GEOLOGIC SAMPLE AND CORE REPOSITORY

CHALLENGE

The Massachusetts Water Resources Authority (MWRA) geologic sample and core repository must be permanently moved from its current location in Building 4 at the Fore River Shipyard in Quincy, Massachusetts to allow for resale and reassignment of that space.

BACKGROUND

What is the Geologic Sample and Core Repository

The geologic sample and core repository is a collection of rock specimens, thin sections, photographs, soil samples, cylindrical cores of rock or sediment and associated records acquired during the planning and design of statewide water and sewer related construction projects in Massachusetts. These samples were gathered over a period of 80 years dating back to the 1920’s (Figure 1). In some cases, these samples are the only records available documenting particular areas of the subsurface geology of the Commonwealth. The current collection contains over 70,000 linear feet of rock core, 525 thin sections, various rock samples, photographs and records in a 13,000 square foot area 16 feet high.

Figure 1. Map showing the location of some of the borings taken by the MWRA and affiliated agencies during the design of water supply and wastewater construction projects.
Origin of the Collection

The State Legislature established the Metropolitan District Water Supply Commission (MDWSC) in 1926 (Ch. 375, Acts of 1926). The following year, emergency legislation was passed enabling the MDWSC to draw water from the Swift River in western Massachusetts and set the stage for the construction of the Quabbin Reservoir (Ch. 321, Acts of 1927). Section 2 of this legislation stipulates that: “The commission shall collect and publish in its reports such information as to the geology of the region in which any of the works which it is authorized to construct may be located as may be of value in connection with the geological history of the State” (Ch. 321, Acts of 1927, Section 2). Since that time the MDWSC and its affiliated public agencies, including the predecessor Metropolitan District Commission (Ch. 350, Acts of 1919; Ch. 583, Acts of 1947) and successor Massachusetts Water Resources Authority (Ch. 372, Acts of 1984), have continued to collect, retain and publish geologic information from their various projects for the benefit of the public. The collection and analysis of geologic information was integral to the engineering design process for these public works, which were principally created to ensure the provision of reliable, potable water supplies and to safely treat and dispose of municipal wastewater.

Collection as a Public Record

All the materials that have been collected over the years by the various agencies are considered public records (30 MGL 42; 66 MGL 1; 66 MGL 8; 4 MGL 7(26)). Public records include “all books, papers, maps, photographs, recorded tapes, financial statements, statistical tabulations, or other documentary materials or data, regardless of physical form or characteristics, made or received by any officer or employee of any agency, executive office, department, board, commission, bureau, division or authority of the commonwealth, or any political subdivision thereof, or of any authority established by the general court to serve a public purpose” (30 MGL 42). All public records of historic value must be available for exhibition and educational purposes (9 MGL 2). Furthermore, the retention schedule for all geological tests and reports, soil boring records etc. is permanent (Massachusetts Statewide Records Retention Schedule 04/04).

WHY THE MWRA COLLECTION IS SO VALUABLE

Intrinsic Value of Collection

Over the past 80 years, the constantly growing MWRA geologic specimen and core collection has served an important primary earth-science information source for a wide variety of individual citizen, academic, private sector, and government agency inquiries and issues. These collections serve as a foundation for basic and applied geoscience research and education, underpin private and public sector programs to discover and develop natural resources; provide insights that assist in the delineation, prediction, and mitigation of natural and anthropogenic hazards such as landslides; and help guide local and regional assessments of groundwater quantity, quality, protection and remediation.
Collection as a Unique Archive

According to a recent report by the National Research Council (NRC, 2002, p.9-10):

*Geoscience data and collections come in many shapes and forms. Whether they are fossils, rocks, or cylindrical cores of rocks, sediment, or ice, these geological materials record chapters of Earth history. Taken together, these chapters constitute a library that federal and state agencies, university researchers, and private companies use daily to understand the physical world – past, present, and future. This library provides invaluable and, in many cases, unique information with scientific, health, safety, commercial, and educational benefits. Each time a geological sample or piece of data is allowed to deteriorate, or is damaged, misplaced, or thrown away without assessing its merits, the information it contains and the knowledge it represents are lost. Multiplying this loss over and over again is analogous to the destruction or loss of irreplaceable books in a library. Such losses have the potential to result in analyses, interpretations, and policies that reach incomplete, poorly supported, or even erroneous conclusions.*

The geologic samples and data sets in the MWRA collection serve as a permanent geologic reference collection that is regularly added to, but more importantly, re-visited as new analytical techniques, new scientific interpretations, new environmental concerns, and new societal issues require re-examination and re-appraisal of original specimens and related records. Old samples regularly produce new knowledge. As such, the core collection represents an unusual archive with unique value because there are no copies of these materials available anywhere else in the world.

**How the Collection is Organized**

The MWRA currently maintains a complete and very well organized inventory of the rock specimens, thin sections, cores and related records in the collection. The core locations (Figure 1) and associated boring logs are maintained and retrievable by way of a computerized database (GBase). All rock specimens and cores are labeled, easily retrieved and viewed at the core facility. With the help of MWRA staff, anyone can access the collection and utilize the information. The MWRA collection constitutes the most comprehensive source of readily available subsurface data from within Massachusetts in New England.

**Who Uses the Collection**

Private sector consultants, academic researchers, and state and federal agencies have used extensively the rock specimens and cores available in this collection. Since the 1960’s, over 17 geological science faculty and students and many private sector engineering and environmental consultants have made use of the core collection. Access to this important collection has contributed over 70 scientific articles, abstracts, maps, and presentations leading to a better understanding of the geological and natural history of Massachusetts.
While some individuals examine the core themselves, others request information from the collection caretaker and librarian. For example, recent scientific inquiries, customer issues, questions, or information needs that the MWRA collection has helped to address include:

- Crucial data for cross section B-B’ for the 1983 color Bedrock Geologic Map of Massachusetts provided by core from the Quabbin Aqueduct tunnel.
- Key data for unraveling the geology in the Quabbin Hill area from cores in the Windsor Dam and Quabbin Dike.
- Detailed stratigraphy, structural geology, and petrology of the Ware, Barre and Rutland-Wachusett Mountain areas.
- Detailed petrology of sulfide-rich schists in central Massachusetts provided by subsamples from the Quabbin Aqueduct tunnel cores.
- Petrology and mineral chemistry of the Hardwick tonalite obtained from samples of the Quabbin Aqueduct cores.
- Critical data for determining the origin of the sulfide-rich zone in the Monson gneiss obtained from polished sections of samples from the proposed Northfield Mountain-Quabbin Diversion tunnel.
- Preparation of geologic maps for the Boston Basin from data collected from the Malden and Dorchester Tunnels, City Tunnel, Main Drainage Tunnel, and City Tunnel Extension.
- Investigation of the origin of the Cambridge argillite in the Boston Basin using detailed geochemical analyses of samples collected from cores retrieved in the MetroWest Tunnel, City Tunnel Extension, North Metropolitan Relief Tunnel, Main Drainage Tunnel, Inter-Island Tunnel, Dorchester Tunnel, Braintree-Weymouth Tunnel.
- Investigation of the origin and tectonic implications of the Roxbury Conglomerate based on archival cores from the Dorchester Tunnel.
- Development of lesson plans for K-12 school groups and classes.
- Development of earth science teacher workshops for the Massachusetts Audubon Society.
- Preparation of background geological information for the Trustees of Reservations, Boston Harbor Islands National Park and Puddingstone Park in Roxbury, Massachusetts.
- Determination of the cause of failure in the Dorchester tunnel in 1976.
- Study of the characteristics of regional faulting along the Clinton-Newbury fault zone.
- Characterization of the sandstones in the Boston Basin in cores collected from the Dorchester tunnel.
- Evaluation and characterization of the enigmatic “Northern Border Fault” in the Boston Basin using core collected in 1937.
- Completion of seismic stability study in 1991 of the Wachusett Dam and North Dike, Wachusett Reservoir.
- Characterization of the Bloody Bluff Fault zone in the vicinity of the Sudbury Reservoir.
- Determination of the depth to bedrock, groundwater availability and overburden type and thickness as part of quadrangle-scale geological mapping efforts by the Office of the Massachusetts State Geologist.

Geoscience faculty and other interested parties who have made use of the collection are tabulated below. Although the numbers may appear small, this group is responsible for most of the
advances in geological understanding in Massachusetts in the past 30 years. Furthermore, the geologic maps and reports generated from this understanding provide fundamental geologic information that is used by professional consulting disciplines in their detailed site-specific studies. This information, in turn, can reduce potentially (in some cases substantially) the financial costs to both private and public entities in the early stages of project planning. Thus, the benefits of the information residing in the MWRA collection reach individual stakeholders on a daily basis.

<table>
<thead>
<tr>
<th>Some Past and Recent Customers and Beneficiaries of the Core Collection</th>
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<tbody>
<tr>
<td><strong>Geoscience Faculty</strong></td>
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<tr>
<td>Harvard University, Dr. Marland Billings (deceased)</td>
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<tr>
<td>University of Massachusetts, Dr. Peter Robinson</td>
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<tr>
<td>Washington University, Dr. Robert Tucker</td>
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<td>Virginia Polytechnic Institute, Dr. Robert Tracy</td>
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<td>University of New Mexico, Dr. Charles Shearer</td>
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<td>University of Vermont, Dr. Rolf Stanley (deceased)</td>
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<td>Union College, Dr. Kurt Hollocher</td>
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<td>Boston College, Dr. James Skehan</td>
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<td>Wellesley College, Dr. Margaret Thompson</td>
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<td>Boston College, Dr. Rudolph Hon</td>
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<td>Boston College, Dr. J. Christopher Hepburn</td>
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<td>Northeastern University, Dr. Richard Bailey</td>
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<tr>
<td><strong>Other Researchers</strong></td>
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<tr>
<td>Nick Ratcliffe, U.S. Geological Survey</td>
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<td>Norman Hatch, U.S. Geological Survey</td>
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<td>Henry Berry, Maine Geological Survey</td>
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<tr>
<td>Joe Kopera, Office of Massachusetts State Geologist</td>
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<tr>
<td>Dave Ashenden, MWRA</td>
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<td>Steve Mabee, Massachusetts State Geologist</td>
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<td>Patrick Barosh, Independent Consultant</td>
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<td>Ed Landing, NY State Geological Survey</td>
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| **Various Students and Individual Citizens**                  |

**WHY THE COLLECTION MUST BE MAINTAINED**

A suggestion has been made to dispose of the historic cores in the MWRA collection. This is tantamount to disposing of irreplaceable books in a library. Aside from the legal responsibility, there are scientific, health and safety, educational, societal and economic benefits to be gained by maintaining all the cores in the collection.

**Scientific Benefits**

The cores and rock specimens in the collection represent primary geoscience data that have been collected at significant expense with public funds (Figure 2). In many instances, these cores are the only data available documenting the geology of Massachusetts particularly in areas where surface outcrops are completely lacking or in areas that have been fully developed and are
Scientific methods used to study earth processes continually improve. Advances in electron microscopy, new geochemical analysis, and age dating techniques, for example, have opened up a view of the world that was unheard of just 20 years ago. Cores taken from the 1930’s through the 1960’s helped reinterpret the origin of the Boston Basin in the 1990’s and changed the thinking on the crustal evolution of the North American continent (Figure 2). Without the core, this scientific contribution would not have been possible. There is every reason to believe that the historic cores will continue to support new scientific knowledge.

Some have argued that the written logs compiled when the cores were originally acquired can serve as a proxy for the physical core. Unfortunately, written logs are only an interpretation made by a field geologist usually at a single point in time. As the core descriptions are typically

Figure 2. Using cores for scientific research. A) Storage facility at Building 4, Fore River Shipyard, Quincy, MA; B) Open core box; C) Example of a photomicrograph taken from a thin section cut from a core.
Figure 3. Photomicrograph of a thin section taken from a report on the Outfall Tunnel project.
created for a project-specific purpose, they reflect one individual’s interpretations and, accordingly, may edify potential biases or outright inaccuracies revealed upon reassessment of the core specimens. The written logs are often highly variable as to quality and content, and very seldom provide a complete and thorough description of the rock. Accordingly, the logs alone cannot be considered suitable as primary data. Furthermore, no physical examination, age dating technique, or meaningful reinterpretation can be applied to a paper log or record.

**Health and Safety Benefits**

The MWRA actively operates approximately 100 miles of tunnel within bedrock for water and wastewater transport. Approximately 95 miles are under some degree of pressure. The wastewater conduits generally have low pressure sufficient to raise the water to ground level should a leak occur whereas the water aqueducts have much higher pressure sufficient to more than raise water to the ground surface. As such, these conduits have a latent capacity to create a situation ranging from a public nuisance to a danger. Failure of a wastewater conduit under low pressure would not create a formidable gusher but could release significant amounts of contaminated wastewater into the fracture system of the surrounding bedrock, into a local aquifer system or ecosystem, or into the marine environment where sewer lines pass beneath Boston Harbor. Higher-pressure aqueducts, if compromised, could cause water to rise to the ground surface in sufficient quantities to cause flooding, undermining, inconvenience, erosion, loss of property and personal injury.

While the probability of a leak or an escape occurring is low, there is a case on record regarding the failure of the Dorchester tunnel. A portion of the tunnel failed and pressurized water came to the surface, flooding the basements of several homes in the Roxbury/Dorchester area creating a public nuisance. Examination of the exploratory core, which had been submitted and retained in the collection, provided immediate information on the rock and clearly showed the variability in the rock between the section of the tunnel that failed and the sections that did not fail. The accompanying paper logs were too general to pick up the details that were observed in the bedrock core. Numerous other examples of pressure tunnel failures have been documented in the U.S. and abroad.

Unlike vehicular or railroad tunnels, it is difficult to access MWRA water supply and wastewater tunnels after completion without a major disruption in service to customers. Common tunnel construction practice typically requires lining the tunnel in concrete after excavation, eliminating direct access to the tunnel walls for bedrock mapping, observation or sampling. As such, archived cores provide critical material that can be accessed quickly in emergency situations that have an effect on public safety.

**Educational Benefits**

The general public in Massachusetts has demonstrated an increasing interest in engineering, geology and related history, in part, because of the media attention received for specific projects such as the “The Big Dig” and the Outfall, Inter-Island and MetroWest Tunnels. The open exchange of information on these projects has not only provided an opportunity but also
encouraged formal and informal education of the citizens of the Commonwealth. The MetroWest Tunnel Project from the start involved homeowners, educators, parents, teachers and students to become familiar with the past and ongoing history of achievement involved in the century and a half in delivering water to greater Boston.

The cores, along with the information gleaned from them, have been translated and used for educational purposes already. For example, geological information based in the MWRA cores has been used to develop lesson plans for K-12 school children, create workshops for earth science teachers and supplied geological information to the Trustees of Reservations, Boston Harbor Islands National Park and the newly created Puddingstone Park in Roxbury. The educational outreach of the core extends far beyond the traditional geoscience community. With increased publicity, the MWRA core collection and associated records could have even broader educational outreach.

**Societal Benefits**

One growing area of concern in Massachusetts is the availability of drinking water, particularly in those communities not served by the MWRA. Development along the I-495 corridor, for example, has accelerated in the last 30 years and is placing considerable stress on water resources. Increased water withdrawals are causing water level reductions in overburden aquifers and wetlands, and are reducing flows in some streams such that riparian ecosystems are threatened. Despite receiving 42 inches of rainfall a year, groundwater withdrawals in parts of Massachusetts are causing some streams to cease flowing altogether. Thus, conflicts are arising between the need for water to meet potable demands and the requirements to maintain functioning ecosystems.

Geologic maps provide basic information on the location of potential future water supplies, delineation of groundwater recharge and discharge areas, and probable travel paths for groundwater. A geologic map is a fundamental tool used by planners, engineers, and state agencies to make land use and resource management decisions that directly affect the general public. However, due to the limited number of outcrop exposures available at the surface, geologic mapping must rely also on subsurface information, including bedrock core, when available. Thus, the MWRA collection is used to the extent possible in mapping the bedrock lithology, locating and verifying the presence of faults which may be a source of water, determining the depth to bedrock and the type and thickness of overburden soils, delineating regional groundwater flow directions, and identifying aggregate resources for construction materials. The MWRA core and associated records were important in the recent publication of the new geologic map of the Marlborough quadrangle prepared by the Office of the Massachusetts State Geologist (Kopera et al., 2004).

**Economic Benefits**

The core archive represents a valuable public resource that cannot be replaced without considerable expense. Furthermore, it may be impossible to replace some of the core because access to acquire it is no longer available. The estimated replacement cost of the entire core collection is estimated to range between $13 and $20 million, in 2004 dollars, depending on the
proportion of marine vs. land boring used in the analysis. The cost to initially acquire these cores over an 80-year period is substantially less.

Tangible economic benefits of the core collection are realized also when planning subsurface programs for new projects. As an example, the 8-mile long, Second Avenue Subway project in New York City is the largest proposed infrastructure project in the world. A total of 1,560 borings averaging 80 feet deep had been acquired in the area over the period extending from the 1960’s to the 1990’s. However, no cores were ever retained from these previous projects. During a review of the past boring logs, it was discovered that the Rock Quality Designation (RQDs) recorded on the borehole logs were quite variable and different from standard engineering practice. However, no cores were available to verify or recalculate the data. As a result, the subsequent subsurface investigations cost about $4 million. It is estimated that had the cores been available, these project costs could have been reduced by greater than 50%.

By having both the existing cores and paper logs available from past projects, better decisions can be made regarding the planning of subsurface investigations for new projects resulting in substantial cost savings.

THE FUTURE OF THE CORE COLLECTION

Estimated Moving Costs and Space Requirements

Current cost estimates for moving the core collection range from $150,000 to $250,000, depending on logistics and final destination. These figures exclude any costs associated with refurbishing an existing building. The U.S. Geological Survey estimates the public cost of core storage per year at their federal core research center in Denver, Colorado is about 0.05 percent of what it would cost to drill the cores today and only 0.5 percent of the original cost of drilling. The actual cost is probably somewhere between these two figures. The U.S. Geological Survey estimates that they can store the cores for at least 200 years before reaching the original cost of drilling (http://geology.cr.usgs.gov/crc/resource.htm). The cost to maintain an archive collection is significantly less expensive than the acquisition cost.

At a minimum, the storage requirements for the core collection are as follows:

- 15,000 square feet of space desired
- 15 to 18 foot ceilings desired but not mandatory
- must be dry with fire suppression system (unfinished underground facilities not acceptable)
- must be a facility that is accessible to the public
- must have attached lighted office space where individuals can examine cores and geologic materials
- desire an underutilized active property but will consider others
- prefer a location inside the I-495 beltway but will consider Worcester and the greater Springfield area
To the extent possible existing shelving from the current facility will be used in the new storage facility.

**Next Steps**

Securing a new home for the MWRA core collection will most likely require two phases. Phase 1 involves identifying an immediate temporary home for the cores and represents the highest priority. The goal is to have the cores relocated by April 2005. A list of potential surplus state properties is being reviewed for possible candidate sites for temporary storage.

Phase II will involve identifying a longer-term storage solution that is more amenable to research and educational opportunities. An appropriate space would not only house the collection in a clean well-lit, and dry condition of sufficient size to permit storage, expansion and access to the holdings but would support on-site examination and study of the samples and educational activities. The space would allow for educational events such as more effective training of field geologists, field technicians, engineers, drillers, staff of other State agencies, K-12 earth science teachers and University hydrogeology and geology faculty and students from across the state, and other customers and clients engaged in working to understand, manage, protect and maintain Massachusetts’ natural resources, environmental quality and human health.

Phase II might involve also the concept of developing a State natural history museum that includes not only geological data but botanical, zoological and archaeological archives, among others. Such an approach that incorporates all the elements of the State’s natural history might command greater interest from a consortium of federal, state and private funding sources.

**SUMMARY**

The MWRA core collection is a well-organized and well-catalogued resource that provides an unparalleled record of earth history in New England. It was assembled over many years at great expense with public funds. The collection has significant scientific, public safety, educational, societal and economic benefits that directly affect the citizens of the Commonwealth. The collection is a Massachusetts treasure and should be preserved at all costs. However, the collection must be relocated to a new facility as soon as possible. A core repository advisory committee has been formed to assist the MWRA in finding a new storage facility. The committee is looking forward to working with the MWRA and any other agencies, non-governmental organizations, legislators and individuals to locate a new home for the collection.
References Cited

Chapter 375, Massachusetts Acts and Resolves of 1926
Chapter 321, Massachusetts Acts and Resolves of 1927
Chapter 350, Massachusetts Acts and Resolves of 1919
Chapter 583, Massachusetts Acts and Resolves of 1947
Chapter 372, Massachusetts Acts and Resolves of 1984

The following statutory references include all amendments through October 31, 2004.

Chapter 4, Massachusetts General Laws, Section 7 (26)
Chapter 9, Massachusetts General Laws, Section 2
Chapter 30, Massachusetts General Laws, Section 42
Chapter 66, Massachusetts General Laws, Section 1
Chapter 66, Massachusetts General Laws, Section 8
