that the plant water was unlikely to be the cause unless “plugs” of bleach escaped the plant – a highly unlikely occurrence. It was suggested that laundry products in combination with the water may be the cause or laundry products alone may be the source of bleaching. Other than verifying that the ClO<sub>2</sub> concentrations had to be much higher than the Plant Tap concentration, there was nothing else conclusive.

An additional theory was proposed in the January 2002 letter report that suggested aeration that occurs from top loading washers could cause free chlorine to come out of solution and then being trapped under the washing machine lid, potentially splotching any protruding fabric. This theory was put forth without any supporting evidence and no subsequent evaluation or analysis was performed to support this theory.

The B&N report is included in Appendix 4.

**Vulcan Memo** – This chemical manufacturer documented in April 2002 that the bleaching effect on denim does not occur until ClO<sub>2</sub> concentrations are 3 mg/L or greater, which concentrations are multiples greater than the distribution levels. This letter report can be found in Appendix 5.

**Nazarene College Study** – Two chemistry students from the local Nazarene College worked with City staff to perform bleaching tests on hunter green bath towels at various concentrations of  $\text{ClO}_2$  in May 2002. They reported no bleaching until concentrations reached 3.0 mg/L and concluded that the concentration would have to be eight times the maximum plant concentrations of  $\text{ClO}_2$  for bleaching to occur. This report is included in Appendix 6.

**Potable Water Analytical Report** – A test for metals and volatile compounds was performed on water samples taken February 5, 2003 at 1550 Old Delaware Road of the potable water. As shown in Appendix 7, no concentrations exceeded the reporting threshold limit.

**Spotting Problem Scans and Comparisons** – In May and August 2003, grab samples of City water were taken at different locations to be analyzed for semivolatile and volatile organics. The sampling locations varied and included a personal residence outside the City, a City raw water well, the Plant Tap and a raw water sample from the City of Fredericktown. The purpose of this testing was to compare City of Mount Vernon water to other community waters. All results were well below reporting threshold limits and further analysis in an attempt to identify other unusual characteristics typically unreported revealed nothing. Appendix 8 includes this data.

**Proctor & Gamble (P&G) and Water Plant Tap Study** – Proctor and Gamble conducted product (fabric) testing on damaged clothing from residents to determine if this could be a possible source as reported in correspondence dated from May 2002 through November 2003. At their request, the City also analyzed samples from the water Plant Tap in November 2003.

Bleach was eliminated as the problem as microscopy revealed no damage to the fabric integrity. Fabric brightener was also eliminated as a cause due to its deposition methodology rather than “stripping” dye from fabric. Sulfur dye testing revealed that damaged clothes from residents did not have clothing made with sulfur dyes which could produce a bleaching effect by a reducing agent. There was nothing in the analysis of the Plant Tap water that raised any concern to the P&G chemists. This report is in Appendix 9.

**OEPA Letter** – A November 25, 2003 letter from the Ohio EPA recognized the concern of a number of residents about the color spotting problems but went on to affirm that City water quality meets or exceeds regulatory standards. This letter is located in Appendix 10.

**Colored Rag Test** – In March 2004, test results for a blue rag, a mauve rag and a green rag were conducted to determine if there were any volatile compounds, base neutral compounds or acid compounds in them that were above reportable limits. None were found that would provide any reason for reactivity in the fabrics to cause bleaching. These test results are provided in Appendix 11.

**General Information** – Various articles and items of interest from newspaper columns to website resources have been collected in relation to this problem. These have suggested various causes of splotching including the use of household laundry detergents and laundry aids. Information from manufacturers would indicate that their products are designed to perform over the typical ranges for alkalinity and pH experienced in typical household waters. There is nothing to suggest from the water samples collected or the products tested that there is a splotching effect due to the chemistry between the water and the laundry aids.

It has also been suggested that fabric characteristics have been changing, possibly causing materials to be less colorfast. EPA regulations have also been named as a possible culprit because of limiting the number of rinses dyed fabric is allowed to receive in the manufacturing process and therefore having clothes “fade” more quickly. Anyone of these could be a partial reason for some splotching effect, but none explain the pervasive nature experienced by City residents. A collection of some of these items is included in Appendix 12.

**III. Matrix of Theories**

In order to determine the validity of some of the theories proposed, a matrix outlining the theories disproved or still viable are summarized as follows. The classification of “still viable” does not imply an affirmation that the theory is valid, only that there may be a possible connection.

Matrix of Theories			
Theory	Not Viable	Still Viable	Comment
Older piping and plumbing materials may be contributing factors		√	Locations of complaints generally occurred in older neighborhoods (even when considering the relative density of housing), and fewer in outlying “newer” areas
Oxidizable substances in water system	√		July 2000 analyses

Matrix of Theories			
Theory	Not Viable	Still Viable	Comment
Chlorine Dioxide	√		Canadian study, B&N study, Nazarene College study all indicated that bleaching occurs at much higher concentrations of ClO <sub>2</sub> than is found in potable water
Metals, volatile and semivolatile organics may react with laundry products or tap water	√		None of the levels exceed threshold reporting limits
Bleach or fabric brightener may react with potable water	√		P&G Study verified this is not the case
Clothing contained sulfur dyes or fabrics not as colorfast due to overseas production methods		√	Although none of the samples P&G tested had sulfur dyes, some clothing damaged may have sulfur dyes and be a partial explanation for some splotching; also, insufficient colorfastness of some clothing cannot be totally ruled out

**IV. Observations from Surveys**

In review of the surveys collected by the City, some very general observations may be made, but caution must be exercised before drawing any conclusions. The surveys are in response to spotting incidents and are subject to the interpretation of events by the homeowner. However, the following are a few generalizations.

- Affected homes tend to be older homes – more than 20 years in age and most in the 80 to 100+ age category
- Copper plumbing predominant with some galvanized; very little plastic plumbing
- Dark and cotton (or high cotton content) clothing seem to be the most affected; synthetic material does not appear to be impacted by splotching
- Not every clothing item affected in a wash
- Water temperature does not seem to make a difference
- Many claim a strong chlorine odor at times



- At least two incidences were claimed of spotting on clothes in a sink under a dripping faucet

**V. Identified Analyses Gaps**

In reviewing the studies and the surveys, there are a few things that have either not been examined or may need further analysis. The following are for consideration.

**Examination of the Piping Materials of the Distribution System** – The focal point of the complaints appears to center around the historic downtown of Mount Vernon which is generally served by a series of four-inch and six-inch diameter distribution piping. By the age of the homes, many of which are over one hundred years old, it is probable that much of this pipe is sand cast iron or cast iron and very likely unlined. The condition of the pipe walls may be very different than the newer portions of the system which have lined piping. The same may be true of the service connections which may be of other materials no longer used such as galvanized piping. It is recommended that coupons of the distribution system piping and service connections be examined in representative areas to determine the condition of the piping and then have tubercles from the coupons analyzed for content. East Vine Street was one potential area mentioned for this materials testing. A galvanized piping service lateral is suggested for testing. It may be possible to obtain the service lateral material sample from inside a customer's home.

**Review of Water Treatment Plant Stability** – What may be considered “stable” and not causing corrosive issues in lined or PVC piping may be slightly corrosive and attack unlined piping. In addition to examining the softening and recarbonation targets at the water treatment plant to determine relative stability, it is also recommended that an Alkalinity Profile be developed. One profile should be in the historic areas with sampling from the four and six-inch diameter distribution system piping and one or two other Alkalinity Profiles should be developed simultaneously in an area of town where there has not been the laundry spotting problems. If the alkalinity increases, this would be an indication that the pipe wall is having CaCO<sub>3</sub> removed (corrosive) which could release localized mineral deposits. If the alkalinity decreases, then the water is in a scale forming mode (non-corrosive).

## **VI. Recommendations**

There is no apparent solution to the laundry splotching problem since the cause(s) has yet to be identified. However, to narrow the knowledge gap about this issue and possibly get to the answer, there are some additional evaluations recommended as follows.

**Examine Piping Materials in Historic Area** – It is recommended that coupons of the distribution piping and service connections be examined from representative areas to determine the condition of the piping and have tubercles from the coupons analyzed for content.

**Review Stability of Water** – Examine the treatment plant targets used to maintain stability and perform an Alkalinity Profile in both the historic area of town and in an area that has not had laundry splotching complaints.