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Madame John's Legacy
Pilot Project to Develop a Treatment Protocol for Salt Damaged Brick Masonry Resulting from Rising Damp

FINAL REPORT

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EXECUTIVE SUMMARY

The following report represents the culmination of a pilot conservation project focused on the ground floor brick masonry at Madame John's Legacy. The intention of the project was to develop a means to reduce the high concentration of salts from a section of wall while also removing the source of salts and moisture—the rising damp. The pilot project consisted of three elements: installing a physical damp proof course in the wall, wetting one side of the test wall with an irrigation system, and poulticing the opposite side. A full description of the materials and methods used can be found within the following report. Results of the pilot project revealed that the tested method is successful at removing a significant amount of salts, but the treatment protocol should be modified in a number of ways to improve results. The suggested modifications are discussed in the *Conclusions* section of this report.

Several valuable lessons were learned from the pilot project and important information was gleaned from the project that can be potentially be applied at other sites. For instance, the pilot project found that wetting the wall on one side with continuous irrigation appeared to be successful in driving the salts from the wetting side through the wall to the poultice side. This method can be an effective way to remove salts from the core of a wall. However, it also found that environmental conditions within the space significantly impacted the drying rate of the poultice, which reduced the salt diffusion into the poultice. The high relative humidity (RH) during most of the project duration resulted in limited salt diffusion to the poultice. The favorable environmental conditions at the end of the project increased the effectiveness of the poultice, resulting in a nearly 20% (by weight) of salt in the poultice material at the end of the treatment. Results would likely be improved if the treatment was performed during periods of RH below 65%. The project also provided evidence that the impermeable repair mortars are significantly contributing to the deterioration of the historic materials by forcing salts into the more permeable brick. The full report includes a summary of recommended modifications to the treatment protocol, as well as general considerations about the pilot treatment and recommendations for Madame John's Legacy in particular.

The results and conclusions are based on limited analysis of samples during the project implementation. The full effectiveness of the damp proof course cannot be determined until the irrigation system moisture has evaporated, a condition that will continue to be monitored after the close of this project. In addition, the final testing found that salts do, in fact, remain in the wall. The effect of the treatment and the potential redistribution of salts as a result of the treatment will not be fully understood until the wall has dried.

1.0 INTRODUCTION

One of Louisiana's most distinguished historic structures and a National Historic Landmark, Madame John's Legacy is currently exhibiting severe brick masonry deterioration at its ground floor due to salt damage associated with rising damp (Appendix A, Image 1). The current project was undertaken to better understand the deterioration mechanisms at work and to develop a practical treatment for the deterioration. Severe deterioration of historic masonry due to absorption of salt-laden groundwater is pervasive throughout the United States, but few effective treatment options address both the reduction of rising damp and the comprehensive removal of soluble salts. This project developed such a two-pronged strategy and implemented it in a pilot project at Madame John's Legacy.

This current project builds upon research performed by The Getty Conservation Institute in 2008 and the Tulane University Master of Preservation Studies Program in 2013. The goal of the project is to address the fundamental problems identified in both studies: rising damp and the gradual concentration of soluble salts within the wall core over time. The novel two-part process proposed for the pilot project reduces available saline moisture for rising damp with a damp-proof course and dilutes residual salt concentration by simultaneous saturation and poulticing of the wall from opposite faces. This coordinated treatment could resolve the issue of isolating rising damp in historic walls without incurring salt damage.

Following a summary of the building's history and the project goals, this report describes the implementation and results of the pilot treatment. At the end of the report is a summary of "lessons learned" regarding the pilot treatment and its potential for use elsewhere, as well as some recommendations specific to Madame John's Legacy. Information in this report will also be available on the project website, which will be maintained following the completion of the project.

The project was sponsored by the Louisiana Museum Foundation on behalf of the Louisiana State Museum and funded through a "Preservation Technology and Training Grant" from the National Center for Preservation Technology and Training. The project team included: Greg Lambousy, Director of Exhibits for the Louisiana State Museum; Michael C. Henry of Watson & Henry Associates; Dorothy S. Krotzer and Marlene Goeke of Building Conservation Associates, Inc.; and Michael Shoriak and Courtney Williams of Cypress Building Conservation.

1.1 Brief History Of Madame John's Legacy

Madame John's Legacy is located at 632 Dumaine Street in the Vieux Carre. Dating from 1788, Madame John's Legacy is the oldest residential structure in the French Quarter. When it was built, it replaced and essentially replicated a previous building that was lost in the great New Orleans fire of 1788. Recent archaeological excavations performed by D. Ryan Gray of the University of New Orleans have documented that portions of the brick foundation were re-used as part of the reconstruction, making portions of the ground floor even earlier.[1]

Because it was built in imitation of a much earlier building, it looks slightly out of place with its neighbors, which are typically two or three-story brick townhouses and one-story shotgun

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[1] Gray, D. Ryan, et al. *Archaeological Test Excavations in the Interior of Madame John's Legacy (16OR51), Orleans Parish, Louisiana*. University of New Orleans, Department of Anthropology: December 2014.

houses dating to the early- and mid-19th century. Madame John's Legacy features a raised brick basement flush with the sidewalk and a deep front porch running lengthwise with the street (Appendix A, Image 2). Its second floor is composed of wood framing and "brick between post" construction. It also has a large, hipped roof with two small dormers. It is more reminiscent of the 18th century French-Creole plantations that dot the rural levees of the Mississippi River outside of town, than of the typical urban dwellings in the French Quarter.

The building was used as a house with a series of owners throughout the 19th century, and was divided into apartments in the mid-19th century. In 1947, the building was donated to the Louisiana State Museum (LSM). The building is currently open and free to the public, and is used by the LSM for exhibitions and modestly-sized special events.

Madame John's Legacy has undergone multiple restoration and repair campaigns in the 20th and 21st centuries. The most notable include restorations by Richard Koch in 1948, Monroe Labouisse in 1971-72 and NY Associates in 1997-98. Comprehensive documentation of the building's history, including all previous restorations, was included in the 2013 *Madame John's Legacy Technical Conservation Study* prepared by the Tulane University Master of Preservation Studies Program.

The 2013 *Technical Conservation Study* also documented the construction of the ground floor masonry. By performing a series of through-wall cores, it was documented that the interior walls are three bricks (wythes) thick and the front wall is four wythes thick. The centers of the cored walls are typically composed of the original earthen mortars which are intact (i.e., the brick and mortar are fairly well-bonded to each other).

Both the brick and original mortar materials were documented through petrographic analysis. The brick analyzed (believed to date to 1788 or earlier) was identified as being low-fired and excessively permeable, making it highly susceptible to water infiltration through capillary action. Its primary ingredients (silt particles and clay) are only loosely bound together, and therefore have poor tensile strength.

The original mortar was also analyzed. It was identified it as a "lime-stabilized" earthen mortar, which is simply a mortar composed of soil with lime added to it to strengthen the mortar. The silt in the soil provides the aggregate and the clay provides an additional binder. It is a soft, permeable mortar that is highly porous.

Both the brick and mortar have characteristics that help to explain the deterioration processes visible on the building. The high permeability of the brick promotes the absorption and wide distribution of salt-laden moisture from the ground. In addition, the lack of adequate cohesion within the bricks themselves, due to the sparse amount of clay coating the silt particles, results in a brick with poor tensile strength. The lack of cohesion and tensile strength makes the brick at Madame John's Legacy susceptible to the pressures created through the hydration and crystallization of salts, which results in the extensive loss of material visible throughout the ground floor. Like the brick, the original earthen mortar is highly permeable and readily absorbs moisture. The combination of a permeable mortar and a highly permeable brick results in a particularly absorptive masonry assembly.

1.2 Project Description

1.2.1 Definition of the Problem

Recent research on the severely deteriorated brick masonry ground floor walls at Madame John's Legacy indicates the damage is due to salt-laden moisture being absorbed by the walls from the ground. The brick walls are in direct contact with soil, which contains both nitrate and chloride salts. The uninterrupted absorption of moisture from the soil over many decades has resulted in the accumulation of extremely high concentrations of salt in the brick throughout the depth of the walls. The high permeability of the historic brick and the original lime-stabilized, earthen mortars facilitates the rising damp. Subsequent incompatible repair materials—including high-fired brick and impermeable Portland cement-based mortars, as well as the installation of a concrete sub-pavement with moisture barrier—have exacerbated the problem. In addition, the environmental conditions within the building are conducive to deterioration as the salts move in and out of solution due to the fluctuating relative humidity.

Deterioration of the masonry is ongoing and very visible to anyone entering the ground floor of Madame John's Legacy. Salts and moisture continue to wick up into the walls and the hygroscopic salts in the wall hold and absorb moisture from the air. Therefore, the problem is both salts and moisture, and both work together during the hydration/drying processes to cause deterioration. It is important that any future treatment addresses the sources of both problems. An ideal remedy to prevent future deterioration would involve the elimination of both factors simultaneously.

1.2.2 Concept and Goals of the Project

This project aimed to reduce rising damp while, at the same time, diluting and removing the high concentrations of salt from the depth of a test wall at Madame John's Legacy. Simultaneous wetting and poulticing were expected to eliminate the cause of the salt deterioration (salts and rising damp) while avoiding the risk of salt crystallization within the wall as it dries out, preserving as much of the historic brick as possible.

There were three key elements of the pilot treatment:

- Damp proofing: Damp proofing was implemented to cut off the source of moisture and salts from the bottom, to prevent future contamination of the wall from salts in the soil, and to limit the sources of moisture.
- Wetting: Wetting with non-saline water presented two potential benefits – the first is that following installation of the damp proof course, the wall would remain wet and the salts would stay in solution, reducing the potential for any damage caused by drying the salt-laden brick. The second potential benefit is that the wetting water would move through the wall, drying out the other side, theoretically pulling salts with it. Wetting, it was assumed, should help speed up the salt extraction by encouraging moisture and salt diffusion through the depth of the wall and out to the poultice material.
- Poulticing: Applying a poultice to the opposite side of the wall was expected to draw moisture and salts out of the wall. The application of water and poultice to the wall's opposite sides should enhance the removal of salts within the core of the wall by encouraging moisture diffusion through the entire width of the wall.

While not a part of the pilot treatment *per se*, removal of inappropriate repair materials is a vital step for the preservation of historic materials and particularly for the materials in the walls at Madame John's Legacy. Moreover, it is important to have a permeable mortar if there are any salts left in the wall after the pilot treatment to encourage continued moisture movement and salt diffusion. Therefore, as part of this project, the wall was repointed with a compatible, permeable mortar at the end of the treatment.

2.0 METHODS AND MATERIALS

2.1 Project Design

2.1.1 Selection of Materials

Damp Proof Course

Damp-proof courses create an impermeable barrier between the walls of a building and the ground to prevent the uptake of water from the soil in rising damp. They are located near or at grade, below the interior floor, and are typically installed during the construction of the wall. A damp proof course can be retrofitted to an existing wall.

A wide variety of physical barriers can be used as damp proofing. These include both flexible and rigid materials, such as: metals like lead and copper; bituminous felts; heavy plastics; stone materials, like slate; and impervious bricks. To retrofit a wall, a physical damp proof course can be inserted into a slot cut into the wall, or, if it is not possible to cut into the wall, it can be partially dismantled in sections and rebuilt on top of the new damp proof course.

In addition to physical barriers, chemical barriers can be used as damp proofing. Typically made from siliconates, silicone or stearates, these chemicals act as water repellents in the masonry. They are injected into a series of holes drilled into the base of the wall and cure to create a water-repellent layer within the existing masonry. Chemical damp proof courses are more typically used to retrofit an existing wall.

There are advantages and disadvantages to both types of barriers. The advantage of a chemical damp proof course is that it is usually easier to install, so it is often more efficient and inexpensive than a physical damp proof course. However, because the chemical is being injected into holes in the wall, there is a risk that a continuous barrier has not formed. If there are large voids or discontinuous spaces within the wall, the chemical won't adequately migrate through to create the barrier layer. In addition, chemical damp-proofing is not reversible, and a wall saturated with a chemical is unlikely to be retreatable.

While physical damp proof courses are more difficult to install in an existing wall, the continuity of the moisture barrier created usually can be visually confirmed. In addition, it is possible to remove them later, or replace them with a new material if required. For these reasons, a physical damp proof course of slate, a traditional damp proofing material for the region, was selected for the pilot treatment at Madame John's Legacy.

Wetting Method

The best way to keep the wall wet throughout the pilot treatment was also considered. It was essential to have a continuous supply of water to ensure that the entire wall remained wet. Monitoring the water consumption of the wall could provide evidence that the moisture was drying out the poultice side, even if the poultice appeared saturated. For practical reasons, it was desirable that the system was relatively hands-off so it could be left for several days or a week at a time. The ability to use distilled water rather than tap water was important to ensure that additional impurities were not being added to the wall.

Several wetting methods were considered. One option was to mist the wall periodically with a system of pipes and nozzles, but there was concern about containing the spray and containment of the run off. Tubing, such as that used for drip irrigation systems, was another option. The benefits of tubing are that it is flexible and can be easily customized. It comes in a variety of sizes and there are a number of accessories available to create a custom system. In addition, it was available at a local hardware store. The tubing could then be gravity-fed from water tanks holding distilled water placed above the height of the wall. In this study, polyethylene drip tubing (1/4") was used to create the continuous wetting system.

Use of a membrane was also explored to hold the moisture on the wall and contain any bulk water. The membrane needed to be flexible so it could be pressed up against the wall to ensure contact. Ideally, the membrane would be absorptive and stay evenly moist but wouldn't dry out the back. It also needed to be durable so that it would stay in place for the project duration.

A wet-curing blanket, Ultra Cure NCF, was selected for the pilot treatment. These blankets are used to wet-cure concrete. Ultra Cure NCF is made from a highly absorptive, natural cellulose fabric and an impermeable polyethylene backing and is intended to keep concrete moist for up to seven days after installation without additional water. Each square foot of the fabric side is able to hold a half a cup of water against the surface of the wall. An added benefit was that the polyethylene backing and fabric were not fully fused together, so that there were pockets between the two, through which the irrigation tubing could be run.

<u>Poultice</u>

The application of poultices is a commonly used method for desalination. Poultices are made from hydrophilic materials and are applied wet to dissolve salts at the wall/poultice interface and pull them into the poultice material.

Poultices function through two physical processes: diffusion and advection. In diffusion, the poultice is kept wet and salts are drawn into the poultice material because of the differences in ion concentration between the material and the poultice. This slow process can take months. In advection, the poultice is allowed to dry, which draws the salts into the poultice. Depending on the drying conditions, this process can take a few days to a few weeks. Poultices are usually applied multiple times to fully extract the salts. Since poultices work at the surface of materials, it would take many applications over a long period of time to remove salts from the interior core of a wall, particularly at the levels previously found at Madame John's Legacy.

There are many factors to consider when choosing a poultice, including: pore size and distribution; porosity of both the substrate and the poultice material; the adhesion of the poultice to the substrate; and the amount of water introduced by the poultice. Selection of a material to use as a poultice will vary based on the substrate, environmental conditions, and amount of salt in the wall.

The previous study by the Getty evaluated the efficacy of several different types of poultices. Because the focus of this treatment was to evaluate the use of a poultice in combination with the wetting and damp proof course installation, it was important to select a poultice that was known to be effective. Westox's Cocoon, a commercial poultice made from pharmaceutical grade filter paper, was one of the more effective poultices during the Getty treatment and was selected for the pilot treatment.

The Getty researchers had also found that leaving the poultice on for an extended period of time (six months) resulted in the extraction of a significant amount of salts as the poultice slowly dried in the high humidity. However, it was unclear how the saturation (wetting) of the wall that was part of the current project would affect the ability of the poultice to draw salts during the pilot treatment. There was also some concern about the potential for reverse migration of the salts back into the wall from a saturated poultice if the poultice remained on the surface for an extended period of time. Therefore, two methods were tested: periodically removing the poultice throughout the project (discussed below as "Section A" of the wall) and leaving the poultice on for the entire project duration ("Section B").

2.2.1 Monitoring the Process and the Results

Salt Removal/Testing Protocol

The project team developed a salt testing protocol to monitor the efficacy of the poultice throughout the duration of the pilot project and to help determine when the poultices should be removed. The testing protocol varied between Section A (periodically-removed poultice) and Section B (long duration poultice).

Poultice samples (2" by 2" squares) were removed from the wall at three different heights for both Section A and Section B. These heights – 1' 6", 3' 2", and 5' 3" – correlated with initial sample locations and the core locations of the previous study. Samples were removed from the Section A poultice each time it was removed and replaced with new poultice material. Samples of poultice were removed monthly from Section B.

For Section B, the long duration poultice, two samples were removed from each height each month. Both sample locations were replenished with new poultice material. The "a" series of samples was taken in the same location for the project. The "b" series of samples was taken from a new location along the same height. It was known that the materials in the wall varied, and that that variation affected permeability of materials, and consequently, the salt concentration. Since the "a" series samples were taken from the same location, that variability would be reduced as the samples were being removed from the same brick/mortar each month. For the "a" series, it was expected that the salt quantity in the sample would decrease over time as new, clean poultice was being applied each month. Since there was risk of lateral migration of salts through the poultice, the "b" series was also taken at the same time. For the "b" series, it was expected for the salts in the sample to increase. The "b" series ran the risk of the samples occurring over disparate materials that would affect the underlying salt content.

The poultice samples were analyzed using Quantofix strips, which are semi-quantitative test strips used to analyze for particular ions. Since previous research had shown the presence of chlorides, nitrates and sulfates, the analysis focused on these three ions. The analysis of the poultice samples was performed as follows:

1. Samples were dried to a constant weight.
2. Samples were placed in distilled water to dissolve the salts and create a solution. Weights and volumes were kept constant so results could be compared from month to month.
3. An aliquot of the solution was taken to perform the test. The amount removed was constant throughout the testing so results could be compared.
4. Test strips were dipped into the solution and quantity of ions in mg/L was recorded.

5. Results were graphed from each testing method each month to determine the rate of salt extraction.

Environmental

Exterior Climate

The exterior climate at Madame John's Legacy may be characterized by published data from the National Climate Data Center for the New Orleans Naval Air Station (29.83N, 90.03W), located approximately five miles south. The NCDC statistics are based on data collected between 1973 and 1996 and reflect the latest available version of the Engineering Weather data:

- Summer median extreme high temperature: 96°F, 128 grains moisture/pound dry air;
- Summer 1.0% occurrence, high temperature: 92°F, 125 grains moisture/pound dry air;
- Summer median extreme high humidity ratio: 90°F, 183 grains moisture/pound dry air;
- Summer 1.0% occurrence, high humidity ratio: 84°F, 151 grains moisture/pound dry air;
- Winter median extreme low temperature: 24°F, 22 grains moisture/pound dry air;
- Winter 99.0% occurrence, low temperature: 33°F, 30 grains moisture/pound dry air;
- Median daily dry bulb temperature range: 18°F;
- Freeze-thaw cycles: 10 per year;

The average monthly dry bulb temperature, dew point temperature, and precipitation are shown in Figure 1, below.

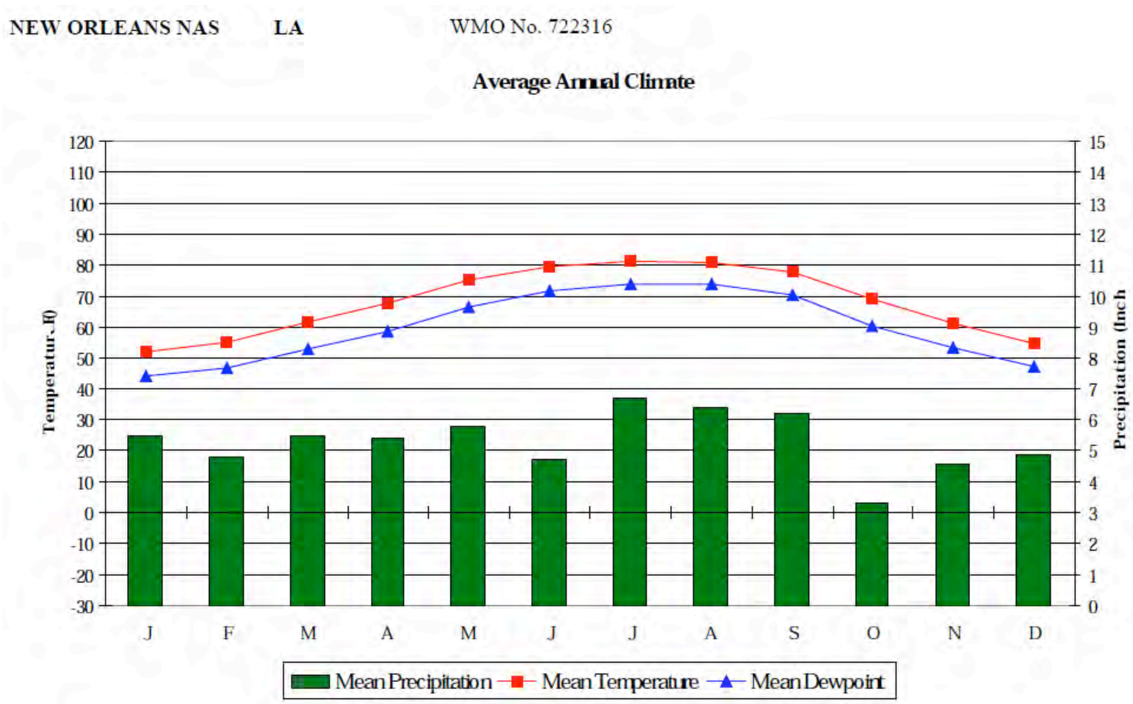

Figure 1: Average Annual Climate, New Orleans, Louisiana

The exterior climate is classified as International Climate Zone 2A, Hot-Humid. Seasonally, the climate may be characterized as having six months of cooling and dehumidification (May through

October), four months of heating and occasional dehumidification (December through March) and two transition months dominated by dehumidification with occasional heating (May and November).

On a degree-day basis, sensible cooling loads dominate from May through October, and are 1.7 times annual sensible heating loads. With respect to infiltration air, cooling loads dominate May through October, with about 84% of the total cooling load from infiltration being attributable to dehumidification (to 60% RH). About 6% of the total annual heating load from infiltration is attributable to latent heating (humidifying to 30% RH).

Interior Climate

The first floor of Madame John's Legacy is conditioned with a heating, ventilating, and air conditioning (HVAC) system. On the ground floor, a thermostat and grilles for air supplies and returns indicate that the ground floor spaces were once conditioned by the HVAC system. However, museum staff reported that the ground floor system was not operated during the pilot project period.

Comparison of interior and exterior dew point temperatures for the pilot project duration strongly suggests that the interior temperature and dew point conditions at the ground were influenced by HVAC systems elsewhere in the building, particularly during summer, when dehumidification is an incidental consequence of cooling. The trend plot in Figure 2, below, indicates exterior dew point temperature.[2] For comparison, the trend plot in Figure 3 indicates interior dry bulb and dew point temperature in the ground floor during the same period.

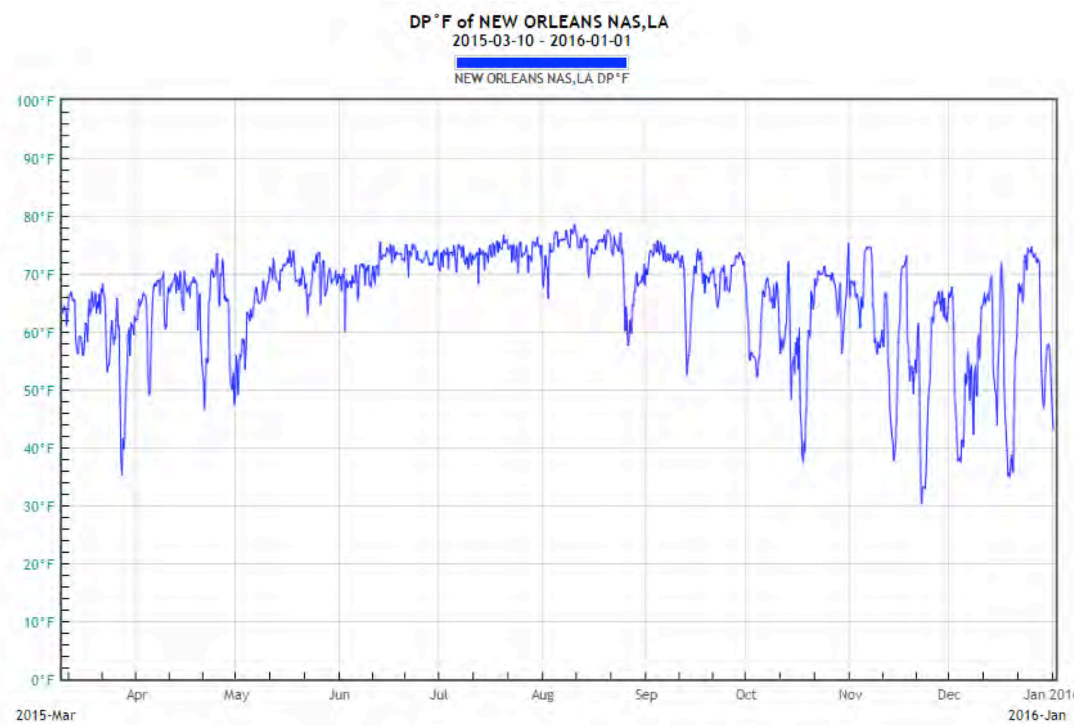

Figure 2: Dew point temperature (exterior), New Orleans, Louisiana

[2] https://www.eclimatenotebook.com

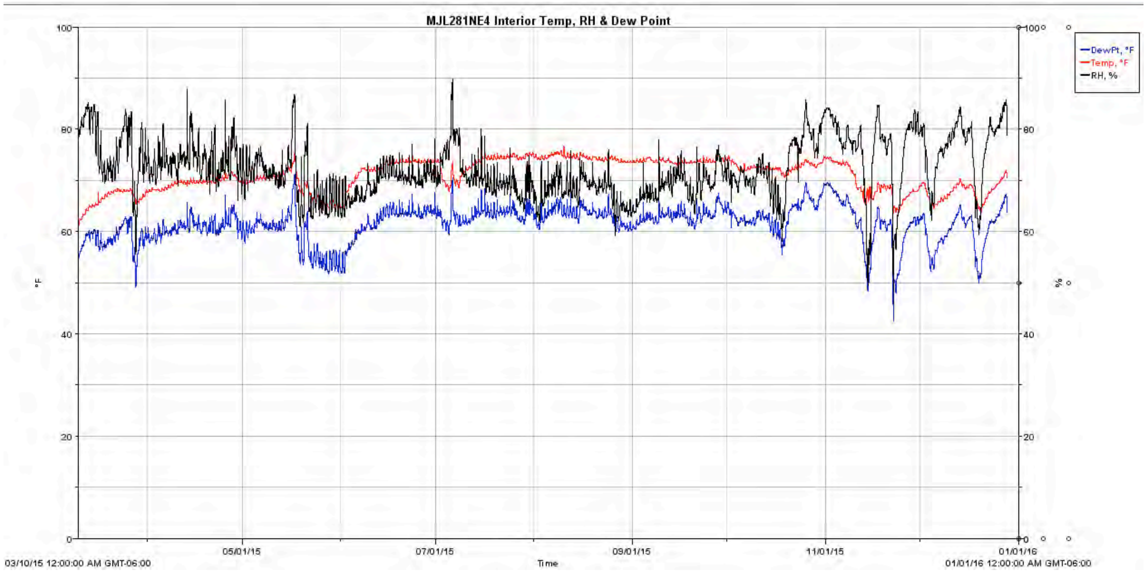

Figure 3: Dry bulb temperature and dew point temperature, interior of Madame John's Legacy.

Comparison of the two plots in Figure 2 and 3 suggests that the ground floor is more strongly influenced by leaking conditioned air from HVAC ducts and the story above rather than by infiltration of exterior air.

These considerations are important because the rate of desalination of the wall is dependent in part on the rate of evaporation of water from the salt solution drawn from the wall by the poultice. The rate of evaporation is influenced by air speed and relative humidity and relative humidity is dependent on dry bulb temperature and the absolute moisture content of the air, the latter being indicated by dew point temperature.

Based on the trend graph of interior conditions, episodes of low interior moisture in late May, November and December would have been favorable for evaporation.

2.2 Pilot Project Execution

2.2.1 Documentation and Stabilization

The wall chosen for the pilot project is a short, interior wall in the center of the ground floor. The wall is 4' wide, 7' tall and 12" deep, and is connected to another interior partition wall at one end. The wall is accessible from both sides, which is key for this treatment, allowing for easy installation and monitoring. Monitoring equipment had been installed in the wall during the 2013 study, so there was information available about the moisture content of the wall at the start of the project.

There is a variety of brick and mortar types in the selected wall. The two sides of the wall contained different types of repointing mortar. The "poultice" side of the wall, in room 281, had been almost entirely repointed in a hard white mortar that most likely dates to the 1990s (Appendix A, Image 3). The "wetting side" of the wall, facing room 280, contained a significant amount of brown mortar, which was relatively soft and similar in appearance to the original mortar (Appendix A, Image 4). There were also areas of spot repointing with a very hard, dark gray Portland cement-based mortar and several modern replacement bricks. The upper part of the wall end had been previously replaced with modern bricks set in the hard white mortar and the lower part of the wall end had been repointed with the dark gray mortar (Appendix A, Image 5). There was visible efflorescence at the bottom and middle of both sides of the wall and thick salt crusts on the bricks on the poultice side. There were some areas of actively powdering bricks, particularly on the end wall.

Before any work began, photographs were taken, including infrared (IR) images, to document the conditions at the start of the project. The IR images were similar to those taken for the 2013 *Technical Conservation Study*. From these images, the bottom of the wall appeared cooler and was interpreted to be more moist than the top, with the coolest area concentrated at the masonry closest to the interior partition wall, which presumably is also moist. These images, combined with the environmental monitoring data from within the walls, suggest that the source of the moisture is from below. The IR images also suggest that there could be lateral moisture and salt movement between the test wall and the adjacent partition wall.

A wood framing member for the floor above is located over the wall. To ensure the stability of this framing member during the pilot project, the team installed a steel support column adjacent to the wall before treatment began (Appendix A, Image 6). The support column has a weight capacity range of 20,000 to 38,000 lbs and was left in place at the conclusion of the project as the test wall is allowed to slowly dry.

2.2.2 Pre-treatment Sampling and Results

Previous testing showed high levels of salts in an adjacent wall, particularly sodium nitrate, potassium nitrate, and sodium chloride. Since the goal of the project was to remove as much salt as possible, it was important to understand the concentration of salts in the pilot project wall. Samples were removed from eight locations on both sides of the wall to quantify the salt concentration at the start of the treatment. After the treatment, the wall was sampled again and results compared.

Because salts tend to accumulate at different heights based on their solubility, samples were removed from multiple heights along the wall (Appendix A, Images 7 and 8). Three of the heights corresponded to the heights of previous cores on different walls so that we would have some comparative data. One additional area had visible, active salts on the surface. All initial samples were removed from the outer surface of the wall and were either pointing mortar or mortar that had been exposed because of a previous loss of pointing mortar.

The eight initial samples were analyzed by Dr. George Wheeler, Research Scientist with the Department of Scientific Research of the Metropolitan Museum of Art, using conductivity tests, which allows for the calculation of the percent weight of salt in a sample. To perform the test, the samples are soaked in distilled water to dissolve the salts. A conductivity reading of the solution is taken. The conductivity reading is calibrated according to the salt types found in the sample (in this case, a combination of sodium chloride and sodium nitrate) to determine weight percent. Anything above 0.1% by weight is often considered potentially damaging.

Results for the initial samples ranged from 1.86 weight % of salt to 11.36 weight % of salt (see Table 1). All samples revealed significant salt contamination and the results were even higher than those found in the previous study. The results were interesting because they differed on either side of the wall—the poultice side had lower concentrations overall. It was a clear lesson in how the mortars in this wall are affecting the salt distribution, and ultimately, damaging the brick.

Table 1: Initial Salt Quantification Results

Sample #	Room	Wall	Poultice Side/ Wetting Side	Inches from Floor	Initial Sample of Pointing Mortar Removed 3/5/15 w/w%
1	281	281-NE4	Poultice	77-78	1.86
2	281	281-NE4	Poultice	65.5	2.83
3	281	281-NE4	Poultice	42	3.49
4	281	281-NE4	Poultice	22-23	2.58
5	280	280-SW1	Wetting	80	4.63
6	280	280-SW1	Wetting	64.5	11.36
7	280	280-SW1	Wetting	41	8.25
8	280	280-SW1	Wetting	22-23	2.72

The highest weight percent was found in sample 6, which was removed approximately 5 feet above the floor. This location showed some visible salt, but not as much as other locations. However, the mortar surrounding sample 6 was dark gray and very hard, and was believed to be a Portland cement-based repointing mortar. The existence of this impermeable cement mortar likely raised the local concentration of salt in sample 6, which was a more permeable mortar.

A lower salt concentration range was measured in samples removed from the opposite side of the wall, which may be due to the uniform repointing previously done on this side. However, the lower concentrations in these initial samples suggests that this mortar is less permeable than the brick. Rather than migrating into the sacrificial mortar, salts on this side are being directed into the brick. This was evidenced by the thick salt crusts on some of the bricks on this side, as well as the more extensive damage to the brick overall.

The tests on these samples provided baseline data that were used to compare with data from samples taken at the end of the project.

2.2.3 Installation of System

A physical barrier, slate, had been selected for the damp proof course. The slate tiles were 8.5" wide by 1' 2" long and ¼" thick and were initially intended to be installed in a slot cut in the wall. A Husqvarna Cut-and-Break saw, capable of cutting a slot as deep as 16 inches, was chosen to cut the slot. However, this saw is gas-powered and there was concern about using it indoors. In addition, it was noted that the mortar at the ground was saturated, and it appeared likely that it would not be possible to cut a clean slot in the wall.

To avoid the risks of cutting a slot into the wall, the slate damp proof course was inserted manually. In order to insert the slate, the mortar was scored and then chipped away using a small masonry cold chisel. Because the mortar was so much harder than the surrounding brick, it was difficult to chip off the surface without damaging the brick. This process continued until reaching the softer lime-stabilized, clay bedding mortar.

Steel bars (approximately 6 inches wide) were shaped with an angle grinder in order to create a wedge at one end. These bars were then driven through the wall using an engineer's hammer. Once the bar passed through the entire wall, it was removed and inserted again to open the mortar joint to one full width of slate (Appendix A, Image 9). Mortar and debris was cleared out as much as possible at this point. The slate was then driven through the wall using a rubber mallet (Appendix A, Image 10). This process was continued until slate tiles were inserted across the entire length of the wall. The tiles were overlapped to prevent gaps between individual pieces. Six pieces were installed in all. Many of the pieces cracked in half during installation; at least one broke into multiple pieces. Where the cracked pieces were visible, voids were filled in with small pieces of slate. The fact that the slate cracked may have compromised the effectiveness of the damp proof course. Because this process was performed blindly, it was not possible to evaluate the continuity of the slate damp proof course installation.

The drip irrigation system was put in place after installing the damp proof course. The system consisted of a series of four water dispensing units (3 gallon capacity) connected to the wet-cure blanket with the custom drip irrigation tubing (Appendix A, Image 11). The four dispensing units were set on top of a metal shelving unit adjacent to the wall, positioning the spigots above the top of the wall. Valves were installed at the spigots so that the water flow could be adjusted, and the four units were connected with solid tubing. The tubing installed in the blanket was punctured with small pinholes every few inches to allow for a drip of water. The ends of the tubing were capped. The tubing snaked through the blanket along its height so that the entire wall would be exposed to the moisture. The wet-cure blanket was stapled to a wooden frame constructed to fit the dimensions of the wall. The frame was clamped at the top of the wall using custom wooden blocks in order to avoid screwing into the wall (Appendix A, Image 12). Rigid insulation, furring strips and shims were used to push the blanket onto the surface of the wall, especially in areas of voids or irregularities, in order to provide uniform contact.

Before applying the poultice to the opposite side of the wall, the surface of the wall was vacuumed to remove crystallized salts and loose material. The poultice was then applied in two sections: Section A was 24 ½" wide, and Section B was 25 ½" wide. The two sections were separated by a 1" strip where no poultice material was applied and where the moisture monitoring meters were installed (Appendix A, Image 13).

2.2.4 Project Monitoring and Treatment Maintenance

During the first two months of treatment, the site was visited every 2-5 days to observe the entire system. The irrigation system was checked each time to ensure operability. No leaking was reported and water levels in the jugs were replenished as needed. As water intake tapered off, the site was visited less frequently (every 1-2 weeks). Poultice samples were removed monthly, and Section A was removed and reapplied 3 times throughout the pilot project duration (Appendix A, Image 14). Results of the poultice sampling are discussed in section 3.0.

The system took in approximately 10 gallons of water every 3-5 days for the first two months of treatment (until May). After that point, water intake gradually slowed. When the wall stopped rapidly absorbing water approximately two months after treatment began, little drying was observed for several months. Most likely, the high moisture content of the wall and the high relative humidity in the space inhibited evaporation from the poultice, thereby preventing the wall from absorbing more water.

At the beginning of September 2015 (after seven months of poulticing), it was observed that the water uptake had stopped. At this point, the water system was dismantled and cleaned to ensure that there were no blockages, and then reinstalled. The water uptake did not change, so an oscillating fan was placed in front of the poultice wall in order to encourage evaporation. This failed to produce a marked difference in the drying. When the relative humidity in the space dropped in October 2015, water intake resumed again but still at a slower pace—approximately 10 gallons every 15 days.

Six months after treatment began, salt crystals were observed on the surface of both poultice sections, concentrated at the top of the wall. Mold growth was also observed at the very bottom of the wall—directly above the slate damp proof course.

Poultice drying levels were also noted during site visits (Appendix A, Image 15). The drying patterns varied across the surface of the wall. Generally, the bottom and top of each section of poultice eventually dried, while the middle portion stayed saturated throughout the entire treatment. Seemingly random, indiscriminate dry patches were observed across the wall surface. By the end of the treatment, the poultices of both sections were still largely saturated. Drying patterns mirrored the substrate—the poultice dried over mortar joints, but stayed saturated over bricks.

The poultices and the wetting system were removed in January 2016, after 10 months. The poultice was manually removed using plastic spatulas. The wall was then dusted with a soft, natural-bristled brush. Most of the poultice was still saturated, which made removal somewhat difficult.

The poultice used on both sections was retained and samples of mortar were removed from both sides of the wall for salt quantification. The results of the post-treatment monitoring are discussed in Section 3.0.

The irrigation system was cut off and the blanket removed. The "wall-side" of the blanket exhibited heavy mold growth. The wall behind the blanket was completely saturated. It was scrubbed clean in order to remove any residual mold growth.

2.2.5 Mortar Removal and Repointing

Following poultice removal, the surface mortar was removed from both sides of the wall. The mortar was scored and then chipped away using a small masonry cold chisel. Because the mortar was so much harder than the surrounding brick, it was difficult to chip off the surface without damaging the brick. This was especially true on the "poultice" side of the wall, which held harder mortars than the "wetting" side of the wall. As a result, the poultice side of the wall experienced more brick deterioration.

The mortar removal process continued until the softer lime-stabilized clay bedding mortar was reached. One top section of the wall had previously been completely re-bricked. This section was avoided during mortar removal for fear of compromising stability.

Samples were taken of the original lime-stabilized clay mortar in order to determine a proper color match for the repointing mortar. The selected binder was a feebly hydraulic Natural Hydraulic Lime (NHL 2). NHL 2 was chosen for its compatibility with the soft bricks and also its ability to cure under the moist wall conditions. Sample mortars were made in order to test pigment variations using a combination of dark brown and buff pigments. The final mix design (by volume) is as follows:

1 part St. Astier Natural Hydraulic Lime 2 (TransMineral, USA)
3 parts masonry sand
distilled water to achieve desired workability
1/32 part dark brown pigment (Solomon Colors Mortar Color)
2/32 part buff pigment (Solomon Colors Mortar Color)

The custom-mixed mortar was installed using 5/8" pointing tools and a mason's hawk (Appendix A, Images 16 and 17).

3.0 RESULTS AND DISCUSSION

3.1 Project Monitoring Results

3.1.1 Poultice Salt Testing Results

Section A was removed and replaced three times (in May, August, December and January), for a total of four applications. Section B remained on the wall for 10 months, from March 2015 to early January 2016.

Monthly salt analysis of the poultice was intended to provide information about how much salt was being removed from the wall to help identify when the treatment was successful and could be removed. However, analysis of the poultice failed to produce reliable results. Rather than seeing trends in the quantity of salts in the samples, the analysis either showed inexplicable movement in the salt quantity or no movement at all. (See Appendix A for the poultice salt quantification results throughout the project.) The unreliability of results made it difficult to judge the ideal time to remove the poultice. As with the salt quantification of the mortar samples, variability in the materials in the wall will have a direct effect on the poultice. It was clear from this project that taking small samples of the poultice would not provide accurate enough results to be able to determine the effectiveness of the poultice.

One problem with testing the poultice is that salt removal is not necessarily a linear process. The ability of the salt to exit the wall changes throughout the treatment, particularly for materials with a high salt content. Exterior pores can get clogged with salts, reducing the diffusion of salts to the exterior of the material. The first application of a poultice can clear those pores, thus enabling more salts to diffuse through during the second application. This would result in the salt quantity of the second application being higher than the first. This back and forth can be particularly difficult to interpret with small samples.

At the end of the project, salt quantification was performed on the entire poultice removed from each section. In doing this, the salt distribution is irrelevant, and the problem of sampling over different substrates is avoided. This provided a more accurate understanding of the amount of salt removed, and is more likely to show trends over time. This method is recommended for any future poulticing at the site.

The poultice removed from Section A contained 18.6 w/w % of salt. The poultice removed from Section B contained 15.9 w/w % of salt. This amount of salt was somewhat surprising, as Section A had only been on for approximately one month, while Section B has been on for the duration of the project. This, combined with the results of the mortar salt quantification, suggests that the poultice in Section B and the wall had likely reached equilibrium in salt content and that diffusion to the poultice was not occurring. Combined with the fact that there was little drying over much of the time the poultice was on the wall, there was not as rapid extraction as there was during the final application on Section A, which was put on during a period of low relative humidity.

3.1.2 Environmental Monitoring and Rate of Desalination

It became clear during the pilot project that the environmental conditions in the room had a profound impact on the rate of desalination. The wall took in water rapidly for the first two months. After that, the water consumption gradually declined. It was assumed that the wall was saturated and that the water consumption would be lower for the rest of the treatment duration. However, the wall stopped taking in water at the end of the summer, indicating that drying was not occurring on the poultice side. The environmental conditions in the room at the time (during the summer) reflected a high moisture content in the air. Except for a small drop at the beginning of the project, the RH in the room remained above mid-60%, and sometimes much higher.

Starting in early October 2015, the RH started to drop below the mid-60% mark. At this point, the fluctuations in the environmental conditions became more widespread, presumably since the air conditioning was turned off from the museum above which affected the ground floor temperatures (discussed in Section 2.2.1). Also in October, salt crystals started to appear on the surface of the poultice, indicating that some drying was occurring. Based on the results of the full poultice testing performed at the conclusion of the project, it appears that there was a significant amount of desalination occurring during December and January (discussed in 3.1.1), periods when the RH was dropping occasionally below 65% RH.

3.2 Post-treatment Samples

After removal of the treatment, mortar samples were removed for salt quantification (Table 2). On the wetting side of the wall, samples were removed from the same approximate locations as the initial samples at four heights along the wall. On the poultice side, samples were removed at the same heights from both the Poultice Section A side and the Poultice Section B side to be able to compare residual salts resulting from both methods. Samples of pointing mortar and subsurface mortar were taken for Section A. For Section B, only subsurface mortar was sampled. As with the initial samples, there is likely variability in the post-treatment pointing samples as a result of the mortar type. However, the subsurface mortar samples were essentially the same mortar since they were taken after the various repointing mortars were removed.

On the wetting side of the wall, all of the samples, both pointing and subsurface mortar, contained lower salt concentrations than was found during initial sampling. Most of the concentration dropped dramatically, including sample location 6, which initially contained the highest concentration of salt. This sample location went from 11.36 w/w % of salt to 1.03 w/w % of salt in both pointing and subsurface mortar. Since there was no poultice applied to this side of the wall, the results suggest that the system of wetting was successful in encouraging salt movement through to the opposite side of the wall.

On the poultice side of the wall, most of the sample locations showed an increase in salt concentration from the initial samples, ranging from a low of 1.03 to a high of 4.12 w/w % of salt. For the Section A samples, salt concentrations in three out of four pointing mortar samples increased modestly, and one reduced modestly. The subsurface samples were more varied, with salt concentrations increasing in two and decreasing in two. For the Section B samples, salt concentrations in all of the samples were higher than both the Section A samples and the initial samples. Salt concentrations in the section B samples ranged from a low of 6.18 to high of 7.73 w/w % of salt. It is likely that there will be some visible efflorescence on the wall at a future time as the wall dries. It is hoped, however, that any crystallization will occur either in the newly installed mortar or on the surface of the brick since the treatment removed any salts clogging the pores of the brick.

Table 2: Post-Treatment Salt Quantification Results

Sample #	Room	Wall	Poultice Side/ Wetting Side	Inches from Floor	Pointing Mortar (Section "A") w/w%	Deep Mortar (Section "A") w/w%	Deep Mortar (Section "B") w/w%
1	281	281-NE4	Poultice	77-78	2.58	3.09	6.69
2	281	281-NE4	Poultice	65.5	3.09	1.03	7.73
3	281	281-NE4	Poultice	42	2.83	2.58	7.73
4	281	281-NE4	Poultice	22-23	3.1	4.12	6.18
5	280	280-SW1	Wetting	80	1.03	4.13	n/a
6	280	280-SW1	Wetting	64.5	1.03	1.03	n/a
7	280	280-SW1	Wetting	41	1.29	0.52	n/a
8	280	280-SW1	Wetting	22-23	0.77	0.77	n/a

The fact that the samples from Section B contained a higher concentration of salts overall than Section A suggests that periodic removal of the poultice is an important aspect of the treatment, even in the highly humid environment of New Orleans. This conclusion is reinforced by the final poultice testing, which showed that Section A contained a higher percentage of salt overall than Section B, even though Section B had been on the wall for 8 months. As discussed in Section 3.1.2, the conditions in the space during the last application of Section A were favorable for evaporation. This appears to have significantly improved the salt extraction by the poultice.

There also could have been some lateral salt movement from the adjacent wall, which may have affected the results in Section B. However, when looking at the results from the final poultice testing, it is clear that the Section B poultice did not remove salts as effectively as the Section A poultice. If a poultice is left on for an extended period of time, it is important to coordinate treatment with favorable environmental conditions.

3.3 Effectiveness of Treatment

To determine if this treatment protocol is a feasible and practical methodology for desalinating and drying masonry walls, the effectiveness of each aspect of the pilot project methodology was assessed.

- Damp Proof Course: The effectiveness of the damp proof course cannot be fully evaluated until the irrigation system moisture has evaporated from the test wall. While it seems that the slate has provided a physical barrier between the masonry under ground and the wall above, it was still unclear at the end of the project whether the barrier is fully continuous or if there is any capillary leakage around it.

- Irrigation System: The irrigation system proved to be effective throughout the duration of the pilot project. The project team did not observe any leakage or blockages in the tubing that prevented water flow. The wall stayed wet for the duration of the project, as evidenced by the saturation of the poultice.
- Salt Removal: The combination of wetting and poulticing appears to have been at least somewhat successful, as discussed in Section 3.2. However, several modifications to the methodology are recommended to improve the results—both to increase the amount of salt removed as well as to shorten the overall duration of the treatment. It is known that salts remained in the wall at the termination of the pilot treatment project, particularly on the poultice side. The effects of the treatment and the redistribution of the salts will not be fully understood until the wall dries. Therefore, the wall will continue to be visually monitored following the completion of this project.

4.0 CONCLUSIONS

For the particular conditions found at Madame John's Legacy, the pilot treatment protocol works. However, each building is different and its unique conditions must be carefully considered before considering the application of this treatment to a different site. Below are some practical considerations related to the feasibility of performing this treatment at Madame John's Legacy and elsewhere, as well as recommendations on how to improve the protocol used for this pilot project. Following these are some "big picture" reflections on what to consider when faced with a deteriorated masonry wall affected by rising damp and salts.

4.1 Lessons Learned

4.1.1 Recommended Modifications to the Pilot Project Treatment Protocol

- *Documenting initial and final salt quantities*: It is important to establish the quantity and distribution of salt in the wall at the beginning of the project in order to determine if the salt has been sufficiently removed. Samples should be removed from different depths of the wall, including the wall core, and the salt concentration at different depths should be established. There are a number of ways this could be achieved, including drilling holes at different depths and collecting samples, removing small cores, or dismantling portions of the wall. It is important to establish a reproducible sampling method prior to beginning treatment.
- *Removing surface salts before the start of the treatment:* Consideration should be given to the removal of surface salts from the wetting side of the wall even before the treatment starts to reduce the amount of salt being pulled through the masonry. Since salts tend to concentrate at wall surfaces, where drying occurs, removing the salts from the surface could potentially significantly reduce the quantity of salts in the wall that would need to be removed with this treatment. It would also open the pores, making the next poultice application more effective. This salt removal could be done by applying a poultice immediately before the damp proof course is installed. While there is some concern about accelerating the rising damp by poulticing without a damp proof course installed, leaving the treatment on for just a few days, rather than weeks or months, would likely not significantly increase the salt level in the wall.
- *Repointing with a compatible, permeable mortar before the treatment:* Repointing the masonry before treatment has two potential benefits. First, if the existing mortar is an impermeable replacement mortar, the new mortar will provide a more permeable vehicle for the salts to exit the wall, thus reducing the salts in adjacent brick masonry. Second, if the existing mortars are permeable mortars, they presumably contain a significant amount of salts, which would then be mechanically removed by raking. In either case, there is a benefit to replacing the existing mortar with permeable mortar at the beginning of the project.
- *Designing the damp proof course:* The damp proof course must be designed according to the wall condition. The slate installation method used for the pilot project worked at Madame John's Legacy because of the poor condition of the wall and mortar. However, it was labor intensive and is not the best method for a large-scale installation. In addition, there is some uncertainty with installing the damp proof course blindly. Using a system of underpinning and rebuilding the lower part of the wall would be more predictable in terms of continuity of the damp proof course but is more involved and expensive. There may be other installation methods, materials or tools that are more

appropriate for different locations. Because the damp proof course will prevent further deterioration in the wall, it is imperative that the design is carefully considered ahead of time, particularly if the damp proof course is being installed throughout an entire building.

- *Sampling the poultice*: Sampling of the poultice during treatment proved to be a challenge. The salt gradient across a wall is dependent on a number of factors, including the permeability and porosity of the substrate materials and the types of salt present in the wall. Moreover, salts move depending on the moisture conditions and it is unclear what effect saturating the wall had on the salt gradient, both in the wall and in the poultice itself. Therefore, it was difficult to compare samples of poultice from one month to another. A more accurate method would be to analyze the quantity of salt in the entire poultice to establish if the wall is sufficiently desalinated.
- *Replacing the poultice periodically:* It appears to be more effective to remove the poultice periodically than to keep the poultice on the wall for extended periods of time. Removing the poultice periodically has two benefits. First, it prevents the possibility of salts migrating back into the wall during the saturation process. Second, it allows for the salt quantities being removed to be quantified in a more accurate way by testing the entire poultice rather than a small sample.
- *Timing the Treatment:* Timing the application of the poultice to ideal environmental conditions will also improve the efficacy of the poultice. This will likely also reduce the overall duration of the treatment.

4.1.2 Practical Considerations for General Applications

- *Appropriateness of wall construction:* For this treatment to work, there needs to be access to both sides of the wall. In addition, since the irrigation system is gravity-fed, there must be space over the wall to allow for the water tanks.
- *Impact of environmental conditions*: The pilot project showed that the environmental conditions in the treatment area had an impact on the efficacy of the treatment. The relative humidity in the room had a significant impact on the ability of the wall to take in water, as there was virtually no drying on the poultice side during times of high RH. Understanding the overall climate cycles of a location can help identify when a treatment will be most successful. At Madame John's Legacy, it would be best to start the treatment in autumn, when the relative humidity falls, rather than in summer, when it is rises.
- *Supervision and monitoring of treatment*: While the treatment did not require a significant amount of on-going attention, it does require some degree of supervision throughout the process to ensure that it is working properly. Ensuring that the water tanks are full of clean, non-saline water and making sure there are no leaks, blockages or other problems with the irrigation system is essential. Large treatment areas will require a large supply system since continual refilling of the water dispensing units was required at the beginning of the treatment, even on the small pilot wall.
- *Considerations for Load-Bearing Masonry*: The ground story masonry walls at Madame John's Legacy are load-bearing. The ratio of masonry bearing surface to building floor area is comparatively low, as might be expected with a building constructed on problematic soils with high silt content. As a consequence, the compressive stresses in the masonry from live and dead building loads are likely to be low, and well within the capacity of the original masonry units. However, the extent of cumulative salt damage

within the walls is not known, nor is the degradation in compressive strength resulting from salt damage.

The irrigation of the wall for the pilot desalinization project was accomplished with negligible hydrostatic pressure on the brick, since the water was introduced by absorption from a saturated curing blanket that was fed by a weep irrigation system.

However, despite precautions taken to limit hydraulic damage from the desalination process, the question of cumulative salt damage prior to desalination remains unanswered. In the case of heavily damaged walls or building renovation, the load capacity of the walls should be assessed by testing before undertaking desalination, in the event that major reconstruction is needed to re-establish structural capacity.

4.1.3 Whole Building Considerations

This pilot project explored the feasibility of this type of treatment in a specific context. The combination of a high water table, silty soil, permeable materials, and a hot and humid climate makes the brick masonry at Madame John's Legacy inherently susceptible to damage from rising damp and salts. This treatment method may not be appropriate or necessary for other situations.

While the context surrounding Madame John's Legacy is inherently susceptible to deterioration from rising damp and salts, changes to the building clearly had an impact on the rate and extent of deterioration of the masonry walls. Converting the building into a museum setting required closing off areas of the ground floor that were once open and installing an HVAC system led to changes in environmental conditions. Previous interventions, such as the installation of the impervious concrete slab at the ground floor and the use of cementitious mortar for repointing, affected the movement of moisture and salts through the walls. Understanding the impact of such changes, both for past intervention and future interventions, is essential.

Source moisture control is vital to reducing the damaging potential of salts, particularly in the context of Madame John's Legacy. The installation of impervious materials in and around the building might direct moisture from rain into the permeable walls. Controlling and directing that moisture away from the building's wall is a relatively easy way to minimize unnecessary moisture in the walls.

4.2 Recommendations for Madame John's Legacy

Below are recommendations listed in order of priority based on the finding of this study, as well as the 2013 *Technical Conservation Study*. The 2013 study made several short-term recommendations that are repeated here, all of which are still valid and many of which have not yet been addressed. These recommendations are particularly important to address before embarking on any large-scale projects involving desalination.

1. *Load capacity testing of the damaged masonry by a preservation engineer:* The existing load bearing capacity of the masonry walls of Madame John's Legacy should be determined by testing before embarking on building-wide remedial treatments for salt damage to the walls. The impact of cumulative salt damage and inappropriate repairs on the structural capacity of the existing masonry walls is not known. If the diminishment of structural capacity requires reconstruction of the walls, desalination is a moot point.

2. *Eliminate Additional Sources of Moisture*: Improving and maintaining the roof and pavement water conduction system is essential to control moisture entering the building. Controlling ground moisture with a damp proof course is futile without controlling these secondary sources of moisture. The following steps should be taken:
    a. Repair gutters (patch holes and open seams) and leader heads and clean on a regular basis to remove debris, including bird nests.
    b. Correct the pitch of gutters to ensure proper drainage to leader heads/downspouts.
    c. Re-attach or provide new downspouts that are detached from gutters.
    d. Install bird proofing or bird deterrent to prevent return infestations.
    e. Repoint brick pavement and replace broken or missing brick, particularly adjacent to downspouts and in in-grade gutters.
    f. Install flexible tubing or splashboard where downspouts meet masonry to carry water away from base of walls.
    g. Repair catch basins at Dumaine Street alleys where in-grade gutters drain to storm drains to ensure rainwater is being effectively removed from the site. Clean out basins routinely.
    h. Clean out drains in foyer to make functional.
    i. Repair leaky hose spigot at south corner. Consider removing spigot and re-locating to another location not adjacent to ground floor masonry walls.
    j. Repair leaky faucet in utility sink in south cabinet/bathroom. Repoint masonry in this location.
3. *Repoint with a vapor permeable mortar*: Remove all Portland cement-based repair materials (mortar and stucco) and replace with a compatible mortar. As part of this task, there should be a thorough evaluation of the best repair mortar for the walls. While it is believed that a mortar based on a feebly Natural Hydraulic Lime is compatible with the existing system, there may be other repair options or requirements that are unknown at this time. To evaluate the best repair mortar, the following is recommended:
    a. Coordinate the study of the repair mortar with the preservation engineer to identify the requirements of the new mortar.
    b. Perform testing on lime-stabilized earthen mortars to identify their properties and determine if they might be a viable option as a repair material. At a minimum, testing should include compression strength, water vapor permeability, and capillary rise, as well as any other tests required by the preservation engineer. Testing for salt resistance is also desirable. Testing should be performed on both existing mortars as well as replacement mortars based on the previously performed mortar analysis.
4. *Fine-tune damp proof course design based on load capacity testing:* The design of the damp proof course should be developed after the load capacity testing and in conjunction with the preservation engineer to ensure that the method chosen is compatible with the existing walls.
5. *Environmental Monitoring Program:* Continue the environmental monitoring program and have a conservation consultant review collected data quarterly. The current program monitors conditions in the room, air, walls and soil. Collection and analysis of this information will be critical to developing a more complete understanding of the deterioration mechanisms and possible mitigation strategies. The quarterly review of data will also allow for any adjustments, as data is analyzed.
6. *Photograph walls on a regular basis to document wall deterioration:* High-resolution photography is a relatively simple and inexpensive way to document the rate of

deterioration of the wall materials. The photographs can also be coordinated with the environmental data to determine if there are trends in the appearance of salts and/or brick damage. This documentation will help identify the most problematic areas of the ground floor and how the damage is manifesting.

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6.0 REFERENCES

The list below contains the resources consulted during the research, design and implementation of the pilot treatment.

Bourges, Ann and Veronique Verges-Belmin. "Comparison and optimization of five desalination systems on the inner walls of Saint Philibert Church in Dijon, France." In *Proceedings of Salt Weathering on Building and Stone Sculptures*, edited by Judith Selk Albertsen. Copenhagen: Technical University of Denmark.

Charola, A. Elena. 2000. "Salts in the Deterioration of Porous Materials: An Overview." *Journal of the American institute for Conservation* 39, No. 3: 327-343

Doehne, E., Schiro, M., Roby, T., Chiari, G., Lambousy, G., and Knight, H. 2008. "Evaluation of poultice desalination process at Madame John's Legacy, New Orleans." In *Proceedings of the 11th International Congress on Deterioration and Conservation of Stone*, edited by J. Lukaszewicz, and P. Niemcewicz.: 857-864. Torun; Nicolaus Copernicus University Press.

Gale, Frances. 1991. "Stopping Rising Damp." *Masonry Construction*. January 1991.

"Guideline for Desalination of Porous Building Substrates." EU Desalination Project. http://www.bk.tudelft.nl/fileadmin/Faculteit/BK/Over_de_faculteit/Afdelingen/RMIT_en_MediaStudies/RMIT/Onderzoek/Projecten/Desalination/Content/Desalinationbrochure.pdf.

Hall, Christopher and William D. Hoff. 2007. "Rising Damp: Capillary Rise Dynamics in Walls." In *Proceedings: Mathematical, Physical and Engineering Science* 463, No. 2084: 1871-1884.

Lubelli, B. R.P.J. van Hees and H. De Clercq. 2011. "Fine Tuning of desalination poultices: try outs in practice." *Salt Weathering on Buildings and Stone Sculptures*: 381-388. Limasso, Cyrprus.

Massari, Giovanna and Ippolito Massari. 1993. *Damp Building Old and New*. Rome: ICCROM.

McInerney, Michael, Sondra C. Cooper, Voncent F. hook, and Sean W. Morefield. 2002. "Using Electro-Osmotic Pulse Technology to Prevent Rising Damp and Moisture Intrusion." *APT Bulletin* 33, No. 4: 47-43.

Price, Clifford. 1997. "Salt Damage in Porous Material: A Threat to the Cultural Heritage." *Archaeology International* 1: 47-48. doi: http://dx.doi.org/10.5334/ai.0114.

Rodrigues, J. Delgado, C. L. Paulos Nunes, and Doria Costa. 2008. "Preparatory Studies for the Consolidation of Granite in Evora Cathedral. Desalination by Poulticing." Proceedings of the International Symposium "Stone Consolidation in Cultural Heritage, Research and Practice." Edited by J. Delgado Rodrigues & J. M. Mimoso: 159-167. Libson: LNEC.

Sawdy, Alison, Barbara Lubelli, Victoria Voronina, and Leo Pel. 2010. "Optimizing the Extraction of Soluble Salts from Porous Material by Poultices." *Studies in Conservation* 55, No. 1: 26-40.

APPENDIX A:

Photographs

Image 1: Ground floor of Madame John's Legacy.

Image 2: Madame John's Legacy, elevation facing Dumaine Street.

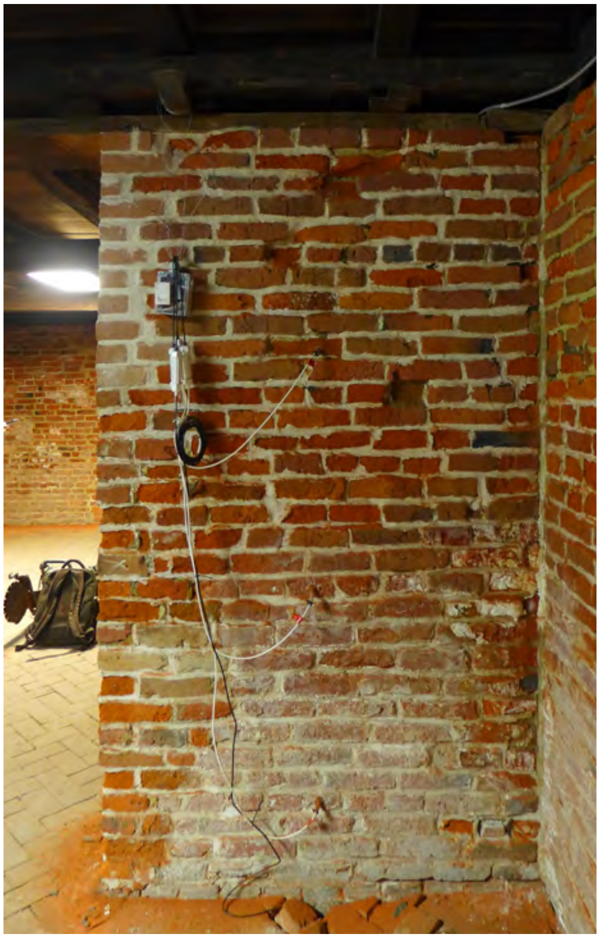


Image 3: Wall from room 281, the "poultice" side during the pilot project.

Image 4: Wall from room 280, the "wetting" side during the pilot project.

Image 5: End of test wall. The upper part of the wall had been previously rebuilt with new brick and hard mortar.

Image 6: The wood member on top of the wall was supported by a steel column before the start of the treatment.

Image 7: Locations of samples removed from 281-NE4

Image 8: Locations of samples removed from 280-SW1.

Image 9: Installing the damp proof course.

Image 10: Slate installed as a damp proof course.

Image 11: Water dispensing units with valves installed on metal shelving adjacent to the test wall.

Image 12: Wet curing blanket and frame installed at wetting side of the test wall.

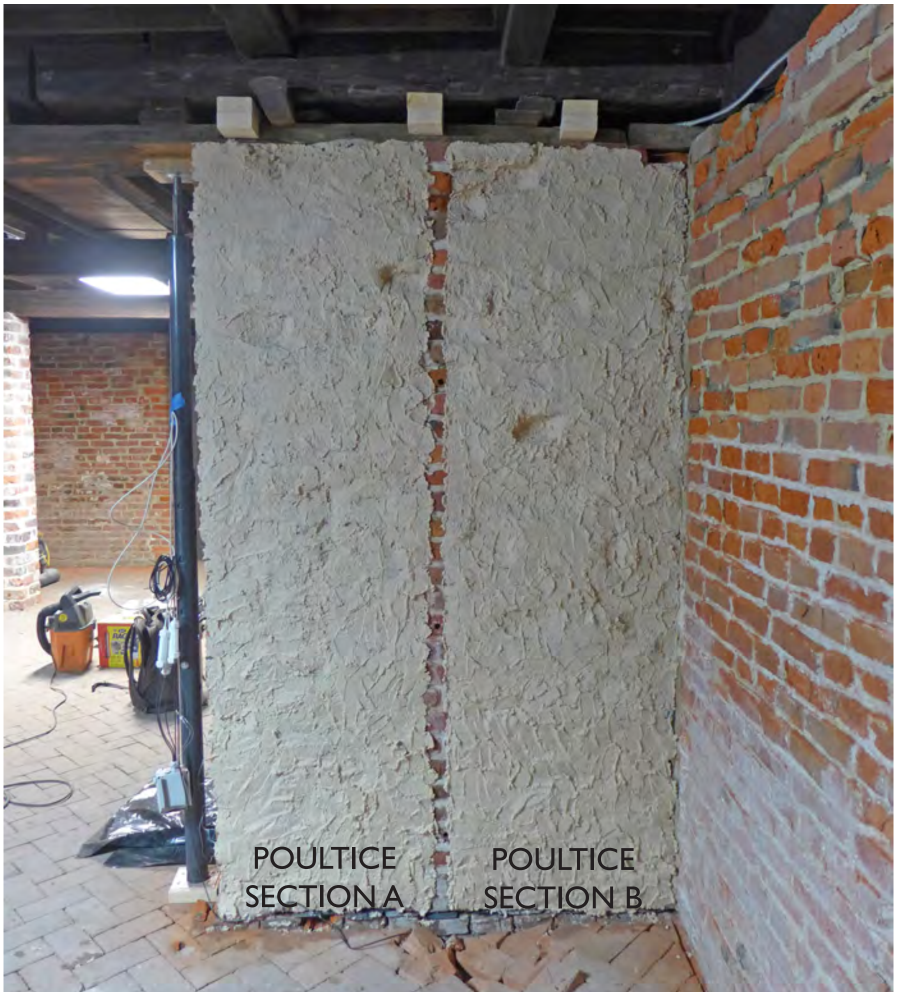


Image 13: Poultice applied to poultice side of wall in two sections—Section A (left) and Section B (right).

Image 14: Poultice sampling throughout the treatment duration.

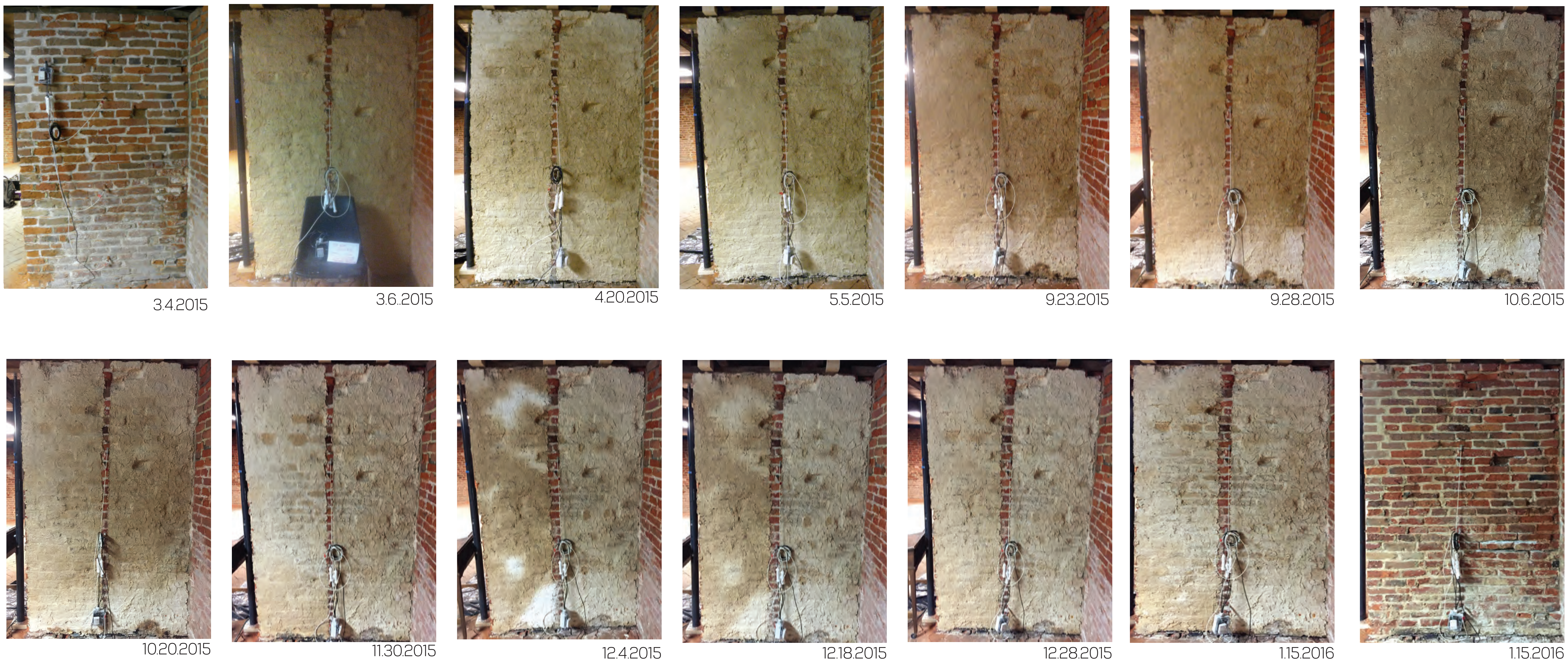


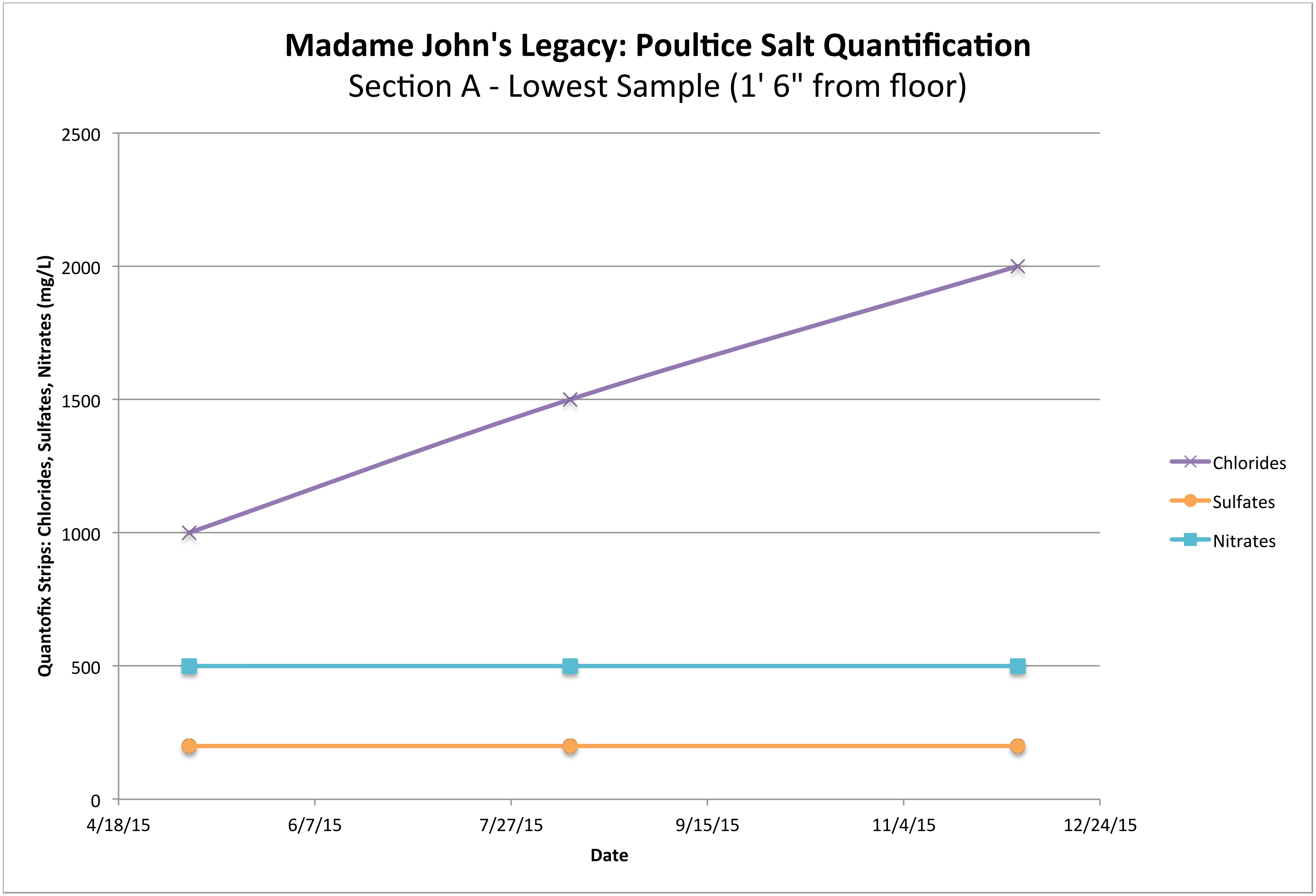
Image 15: Photographs taken of wall throughout treatment duration.

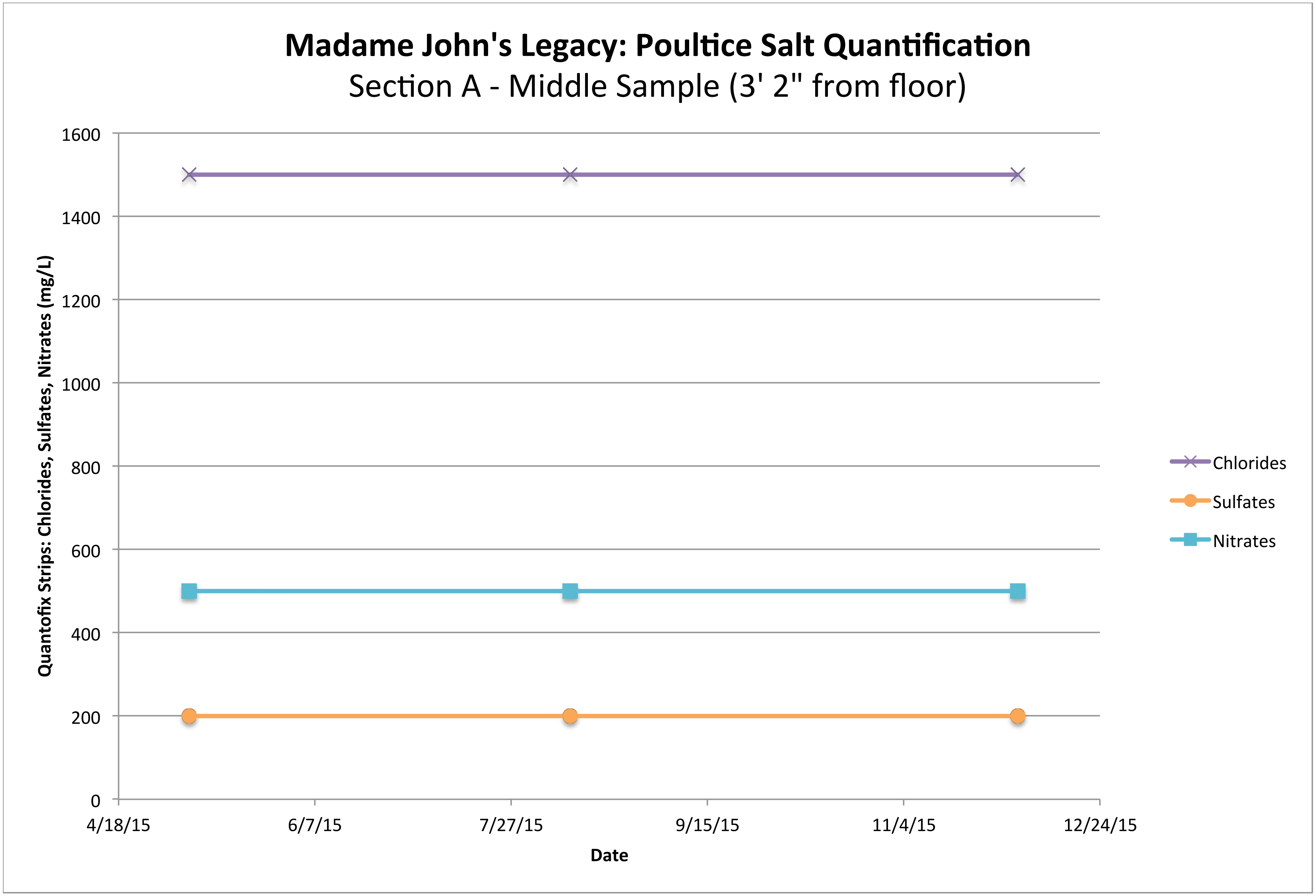
Image 16: Poultice side of wall, after repointing.

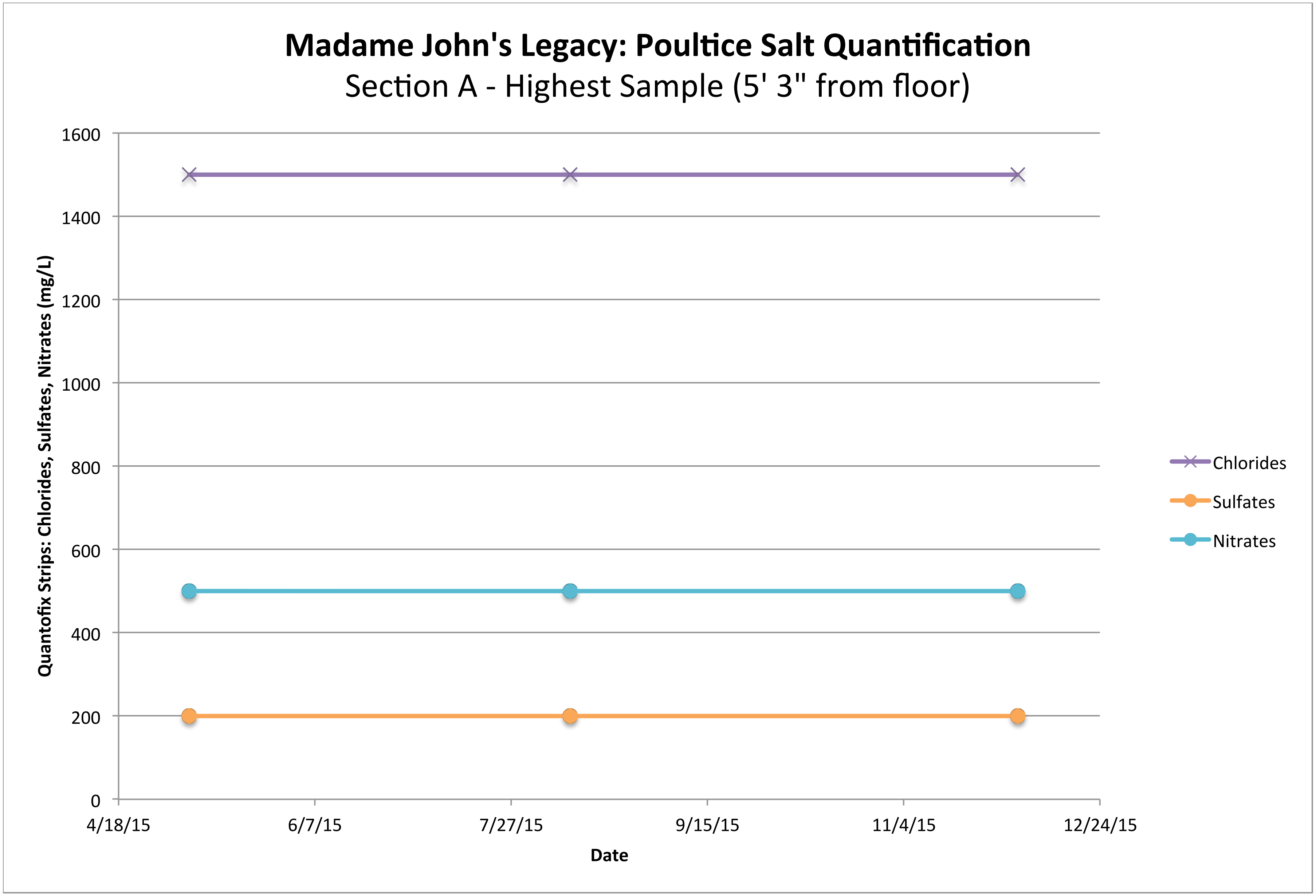
Image 17: Wetting side of wall, after repointing.

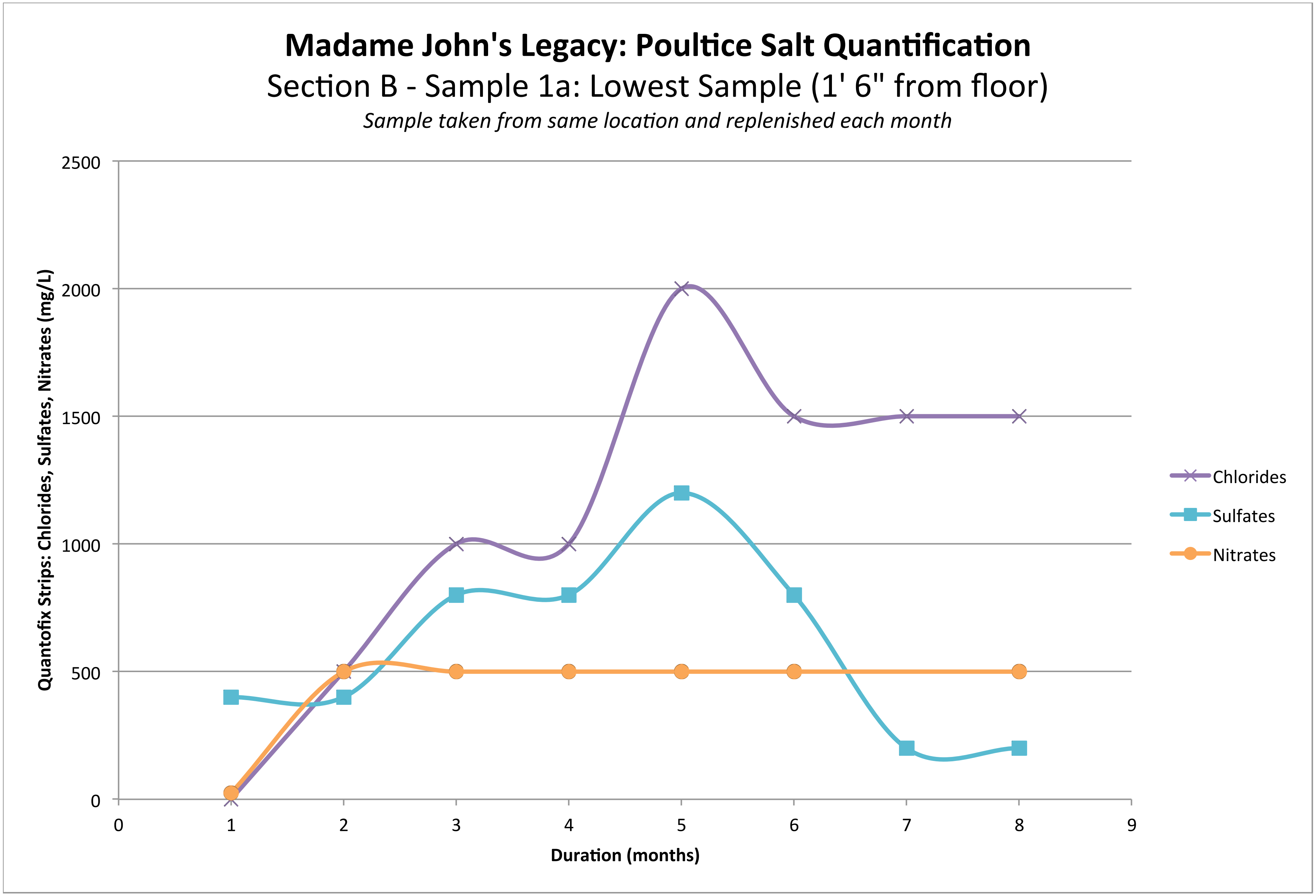
APPENDIX B:

Poultice Monitoring Data

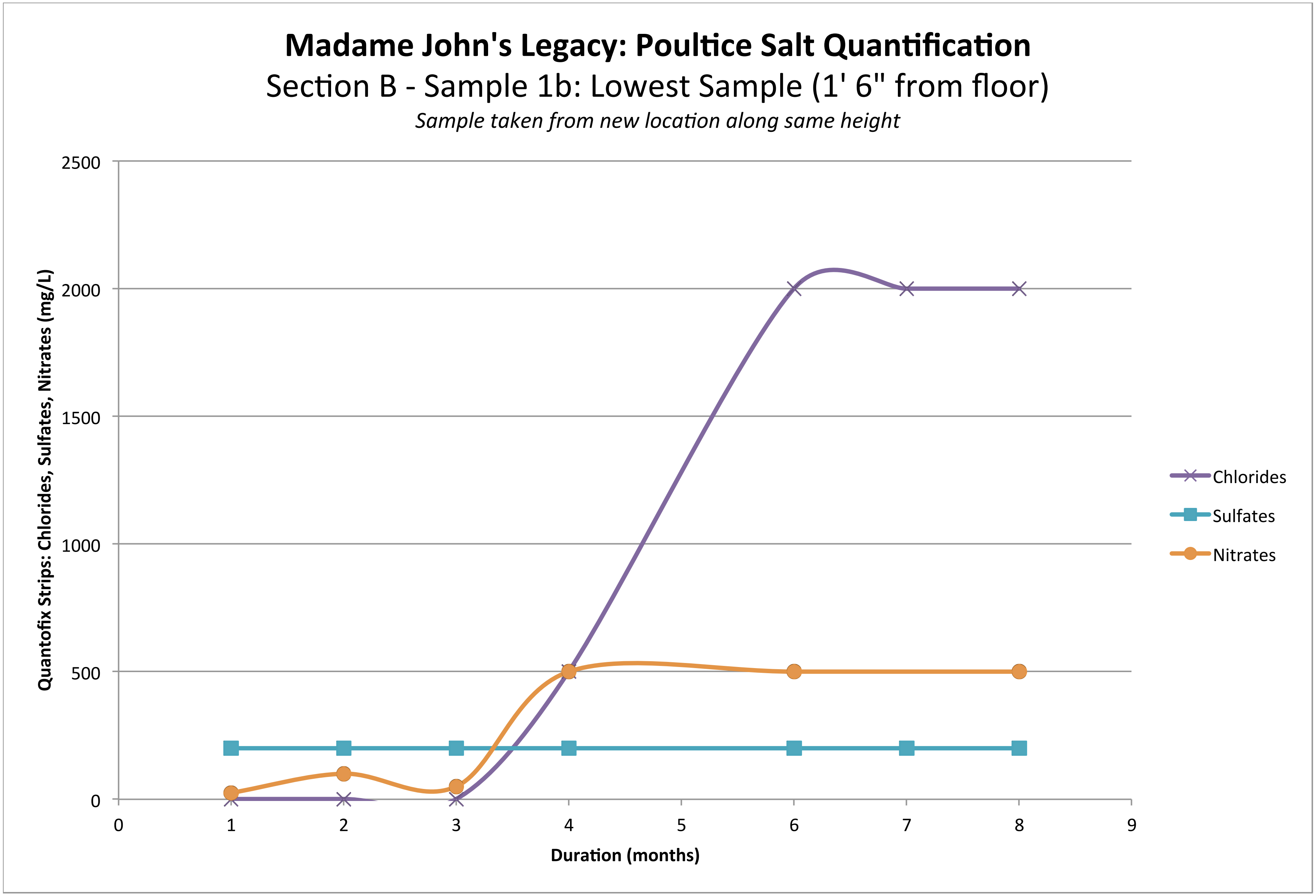

Madame John's Legacy: Poultice Salt Quantification
Section A - Lowest Sample (1' 6" from floor)
Quantofix Strips: Chlorides, Sulfates, Nitrates (mg/L)
2500
2000
1500
1000
500
0
4/18/15
6/7/15
7/27/15
9/15/15
11/4/15
12/24/15
Date
Chlorides
Sulfates
Nitrates

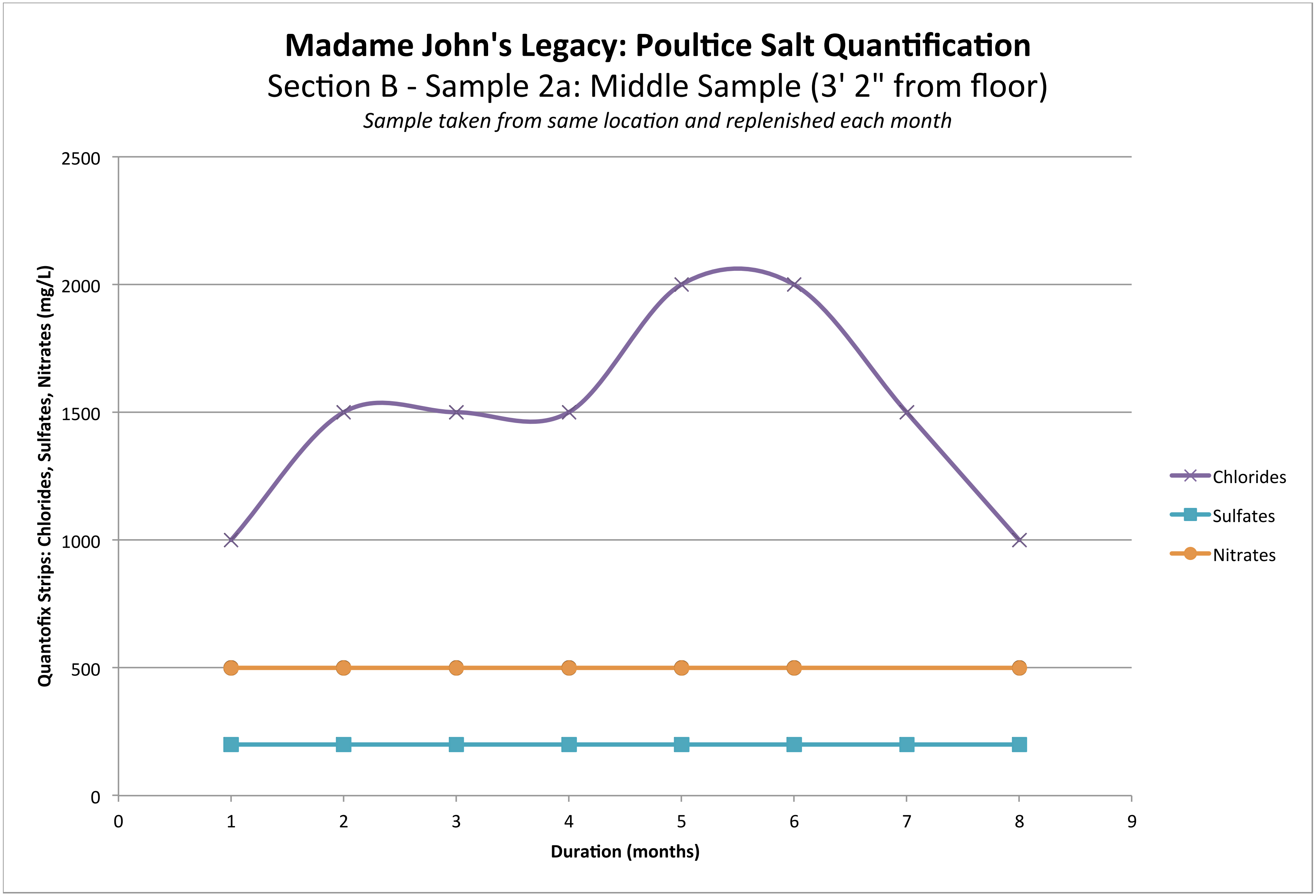

Madame John's Legacy: Poultice Salt Quantification
Section A - Middle Sample (3' 2" from floor)
1600
1400
1200
1000
800
600
400
200
0
Quantofix Strips: Chlorides, Sulfates, Nitrates (mg/L)
4/18/15
6/7/15
7/27/15
9/15/15
11/4/15
12/24/15
Date
Chlorides
Sulfates
Nitrates

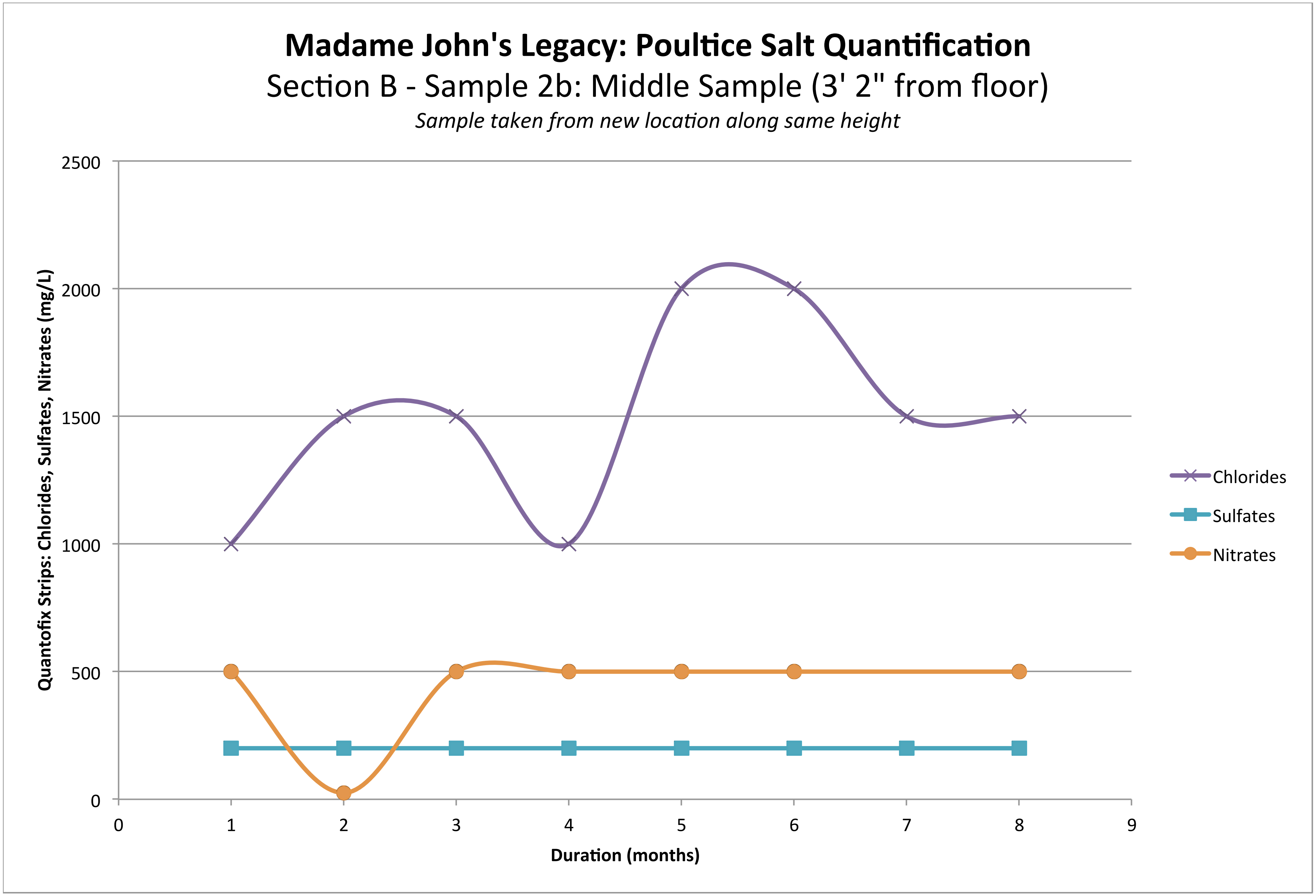

Madame John's Legacy: Poultice Salt Quantification
Section A - Highest Sample (5' 3" from floor)
1600
1400
1200
1000
800
600
400
200
0
Quantofix Strips: Chlorides, Sulfates, Nitrates (mg/L)
4/18/15
6/7/15
7/27/15
9/15/15
11/4/15
12/24/15
Date
Chlorides
Sulfates
Nitrates

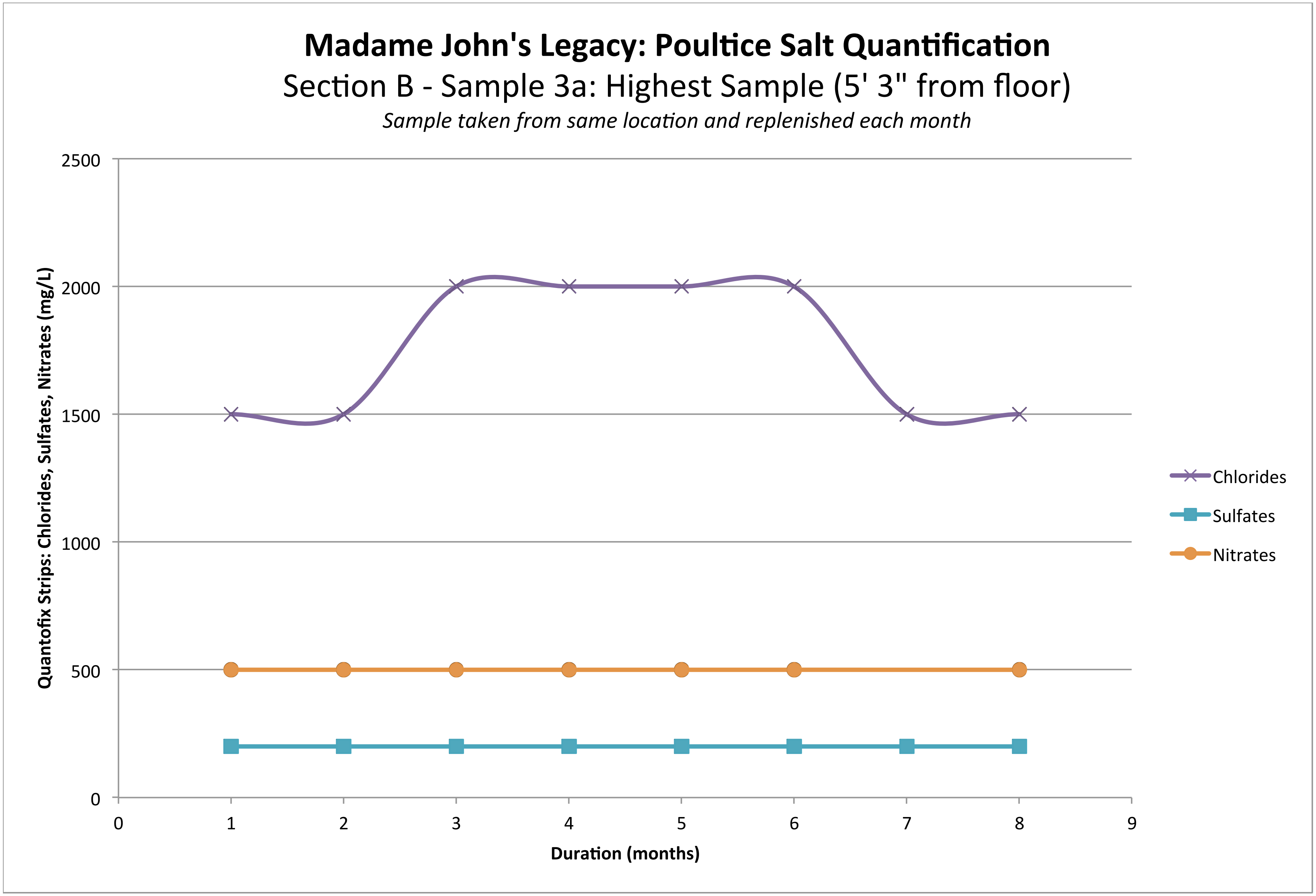


Madame John's Legacy: Poultice Salt Quantification
Section B - Sample 1a: Lowest Sample (1' 6" from floor)
Sample taken from same location and replenished each month
Quantofix Strips: Chlorides, Sulfates, Nitrates (mg/L)
2500
2000
1500
1000
500
0
0
1
2
3
4
5
6
7
8
9
Duration (months)
Chlorides
Sulfates
Nitrates

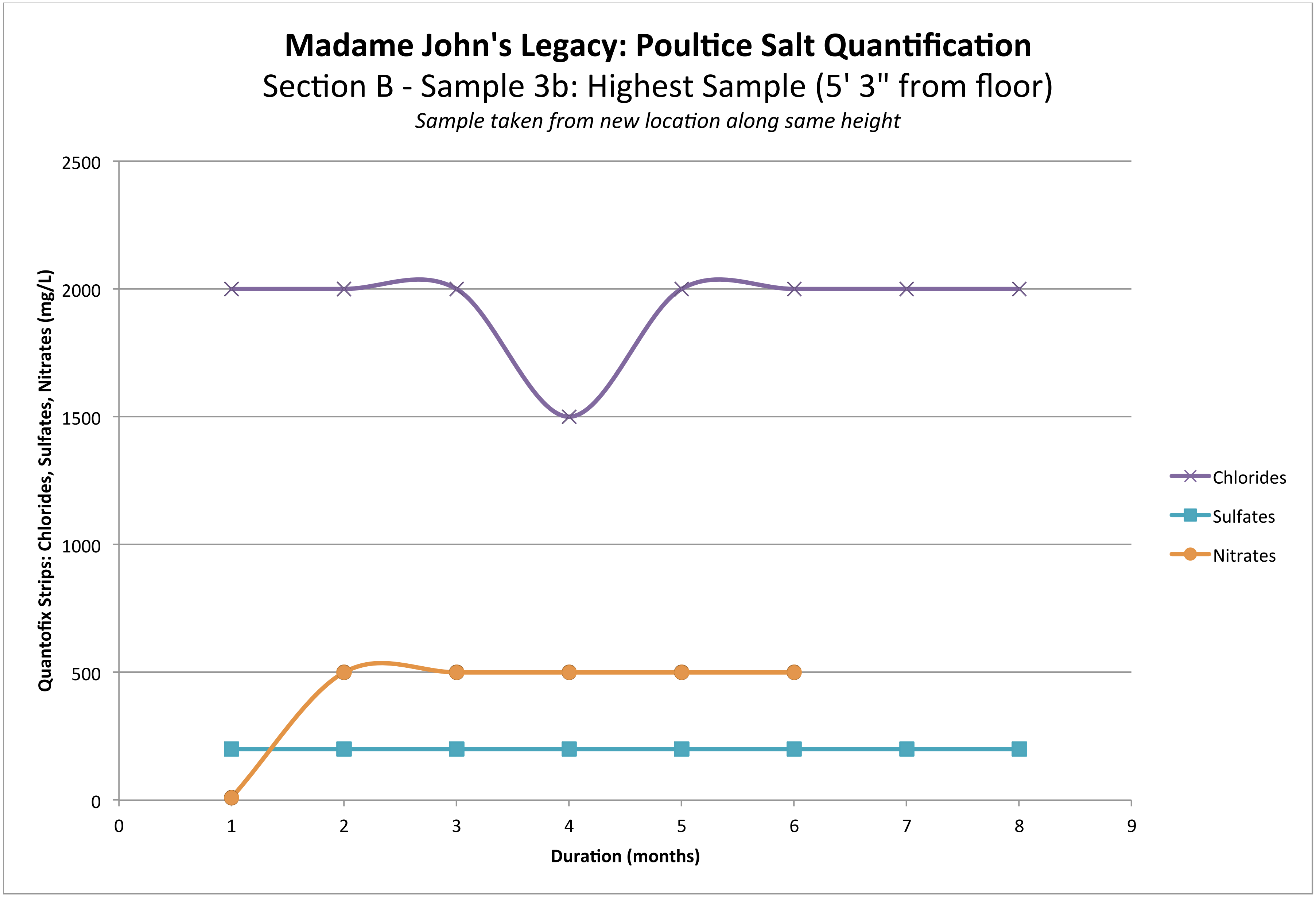

Madame John's Legacy: Poultice Salt Quantification
Section B - Sample 1b: Lowest Sample (1' 6" from floor)
Sample taken from new location along same height
Quantofix Strips: Chlorides, Sulfates, Nitrates (mg/L)
2500
2000
1500
1000
500
0
0
1
2
3
4
5
6
7
8
9
Duration (months)
Chlorides
Sulfates
Nitrates


Madame John's Legacy: Poultice Salt Quantification
Section B - Sample 2a: Middle Sample (3' 2" from floor)
Sample taken from same location and replenished each month
Quantofix Strips: Chlorides, Sulfates, Nitrates (mg/L)
2500
2000
1500
1000
500
0
0
1
2
3
4
5
6
7
8
9
Duration (months)
Chlorides
Sulfates
Nitrates


Madame John's Legacy: Poultice Salt Quantification
Section B - Sample 2b: Middle Sample (3' 2" from floor)
Sample taken from new location along same height
Quantofix Strips: Chlorides, Sulfates, Nitrates (mg/L)
2500
2000
1500
1000
500
0
0
1
2
3
4
5
6
7
8
9
Duration (months)
Chlorides
Sulfates
Nitrates



Madame John's Legacy: Poultice Salt Quantification
Section B - Sample 3a: Highest Sample (5' 3" from floor)
Sample taken from same location and replenished each month
Quantofix Strips: Chlorides, Sulfates, Nitrates (mg/L)
2500
2000
1500
1000
500
0
0
1
2
3
4
5
6
7
8
9
Duration (months)
Chlorides
Sulfates
Nitrates

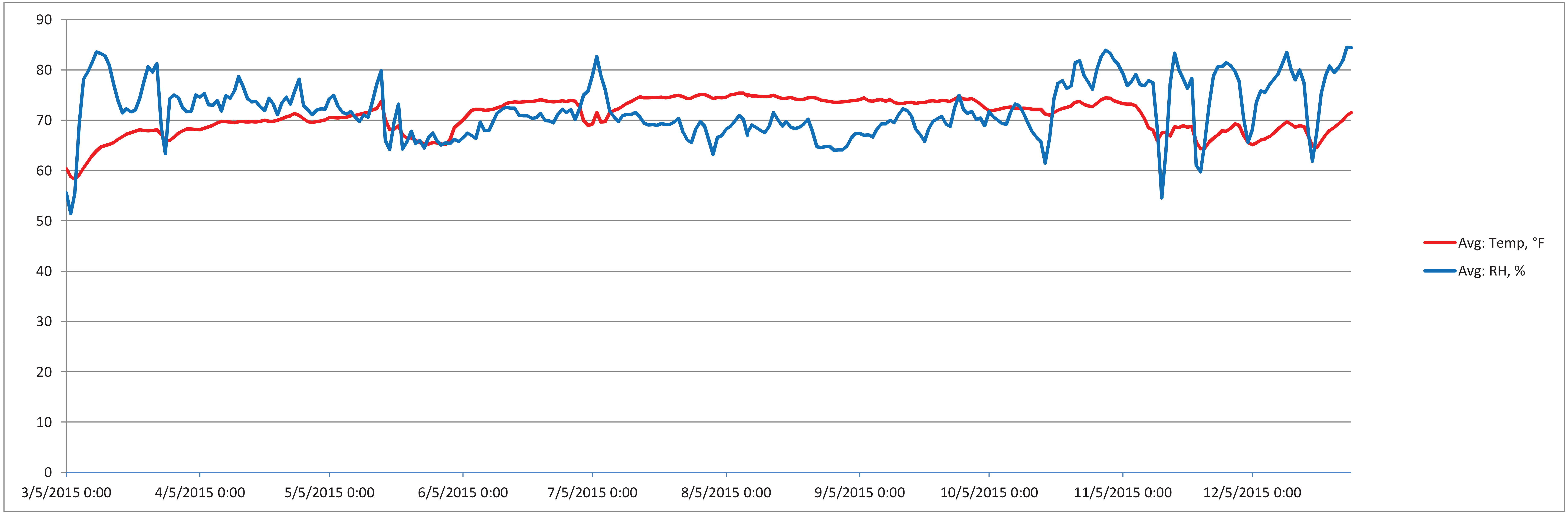


Madame John's Legacy: Poultice Salt Quantification
Section B - Sample 3b: Highest Sample (5' 3" from floor)
Sample taken from new location along same height
Quantofix Strips: Chlorides, Sulfates, Nitrates (mg/L)
2500
2000
1500
1000
500
0
0
1
2
3
4
5
6
7
8
9
Duration (months)
Chlorides
Sulfates
Nitrates

APPENDIX C:

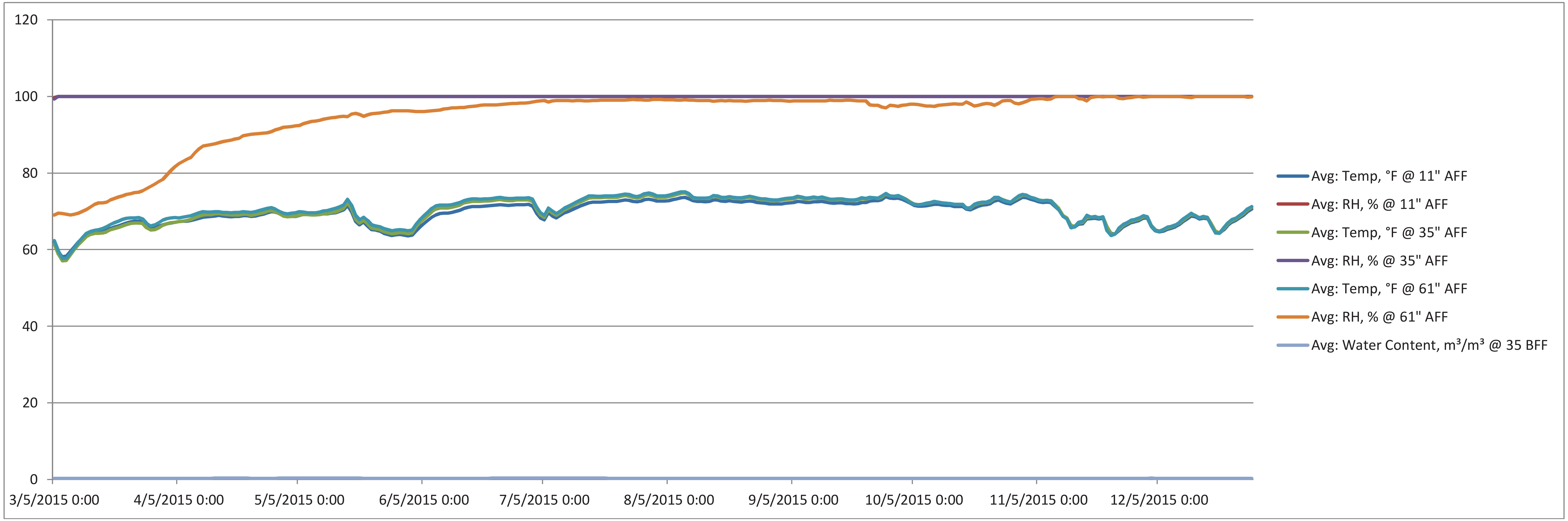
Environmental Monitoring Data

MADAME JOHN'S LEGACY PILOT PROJECT



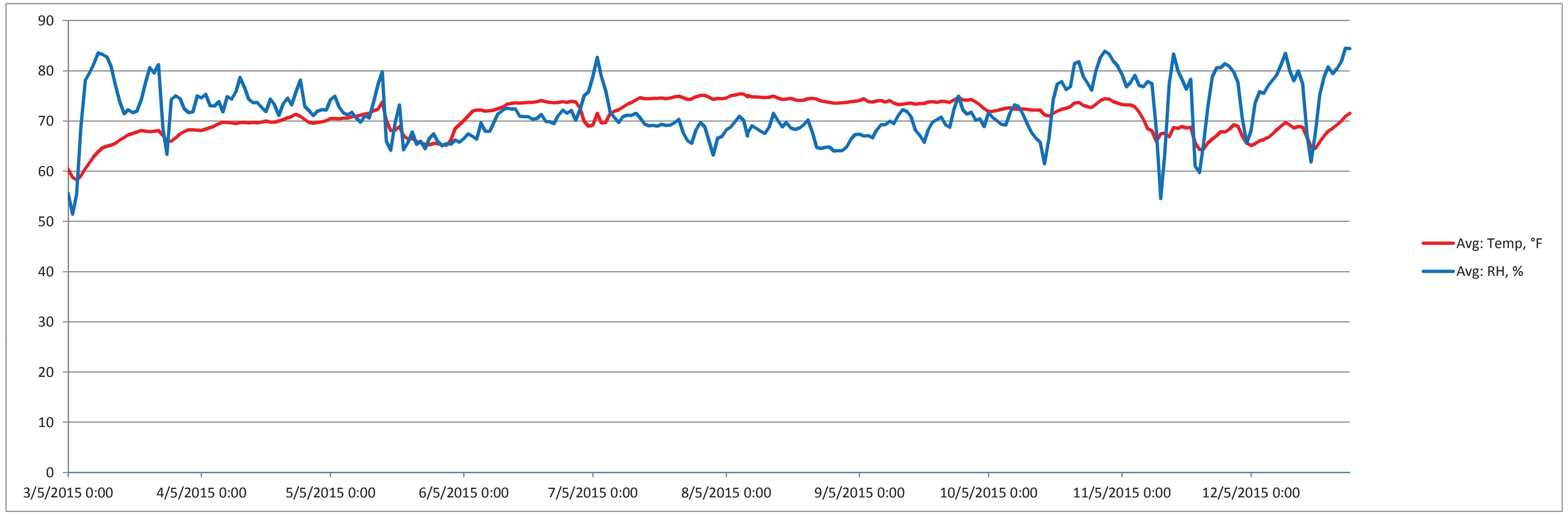
AMBIENT TEMPERATURE AND RELATIVE HUMIDITY (3.4.2015–1.15.2016)

MADAME JOHN'S LEGACY PILOT PROJECT

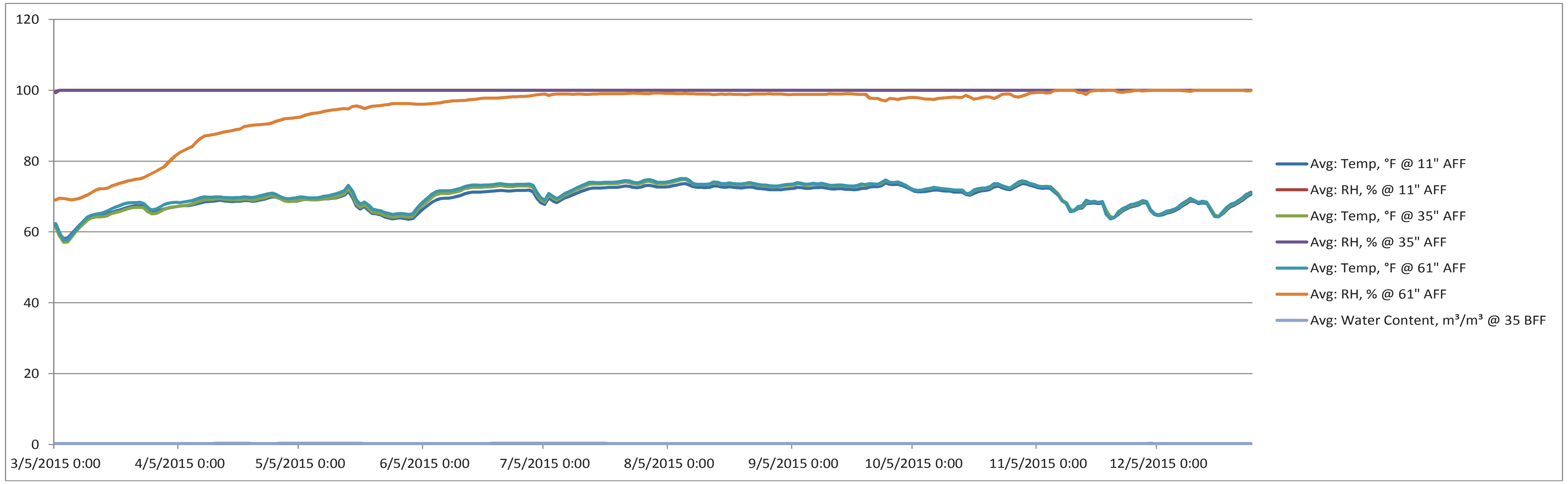


INTERNAL WALL AND SOIL CONDITIONS (3.4.2015-1.15.2016)

MADAME JOHN'S LEGACY PILOT PROJECT



AMBIENT TEMPERATURE AND RELATIVE HUMIDITY (3.4.2015-1.15.2016)



INTERNAL WALL AND SOIL CONDITIONS (3.4.2015-1.15.2016)

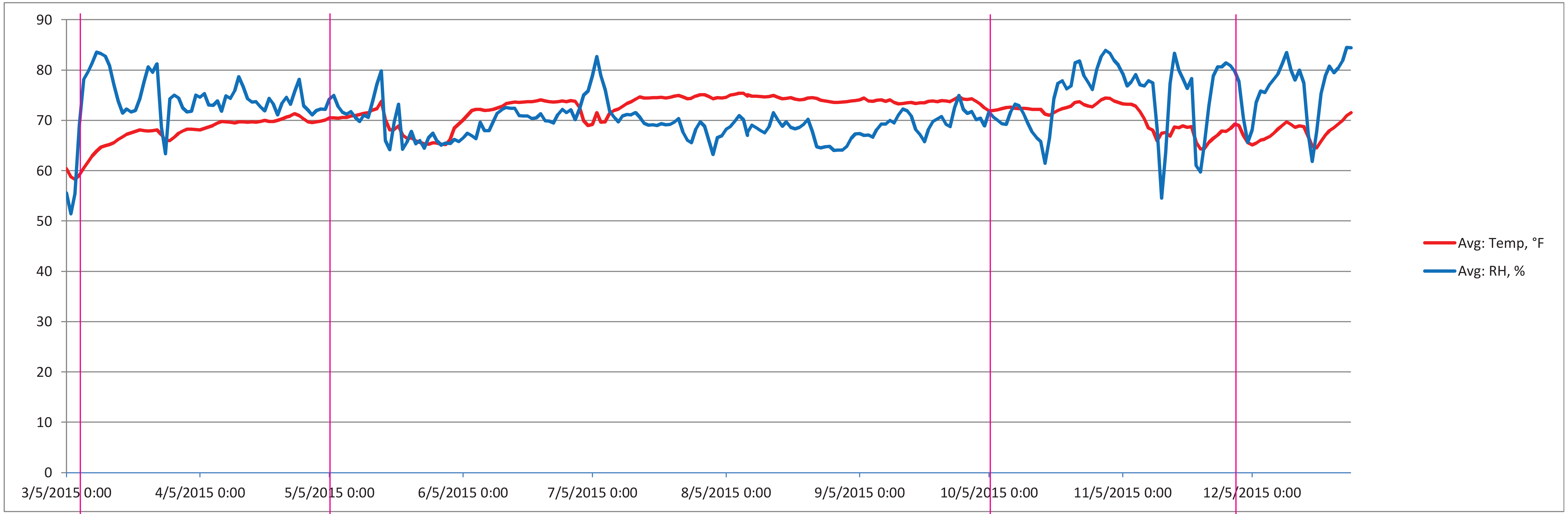
10.6.2015

11.30.2015

12.18.2015

1.15.2016

MADAME JOHN'S LEGACY PILOT PROJECT




3.6.2015


5.5.2015


10.6.2015


11.30.2015


1.15.2016


10.20.2015

APPENDIX D:

Cost Implementation

Estimate of Cost Implementation

The following estimate reflects the time and materials costs expended during the pilot project for the test wall, excluding costs associated with research, meetings, website development, grant management, report writing and organizing the symposium. Therefore, the estimate represents the cost for only the physical work on the test wall, including testing and monitoring. The expenditures were divided by the overall square footage of the pilot wall to reach a cost per square foot. There may be some economy of scale for materials for a larger project. It should be noted, however, that the estimate assumes a six-month project duration and eight poultice applications rather than the twelve-month duration and four poultice applications performed as part of the grant project, as this represents the poulticing application technique ultimately recommended by the study. The report recommends several modifications to the treatment method to be implemented in the future, such as an alternative damp proof course installation method, that are not accounted for in this estimate.

		Pilot Wall - Both Sides (4' x 7')			
		Fixed Cost ($)	Hours of Labor	Hourly Labor Cost ($)	TOTAL COST ($)
Wetting System					
Materials	Wet cure blanket	175			175
	Wood frame	50			50
	Irrigation tubing	50			50
	Tanks	15			15
	Shelving	75			75
	Distilled water	100			100
Installation	Conservator		16	50	800
Maintenance	Conservator		40	50	2000
Poultice					
Materials	Poultice material (4 buckets @ $60/each)	240			240
	tools	20			20
Initial Installation	Conservator	n/a	2	50	100
Reapplication (8)	Conservator	n/a	32	50	1600
Damp Proof Course					
Materials	Slate tiles and tools	100			100
Support	floor jack	50			50
Installation	Contractor/Conservator	n/a	8	50	400
Project Monitoring					
Monitoring Equipment	new sensors, batteries, etc.	225			225
Poultice analysis ($400/sample, assume 8 applications)*	Consultant	3200			3200
Sample analysis ($600/sample, assume 6 core samples)*	Consultant	3600			3600
Environmental	Conservator/Consultant		8	90	720
Synthesis of Monitoring	Conservator		32	90	2880
Repointing					
Materials	Lime	80			80
	Sand	20			20
	Pigment	15			15
Labor - raking	Contractor/Conservator		32	50	1600
Labor - repointing	Contractor/Conservator		16	50	800
TOTAL COST					18915
COST PER SQUARE FOOT					337.77

*Salt analysis of poultice and mortar samples assumed to be quantitative with initial screening to identify the salt type. Prices are estimates from Highbridge Materials Consulting, Inc.