

A Cost Analysis of Book Storage Options  
at the National Library of Medicine

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## Table of Contents

Executive Summary	iii
List of Figures	v
List of Tables	vi
Acknowledgements	vii
Data Sources	viii
Introduction	1
Collection and Use Patterns	2
Collection Growth	2
Collection Usage	3
Construction Cost Analysis of Alternatives	6
Remodel Building 38A Level B2	6
Underground Storage Facility on NIH Campus	9
Multi-Use Building with Basement Stack Space	11
Above-Ground Storage Facility on the NIH Campus	11
Rent Space in an Existing Storage Facility	13
Construct a Facility Comparable to that of WRLC	14
Processing Costs	17
Circulation Costs	18
Delivery Time	23
Cost Comparison of Alternatives	29
Summary and Conclusions	36
References	37
Appendix	38

## Executive Summary

This report analyzes the cost of six alternative facilities that could be used to house the NLM collection in two different types of shelving configurations.

In a 'normal' library, books are stored in *stacks*, namely shelving placed at fixed positions on the floor. An alternative is to use *compact shelving* in which the shelves are not fixed to the floor but move on tracks so that at any one time only one aisle might exist between, say, nine or ten stacks. This saves space by eliminating all the aisles between the stacks. About 28 volumes per square foot can be stored in compact shelving. Even more books can be stored in *high density shelving* which is usually about thirty feet high and more than two feet deep. Books are stored in containers on these shelves and also by book height so that the maximum number of books are fit in one container (about 100 volumes per square foot). Containers are retrieved by mechanical devices that move down the aisles and remove a container at a time.

The alternative facilities that were considered in this report include remodeling NLM's Building 38A Level B2 for compact shelving, building an underground on-site facility with high density shelving, building an above-ground on-site facility with high density shelving, building a multi-use building with basement stack space for compact shelving, building an off-site facility with high density shelving, and renting space in an existing facility having high density shelving.

Two major fixed costs were considered: the cost of construction of the facilities (including installing shelving), and processing costs. The later are the costs of moving an item from its current location to the new facility.

The estimated per volume construction and processing costs for the above options are as follows:

Build an above-ground on-site facility with high density shelving:	\$3.34
Build an off-site facility with high density shelving:	\$5.23
Build an underground facility on-site with high-density shelving:	\$5.28
Remodel Building 38A Level B2 with compact shelving:	\$7.37
Build a multi-use building having compact shelving in the basement:	\$8.80
Leased space in an exiting facility having high-density shelving:	\$11.16

One important caveat must be mentioned about the relatively high cost of constructing an on-site multi-use building. Only the cost of the underground part of this facility was considered in this paper. As the name implies, the building is multi-use. The stack space underground will serve as the foundation for the remainder of the building, and thus there are joint costs that must be shared between the stack space and the space used to house other facilities. These are not taken into account in the analysis and could significantly change the results of the analysis.

Each time an item is used, a cost of circulating that item is incurred. This cost varies by the distance that the facility is from the NLM Reading Room and by the type of shelving used to house the material. If the physical volume circulates from Building 38 the cost per circulation is \$2.93, from the basement of Building 38A Level B2 the cost is \$3.28, from a multi-use building, \$3.37, from an underground facility on-site and an above-ground on-site facility \$3.81. If an item is stored off-site at an NLM-owned facility the circulation cost is \$9.48. This later cost is high because of a \$6.50 transportation cost per volume.

An important aspect of selecting an alternative storage facility is the length of time it would take to delivery materials to the user once a request has been submitted. For facilities adjacent to NLM this is in the range of 30-80 minutes while for a storage facility it is close to eight hours. This later value is a significant deterrent to high quality service. It is possible to have multiple deliveries that would reduce waiting time, and also make good decisions about what is stored off-campus. Nevertheless, the nature of a storage facility away from the NIH campus is that long delays come with the location. They are not a particularly appealing alternative. Scanning and electronic delivery of requested journal articles would reduce delays but involve additional costs to NLM of \$33,480 - \$54,000 per year.

An average cost analysis of the options divided costs into those that are fixed (such as construction, remodeling, and processing), and variable (circulation), and examined the effect on average cost per circulation of changes in the number of times materials circulated. The most expensive option over all levels of circulation is again to rent space in an existing off-site storage facility. The average cost analysis in Figure 4 shows that some alternatives have very similar costs when the number of times an item circulates is above about four. This means that one can not simply accept one alternative simply because it has a low construction cost but rather examine how costs vary with use.

The existing stacks in Building 38 will hold the collection until 2008, assuming that alternative space can be found for staff currently located in stack areas. As this date gets closer the effort of trying to keep order in the stacks will increase. The most expeditious interim solution is to remodel Building 38A Level B2. This alternative also requires that offices currently housed on that floor be relocated. After Building 38 and Building 38A are filled (around 2016) NLM will be out of space again and other alternatives must be considered for NLM's longer range collection needs.

An above ground high density storage facility built on NIH property is the least expensive solution. However, factoring in the longer retrieval time associated with high density storage, competing uses of NIH's land, NLM's need for a significant amount of additional staff space for expanding programs, and the considerable cost savings involved in building one new facility rather than two, storing collections in the basement of a new multi-use facility appears to be the most reasonable long-term plan.

## List of Figures

Figure 1. Collection Growth

Figure 2. Total On-Site Requests and Total Requests Received

Figure 3. Percent Distribution of Reading Room Requests by Hour

Figure 4. Average Cost Per Circulation for Alternative Storage Options

Figure 5. Average Cost Per Circulation for On-Site Storage Options

Figure 6. Average Cost Per Circulation for High Density Storage Options

Figure 7. Average Cost Per Circulation for Delivery from Off-Site Facilities by Scanning

## List of Tables

Table 1. Estimated Construction and Processing Costs to Remodel Building 38A Level B2

Table 2. Estimated Construction and Processing Costs for Underground Storage Facility

Table 3. Estimated Construction and Processing Costs for Multi-Use and Above Ground Facilities

Table 4. Estimated Construction and Processing Costs for Off-Site Storage Facility or Washington Research Library Consortium Facility, Upper Marlboro, Maryland

Table 5. Estimated Construction Cost Per Volume of the Washington Research Library Consortium Facility, Upper Marlboro, Maryland

Table 6. Cost to Circulate an Item from On-Campus Facilities to the NLM Reading Room

Table 7. Alternative Costs of Delivery of Materials from Off-Site Storage Facility to NLM Reading Room

Table 8. Summary of Estimated Cost to Circulate Materials from Off-Site Storage Facility to NLM Reading Room

Table 9. Estimated Delivery Time of a Volume from Library Facility to NLM Reading Room

Table 10. Estimated Time to Deliver a Volume from an Off-Site Storage Facility to NLM Reading Room Assuming One Delivery Per Day

Table 11. Estimated Time to Deliver a Volume from an Off-Site Storage Facility to NLM Reading Room Assuming Two Deliveries Per Day

Table 12. Construction, Processing, and Circulation Cost Summary for Alternative Construction Options

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My major debt is to Margaret Byrnes, the head of the Preservation and Collection Management Section of NLM. Margaret provided a solid framework for my thinking on the issues, served as a sounding board for my ideas, and pointed me in the right direction. And she did everything possible to provide me with the data necessary to produce this analysis.

## Data Sources

The data used for the analysis in this paper was supplied to the author by a number of staff members of the National Library of Medicine as well as staff at the Washington Research Library Consortium, consultants, and architects. Where possible, these sources have been listed for each table. When no attribution is supplied, it should be assumed that the data came from primary data analyses, sampling, and estimates provided by NLM.

## Introduction

The National Library of Medicine (NLM) has a number of options available to house its growing collection of library materials. This report analyzes several available alternatives including remodeling space in an existing adjacent building, building a new underground building near the existing library building, constructing a multi-use building with basement storage space, building an above-ground storage facility on the National Institutes of Health (NIH) campus in Bethesda, Maryland, building a storage facility away from the NIH campus, and renting space in an existing storage facility off-campus.

The methodology used to analyze the alternatives is to compare unit costs. Several costs are considered including construction and remodeling, material processing, and circulation. For each construction alternative and for each cost category, the unit cost of performing the operation for a single piece of library material is calculated. For example, the cost per volume of constructing a new building, the cost of processing a volume (performing operations to move it to its new storage location), and the cost per circulation are computed. With this information, an analysis is conducted in which the average cost each time an item is circulated is computed based on estimates of the number of times the item will circulate. In addition, the time that the user will have to wait for materials to be delivered is analyzed for each alternative.

The report has several parts. It begins with an overview of the quantitative characteristics of the NLM collection, including size, growth, and usage patterns. This is presented to provide a context for the remaining discussion. Next, construction costs are analyzed, followed by processing costs and delivery time. The report concludes with a cost comparison of the alternatives.

There are two major issues that are not addressed in this report. One is the growth of the collection of library materials and how the collection should be distributed among existing and planned facilities. The second is how many uses of the collection will come from material that might be placed in a storage facility. Information about alternative costs for alternative use assumptions is given, as is information about usage of materials by year of publication, but it is extremely difficult to predict level of use of specific items.

## Collection and Use Patterns

### Collection Growth

As of 1998, the NLM collection of book and non-book material consisted of about 5.3 million items, of which about 1.1 million were bound serial volumes, 0.3 million monographs, and 3 million pieces of non-book materials. Figure 1 shows the pattern of growth of the collection over the last nine years. It demonstrates a controlled but substantial increase of the library's holdings by about 14% per year over the nine year period. Table A1 gives details on these patterns.<sup>1</sup>

NLM currently houses its collection in its main building, termed Building 38 which consists of three floors of storage space, levels B1, B2, and B3. Adjacent to Building 38 is Building 38A which houses a number of specialized programs including the Lister Hill National Center for Biomedical Communication. Building 38A has two below-grade levels, B1 and B2. Level B2 is a candidate location for storing NLM materials since it is on-grade and can support compact shelving.

Library materials are currently stored in compact shelving in Building 38 level B3, and on standard shelving on levels B2 and B1 in the same building. Even with a considerable amount of shifting, moving, and relocation, the time within which Building 38 can hold the NLM collection is still finite. The table below gives an indication of the timeline.

Level	Total Number of Shelves on the Level	Number of Available Shelves	Yearly Shelf Growth	Year Level Will Be Completely Full
B1	12,208	-	1,000	2012
B2	26,673	5,652	500	2009
B3	40,851	14,395	1,000	2008

As can be observed, there is still some available space on each of the levels in Building 38, but as the number of available shelves declines, stack shifting operations will become more frequent and costly.

One of the most viable options for meeting NLM's space problems is to use Level B2 of Building 38A. This area is currently occupied by a number of offices that must be relocated if shelving is installed. Should that take place, the area would meet eight or nine additional years worth of growth of the collection. If one adopts a twenty year planning horizon, other alternatives must be found. The purpose of this report is to examine some of them from a cost standpoint.

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<sup>1</sup> Tables and figures beginning with the letter A can be found in the Appendix.

## Collection Usage

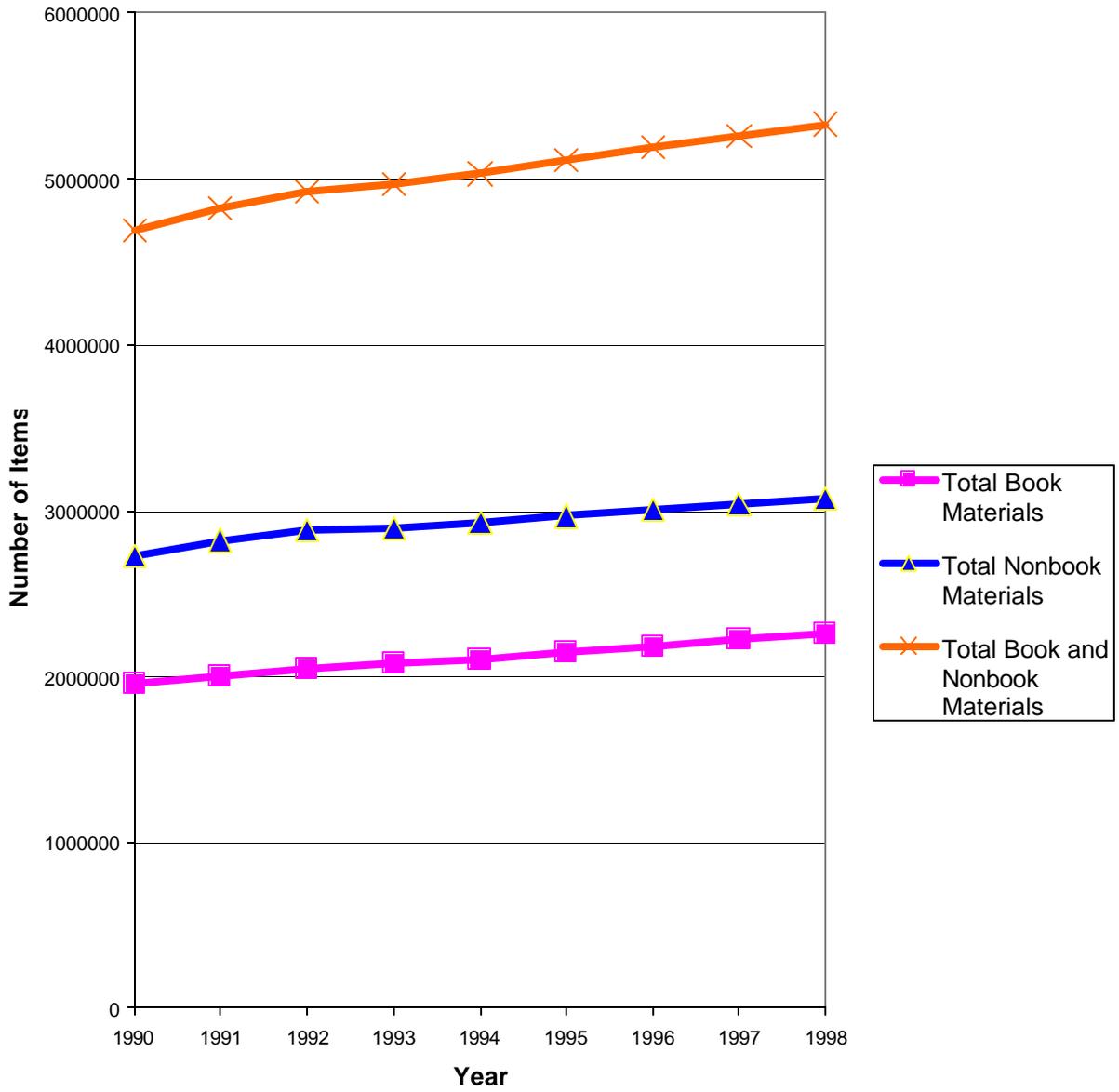
The use of the NLM collection can be gauged by the number of requests for materials that are received in the Reading Room and the number of inter-library loan requests received. Figure 2 shows historical data and projects this data to 2010. (Table A2 provides the details.) Historically, overall requests have been increasing at about 4% per year, but in recent years this has increased substantially. It is expected that in the future request will increase at about 10% per year, and this accounts for the rapid rise in the projection period.

If the library is considering moving materials from its current buildings to a site away from the NIH campus, it must make a decision about which items to move and which items should stay on-campus. Two major rules can be used in this decision: age and usage. An age rule says that items of a certain age (publication date) are candidates for being sent to storage. A usage rule says that items that have been used less than X times in the last N years are candidates for removal to storage.

A significant proportion of the demand for materials in most libraries comes from recently published items. NLM is no exception. In a sample of NLM's DOCLINE requests for the period January-March 1998 it was found that 767 serial titles published from 1800-1950 were requested. About 87% of the volumes were requested only once, about 9% were requested twice. Thus, 96% of the requested volumes published before 1950 were requested fewer than three times. If 1950 were chosen as a cut-off point for moving materials to a storage facility, and the numbers above were representative of the population, a large proportion of requests could be met from a small proportion of physical volumes and have a small impact on service levels. This issue is explored later in the paper.

Another aspect of this same phenomenon is the number of times a specific journal title is used and the number of times a unique article is used. If the universal pattern of use holds at NLM like almost all other libraries, it will be found that a very few journal titles will be requested very frequently and a large number used infrequently.

**Figure 1  
Collection Growth**



**Figure 1  
Collection Growth**

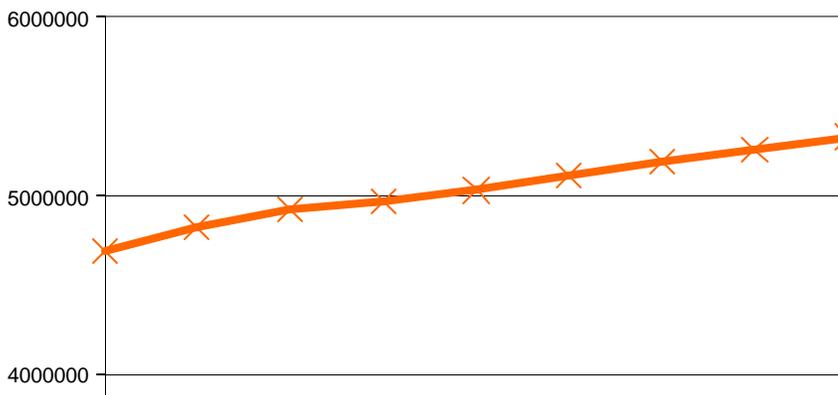
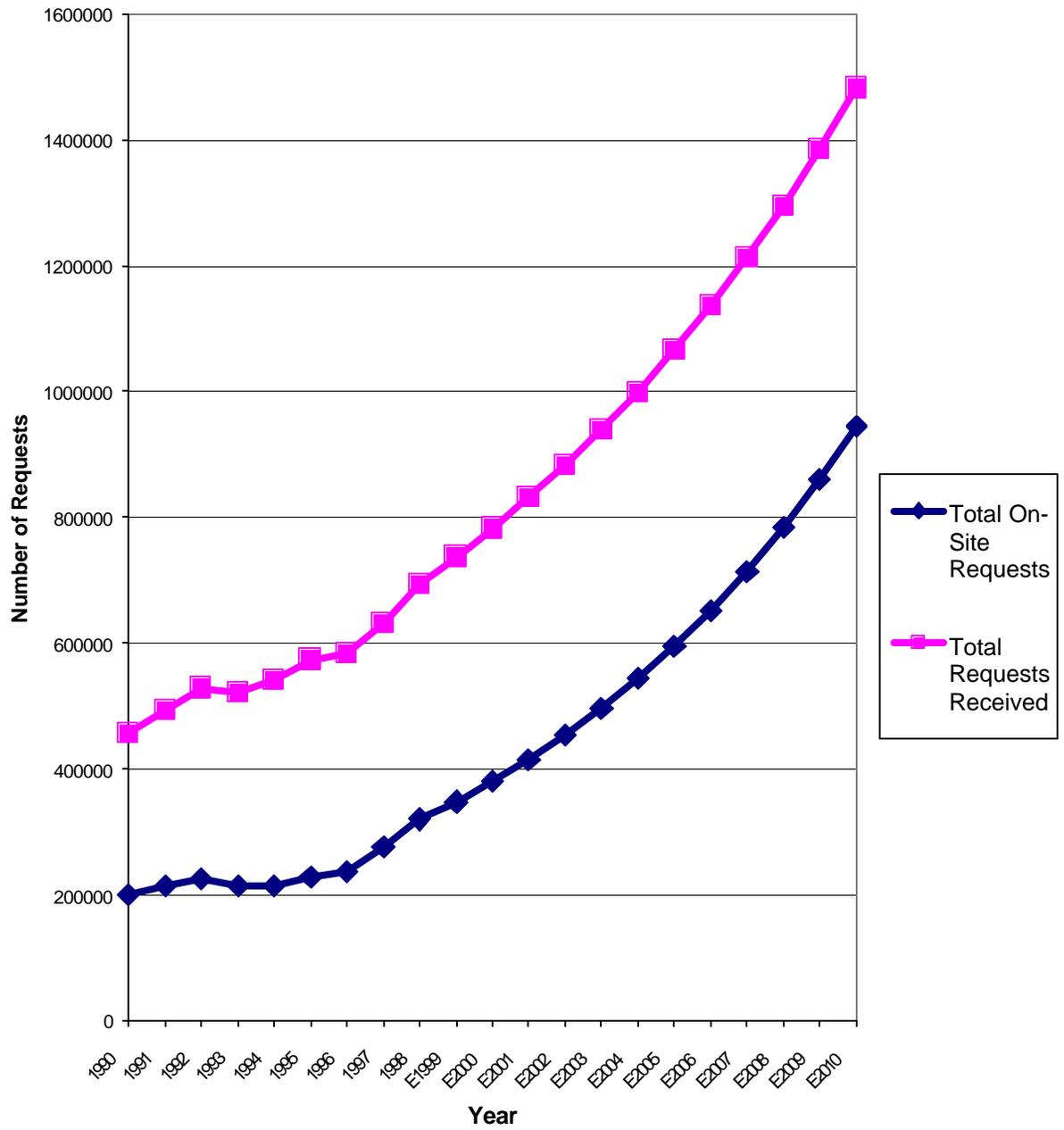




Figure 2

Total On-Site Requests and Total Requests Received



## Construction Cost Analysis of Alternatives

The library has a number of options available to it for building a facility to store its collection and options of the type of shelving used in each facility. Shelving options include compact, which allows about 28 volumes to be stored in a square foot of space, and high density which allows about 100 volumes to be stored in the same area. High density storage usually involves shelving volumes by size on shelving thirty feet high.

Six alternatives for storing the library collection are compared in this report. They are:

- Remodel Building 38A Level B2 by relocating existing personnel and services and replacing them with compact shelving to house the collection. Use compact shelving.
- Build an underground storage facility on the NIH campus that would house library materials. Use high density shelving.
- Build a multi-use building on the NIH campus with basement stack space. Use compact shelving.
- Build an above-ground storage facility on the NIH campus. Use high density shelving.
- Rent space in an existing off-site storage facility to house part of the collection. Use high density shelving.
- Build an off-site storage facility in an area away from the NIH campus to house part of the collection. This facility would be constructed in an area having relatively low land costs. Use high density shelving.

### Remodel Building 38A Level B2

Level B2 of Building 38A consists of 24,911 square feet of space, of which 12,707 is usable for book storage. In order to use this space for storage it must be remodeled and then compact shelving installed.

Remodeling cost was assumed to be \$80 per square foot for the facility and electrically operated compact shelving was assumed to cost \$70 per square foot. Mechanical compact shelving could be installed at a cost of \$40 per square foot. Roughly 1271 units will be required to fill level B2.<sup>2</sup> When the cost per square foot values are converted into

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<sup>2</sup> Assume for these calculations that 28 volumes of mixed journals and other types of materials can be stored in one square foot of shelving.

cost per volume, remodeling and shelving cost total \$5.36 per volume for Building 38A Level B2.

Table 1

Estimated Construction and Processing Costs to Remodel  
Building 38A Level B2

Remodeling Cost Calculations	
Area to be used for storage (square feet)	12,707
Estimated remodeling cost per square foot	\$80
Estimated cost of compact shelving:	
Number of square feet occupied by one double-faced shelving unit	10
Number of shelving units needed	1271
Cost per double-faced shelving unit	\$700
Total Shelving cost	\$889,490
Total Shelving cost per square foot	\$70
 Total Remodeling and Shelving Cost per square foot	 \$150
 Number of volumes per square foot of storage space	 28
Total Remodeling and Shelving Cost per volume	\$5.36
 Material Processing Costs per volume	
Select, pull & pack item at NLM to be transferred to Building 38A Level B2	\$0.53
Process item at NLM before it is sent to facility	\$1.13
Transport item from NLM to facility	\$0.05
Initial shelving of item in facility	<u>\$0.30</u>
Material Processing Costs per volume	\$2.01
 Remodeling, Shelving, and Processing Cost per volume	 \$7.37

## Underground Storage Facility on NIH Campus

In 1995 NLM considered construction of a single-use underground facility behind Building 38. Estimates were prepared and costs supplied. The estimates included excavation and construction of a facility having 12,040 square feet of shelving space and holding 1.2 million volumes on high density shelving.

The project was not continued, but the cost estimates still appear to be valid. In calculating the cost of an underground storage facility for this report, the 1995 estimates were used as a basis and adjusted for the change in construction costs from 1995 to the present. They are summarized in Table 2. The table gives an estimated construction cost of \$3.27 per volume. This assumes that about 100 volumes are stored in each square foot of shelving and that the standard construction cost index value changes reflect actual conditions on the NIH campus.

Table 2

Estimated Construction and Processing Costs for Underground Storage Facility

Construction Cost Calculations	1995	1999
Construction Cost	\$3,630,000	\$3,926,877
Total Square footage	12040	12040
Construction Cost per square foot	\$301.50	\$326.15
Capacity in Volumes	1,200,000	1,200,000
Construction Cost per Volume	\$3.03	\$3.27
Material Processing Costs per volume		
Select, pull & pack item at NLM to be transferred to Underground facility	\$0.53	\$0.53
Process item at NLM before it is sent to facility	\$1.13	\$1.13
Transport item from NLM to facility	\$0.05	\$0.05
Initial shelving of item in facility	\$0.30	\$0.30
Material Processing Costs per volume	\$2.01	\$2.01
Construction and Processing Cost per volume	\$5.04	\$5.28

Notes:

1. Facility construction cost estimates for 1995 are based on those prepared by James G. Davis Construction Corporation dated 23 August 1995.
2. Material processing costs include cost to move material from existing shelving location at NLM to new NLM facility.
3. 1999 Construction costs estimated using R.S. Means Building Construction Cost Data [1, p. 604] adjusting 1995 value to 1999.
4. January 1999 Historical Cost Index Value 116.4
5. January 1995 Historical Cost Index Value 107.6

## Multi-Use Building with Basement Stack Space

While this report focuses almost completely on book storage economics, other considerations come to bear when one examines the alternative of constructing a new facility on the NIH campus to house library materials. The most obvious consideration is that it may not be reasonable to create a building simply to house the collection when there are strong competing demands to provide space for individuals and facilities that directly contribute to the NIH mission. Thus it seems reasonable to think about another facility as multi-use; one in which library materials are stored below ground and people work above ground. Table 3 summarizes construction costs for this alternative. It assumes that the underground part of the building can be built for \$120 per square foot and that electrical compact shelving will cost an additional \$70 per square foot. Thus the total cost per square foot is \$190. If it is assumed that 28 volumes per square foot can be housed on the compact shelving, the construction and shelving cost for this alternative is \$6.79 per volume housed.

## Above-Ground Storage Facility on the NIH Campus

The proposed design of the multi-use building discussed above included electrical compact shelving to facilitate access to the collection and to make the building's stack space more of an extension to existing stacks than true storage space. NLM has the option of building an above-ground storage facility with high density shelving in it, similar to the underground facility described earlier. This approach minimizes land cost because there is no direct expenditure for the land on the NIH campus and it minimizes construction cost because it is less expensive to build above, than below, ground. The estimate included here suggests that there is a savings of \$20 per square foot for building above ground vs. below ground. In addition, there is a considerable increase in the density with which materials can be stored: from 28 volumes per square foot to 100.

Table 3 summarizes the cost of this alternative. Construction and shelving costs per volume are calculated at \$1.33 compared to \$6.79 for a multi-use building, and \$5.43 for an underground facility (Table 2).

Table 3

Estimated Construction and Processing Costs for Multi-Use and Above Ground Facilities

	Multi-Use Building with Basement Stack Space	Above- Ground Storage Facility on NIH Campus
Construction Cost Calculations		
Construction Cost per square foot	\$120	\$100
Shelving Cost		
Electrical Compact Shelving	\$70	
High Density Shelving		<u>\$33</u>
Total Construction and Shelving Cost per square foot	\$190	\$133
Number of volumes per square foot of storage space	28	100
Construction and Shelving Cost per Volume	\$6.79	\$1.33
Material Processing Costs per volume		
Select, pull & pack item at NLM to be transferred to Multi-use Facility	\$0.53	\$0.53
Process item at NLM before it is sent to facility	\$1.13	\$1.13
Transport item from NLM to facility	\$0.05	\$0.05
Initial shelving of item in facility	<u>\$0.30</u>	<u>\$0.30</u>
Material Processing Costs per volume	\$2.01	\$2.01
Construction and Processing Cost per volume	\$8.80	\$3.34

Notes:

1. Estimated cost for high density shelving is based on shelving cost supplied for construction of underground facility in 1995, adjusted to 1999. Shelving cost in 1995 was \$350,000 to hold 1.2 million volumes in 12,000 square feet of space.
2. Material processing costs include cost to move material from existing shelving location at NLM to new facility.
3. 1999 Construction costs estimated using R.S. Means Building Construction Cost Data [1, p. 604] adjusting 1995 value to 1999.
4. January 1999 Historical Cost Index Value 116.4
5. January 1995 Historical Cost Index Value 107.6

## Rent Space in an Existing Storage Facility

The Washington Research Library Consortium (WRLC) operates a book storage facility for libraries in the Washington, DC region in Upper Marlboro, Maryland. NLM has been in contact with them in the past to explore the possibility of storing NLM's materials at the facility.

One of the storage options considered in this report is the use of the WRLC facility. In order to make cost estimates that were consistent with the others, data was obtained from WRLC and adjusted in a number of ways. WRLC was extremely forthcoming with estimates of their costs and fees and throughout the dialog with them they stressed that the numbers they were supplying were estimates and that final figures could be supplied when necessary. Thus in reviewing the cost analysis of the WRLC facility it must be understood that the data does not represent a WRLC offer to supply its services at the prices given, rather an estimate of the prices they might charge.

WRLC has offered to store a volume at a price of between \$0.40 and \$0.50 per year. If it is assumed that the life of the WRLC building is 20 years, and the \$0.40 figure is used, the storage cost per volume for the life of the building would be \$8.00.

## Construct a Facility Comparable to that of WRLC

Another option for NLM is to construct its own storage facility in an area where land costs are lower than on the NIH campus, and where construction costs might be lower.

A starting point for deriving the cost of constructing such a facility is to estimate the cost NLM would incur in building a facility similar to that of the Washington Regional Library Consortium's building in Upper Marlboro, Maryland.

Tables 4 and 5 summarize the estimated construction cost per volume at the WRLC facility. The building was constructed in 1993 on land that cost \$214,000 and is estimated to have a value of \$510,000 in 1999. The facility is 32,000 square feet in size, of which 18,000 square feet is devoted to book storage and processing. The maximum capacity of the facility is 1.2 million volumes which are stored on high density shelving.

Construction cost in 1993 was \$4 million. After adjusting for construction cost changes between 1993 and 1999, this figure rises to \$4.6 million. Since not all the facility is used for book storage, construction costs are apportioned between uses and the result is a construction cost per volume figure of \$2.15 if NLM would construct the facility itself. When land costs are added, the 1999 construction cost per volume rises to \$2.57.

Obviously, a comparison between the \$8.00 per volume charged by WRLC and \$2.57 that NLM would incur if it built the facility is not quite that simple since the cost of capital is not considered, nor the cost of planning or managing the facility. Nevertheless, there are potentially significant savings if NLM decided to build its own storage facility.

Table 4

Estimated Construction and Processing Costs for Off-Site Storage Facility or  
Washington Research Library Consortium, Upper Marlboro, Maryland

	Off-Site Storage Facility	Off-Site Storage Facility	Storage Facility Operated by WRLC
Year of Cost Estimate	1993	1999	1999
<b>Facility Land and Construction Costs</b>			
Land Cost	\$214,000	\$510,000	
Construction Cost for Book Storage	\$2,250,000	\$2,575,221	
Land and Building Construction Cost	\$2,464,000	\$3,085,221	
Storage Capacity (in volumes)	1,200,000	1,200,000	
Land and Building Cost per Volume	\$2.05	\$2.57	
Storage Cost per Volume per Year			\$0.40
Storage Cost per Volume for Building life			\$8.00
<b>Material Processing Costs per volume</b>			
Select, pull & pack item at NLM to be transferred to Off-Site Facility		\$0.53	\$0.53
Process item at NLM before it is sent to storage		\$1.13	\$1.13
Transport item from NLM to storage facility		\$0.50	\$0.50
Processing cost once item arrives at storage		<u>\$0.50</u>	<u>\$1.00</u>
Material Processing Costs per volume		\$2.66	\$3.16
Construction and Processing Cost per volume		\$5.23	\$11.16

Table 5

Estimated Construction Cost Per Volume at the  
Washington Research Library Consortium, Upper Marlboro, Maryland

Construction Cost Calculations	1993	1999
Construction Cost	\$4,000,000	\$4,578,171
Total Square footage	32000	32000
Book Storage footage	12000	12000
Processing Storage footage	6000	6000
Total Book Storage	18000	18000
Capacity in Volumes	1200000	1200000
Percent of Space for Books	56.25%	56.25%
Construction Cost for Books	\$2,250,000	\$2,575,221
Construction Cost Per Volume	\$1.88	\$2.15

Notes;

1. Construction cost and size information for 1993 supplied by Washington Research Library Consortium.
2. 1999 Construction costs estimated using R.S. Means Building Construction Cost Data [1, p. 604] adjusting 1993 value to 1999.
3. January 1999 Historical Cost Index Value 116.4
4. January 1993 Historical Cost Index Value 101.7

## Processing Costs

Two major cost components are involved in calculating the fixed cost of moving an item from an existing to a new facility. One is construction cost, which has been reviewed above, and the other is processing cost.

Upon completion of a new facility, some materials that are stored in the current building will be transferred to the new one. This process involves the intellectual or operational activity of selecting the items that will be transferred, changing any information in the bibliographic record in the computer catalog to reflect the new location, physically picking the item off the shelf of the current facility, moving the item to the new facility, and shelving it at the new facility. These are one-time costs and are not the same as circulation costs because they involve the initial installation of the materials in the new site. Circulation costs (which will be reviewed later) are incurred as often as the item circulates. Processing costs occur once.

Three different unit costs of processing occur for the six alternative construction, remodeling, or leasing options presented. The first is for processing materials that will be moved to on-site facilities such as Building 38A Level B2, an underground facility, a multi-use on-site building, or an on-site storage facility. The second is for materials that will be moved to an off-site storage facility that NLM constructs, and the third is for one in which NLM leases space. Tables 1, 2, and 3 summarize the former and derive a unit cost of \$2.01 for processing. Table 4 summarizes the latter, showing a unit cost of processing at \$2.66 at an NLM-constructed facility and \$3.16 for one in which NLM leases space.

The cost of selecting, pulling and packing an item to be sent to a new location is estimated at \$0.53 per volume, while the cost of processing the item at NLM before it is moved to its new location is estimated at \$1.13. This later cost is primarily associated with changing location information in the bibliographic record. Transportation costs vary by destination. For on-site facilities they are \$0.05 while for off-site facilities they are \$0.50. Once the item arrives at the facility processing and shelving costs come into play. And these range from \$0.30 to \$1.00 per volume.

## Circulation Costs

When an item is delivered to a user, a circulation cost is incurred. Table 6 summarizes the cost to circulate an item when it is stored in the stacks in Building 38, Building 38A Level B2, an underground facility, an above-ground on-campus storage facility, and a multi-use building's basement. The cost estimates are derived from an NLM study prepared in 1995 and adjusted for labor and equipment cost changes between 1995 and 1999. No adjustments are made for changes in volume of circulation handled, automation improvements or degradations, changes in distribution of items on shelves, nor classification schemes that would reduce or accelerate the efficiency of the process. Two separate circulation costs are shown. One is for circulation out of buildings that have standard or compact shelving, and the other from buildings that have high density shelving. Additional labor cost is incurred in selecting materials from a facility having high density shelving and this is estimated to increase costs by 20% from the base amount.

The estimated circulation cost for Building 38 is \$2.50 per volume. For Building 38A Level B2 circulation cost is \$3.28 per volume. In a multi-use facility, the cost is \$3.37, an underground facility \$3.81, and an above-ground storage facility \$3.81. These cost variations arise because of the difference in time it takes to retrieve an item from each facility.<sup>3</sup> These figures excluding reshelving cost. The process of reshelving materials is done by contract employees. In 1995 the reshelving cost per volume was \$0.38, and the 1999 rate is \$0.43

When items circulate from an off-site storage facility, different procedures and cost factors come into play depending on the organizational structure and organizational relationship between the facility and NLM. If NLM were to rent space at WRLC, there would be the potential for duplication of the circulation function. When an item is requested, the request is forwarded to the storage facility, selected from the shelf of the facility, checked-out of the facility, transported to the requesting library, checked-out to the user at the library, returned to the library, checked-in at the library, transported to the storage facility, checked-in at the storage facility, and returned to the shelf. However, if NLM were to operate the facility itself, there would be no need for duplication of the circulation function because requests could be transmitted electronically to the off-site facility and all materials would be under the control of NLM at all times.

Tables 7 and 8 summarize the alternative circulation costs from an off-site storage facility. Two factors are involved in computing circulation costs. The first is the volume of items that will be requested, and the other is the way in which material will be delivered (physical volume delivered, scanned image delivered).

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<sup>3</sup> It is assumed that an additional 15 minutes is required to retrieve items from Building 38A Level B2 beyond that from Building 38, an additional 25 minutes from a multi-use building, and 45 minutes from an underground or above-ground storage facility.

The number of items that are requested from an off-site storage facility is a function of the type of material stored. If a scenario were envisioned in which all material published before 1950 were moved off-site, this would result in about 4% of all requests being filled from the storage facility. Using data from a sample period, it is known that about 9.7% of these requests are for monographs and the remainder are for serials. Almost all the demand for serials could be met by scanning the article and sending the scanned image to the NLM Reading Room. The remainder of requests might require the physical volume being shipped. If this scenario is followed, only eight physical volumes of material are likely to be shipped from the off-site facility to the Reading Room in one day. (See Table 7).

Delivery of a physical volume from an off-site facility to NLM would be made by a contractor who is estimated to charge \$50 per trip. If eight items are delivered per day, this makes the delivery cost per item \$6.50.

If NLM contracts with WRLC, a fee of \$3 is paid for each item removed and reshelfed at the facility. In addition, delivery is charged at \$6.50 per item.

Items can be delivered from storage to the NLM Reading Room by scanning. WRLC charges between \$4-\$5 to scan and deliver an item. If NLM were to build its own facility, it is estimated that it would cost about \$2.79 per item to perform the scanning at the storage facility. The calculations presented here assumed labor cost of \$2.50 per scanned item. Scanning and electronic delivery of an estimated 12,000 journal articles would involve additional costs to NLM of \$33,480 - \$54,000 per year.

In Table 8, circulation costs are summarized for four options: circulation from a facility operated by WRLC, circulation from an off-site facility built and operated by NLM, delivery of a physical volume, and delivery of a scanned image.

Circulation of a physical volume from the WRLC facility is the sum of their fixed cost to make an item available (\$3) plus delivery and handling costs. This totals \$9.61. Circulation of a physical volume from a facility that NLM operates is assumed to total \$9.48. WRLC charges \$4.50 for delivering a scanned image of an item, and NLM's costs are estimated at \$2.79 per item.

Table 6

Cost to Circulate an Item from On-Campus Facilities to the NLM Reading Room

	Building 38	Building 38	Building 38A Level B2	Multi-Use Building with Basement Stack Space	Underground Storage Facility behind Building 38	Above- Ground Storage Facility on NIH Campus
Year	1995	1999	1999	1999	1999	1999
Type of Shelving	Regular & Compact	Regular & Compact	High Density	Compact	High Density	High Density
Labor to serve reading room users						
Regular Employees	\$169,512	\$185,548				
Students	\$68,454	\$74,930				
Overtime	\$57,330	\$62,753				
Direct labor cost	\$295,296	\$323,231				
Fringe Benefits for Regular Employees- 18%	\$30,512	\$33,399				
Total labor cost	\$325,808	\$356,630				
Equipment Cost	\$18,024	\$19,826				
Total Labor and Equipment Cost	\$343,832	\$376,456				
Number of items retrieved for reading room users	150843	150843				
Cost per item retrieved for reading room user	\$2.28	\$2.50	\$2.76	\$2.94	\$3.29	\$3.29
Reshelving cost per item	<u>\$0.38</u>	<u>\$0.43</u>	<u>\$0.52</u>	<u>\$0.43</u>	<u>\$0.52</u>	<u>\$0.52</u>
Total Circulation Cost per item	\$2.66	\$2.93	\$3.28	\$3.37	\$3.81	\$3.81

Notes:

1. Labor costs assumed to increase 9.46% from 1995 to 1999
2. Equipment costs assumed to increase 10% during same period
3. 1999 estimates are adjusted for cost increases but assume same units processed in order to provide comparability between years.
4. Reshelving is done under contract not by NLM staff
5. Source for 1995 values: "Unit Price for Items Delivered to the Main Reading Room" Spreadsheet p:\psd\casmg\circost2.xlw.
6. Circulation costs from facilities having high density shelving is assumed to cost 20% more than from standard & compact shelving.
7. Labor costs for circulation from proposed on-campus sites are adjusted for increased time required to deliver items.

**Table 7**  
**Alternative Costs of Delivery of Materials from Off-Site Storage Facility**  
**to NLM Reading Room**

<b>Delivery Volume</b>	
Estimated total number of on-site requests (1999)	348,083
Estimated percent of requests filled from storage	4%
Total number of requests filled from storage	13,923
Percent of requests that are for monographs	9.7%
Number of requests filled from storage that are monographs	1,351
Number of requests filled from storage that are serials	12,573
Estimated volume of requests from storage for serials that can be filled by scanning rather than physical delivery of volume	12,000
Total number of physical items to be delivered to reading room per year	1,923
Number of delivery days per year	250
Total number of physical items to be delivered to reading room per day from off-site storage facility assuming partial delivery by scanning	7.69
<b>Delivery Options</b>	
1. Physically deliver one item at a time from off-site storage facility to NLM	
Cost per shipment	\$50.00
Items delivered per trip	7.69
Cost per item for bulk delivery	\$6.50
Washington Regional Library Facility Fee per item delivered.	\$3.00
2. Bulk delivery of items from off-site storage facility to NLM Reading Room	
Cost per shipment	\$50.00
Items delivered per trip	7.69
Cost per item for bulk delivery	\$6.50
3. Scan item at off-site storage facility and transmit it electronically to NLM	
a. WRLC Estimated fee per scanned item	\$4.50
b. NLM Estimated cost per scanned item	
Cost of purchase of Relais workstation	\$16,500
Cost of purchase of software	\$895
Total cost of equipment and software	\$17,395
Estimated lifetime of workstation and software in years	5
Cost of equipment and software per year	\$3,479
Number of requests processed via scanning per year	12,000
Cost per item scanned	\$0.29
Estimated Labor cost for scanning one item	<u>\$2.50</u>
NLM Total cost per item scanned	\$2.79

**Notes:**

1. NLM's cost of bulk delivery of an item is assumed to be the trip fee divided by the average number of items delivered per day.
2. WRLC estimates the scanning fee per item as \$4-\$5. A figure of \$4.50 was used in the calculations.
3. If 1950 is used as a cutoff for sending materials to storage, this will result in about 4% of all requests being filled from storage.

Table 8

Summary of Estimated Cost to Circulate Materials from Off-Site Storage Facility to NLM Reading Room

Method of Delivery	Storage Facility Operated by WRLC	Off-Site Storage Facility	Storage Facility Operated by WRLC	Off-Site Storage Facility
	Physical Volume	Physical Volume	Scanning	Scanning
Select, circulate, and reshelve item	\$3.00	\$2.93		
Deliver a volume from Storage Facility to NLM	\$6.50	\$6.50	<u>\$4.50</u>	<u>\$2.79</u>
Unpack item at NLM	\$0.06	<u>\$0.06</u>		
Charge out item to Patron/Discharge item	<u>\$0.06</u>			
Total Circulation Cost per volume or item	\$9.61	\$9.48	\$4.50	\$2.79

Notes:

1. WRLC scanning fee is estimated at \$4-\$5 per volume. The figure \$4.50 was used in calculations.

## Delivery Time

Users expect a delay between the time they submit a request for material and it arrives in the Reading Room. This delay is a function of the time to print the request, retrieve the item from the stacks, update the request transaction record, transport the item to the Reading Room and deliver it to the user.

Table 9 summarizes the delivery time for eight options. The number of items pulled from shelves in a period of time is mainly a function of the type of shelving used. In Building 38 Level B1 where standard shelving is used, 60 items per hour can be pulled, while in the same building where compact shelving is employed, the number reduces to 30 per hour. In the proposed facilities (Building 38A Level B2, an Underground Storage Facility, an above-ground on-site storage facility, a multi-use building, and the Washington Regional Library Facility) the values range from 20 to 30 items per hour.

Given the number of items that can be pulled from the shelves, it is possible to estimate the *time* to sort requests, pick requests from shelves, and charge out items. This varies from 20-160 minutes.

Finally, delay time must be factored in. Delay time is an additional amount of time that must be added above normal waiting time when the request is filled from a storage facility. In the case where material is stored at a facility like WRLC this value is calculated at about 5 hours 37 minutes assuming one delivery per day from the facility to the Reading Room.

In order to compute this value of 5 hours and 37 minutes, a number of assumptions must be made. They include the time distribution of receipt of requests for library material at the Reading Room, the cut-off time after which requests submitted today can not be filled today, and the time-of-day at which delivery of the requested item is made. Figure 3 plots the distribution of the percent of all NLM Reading Room requests received during a specific one-hour block during a sample period. In the distribution, roughly 18% of all requests come in the 11am-Noon block of time, and another 18% from Noon to 1pm. Use drops off as the day ends.

Given the distribution of requests over time, it is possible to calculate this average amount of time a user will have to wait. If it is assumed that the cutoff time for accepting requests is 2:30pm and delivery takes place at 5pm, the 5 hour 37 minute figure is derived.

What would happen if there were two deliveries per day, one with a cutoff at 10:30am and delivery at 1pm, and another with a cutoff at 2:30pm and delivery at 5pm? Table 11 shows that delay time would drop to close to 3 hours and 43 minutes (3.71). Obviously there would be the additional expense of another delivery at \$50 per trip, but this might be outweighed by the reduction in waiting time. Still, four hours is a long time to wait for

materials to be delivered if one is used to a 35-55 minute service interval. Optimization of the delivery schedule is certainly a possibility.

Table 9

Estimated Delivery Time of a Volume from Library Facility  
to NLM Reading Room

	Building 38 Level B1	Building 38 Level B2	Building 38 Level B3	Building 38A Level B2	Multi-Use Building with Basement Stack Space	Underground Storage Facility behind Building 38	Above- Ground Storage Facility on NIH Campus	Off-Site Storage Facility
Type of Shelving	Standard	Standard	Compact	Compact	Compact	High Density	High Density	High Density
Number of items per hour pulled from shelves	60	30	30	30	30	20	20	20
Time (in minutes) to sort requests, charge out item, pick item from shelves (including travel)	20	35	35	50	60	80	80	160
Delay time between submitting request and arrival at NLM								337
Total Delivery Time	20	35	35	50	60	80	80	497

Notes:

1. A complex classification scheme reduces retrieval speed at Building 38 Level B2
2. It is assumed that the entire floor of Building 38A Level B2 is compact shelving
3. It is assumed that one delivery per day is made between the Off-Site Storage Facility and NLM.

Table 10

Estimated Time to Deliver a Volume from an Off-Site Storage Facility to  
NLM Reading Room Assuming One Delivery Per Day

Time at which it is assumed request is made	Percent Distribution of requests by hour	Number of requests by hour	Delay time in hours	Number of hours of delay for requests
8:30	6	0.5	8.5	4.2
9:30	11	0.8	7.5	6.3
10:30	12	0.9	6.5	6.0
11:30	18	1.4	5.5	7.7
12:30	18	1.4	4.5	6.2
13:30	12	0.9	3.5	3.3
14:30	9	0.7	2.5	1.8
15:30	6	0.5	1.5	0.7
16:30	3	0.2	0.5	0.1
17:30	<u>4</u>	<u>0.3</u>	<u>23.5</u>	<u>6.9</u>
Total	100	7.7	64	43.2
Mean wait time in hours per request				5.61
Number of items delivered per day				8
Delivery time cutoff				14:30
Delivery time at Reading Room				17:00

Notes:

1. Assume all requests in an hour interval occur at midpoint of interval.  
e.g. 08:00-08:59 interval requests are assumed to arrive at 08:30.

Table 11  
 Estimated Time to Deliver a Volume from an Off-Site Storage Facility to  
 NLM Reading Room Assuming Two Deliveries Per Day

Time at which it is assumed request is made	Percent Distribution of requests by hour	Number of requests by hour	Delay time in hours	Number of hours of delay for requests
8:30	6	0.5	4.5	2.2
9:30	11	0.8	3.5	2.9
10:30	12	0.9	2.5	2.3
11:30	18	1.4	1.5	2.1
12:30	18	1.4	4.5	6.2
13:30	12	0.9	3.5	3.3
14:30	9	0.7	2.5	1.8
15:30	6	0.5	1.5	0.7
16:30	3	0.2	0.5	0.1
17:30	4	0.3	23.5	6.9
Total	100	7.7	48	28.6

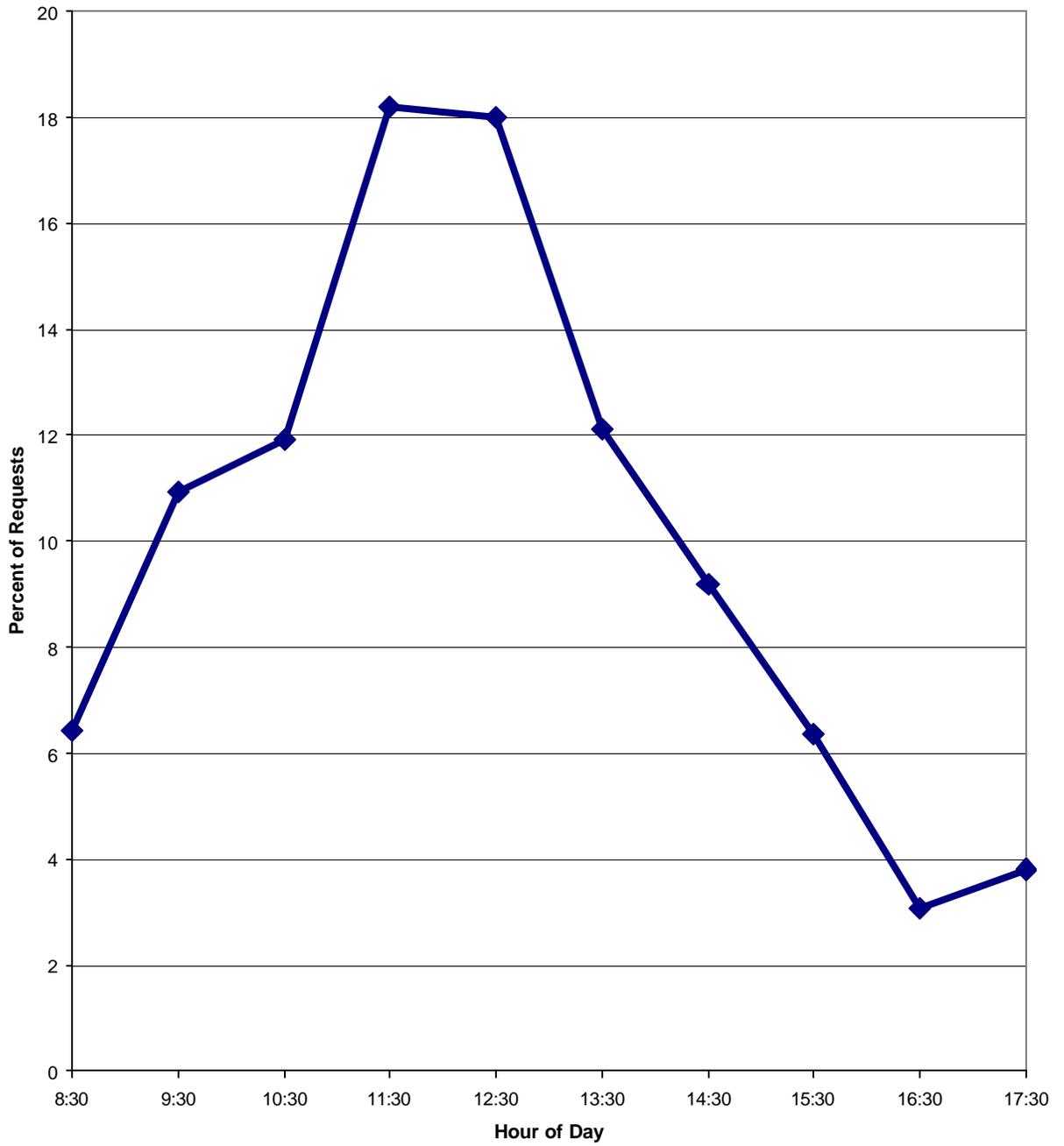
Mean wait time in hours per request 3.71

Number of items delivered per day 8  
 Delivery time cutoff #1 10:30  
 Delivery time at Reading Room #1 13:00  
 Delivery time cutoff #2 14:30  
 Delivery time at Reading Room #2 17:00

- Notes:
1. Assume all requests in an hour interval occur at midpoint of inter e.g. 08:00-08:59 interval requests are assumed to arrive at 08:30

Figure 3

Percent Distribution of Reading Room Requests by Hour



## Cost Comparison of Alternatives

Three major cost factors and one time factor have been calculated for each of the storage options. They are construction or remodeling cost, processing cost, circulation cost, and delivery time. Table 12 summarizes the results for seven major alternatives.

The total construction/remodeling and processing cost per volume ranges from \$3.34 for an on-site above-ground storage facility to \$11.16 for storage at WRLC. Between those alternatives are the costs of remodeling Building 38A Level B2 at \$7.37, building an underground facility at \$5.28, building a multi-purpose building at \$8.80, and building an off-site storage facility at \$5.73. The circulation costs are \$2.93 from Building 38, \$3.28 from Building 38A Level B2, \$3.81 from an underground or above-ground storage facility on-site, and \$3.37 from a multi-use facility. Circulation from off-site facilities vary depending on the form of delivery. If a physical volume is delivered from a facility that NLM constructs, the cost is \$9.48, while if it from WRLC the cost is \$9.61. Delivery of a scanned image is \$2.79 from an NLM facility off-site, and \$4.50 from WRLC.

Delivery time should play an important part in any decision, and it, too, is summarized on Table 12. The shortest delivery time is for material stored in Building 38 (30 minutes), while the longest is from an off-site storage facility (497 minutes).

The most effective way to compare the construction alternatives is through an average cost analysis. With this approach, certain costs of storing materials are considered fixed, such as construction/remodeling and processing, and others considered variable (circulation). Each time a volume circulates from one of the facilities it incurs a variable cost equal to the cost of circulation, and a portion of the fixed cost. As the number of times a volume circulates increases, the fixed cost is distributed over more of the circulation events. The effect of the analysis is to see how costs change as the number of times an item circulates changes.

Figure 4 summarizes the average cost per circulation for all the options discussed previously. (The data upon which the figure is based are in Table A4). The option with the highest average cost across all levels of circulation is renting space at WRLC. Next is an off-site storage facility that NLM constructs. This option is costly because of the transportation cost per volume (\$6.50). Below those two options is the one for having materials delivered from WRLC by scanning. This is relatively costly because the fee WRLC charges is more than the cost NLM would incur for the same service. Below the line representing the WRLC scanning option is the cost curve for the multi-use building. Aside from the average cost curve for circulations from Building 38 (flat), the lowest average cost curve is an above-ground on-site storage facility constructed on the NIH

campus. This is an inexpensive alternative because construction costs are low and there is no direct cost for the acquisition of the land.<sup>4</sup>

It is important at this point to reiterate something about the nature of the multi-use facility. While this analysis has dealt with the multi-use facility as a separate storage entity, the reality of the situation is that it is unlikely that the facility would only be built for book storage, but rather have a number of floors on top of it to house individuals and activities related to NLM's mission. Thus what appears to be a relatively expensive alternative must be viewed in terms of joint costs—the cost of book storage can be merged with the cost of building another facility with other purposes. The net result may be highly efficient but the efficiency is outside the scope of this analysis. It should not, however, be ignored.

As the number of times an item circulates increases, the lines for some of the options merge. This is significant because it indicates that as the number of circulations increases, the average cost per circulation becomes similar for all the options.

Figures 5, 6, and 7 clarify the average cost relationships between the options.<sup>5</sup> In Figure 5 a comparison is made between the average cost for the four on-site alternatives. Even though there are significant differences in the costs per square foot to build or remodel, the average cost per circulation is very similar over most of the projected range of number of circulations. Once there are more than 8 circulations per item, the costs are within the \$3.50-\$4.00 range.

In Figure 6 a comparison is made between the high-density shelving construction alternatives, namely an underground facility, an above-ground on-site storage facility, an off-site storage facility, and the WRLC facility. The figure once again shows that the most expensive alternative is to lease space from WRLC followed by building an off-site storage facility. The least expensive alternative is an above-ground on-site facility, and slightly more expensive is an underground facility

Figure 7 focuses on the average cost per circulation when materials are delivered by scanning. It is clear that the economies are such that NLM is much better operating its own scanning facility than paying WRLC a fee per item scanned.

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<sup>4</sup> The zero point on the x-axis is also of interest because it represents the cost per circulation if the item never circulates. This is the case where an item is, say, moved to storage, and never requested again. There is a construction and processing cost to establish space for the item in the facility, but no circulation cost.

<sup>5</sup> The supporting data upon which these figures are based is given in Table A4.

Table 12

Construction, Processing, and Circulation Cost Summary  
for Alternative Construction Options

	Building 38	Remodel Building 38A Level B2	Underground Storage Facility behind Building 38	Multi-Use Building with Basement Stack Space	Above- Ground Storage Facility on NIH Campus	Off-Site Storage Facility	Storage Facility Operated by WRLC
Type of Shelving	Varies	Compact Electrical	High Density	Compact Electrical	High Density	High Density	High Density
Construction Cost or Remodel Cost per volume		\$5.36	\$3.27	\$6.79	\$1.33	\$2.57	\$8.00
Processing Cost per volume		\$2.01	\$2.01	\$2.01	\$2.01	\$2.66	\$3.16
Total Construction and Processing Cost per volume		\$7.37	\$5.28	\$8.80	\$3.34	\$5.23	\$11.16
Alternative Circulation Costs per volume							
Deliver Physical volume	\$2.93	\$3.28	\$3.81	\$3.37	\$3.81	\$9.48	\$9.61
Deliver Scanned copy						\$2.79	\$4.50
Delivery Time in minutes for physical delivery	30	50	80	60	80	497	497

Figure 4

Average Cost Per Circulation for Alternative Storage Options

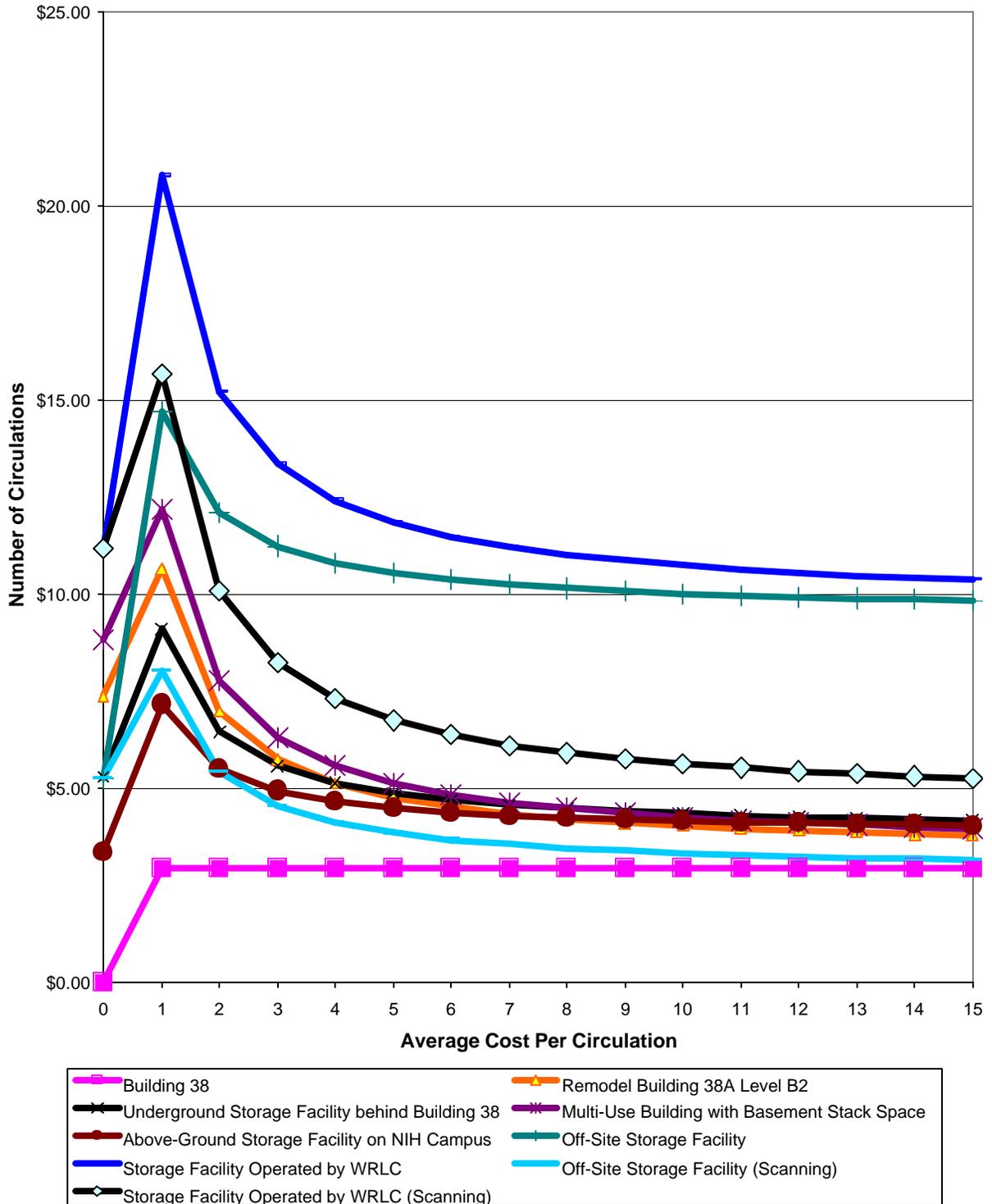


Figure 5

Average Cost Per Circulation for On-Site Storage Options

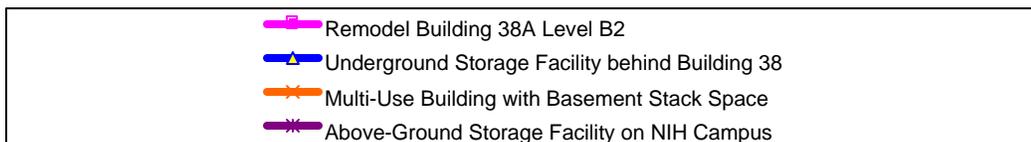
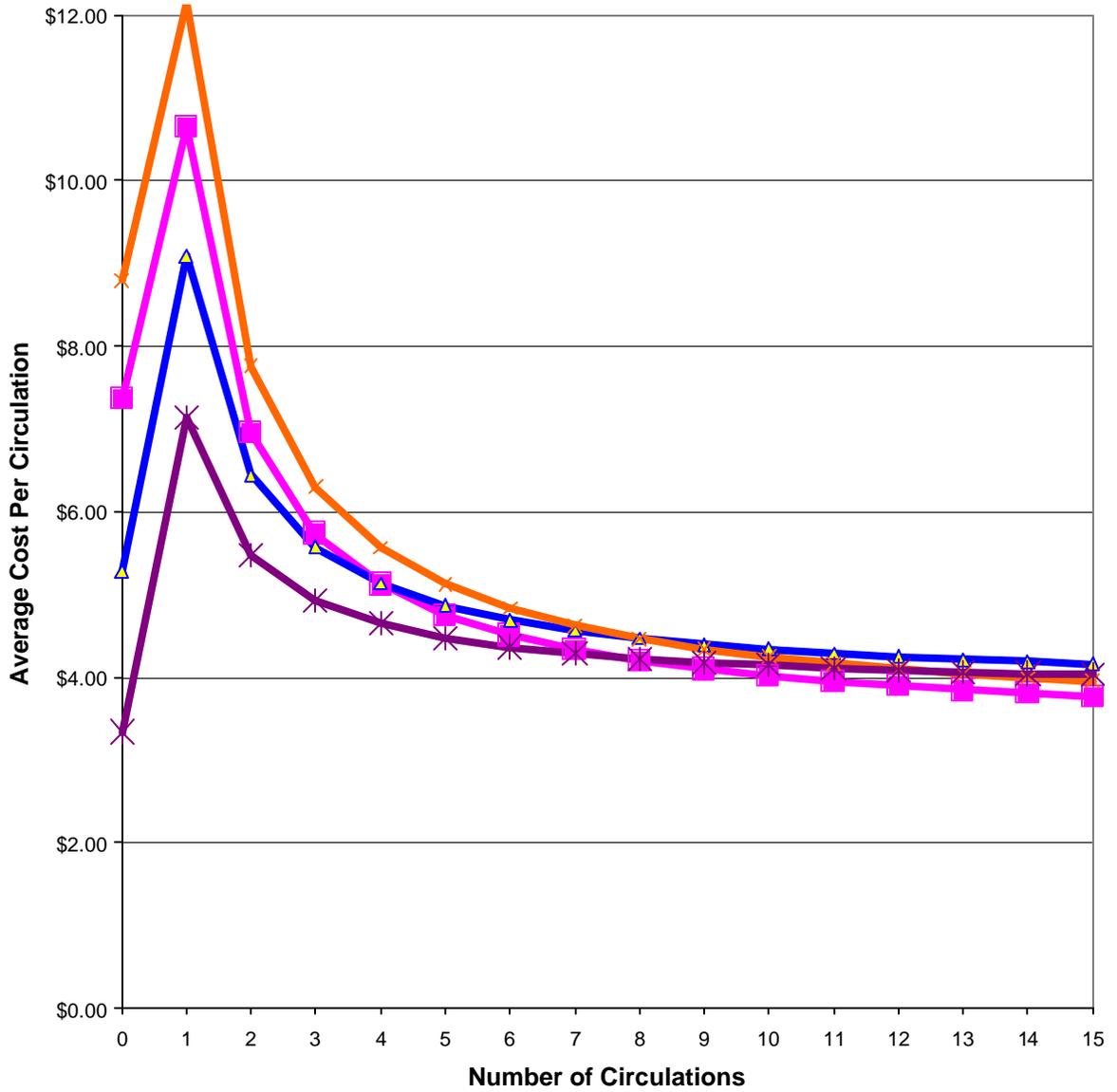


Figure 6

Average Cost Per Circulation for High Density Storage Options

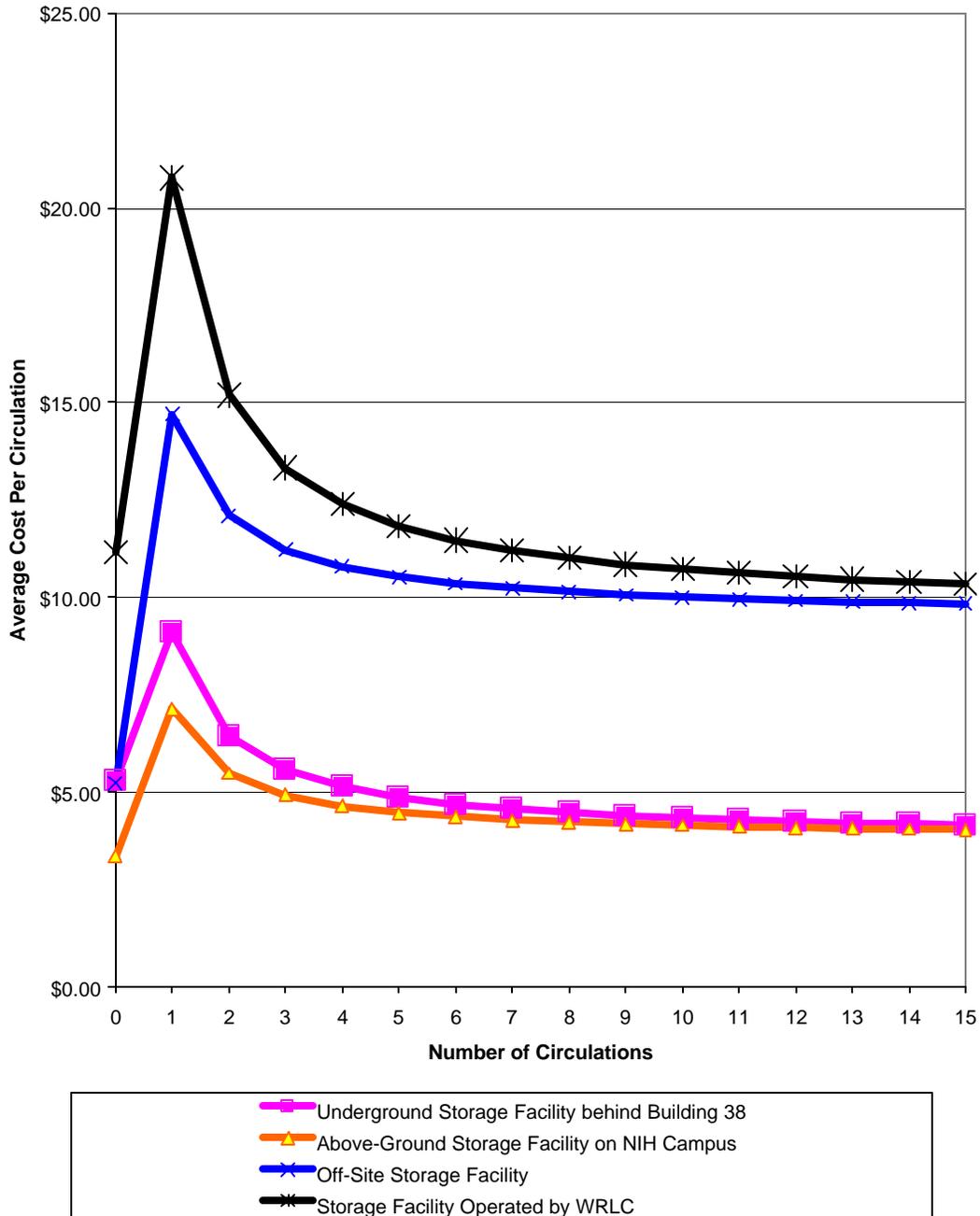
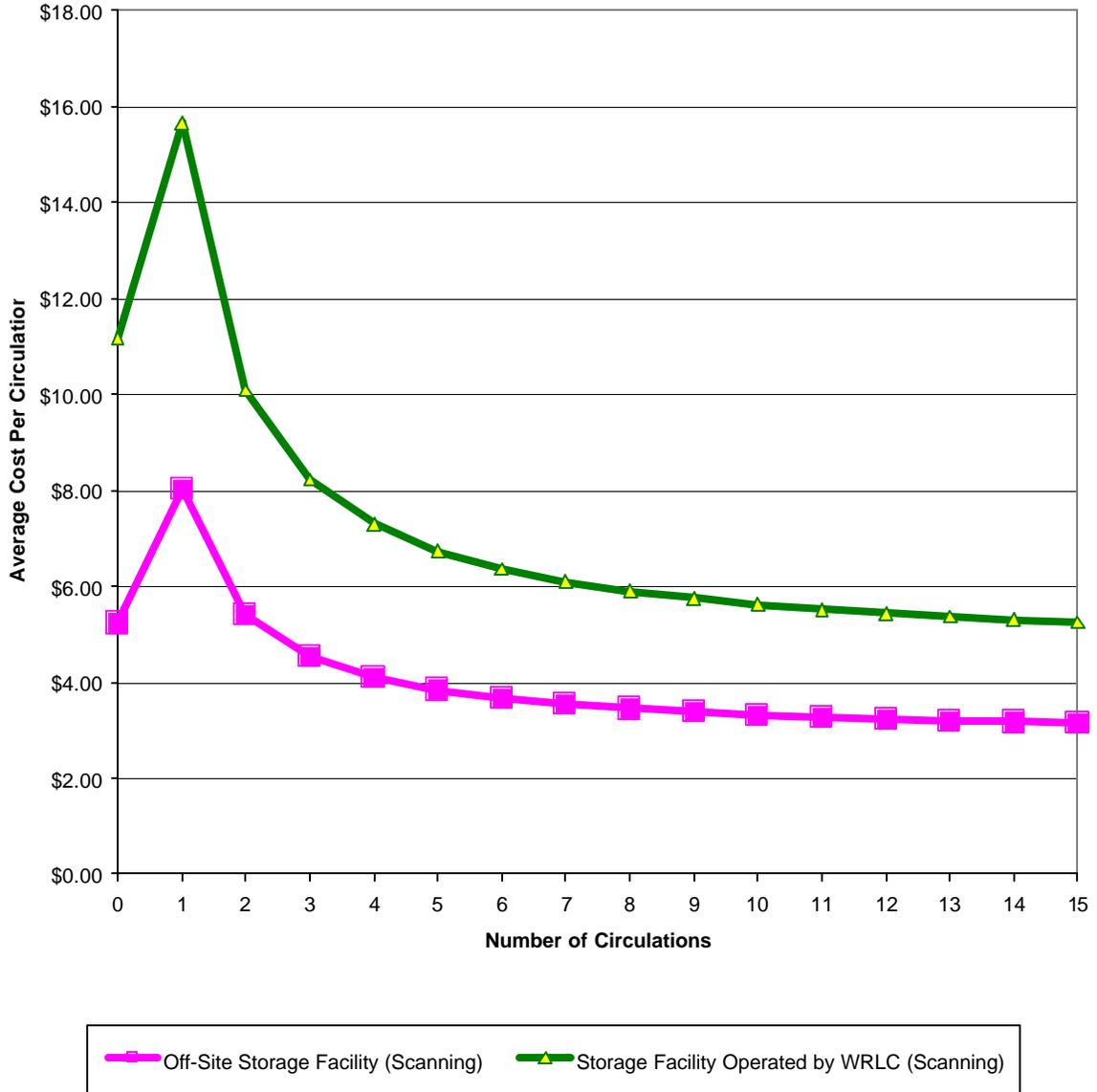


Figure 7

Average Cost Per Circulation for Delivery from Off-Site Facilities by Scanning



## Summary and Conclusions

This report has analyzed a number of options that NLM has available for housing its collection. These include remodeling Building 38A Level B2, building an underground on-site high density storage facility, building an above-ground on-site high density storage facility, building a multi-use building with compact shelving in basement stack space, building an off-site high density storage facility, and renting space in an existing off-site high density storage facility. The construction and processing costs for these alternatives are given in Table 12, along with the cost of circulating materials from the facilities and delivery times.

Given the growth patterns and timing, the most reasonable short-term solution for meeting space needs is to remodel Building 38A Level B2 and install compact shelving. This will allow for collection growth until about the year 2016 when an alternative solution will be needed. The least expensive option in terms of unit cost of construction and processing is to build an above-ground high density facility on the NIH campus. However, factoring in the longer retrieval time associated with high density storage, potential alternative uses of NIH's above-ground on-campus space, NLM's need for a significant amount of additional staff space for expanding programs, and the considerable cost savings involved in building one new facility rather than two, storing collections in the basement of a new multi-use facility appears to be the most reasonable long-term plan.

## References

1. *R.S. Means Building Construction Cost Data*. 57<sup>th</sup> Annual Edition, 1999. Kingston, MA: R.S. Means Company, 1998.

## Appendix

This appendix contains a figure and a number of tables that provide supplementary information to the text. They are:

Table A1. Collection Statistics

Table A2. Collection Usage Statistics

Table A3. Number of Reading Room Requests by Hour of Day for Selected Days

Table A4. Sensitivity Analysis of Total Unit Costs

Table A1

## Collection Statistics

Type of Material	1990	1991	1992	1993	1994	1995	1996	1997	1998
Book Material									
Monographs	620967	634839	649056	659572	679860	698148	713500	728947	743915
Theses	281794	281794	281794	281794	281794	281794	281794	281794	281794
Pamphlets	172021	172021	172021	172021	172021	172021	172021	172021	172021
Bound Serial Volumes	917641	947006	977179	998464	1025504	1049964	1072325	1101264	1129701
Volumes withdrawn	-35034	-35149	-35149	-35149	-55956	-57697	-57857	-60810	-66481
Total Book Materials	1957389	2000511	2044901	2076702	2103223	2144230	2181783	2223216	2260950
Nonbook Materials									
Microforms	292871	309645	322633	325482	356322	394084	431306	462307	492500
Audiovisuals	50176	52117	54000	55736	57226	58722	60723	62083	63782
Computer software	512	316	578	649	662	776	857	1167	1408
Pictures	56600	56600	56600	56600	56601	56601	56601	56601	56601
Manuscripts	2328229	2401617	2445792	2454542	2454542	2454542	2454542	2454542	2454542
Total Nonbook Materials	2728388	2820295	2879603	2893009	2925353	2964725	3004029	3036700	3068833
Total Book and Nonbook Materials	4685777	4820806	4924504	4969711	5028576	5108955	5185812	5259916	5329783

## Notes:

1. Source of these statistics are the NLM Annual Reports.

Table A2

## Collection Usage Patterns

Year	Regular Stack Requests Received	OPS Requests Received	Percent Change in OPS Requests	Total On- Site Requests	ILL Requests Received	Total Requests Received
1990	186334	12149		198483	258423	456906
1991	190637	22274	45.5	212911	281606	494517
1992	159969	66048	66.3	226017	302271	528288
1993	160261	54730	-20.7	214991	307481	522472
1994	167497	47821	-14.4	215318	324670	539988
1995	188564	39559	-20.9	228123	345428	573551
1996	195488	41258	4.1	236746	347992	584738
1997	240959	35823	-15.2	276782	353408	630190
1998	297114	22376	-60.1	319490	374791	694281
E1999	326825	21257	-5.3	348083	389308	737390
E2000	359508	20194	-5.3	379702	402812	782515
E2001	395459	19185	-5.3	414643	416317	830960
E2002	435005	18225	-5.3	453230	429821	883051
E2003	478505	17314	-5.3	495819	443326	939145
E2004	526356	16448	-5.3	542804	456830	999634
E2005	578991	15626	-5.3	594617	470335	1064952
E2006	636890	14845	-5.3	651735	483839	1135574
E2007	700579	14102	-5.3	714682	497343	1212025
E2008	770637	13397	-5.3	784035	510848	1294882
E2009	847701	12727	-5.3	860428	524352	1384781
E2010	932471	12091	-5.3	944562	537857	1482419

Table A3

Number of Reading Room Requests by Hour of Day for Selected Days

Start Time	3/29/99	3/31/99	4/1/99	4/2/99	4/3/99	4/6/99	4/7/99	4/8/99	4/9/99	Total	Percent Dist.	Distrib. By Category
8:30	52	110	111	76	86	49	90	109	87	770	6.42%	6.42%
9:00	92	104	103	104	92	57	102	109	99	862	7.19%	
9:30	44	49	28	51	78	49	36	45	69	449	3.74%	10.93%
10:00	79	84	77	87	90	76	75	52	74	694	5.79%	
10:30	127	80	106	61	75	102	50	48	86	735	6.13%	11.91%
11:00	183	174	222	176	154	165	99	130	146	1449	12.08%	
11:30	73	40	72	106	99	63	149	71	63	736	6.14%	18.21%
12:00	125	73	193	231	155	166	162	145	133	1383	11.53%	
12:30	84	60	116	118	37	79	97	82	102	775	6.46%	17.99%
13:00	98	129	110	96	48	108	105	87	116	897	7.48%	
13:30	74	53	58	60	51	87	74	60	40	557	4.64%	12.12%
14:00	89	94	69	43	87	100	49	29	50	610	5.09%	
14:30	85	45	68	10	48	66	39	76	55	492	4.10%	9.19%
15:00	43	20	35	1	48	56	51	66	68	388	3.23%	
15:30	17	32	15	7	93	70	58	45	37	374	3.12%	6.35%
16:00	25	8	19	57	19	36	31	19	62	276	2.30%	
16:30				35					57	92	0.77%	3.07%
17:00				36					74	110	0.92%	
17:30				33					22	55	0.46%	3.81%
18:00				37					37	74	0.62%	
18:30				15					61	76	0.63%	
19:00				34					37	71	0.59%	
19:30				29					33	62	0.52%	
20:00									9	9	0.08%	
Total	1290	1155	1402	1503	1260	1329	1267	1173	1617	11996	100.00%	100.00%

Notes:

1. Number of observations for a given starting time are the observations that begin at that time and continue to the next time. For example, the cell for 3/29/99 gives the number of requests (44) at the reading room from 9:30-9:59am.
2. The column 'Distribution By Category' collapses two cells to one for simplicity. The percent recorded for 17:30 is the sum of all requests from 17:00 through 20:00.

Table A4

Sensitivity Analysis of Total Unit Costs

Number of Circulations	Building 38	Remodel Building 38A Level B2	Underground Storage Facility behind Building 38	Multi-Use Building with Basement Stack Space	Above-Ground Storage Facility on NIH Campus	Off-Site Storage Facility	Storage Facility Operated by WRLC	Off-Site Storage Facility (Scanning)	Storage Facility Operated by WRLC (Scanning)
0	\$0.00	\$7.37	\$5.28	\$8.80	\$3.34	\$5.23	\$11.16	\$5.23	\$11.16
1	\$2.93	\$10.64	\$9.09	\$12.16	\$7.15	\$14.71	\$20.77	\$8.02	\$15.66
2	\$2.93	\$6.96	\$6.45	\$7.76	\$5.48	\$12.10	\$15.19	\$5.41	\$10.08
3	\$2.93	\$5.73	\$5.57	\$6.30	\$4.92	\$11.22	\$13.33	\$4.53	\$8.22
4	\$2.93	\$5.12	\$5.13	\$5.56	\$4.64	\$10.79	\$12.40	\$4.10	\$7.29
5	\$2.93	\$4.75	\$4.86	\$5.12	\$4.48	\$10.53	\$11.84	\$3.84	\$6.73
6	\$2.93	\$4.51	\$4.69	\$4.83	\$4.36	\$10.35	\$11.47	\$3.66	\$6.36
7	\$2.93	\$4.33	\$4.56	\$4.62	\$4.28	\$10.23	\$11.20	\$3.54	\$6.09
8	\$2.93	\$4.20	\$4.47	\$4.47	\$4.23	\$10.13	\$11.00	\$3.44	\$5.90
9	\$2.93	\$4.10	\$4.39	\$4.34	\$4.18	\$10.06	\$10.85	\$3.37	\$5.74
10	\$2.93	\$4.01	\$4.34	\$4.25	\$4.14	\$10.00	\$10.73	\$3.31	\$5.62
11	\$2.93	\$3.95	\$4.29	\$4.17	\$4.11	\$9.96	\$10.62	\$3.27	\$5.51
12	\$2.93	\$3.89	\$4.25	\$4.10	\$4.09	\$9.92	\$10.54	\$3.23	\$5.43
13	\$2.93	\$3.84	\$4.21	\$4.04	\$4.06	\$9.88	\$10.47	\$3.19	\$5.36
14	\$2.93	\$3.80	\$4.18	\$3.99	\$4.05	\$9.85	\$10.41	\$3.16	\$5.30
15	\$2.93	\$3.77	\$4.16	\$3.95	\$4.03	\$9.83	\$10.35	\$3.14	\$5.24
Type of Shelving	Varies	Compact Electrical	High Density	Compact Electrical	High Density	High Density	High Density	High Density	High Density
Type of Delivery	Physical Volume	Physical Volume	Physical Volume	Physical Volume	Physical Volume	Physical Volume	Physical Volume	Scanning	Scanning
Construction Cost or Remodel Cost per volume	0	\$5.36	\$3.27	\$6.79	\$1.33	\$2.57	\$8.00	\$2.57	\$8.00
Processing Cost per volume	0	\$2.01	\$2.01	\$2.01	\$2.01	\$2.66	\$3.16	\$2.66	\$3.16
Total Construction and Processing Cost per volume	0	\$7.37	\$5.28	\$8.80	\$3.34	\$5.23	\$11.16	\$5.23	\$11.16
Circulation Cost per volume	\$2.93	\$3.28	\$3.81	\$3.37	\$3.81	\$9.48	\$9.61	\$2.79	\$4.50