Article: Plotting a Treatment: Delaminating and Bathing an 18 Foot Manuscript Map
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Plotting a Treatment: Delaminating and Bathing an 18 Foot Manuscript Map

INTRODUCTION

Oversize materials can be intimidating, and an 18 foot laminated manuscript map from San Juan National Historic Site was no exception. The size increased the handling risks during treatment, and required planning and logistics not typically needed for paper conservation. While the treatment steps for this project will be familiar to most paper conservators, their application to a map of this size represented a unique challenge.

The treatment plan evolved from careful testing and from prior observations made when treating two smaller, similarly laminated maps. The overall treatment was successful, with both planning and luck contributing to the final outcome. The goal of this article is to share what was effective and what could be done differently to make the process even smoother in the future.

San Juan National Historic Site

This map, along with 27 other documents and maps in similar condition, came to Harpers Ferry Center (HFC) after being identified as a high priority for treatment during a 2016 collections condition survey at San Juan National Historic Site. This park preserves and interprets the colonial era forts and walls that surround old San Juan in Puerto Rico. The history and collections of the park cover more than 500 years, including the Spanish-American War at the end of the 19th century.

The items conserved, which include letters, telegrams, maps, and covert messages, document US involvement in Puerto Rico and the transfer of power from Spain near the end of the war. They were all given a high priority for treatment during the survey due to an extensive cellulose acetate lamination campaign carried out at some point in the past. Some of the documents incorporated thin layers of tissue with the acetate lamination, whereas others were mounted overall to folder stock, or cloth with multiple layers of cellulose acetate.

LeHardy Map

The 18 foot map (fig. 1) was drawn in 1898 under the direction of George Washington Goethals, chief engineer of 1st Army Corps. Goethals is best known as the chief engineer for the Panama Canal. Paul LeHardy, the topographer, also has a tie to the National Park Service, as he was a member of the Jones expedition in 1873 to map the Yellowstone River. A cascading rapid in Yellowstone National Park was named for him after his party capsized there. The map will be referred to as the LeHardy map throughout this article.

Smaller Maps

The treatment of two smaller maps in the collection contributed significantly to understanding the potential pitfalls for the LeHardy map. The first, *Sketch Map, City of San Juan*, is hand drawn with black and red inks, blue washes, and graphite notations on architectural starched linen. It measures 12 × 24 inches. The second, a drawing in graphite and black media on extremely thin, poor-quality paper, depicts the whole island of Puerto Rico. The solubility and appearance of the black media (discussed in section 4) suggests Conte crayon or something similar. This map is 24 × 36 inches.

DESCRIPTION AND CONDITION

The LeHardy map is one continuous 18 foot sheet of heavyweight, machine-made paper. It is completely hand drawn with a graphite underdrawing and inked lines. The inked areas are opaque, using several colors including black, blue, and brown.

The LeHardy map (fig. 2) and the two smaller maps had been laminated in exactly the same conformation. The paper supports were mounted onto a woven cloth backing and heat- and pressure set with three layers of cellulose acetate film using a hydraulic press (fig. 3): one layer on the recto,

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Fig. 1. During-treatment image of the LeHardy map just prior to humidification and flattening.

one layer between the map and the support, and another layer on the verso of the maps.

Cellulose acetate lamination was established by conservators at the National Archives and Records Administration (NARA) in the 1930s as a standard conservation treatment and was regularly practiced into the 1980s (Page 2003, 55). The idea behind this outdated treatment was to create a rigid and self-sustaining support for fragile documents.

For these three maps, the most dire condition issue was the degradation of the cellulose acetate lamination. This was immediately apparent upon unrolling the LeHardy map, as the map emitted the distinct vinegar odor that is synonymous with cellulose acetate deterioration. Even when kept in optimal storage conditions, cellulose acetate can oxidize and degrade into acetic acid—the same compound found in vinegar.

Cellulose acetate can create a host of condition issues, such as embrittlement, cracking, off-gassing, oxidation, and discoloration, as well as cockling and warping (fig. 4), as the map and support degrade at different rates. In addition, the degradation reaction is autocatalytic and will worsen, more quickly, over time without intervention.

In addition to the cellulose acetate lamination, each of the maps had condition issues typically seen in paper, including discoloration, tears, staining, tide lines, and minor losses.

TREATMENT GOALS

The primary goal of this conservation campaign was to remove degrading cellulose acetate from 28 documents from San Juan National Historic Park. This treatment, along with more typical stabilization treatments like mending and washing, was imperative to slow their deterioration and preserve the objects for long-term access for park visitors and researchers.

Delamination requires solvent baths, which are time and space consuming, often requires the use of hazardous chemicals, and does not always successfully remove the cellulose acetate. Furthermore, even when delamination is successful, total removal of the cellulose acetate is impossible, such as

Fig. 2. Before-treatment images of the LeHardy map.

Fig. 3. A document undergoing lamination treatment at NARA in 1949. Courtesy of the National Archives Catalog.

in this case, where the plastic film was fused with the paper fibers and media during application.

The main challenge of this treatment was determining how to delaminate an 18 foot map. Spatial limitations notwithstanding, establishing and practicing a treatment protocol on smaller objects prior to treating the LeHardy map was crucial in ensuring a successful outcome. Since the other two maps were on a much more manageable scale, treatment was carried out on these first to identify the most successful approach for treating the LeHardy map.

SOLVENT TESTING

To begin, extensive solvent testing was carried out on the media of all three maps. This was the most time-consuming step, taking about three days to identify a solvent that would dissolve the cellulose acetate but would not disrupt the various media found throughout the maps. This step was done with the aid of a microscope and an elephant fume trunk. Solvents were brushed through the layers of cellulose acetate until the paper and media were exposed. It was apparent when the cellulose acetate was dissolved, as the surface turned from

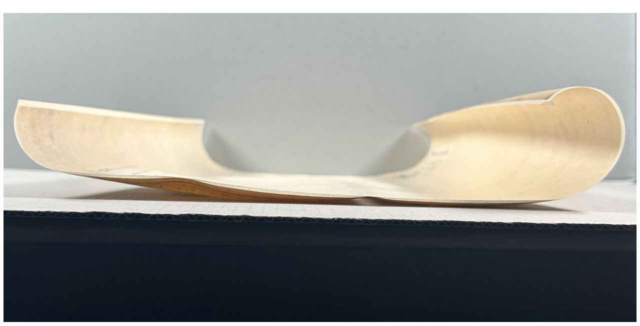

Fig. 4. Laminated and severely warped NARA record.

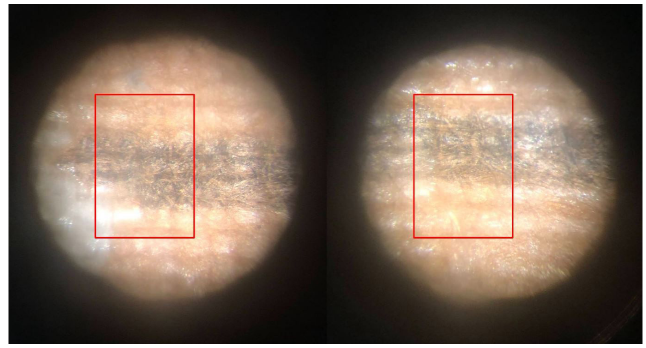

Fig. 5. Left: Microscopic image of a section of the map prior to solvent application; texture is shiny and smooth. Right: Microscopic image of a section of the map after solvent application; texture is matte and fibrous.

shiny and smooth to more matte and fibrous, typical of bare paper (fig. 5).

It is standard to begin this testing with acetone and ethyl acetate, as these solvents are known to dissolve cellulose acetate. While these were both successful in softening the laminate, they disrupted the red media and some of the heavier applications of black media on the two smaller maps. Further research was needed to find a solvent that would dissolve the laminate without damaging the media.

The Teas chart was an invaluable tool when finding a solvent with similar bonding forces as acetone and ethyl acetate. Several solvents were identified using the Teas chart, which were then cross-referenced with the inventory at HFC, including methyl ethyl ketone (MEK). MEK falls close to acetone on the Teas chart (fig. 6), indicating that it has similar solubility characteristics.

Following the same solvent testing procedure, the media of the two smaller maps was tested with MEK and found to be stable. However, the short-term workplace exposure limit for MEK is about 300 parts per million (ppm) (New

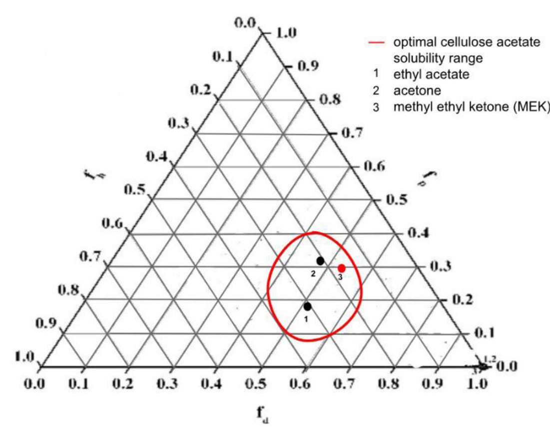

Fig. 6. Teas chart showing the three primary cellulose acetate solvents: ethyl acetate, acetone, and MEK.

Jersey Department of Health and Senior Services 2002), which is significantly lower than that for acetone (750 ppm) (New Jersey Department of Health and Senior Services 2015). To limit unsafe exposure to MEK, a 1:1 mixture of acetone and MEK was tested and had no negative visual impact on the media, and so was chosen to delaminate the smaller maps.

SAFETY

Acetone and MEK are noxious solvents that can cause serious skin and lung irritation in the short term, and reproductive and neurological complications from long-term exposure (New Jersey Department of Health and Senior Services 2002, 2015). To minimize these effects, delamination treatments were carried out in well-ventilated areas and with proper personal protective equipment.

Only the "Sketch Map," the smallest of the San Juan maps, fit inside the fume hood at HFC, so treatment was carried out there using nitrile gloves (fig. 7). For the other small map, the one depicting Puerto Rico, an outdoor treatment area was set up using an industrial fan to encourage further air movement (fig. 8). This treatment was also carried out using just

Fig. 7. The smallest map undergoing delamination in a disposable Mylar tray inside a fume hood.

Fig. 8. Delamination setup of the middle-size map.

nitrile gloves, but it quickly became apparent from the odor that working directly over a solvent bath, without respiratory protection, even outdoors and with a fan, created the potential for unacceptable solvent exposure on a large scale.

The LeHardy map was going to require multiple solvent rinses that would take several hours to complete, so all participants in the treatment were medically cleared and fit tested for respirators. Half-mask respirators equipped with organic vapor filters were worn during the delamination of the LeHardy map.

PRACTICE RUNS ON SMALLER MAPS

Both of the smaller maps were successfully delaminated (fig. 9), which suggested that the LeHardy map would also be successful should the same treatment procedure be followed. However, there were some issues that arose during those treatments that required tailoring the approach according to the object's needs.

To begin, peeling the backing material off the smallest map prior to solvent submersion streamlined the treatment immensely. With the middle-sized map, the paper was too fragile and the adhesive had become too cross-linked to safely remove it prior to the solvent bath, so it was necessary

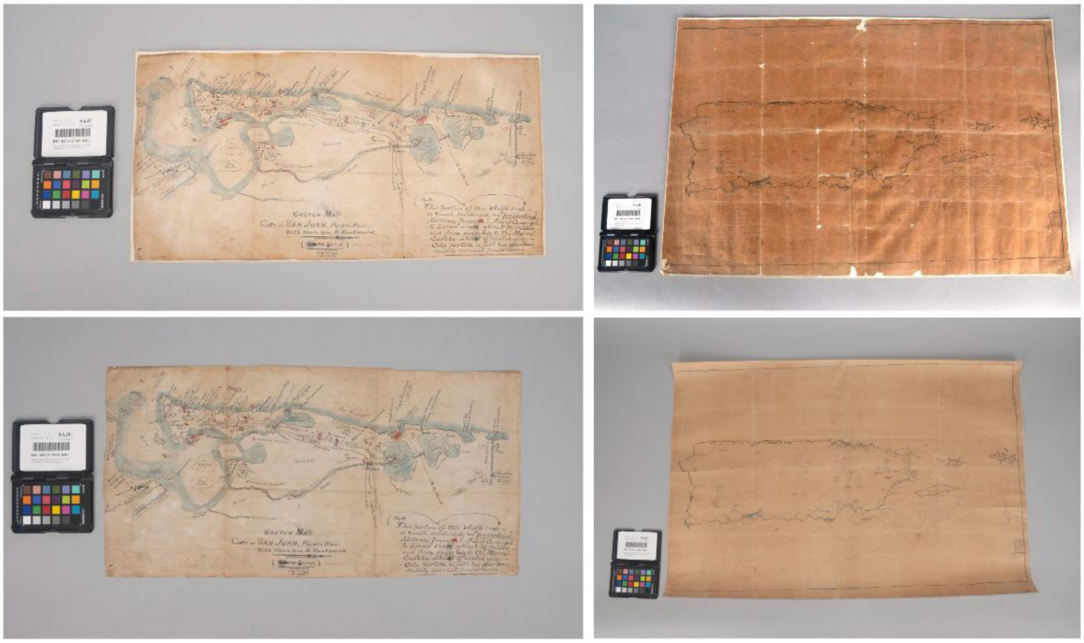

Fig. 9. Top and bottom left: Before- and after-treatment images, respectively, of the smallest map. Top and bottom right. Before- and after-treatment images, respectively, of the middle-size map.

to remove it while the document was submerged, which required additional time and care (fig. 10). Fortunately, the backing material of the LeHardy map peeled off easily before submersion. Furthermore, when stripping the backing material, the middle and bottom layers of the laminate were removed as well, which allowed the delamination treatment to be carried out from just the recto rather than the recto and verso. This saved an enormous amount of time and resources.

Additionally, the container for the solvent bath had to be customized for each map. For the smaller maps, disposable trays were constructed of Mylar (polyester film). The Mylar was cut to 2 inches larger than both the width and length of the map, then stapled at the corners to create walls (see fig. 7). The easy construction and simplicity of the materials allowed multiple trays to be made for each solvent rinse. However, creating multiple 20 foot long Mylar trays to accommodate the full size of the LeHardy map was not going to be feasible or structurally sound. Finding an alternative that would support the weight of the object was necessary. Therefore, the map was delaminated piecemeal, in a smaller, more manageable container with walls able to support the weight of the heavy paper.

Fig. 10. Left: Dry removal of the cloth backing from the smallest San Juan map. Right: Wet removal of the cloth backing from the middle-size San Juan map.

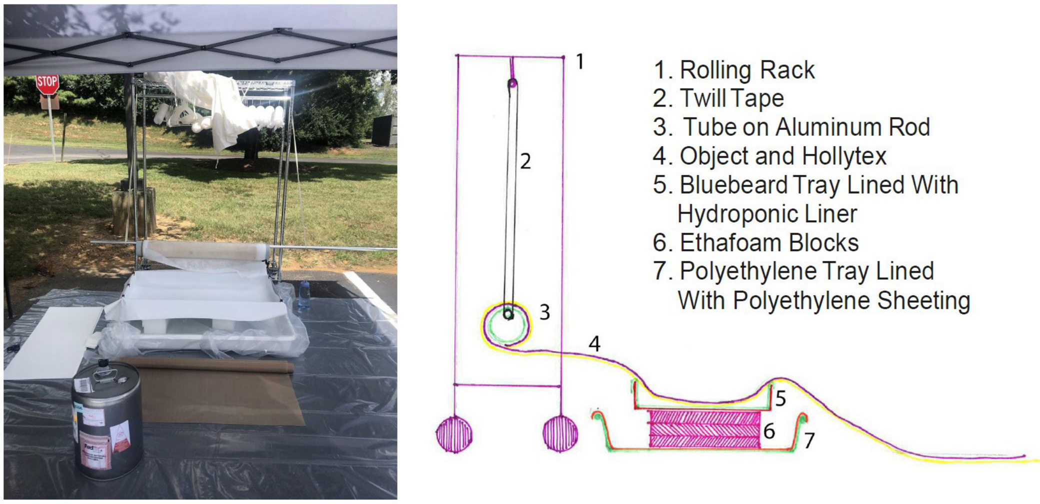

Fig. 11. The delamination setup for the LeHardy map.

THE SETUP

The delamination rig used for this project was assembled using supplies found around the conservation laboratories, such as those presented next (fig. 11).

Rolling Rack. A repurposed storage rack was used to support the map and keep it elevated above the solvent bath.

Tube. A six inch diameter archival tube was used in this case, but any sturdy tube could be substituted. The tube was wrapped with Teflon-coated fiberglass secured with staples to prevent the solvent or cellulose acetate residues from saturating the tube. The tube was then suspended on a pole and hung from the top of the rolling rack with twill tapes. The map was wrapped around the tube on a layer of Hollytex to prevent it from sticking to itself between solvent baths.

Primary Tray. To begin the delamination process, the map was unrolled from the tube, in sections, into the primary tray containing the acetone bath. The tray was constructed using double-walled, blue corrugated cardboard lined with hydroponic liner. The corners of the tray were cut and held together with Velcro tabs (fig. 12). This design allowed the walls to collapse so that used acetone could be drained into a secondary container. The ability to refill the tray with fresh acetone rather than continually adding more acetone to an already dirty bath saved time, resources, and grief. For this object, the dimensions of the tray were 22 × 42 × 4 inches.

Secondary Tray. The primary tray rested on Ethafoam blocks inside a secondary tray, raising it slightly above the lip. This tray served as a drainage basin for spent solvent and dirty blotters used during treatment. A large polyethylene tray was lined with polyethylene sheeting and served as the secondary tray. Such a tray could also easily be constructed from blueboard or any existing corrugated cardboard box.

Polyethylene Sheeting. Polyethylene sheeting was used to line the ground under the entire area used for treatment to keep the setup and object as clean as possible.

Canopy. The treatment took place at the end of August, and shade was essential to getting the treatment done, even on a more temperate day.

DELAMINATION

Although untraditional to delamination practice, the quickest way to delaminate the LeHardy map was to use squares of blotter to manually remove the laminate as it softened (fig. 13). This helped speed the overall process, and helped

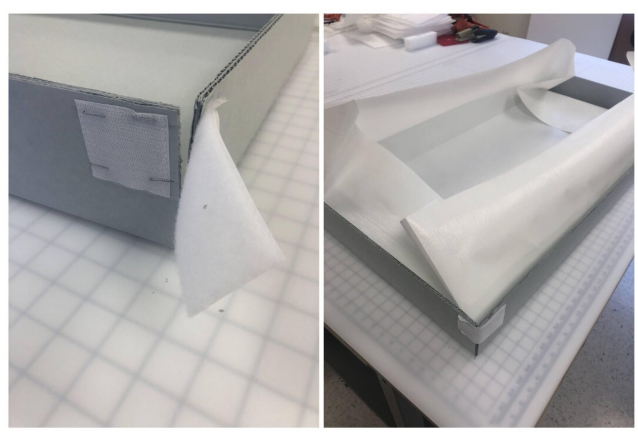

Fig. 12. Construction of the primary tray, highlighting the collapsible Velcro walls.

Fig. 13. Scraps of blotter used to manually remove softened laminate from the submerged object.

the solvent last longer in the tray without becoming thick with dissolved cellulose acetate. The procedure was to have two people on each side of the object: one person scraping the submerged portion of the object and removing the softened laminate, and another person to scrape the previously submerged portion for excess laminate and to help blend the drying front to prevent tide lines (fig. 14). When the time came to move on to the next section, two people would unroll the object from the tube while the other two slid the delaminated portion down.

Acetone was added to the bath, as needed, during each round of delamination. Between each round, two people would roll the object back onto the tube while the other two drained the primary bath into the secondary tray and refilled it with fresh acetone. The first two rounds required more frequent refreshes of acetone, but this slowed down with each subsequent round as more laminate was removed from the object. The used blotter scraps were tossed into the secondary tray along with the used acetone from the bath, containing the waste and simplifying cleanup. In the end, two 20 L drums of acetone were used in the delamination of the LeHardy map.

As was expected, cellulose acetate precipitated back onto the surface of the map as it dried between each round. With each round, this was reduced until there was no remaining visual or tactile evidence of cellulose acetate. The delamination process was repeated for a total of four rounds and took approximately 5 hours from setup to cleanup.

BATHING

The next treatment challenge was determining how to bathe the map. Several options were considered, including

Fig. 14. Clockwise from top right: Sara Leonowitz, Megan O'Brien, Maeve O'Shea, and Allison Holcomb delaminating the LeHardy map.

Fig. 15. Bathing setup for the LeHardy map.

outdoors or on the floor, but each of these presented their own problems and were thus discarded. In the end, there was just enough space to line up the two 4 × 8 foot benches and build a tabletop sink spanning the entire width of the paper laboratory (fig. 15). Blueboard was used to compensate for uneven table height, and 1 × 1 inch wooden boards were used to create a shallow wall around the edges. The same hydroponic liner used to line the acetone bath was used to line the sink. The liner was creased with a bone folder to smooth it flat against the walls of the bath, then clamped in place along with the boards. A small extension to the tables was necessary and was built using double-wall blueboard held in place with the 1 × 1 inch boards and clamps.

A homemade squeegee, slightly smaller than the width of the sink and built with double-wall blueboard, a scrap of hydroponic liner, and a staple gun came in very handy. This was key in draining the sink between each bath.

The bathing process and solutions were similar to those that would be used for any smaller bathing treatment. Ammonium hydroxide and calcium hydroxide were used to adjust the pH of the water. Sodium citrate, a mild chelator, was used to help reduce discoloration and tide lines. Buckets of the solutions were used to fill the sink. By using a dilute stock of ammonium hydroxide, the same pH could be easily and quickly produced in each bucket. For the first bath, the sink was filled with 16 gallons of solution. For each successive bath, 8 gallons was enough to fully immerse the map. The bathing procedure was as follows:

- Ethanol spray to wet out
- Ammonium hydroxide at pH 8
- 1% sodium citrate (pH 8)
- Ammonium hydroxide at pH 8 with local sodium citrate (pH 8)
- Rinse with ammonium hydroxide at pH 8
- Final bath with calcium hydroxide at pH 8

Hollytex was used for support, and the map was never moved during the bathing process. An additional piece of Hollytex was used to cover the object between each bath as the sink was drained. The bathing solutions were emptied through a corner drain, and the map was blotted with Tek-Wipe between each bath. The most time-intensive part of this process was filling and draining the sink, making the bathing a full-day process.

The map was dried in the sink, to avoid moving it while wet, with polyester felts underneath and on top to slow the process.

HUMIDIFICATION AND FLATTENING

The map dried with noticeable distortions, so after mending the small tears and filling the losses, a round of overall humidification was needed. To avoid moving the map, it was humidified and dried in the same place. First, three layers of 100 pt blotter were laid out on the counter, with the seams of each layer staggered. These were covered with a layer of Dartek Nylon film that could be removed after humidification. The map, with a layer of Hollytex on each side, was laid down over the Dartek and covered with dampened Gore-Tex. The Dartek–map–Gore-Tex stack was sealed with Mylar. To simplify the process, the map was only humidified from the top, which lengthened the time necessary but eliminated the handling risk. Once humidification was complete, the plastic was removed, the Gore-Tex was rolled up, and another three layers of 100 pt blotter were layered over top, along with plates of glass and weights.

STORAGE

With treatment complete, the map was returned to the park on a lignin-free, buffered, 6 inch diameter tube rolled with Permalife interleaving paper. The exterior was wrapped with Mylar to protect against dust, pollutants, and water.

DISCUSSION

Overall, the treatment was successful and yielded a map that is still in good condition with enough strength to be handled for research purposes or displayed for short-term exhibits (figs. 16, 17). Treatment increased the map's legibility, revealing subtle graphite details not apparent before. Throughout the treatment process, there were elements that helped and hindered the progress, both through luck and planning.

Successes

Cloth Backing. The cloth backing was easy to remove mechanically, taking the middle layer of cellulose acetate with it. This was most likely due to the thickness of both the paper and the cloth, which prevented proper adhesion of the middle

Fig. 16. After-treatment image of the LeHardy map, on the floor of the photography studio at HFC in West Virginia.

layer of cellulose acetate during the original lamination. With a thinner paper, or a lamination without a cloth backing, it is unlikely that mechanical removal would have been as successful. In turn, this meant that the map could be face up and easily monitored for the entirety of treatment, decreasing the overall time necessary for delamination.

Collapsible Tray Wall. The collapsible tray wall functioned as anticipated and streamlined the process of changing out the solvent with minimal fuss.

Hydroponic Liner. The use of hydroponic liner was suggested by HFC's textile conservator based on a paper presented by Jennifer Cruise at the AIC Annual Conference in 2019. The liner is made from polyethylene and can be treated in the same way as a polyethylene tray used for solvent and aqueous treatments. It is fairly rigid and offers more structural stability than polyester or polyethylene film, but can be folded and creased, which allows for more flexibility in size and shape than traditional trays.

Blotter Scraps. Using blotter scraps to help remove the softened cellulose acetate in the solvent bath greatly reduced the overall time needed for this part of the process and, perhaps more meaningfully, reduced the amount of solvent needed. This was in part possible due to the resilience of the media and the overall texture of the paper. This would not have been possible given friable media or a rougher and more fibrous paper.

Adjustments

Instrumental Analysis. While testing is always a necessary step, it is possible that media analysis prior to treatment could have narrowed the solvent selection prior to treatment. X-ray fluorescence spectroscopy could have given an indication of the presence of specific media, such as iron gall ink, or helped to distinguish between dye and pigment-based inks.

Tide Lines. When wetting out the map at the start of the aqueous bathing process, tide lines not visible when the object was dry became very apparent. The spacing of these lines indicated that they were likely caused during the delamination process despite efforts to feather the wet/dry interface while the object was drying (fig. 18). These tide lines were all but completely reduced during the bathing process, but ideally this could have been mitigated during the delamination through a few different means:

- Polyester film could have been used to cover the paper and slow the solvent evaporation as it was pulled from the acetone bath.
- An additional final run through the acetone bath with the goal of evenly saturating the paper without the stop and start necessary during the earlier baths could also have helped disperse the tide lines.

Solvent Tray. The solvent tray worked very well overall. Tweaks could be made to simplify its use and protect the object:

- The tray was deeper than it needed to be. A 2 inch tray would have been enough to contain the small amount of solvent in the bottom of the tray while allowing the paper to lay with less stress over the edges of the tray.
- The edges of the tray could be rounded with Ethafoam underneath the hydroponic liner, again with the goal of mitigating stress on the object.

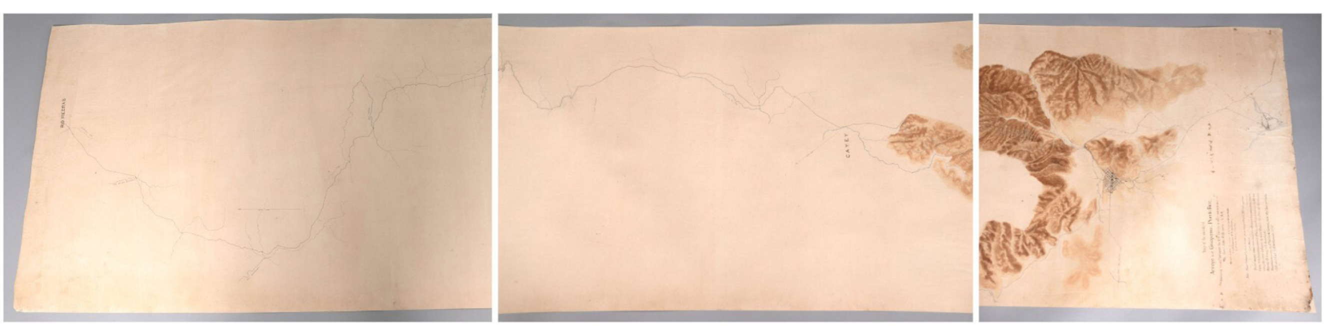

Fig. 17. After-treatment images of the LeHardy map.

Fig. 18. Residual laminate re-formed during the delamination process corresponded with tide lines seen during the early parts of the bathing process.

Additional Hands. While there was the perfect amount of human support for the delamination portion of the treatment, with more people on standby, additional hands for the bathing portion of the treatment would have substantially streamlined the overall process.

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SOURCES OF MATERIALS

Hydroponic liner: Ultra Scrim FGC
Global Plastic Sheeting
1548 Jayken Way, Units C & D
Chula Vista, CA 91911
866-597-9298
https://www.globalplasticsheeting.com

PrecisionFab Teflon-coated fiberglass PC-3 standard
Precision Coating
51 Parmenter Rd.
Hudson, MA 01749
978-562-7561
https://www.precisioncoating.com

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