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Technical Note N-1114

ALLOCATION OF MAINTENANCE FUNDS, NAVY FAMILY HOUSING

By

J. A. South

November 1970

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YF 38.534.007.01.004

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ABSTRACT

This report covers an investigation at activity level of the causes of Operation & Maintenance (O&M) problems. Direct investigation in the field showed that major O&M problems with Navy family quarters are common to all activities, but because of established policies, the local Housing Manager has little control over factors causing maintenance problems. A higher level study of Life Cycle Costs of Family Housing is recommended. By using regression analysis, those factors which best measure O&M requirements were determined. Work sheets are derived which can be used to forecast O&M fund requirements, to make an equitable distribution of O&M funds, and also as a measure of effectiveness.

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INTRODUCTION

By direction of the Congress, Navy Family Housing Activities have been using a number of typical houses as a basis for a measure of effectiveness expressed as Operations and Maintenance (O&M) dollars cost per house of the specific type per year. This expression may be valid for budget and funding purposes, but it offers no measure to evaluate the effectiveness of local management. Housing Managers at field activities report that there is little they can do to control costs since basic causes are outside their jurisdiction. Also, distribution of available funds to field activities has a tendency to follow a historical formula of allocating O&M funds to local commanders in direct proportion to funds available at the bureau level.

To provide a better basis for allocating O&M funds NAVFAC (Naval Facilities Engineering Command), conducted a study of selected Navy activities to:

1. Determine principal operations and maintenance problems and benefits, the Navy receives for its O&M dollar.
2. Develop a measure of effectiveness for operations and maintenance of family housing.
3. Develop a model based on three years of experience data for equitable allocation of maintenance funds.

This study was established in FY-69. Objectives 1 and 2 were conducted by NCEL (Naval Civil Engineering Laboratory). Objective 3 was conducted by Battelle Memorial Institute under contract to NCEL.

APPROACH

Objective 1 was accomplished as an "on-site" investigation of the housing O&M function (reference 1). Fifteen EFD's (Engineering Field Division), and thirty two activities, listed in Table 1, were visited. Problems were discussed with both management and local personnel involved in the O&M operation. Houses were inspected at random, the randomness being whatever houses were unoccupied at the time. However, at least one house of each type was inspected at each activity visited. A few specific houses were inspected while occupied to view specific local problems. Also a tour was made of each housing area to note general conditions.

Table 1

1. Boston (NE DIV)	PWC New Port Quonset Point
3. New York (East DIV)	NSB Groton (New London) NS Brooklyn
5. Norfolk (LANT DIV)	PWC Norfolk
6. Charleston (SE DIV)	NS Keywest MS Beaufort NS Charleston NAS Memphis
8. New Orleans (Gulf DIV)	White Sands Missile Range NAS Corpus Christi
9. Great Lakes (Mid West DIV)	PWC Great Lakes
10. San Juan (Caribbean DIV)	NS Roosevelt Roads NS San Juan
11. San Diego (SW DIV)	MCSC Barstow NWC China Lake NAS Long Beach MCBC Port Hueneme PWC San Diego
12. San Bruno (West DIV)	NAS Alameda NAS Lemoore NPG School Monterey Vallejo (Mare Island)
13. Seattle (NW DIV)	NAS Oak Harbor (Whidbey Island)
14. Pearl Harbor (PACDIV)	PWC Pearl Harbor NAS Barbers Point MCAS Kaneohe Bay
15. Canal Zone	Rodman (Coco Solo)
Washington, D.C. (Chesapeake DIV)	NS Washington Naval Academy, Annapolis
Atlantic Area (LANTDIV)	NS Arentia, Newfoundland
Pacific Area (PACDIV)	PWC Guam

Objective 2 was attained by evaluation of the results of objectives 1 and 3 (reference 2).

Objective 3 was contracted to Battelle Memorial Institute (reference 3). Data obtained from operations over three years was analyzed by regression analysis to determine factors which would give a good measurement of average operations and maintenance costs. Fifty independent variables, Table 2, were considered for each of the four types of houses and separately for operations and maintenance. Some of these factors were found to apply additively and a few were best used as multipliers. The output is in the form of work sheets shown in Appendix A, which require a minimum of data with a small amount of multiplication and addition to arrive at an average cost per year of operations and maintenance by type of house to be expected at any particular activity. These calculations can easily be handled with a desk calculator or if necessary can be done by hand.

RESULTS OF INVESTIGATION

Although there are always a few local problems, the common major problems at all activities was the difficulty to establish a measure of effectiveness of O&M costs which can be uniformly applied, or to devise any optimum O&M policy for uniform application. Most of the difficulties are beyond control of the local housing manager and can be traced to the following causes:

1. Administrative differences between activities. This is recognized by DOD and is emphasized at the Defense Family Housing Management School, Ft. Belvoir, Virginia. This contributes to grade structure anomalies making Housing Management unattractive as a profession.
2. DOD control of directives and regulations for housing. These established basic parameters and constraints for housing construction, operations, and maintenance. Because of these constraints, it is sometimes necessary to change design specifications in order to bring the cost of construction within authorized limits. Resulting lower standards contribute to O&M problems.

Table 2. Data Sources

Variable	Description of Variable	Data Source
X1	No. of dwelling units at an activity of a particular house type (e.g., Appropriated Fund Housing, Encumbered Housing, etc.)	Family Housing Operation and Maintenance
X2	Housing population (total no. occupants) in a particular house type at an activity	Cost Report, NAVCOMPT Form 2100
X3	Thousands of square feet of housing of a particular house type at an activity	"
X4	Cubic yards of refuse from all houses of a particular house type at an activity	"
X5	No. firefighters assigned to a particular house type at an activity	"
X6	Thousands of KWH of electricity consumed by all occupants of a particular house type at an activity	"
X7	Thousands of cubic feet of gas consumed by all occupants of a particular house type at an activity	"
X8	Thousands of gallons of fuel oil consumed by all occupants of a particular house type at an activity	"
X9	Thousands of gallons of water used by all occupants of a particular house type at an activity	"
X10	Thousands of gallons of sewage from all dwelling units of a particular house type at an activity	"
X11	Thousands of square feet of exterior structure of all dwelling units of a particular house type at an activity	"
X12	Thousands of square feet of interior structure of all dwelling units of a particular house type at an activity	"

Table 2. Data Sources (Continued)

Variable	Description of Variable	Data Source
X13	Squares of exterior painting for all dwelling units of a particular house type at an activity	Cost Report, NAVCOMPT Form 2100
X14	Squares of interior painting for all dwelling units of a particular house type at an activity	"
X15	Acres of grounds associated with all dwelling units of a particular house type at an activity	"
X16	Thousands of square yards of surfaced area associated with all dwelling units of a particular house type at an activity	"
X17	Average number of active units (occupied on a yearly basis) of a particular house type at an activity	Navy Quarterly Housing Reports
X18	Average number of move-outs (on a yearly basis) from all units of a particular house type at an activity	"
X19	Average number of move-ins (on a yearly basis) into all units of a particular house type at an activity	"
X20	Yearly average utilization (expressed as a percent) of units of a particular house type at an activity	"
X21	Number of masonry units of a particular house type at an activity that are classified permanent	ADP Report from Real Property Inventory Cards
X22	Number of frame units of a particular house type at an activity that are classified permanent	"
X23	Number of stucco units of a particular house type at an activity that are classified permanent	"
X24	Number of "other" units (construction material classification) of a particular house type at an activity that are classified permanent	"

Table 2. Data Sources (Continued)

Variable	Description of Variable	Data Source
X25	Total number of units of a particular house type at an activity that are classified permanent	ADP Report from Real Property Inventory Cards
X26	Average number of bedrooms at an activity in units of a particular house type classified permanent	"
X27	Average number of bathrooms at an activity in units of a particular house type classified permanent	"
X28	Thousands of square feet of net area of all units of a particular house type at an activity that are classified permanent	"
X29	Number of masonry units of a particular house type at an activity that are classified semi-permanent	"
X30	Number of frame units of a particular house type at an activity that are classified semi-permanent.	"
X31	Number of stucco units of a particular house type at an activity that are classified semi-permanent	"
X32	Number of "other" units (construction material classification) of a particular house type at an activity that are classified semi-permanent	"
X33	Total number of units of a particular house type at an activity that are classified semi-permanent	"
X34	Average number of bedrooms at an activity in units of a particular house type classified semi-permanent	"
X35	Average number of bathrooms at an activity in units of a particular house type classified semi-permanent	"

Table 2. Data Sources (Continued)

Variable	Description of Variable	Data Source
X36	Thousands of square feet of net area of units of a particular house type at an activity that are classified semi-permanent	ADP Report from Real Property Inventory Cards
X37	Number of masonry units of a particular house type at an activity that are classified temporary	"
X38	Number of frame units of a particular house type at an activity that are classified temporary	"
X39	Number of stucco units of a particular house type at an activity that are classified temporary	"
X40	Number of "other" units (construction material classification) of a particular house type at an activity that are classified temporary	"
X41	Total number of units of a particular house type at an activity that are classified temporary	"
X42	Average number of bedrooms at an activity in units of a particular house type classified temporary	"
X43	Average number of bathrooms at an activity in units of a particular house type classified temporary	"
X44	Thousands of square feet of net area of units of a particular house type at an activity that are classified temporary	Type A Annual Inspection Summary, NAVDOCKS 2729
X45	Backlog of essential maintenance (after NAVFAC corrections are made to AIS's) for the year prior to any regression analysis observation year for all units of a particular house type at an activity	"
X46	Backlog of essential maintenance (after NAVFAC corrections are made to AIS's for the same year as any regression analysis observation year for all units of a particular house type at an activity	"

Table 2. Data Sources (Continued)

Variable	Description of Variable	Data Source
X47	Backlog of essential maintenance (after NAVFAC corrections are made to AIS's) for the year following any regression analysis observation year for all units for a particular house type at an activity	Type A Annual Inspection Summary, NAVFOCKS 2729
X48 through X68	These locations are left blank in the data file	
X69	Number of civilian occupants at an activity	NAVFAC working paper
X70	Maintenance organization of the activity - index (1) if not Naval Industrial Funded - index (2) if Naval Industrial Funded	NAVFAC Working paper
X71	Naval district of the activity	Catalog of Naval Shore Activities, OPNAV P09B3-105
X72	Proximity of activity to coast - index (1) if activity is not within 50 miles of coast - index (2) if activity is within 50 miles of coast	Army Map Service, Corp of Engineers Map
X73	Proximity of activity to Washington, D.C. - index (1) if activity is not within 25 miles of Washington - index (2) if activity is within 25 miles of Washington	Army Map Service, Corp of Engineers Map
X74	Population of the city in which the activity is located	United States Census of Population - U.S. Summary
X75	Proximity of activity to Naval District Headquarters - index (1) if activity is not within 25 miles of N.D. headquarters - index (2) if activity is within 25 miles of N.D. headquarters	Army Map Service, Corp of Engineers Map
X76	Average relative humidity (in percent) at 7:00 a.m. at activity	Statistical Abstract of the United States
X77	Average relative humidity (in percent) at 1:00 p.m. at activity	"

Table 2. Data Sources (Continued)

Variable	Description of Variable	Data Source
X78	Inches of snow and sleet on yearly basis	Statistical Abstract of the United States
X79	Inches of precipitation on yearly basis	"
X80	Normal monthly minimum temperature (ten year average), °F	"
X81	Normal monthly maximum temperature (ten year average), °F	"
X82	Primary function of activity (see listing and corresponding index numbers in Table C-2)	Catalog of Naval Shore activities, OPNAV P09B3-105
Y1	Cost of civilian labor for operations (dollars)	Family Housing Operation and Maintenance Cost Report, NAVCOMPT Form 2100
Y2	Cost of materials for operations (dollars)	"
Y3	"Other" cost category for operations (dollars)	"
Y4	Total funded dollars for operations	"
Y5	Military labor costs for operations (dollars)	"
Y6	Total operation costs (dollars)	"
Y7	Cost of civilian labor for maintenance (dollars)	"
Y8	Cost of materials for maintenance (dollars)	"
Y9	"Other" cost category for maintenance (dollars)	"
Y10	Total funded dollars for maintenance	"
Y11	Military labor costs for maintenance (dollars)	"
Y12	Total maintenance costs (dollars)	"
Y13	Total operation and maintenance costs (dollars)	"

3. NAVFAC control of specification and design of construction. This is separated administratively from O&M although a direct relationship exists in that the O&M division costs are based on what the construction division turns over for operations. While design and specification personnel try to make corrections for errors reported from O&M at activity level, there appears to be poor communication so that "feedback" is not always accomplished and errors are repeated.
4. ROICC control of contracting, inspection, and acceptance of new construction. The ROICC is also separated administratively from the O&M division. Closer cooperation between the ROICC and O&M is desirable particularly in the area of review of drawings before contracting and during the inspection period.
5. Differences in costs due to fiscal organization. There are various Public Works Centers, Public Works Departments, and lead activities, each being NIF or Non-NIF funded, and each performing work in-house or by contract. As a result, different charges are made for the same job, depending on the organization procedures and fiscal accounting systems. This tends to be confusing when comparing management effectiveness of each activity. In addition, no basis is available to establish management efficiency.
6. Differences in environmental factors. These include weather, local labor market, local management policies, distance from large urban centers, and other miscellaneous factors, which effect job costs. These differences are real and must be considered in the evaluation of management effectiveness.
7. Differences in costs due to type of houses. This is recognized as a problem by classifying Navy housing under four group types which are considered separately. There still exists a variation in O&M costs within types. The nature of these differences are not difficult to recognize and include in management evaluations.

The establishment of an optimum maintenance policy requires a unified control of factors which enter into the O&M function. As can be seen from the above list of causative factors, the administrative fractionation of responsibilities makes it impossible to set up an optimum O&M policy. Without establishing close communications and cooperation between the different administrative organizations. This could best be done by a Life Cycle Cost study of family housing. This particular study, however, was authorized and funded to cover only O&M and thus could not be expanded to the required extent. A Life Cycle Cost study would best be sponsored by NAVFAC, Code 08 (Assistant Commander for Family Housing).

The equitable distribution of O&M funds (reference 3) requires some guidance to the actual requirements of each activity. The budget value of dollars per house does not recognize the local differences. Some variance between activities is practiced but this is often influenced by past history when funding was handled by the local commander and some had more money than others. This study approached the problem by regression, obtaining average requirements according to a mathematical model of the form.

$$\prod_{k=1}^K F_k(Z_{ki}) \times \sum_{j=1}^j a_j X_{ji}$$

where a_j measures the amount of maintenance or operating resources required for each unit of the j^{th} variable present at the i^{th} house type at a supporting activity and $F_k(Z_{ki})$ is the multiplying constant for the k^{th} multiplicative variable used to modify the estimate of the resource requirement at the i^{th} house type at an activity. The model is applied separately at the housing type level at each activity. These requirements are modified on a local basis by variation in values of the factors used and considering the location (by Naval District) and mission of the activity (Appendix A). If the calculated values are summed at EFD or NAVFAC level as a proposed budget and the percentage requirement of each activity calculated, then each activity is equitably entitled to its percentage of whatever funds are received.

The above method of allocating funds also furnishes a basis for establishing a measure of effectiveness. Since a norm is established for each activity, then the deviation from its norm in O&M actual costs is an indicator of how well the local housing manager is doing his job. On a management-by-exception basis, those activities showing a large deviation can be investigated to determine the reasons involved.

CONCLUSIONS

1. Administration of family housing is not uniform at activity level. Construction is separated from housing management (O&M) at NAVFAC level. Regulatory and constraint authority is retained at DOD level. The responsibilities of the Housing Manager as defined in Chapter 4, NAVDOCKS P352 are inconsistent due the fractionation of functions and administrative authority.

2. There is disagreement between construction and maintenance personnel about the cost-effectiveness of equipment, materials, and design built into new housing. There is also disagreement between maintenance personnel and supply over the quality of material and equipment purchased on GSA specifications. These points of difference can be settled only by a Life Cycle Cost study of family housing. Since such a study would cut across administrative lines of authority, it should be sponsored at the NAVFAC level.

3. There appears to exist a poor communication line between NAVFAC and local housing activities. This could be studied in conjunction with a Life Cycle Cost study.

4. By congressional direction, the housing O&M budget is reported on a dollars per house per year basis. This measurement does not provide a satisfactory basis for comparing O&M between different activities or judging management efficiency. A basis for such comparison was developed (reference 3) by determining what each activity, at housing type level, should require for O&M per year as shown in Appendix A. The results are reported in the form of a work sheet which takes into account local variations in factors measuring O&M requirements. By summing calculated costs for all activities an expected budget requirement is derived. Then, an equitable distribution of funds is found by dividing the activity requirement by total requirement. This is the percentage of funds received from congress to be allocated to the activity.

5. By extending the calculation for funding noted in reference 3, the deviations of local housing activities O&M costs from the expected norm provides a measure-of-effectiveness. This can be used on a management by exception basis to study wide deviations and to compare management efficiency.

Appendix A

APPLICATION OF RESULTS AND WORKSHEETS

Introduction to Worksheet

The results of the final regression analyses have been summarized in the form of worksheets. These worksheets can be used for the direct calculation of predicted Total Maintenance Costs and predicted Total Operation Costs for any house type at an activity. There are also worksheets for the calculation of estimates of statistical confidence intervals associated with each prediction. The first part of this Appendix contains the worksheets used to calculate the predicted resource requirement. Worksheets for the calculation of variances and confidence intervals associated with the predicted resource requirements are at the end of the appendix. Examples of the use of these worksheets are also presented in this appendix.

Table C-4, "Input Data in Master Data File", contains all of the data used in the regression analyses. This table, in Appendix C, can be used as the source for many of the data inputs required for the worksheet calculations. However, many of these data inputs will change in value in the future. In these cases current values of the observed data should be used in the resource requirement calculations.

Worksheets for the Calculation of Total Maintenance Costs and Total Operation Costs

The first four worksheets are used to estimate Total Maintenance Costs for a given house type at an activity. The house types included are:

1. Encumbered Housing
2. Appropriated Fund Housing - 1950 and after
3. Other Public Quarters
4. Substandard Housing

The next four worksheets are used to estimate Total Operation Costs for these same house types. An additional worksheet, which is the result of regression analyses on Total Operation Costs for all types combined, is presented for use as an alternative to the separate house type calculations of Total Operation Costs. This last worksheet can be used for the single calculation of Total Operation Costs of all dwelling units at an activity. Activity level summary data contained on the summary O&M Cost Reports may be used in this special case.

Two numbers are present at the bottom of each worksheet to give some idea of the "goodness of predictability" which can be placed on each resource requirement estimate. The first number is the simple correlation coefficient (r) between observed and predicted values of the dependent variable (the resource requirement). The second number is the standard deviation (s) of the regression predictions before multiplying factors were applied. These two statistics are defined in Appendix F, "Glossary of Statistical Terms", and are formulated in more detail in Section 2.7 of this report.

Procedure for the Calculation of Predicted
Resource Requirement from the Worksheet

1. List the observed value of each independent variable (for a particular house type at an activity) in Column one (1) of the worksheet. (See Table C-4 for complete listing of independent variable values used in this study for those variables whose value remains constant on a yearly basis).
2. Multiply each observed value by the corresponding Coefficient Multiplier listed in the next column and record the product in the next column titled "Product".
3. Multiply this new product by the second coefficient multiplier contained in the next column and record this product in the last column of the worksheet. A negative sign has been entered in the last column where required.
4. Sum the last column and enter the total in the space provided.
5. Add or subtract the constant indicated to obtain the "New Total".
6. Where indicated in a table at the left enter the appropriate "NIF multiplier". "NIF multiplier" is to be used for all activities which are Naval Industrially Funded; "non-NIF" for all activities which are not. For worksheets which do not contain "NIF multiplier" tables (all except two worksheets for Appropriated Fund Housing and Other Public Quarters) steps six (6) and seven are omitted. Go to Step number eight (8) in this case.
7. If a NIF multiplier is indicated in step six (6), multiply the "New Total" obtained in step five (5) by this multiplier and enter in the appropriate space titled "Product".

8. Obtain the Naval District Multiplier from the table at the left and record this below "Product". If no multiplier is indicated, enter the integer one (1).
9. Multiply "Product" by the appropriate Naval District Multiplier entered in step eight (8) to obtain a new "Product" in the space provided under the Naval District Multiplier space.
10. Obtain the Primary Function Multiplier from the table at the left and record this in the appropriate space. Before using the "Miscellaneous" Primary Function Multiplier, see Table C-2 for the complete list of Primary Functions. If the Primary Function is not listed in the table at the left but is contained in Table C-2 and is not a miscellaneous function, then enter the integer one (1) in the space entitled "Primary Function Multiplier".
11. Multiply the previous "Product" by the Primary Function Multiplier to obtain the estimate of the resource requirement. Enter this estimate in the last space provided.

Worksheet to Estimate Total Maintenance Costs
for Encumbered Housing (Type 1)

Activity/Code _____

Observed Data		Co-efficient Multiplier	Product	Co-efficient Multiplier	Product
X10 (Thousands of gallons of sewage)		10		.12978	
[X1] [X80] (no. dwelling units (times) normal monthly minimum temperature)		10		.61615	

Naval District	Multiplier	Primary Function*	Multiplier
1	.68006	Air Station or Facility	.93803
3	.85049	Auxiliary Air Station	.66779
5	.92751	Ammo., Ord, and Wpns.	.86871
6	1.18356	Naval Station	1.05941
8	1.25045	Public Works Center	1.02522
10	.70866	School or Training Center	.87714
11	1.09593	Miscellaneous	.99204
12	.78291		
13	.99971		
14	.94500		
20	1.65047		

*See complete list of primary functions, Table C-2.

r = .9549, s = 125,250

Total	
Subtract	-21,347
New Total	
Naval District Multiplier	X
Product	
Primary Function Multiplier	X
Product	

↑
Estimate of
Encumbered Housing
Maintenance Costs

Worksheet to Estimate Total Maintenance Costs (Including BEM)
for Appropriated Fund Housing (Type 2)

Activity/Code _____

Observed Data		Co-efficient Multiplier	Product	Co-efficient Multiplier	Product
X11 (Thousands of square feet of exterior structure)		1,000		.17462	
X12 (Thousands of square feet of interior structure)		100		.72289	
X21 (No. of permanent dwelling units of masonry construction)		10,000		.20338	
X46 (Backlog of essential maintenance)		-10		.14232	-

	Multiplier
Non-NIF	.94823
NIF	1.34412

Naval District	Multiplier	Primary Function*	Multiplier
1	1.28788	Air Station of Facility	.98736
3	.99181	Research and Test Labs	.86136
5	1.11573	Ammo., Ord., and Wpns.	.94617
11	.88370	Hospitals	2.16014
14	1.14154	Naval Stations	.99420
17	1.05382	Public Works Center	1.00564
20	2.61292	Miscellaneous	.84819
21	.91759		
22	1.31845		
23	1.17766		

Total	
Add	4,050
New Total	
NIF Multiplier	X
Product	
Naval District Multiplier	X
Product	
Primary Function Multiplier	X
Product	

*See complete list of primary functions, Table C-2.
r = .9587, s = 71,035

↑
Estimate of Appropriated Fund Housing Maintenance Costs

Worksheet to Estimate Total Maintenance Costs (Including BEM)
for Other Public Quarters (Type 3)

Activity/Code _____

Observed Data		Co-efficient Multiplier	Product	Co-efficient Multiplier	Product
[X1] [X80] (No. dwelling units (times) normal monthly minimum temperature)		100		.29636	
X3 (Thousands of square feet of housing)		1,000		.86541	
X4 (Cubic yards of refuse)		-10		.67732	-
X6 (Thousands of KWH of Electricity)		10		.62794	
X14 (Squares of interior painting)		-10		.91700	-
X18 (Average yearly No. of move-outs)		-10,000		.49654	-
X23 (No. of permanent dwelling units of stucco construction)		-10,000		.53166	-
X46 (Backlog of essential maintenance)		-10		.14649	-

	Multiplier
Non-NIP	.72506
NIP	1.01707

Naval District	Multiplier	Primary Function*	Multiplier
1	1.03871	Air Station or Facility	.90689
5	.76758	Research and Test Labs	1.90829
6	1.19115	Ammo., Ord., and Wpns.	1.00365
9	1.93347	Naval Stations	1.03702
11	.98736	Public Works Center	1.00598
12	1.01844	School or Training Center	1.15475
13	.53196	Shipyard	.70184
14	.98424	Miscellaneous	.76846

*See complete list of primary functions, Table C-2.
r = .9940, s = 42,589

Total	
Subtract	-2,559
New Total	
NIP Multiplier	X
Product	
Naval District Multiplier	X
Product	
Primary Function Multiplier	X
Product	

↑
Estimate of O.P.Q!
Maintenance Costs

Worksheet to Estimate Total Maintenance Costs (Including BEM)
for Substandard Housing (Type 4)

Activity/Code _____

Observed Data	Co-efficient Multiplier	Product	Co-efficient Multiplier	Product
X32 (No. of semi-permanent dwelling units of "other" construction)	1,000		.32458	

Total

Add

27,356

New Total

Naval District Multiplier

X

Product

Primary Function Multiplier

X

Product

Naval District	Multiplier	Primary Function*	Multiplier
5	1.26247	Air Station or Facility	1.00402
6	1.01561	Auxiliary Air Station	0.91846
8	2.33952	Public Works Center	3.21577
12	0.58584	Shipyard	0.95396
13	0.60715		
20	0.94868		

*See complete list of primary functions, Table C-2.
r = .8219, s = 55,006

↑
Estimate of
Substandard Housing
Maintenance Costs

Worksheet to Estimate Total Operation Costs

Encumbered Housing (Type 1)

Activity/Code _____

Observed Data		Co-efficient Multiplier	Product	Co-efficient Multiplier	Product
[X] [X72] (No. dwelling units (times [1] if the activity is not within 50 miles of coast, [2] if the activity is within 50 miles of coast))		1,000		.22363	
					Total
					Add
					10,910
					New Total
					Naval District Multiplier
					X
					Product
					Primary Function Multiplier
					X
					Product

Naval District	Multiplier	Primary Function*	Multiplier
1	1.37251	Air Station or Facility	0.94048
3	1.01786	Auxiliary Air Station	0.89839
4	1.04809	Ammo., Ord., and Wpns.	1.01124
5	0.91257	Naval Station	1.08314
6	1.23328	Public Works Center	1.04943
8	0.80848	School or Training Center	1.03739
11	0.93139	Miscellaneous	0.98329
12	0.84846		
13	1.25815		
14	0.90966		

*See complete list of primary functions, Table C-2.
r = .9811, s = 84,501

↑
Estimate of
Encumbered Housing
Operation Costs

Worksheet to Estimate Total Operation Costs
Appropriated Fund Housing (Type 2)

Activity/Code _____

Observed Data	Co-efficient Multiplier	Product	Co-efficient Multiplier	Product
X1 (No. dwelling units)	1,000		.12351	
X9 (Thousands of gallons of water)	1		.67654	
X10 (Thousands of gallons of sewage)	1		.63690	
X18 (Average yearly No. of move-outs)	1,000		.43919	
[X1] [X78] (No. dwelling units (times) inches of snow & sleet)	10		.78806	
[X] [X79] (No. dwelling units (times) inches of precipitation)	10		.25253	

District	Multi-plier	Primary Function*	Multi-plier
1	0.79463	Air Station or Facility	0.99251
3	1.37958	Auxiliary Air Station	0.71564
4	1.35554	Research and Test Labs	1.08599
5	0.93853	Ammo., Ord., and Wpns.	1.00900
6	1.01407	Hospitals	0.69378
11	0.95217	Naval Stations	1.00364
12	1.01591	Public Works Center	1.01381
13	1.13918	School or Training Center	0.92257
17	0.92692	Shipyards	0.95776
20	0.97482	Miscellaneous	0.94881

Total

Add

1,736

New Total

Naval District Multiplier

X

Product

Primary Function Multiplier

X

Product

↑
Estimate of Appropriated Fund Housing Operation Costs

*See complete list of primary functions, Table C-2.
r = .9923, s = 14,818

Worksheet to Estimate Total Operation Costs
Other Public Quarters (Type 3)

Activity/Code _____

Observed Data		Co-efficient Multiplier	Product	Co-efficient Multiplier	Product
X1 (No. dwelling units)		-100		.48869	-
X3 (Thousands of square feet)		1,000		.16339	
X10 (Thousands of gallons of sewage)		1		.71319	
[X1] [72] (No. dwelling units (times) [1] if the activity is not within 50 miles of coast, [2] if the activity is within 50 miles of coast)		1,000		.11793	

District	Multiplier	Primary Function*	Multiplier
1	1.14216	Air Station of Facility	0.82122
3	0.95306	Auxiliary Air Station	.87204
4	1.32191	Research and Test Labs	0.67159
5	1.27584	Ammo., Ord., and Wpns.	1.02791
6	0.76372	Supply Activities	1.05737
8	1.26987	Naval Stations	0.95458
9	0.94655	Public Works Center	1.00909
10	1.15916	School or Training Center	1.01628
11	0.97611	Shipyards	0.81255
12	0.94026	Miscellaneous	0.98725
13	1.03997		
14	0.88748		
15	1.54415		
17	1.35287		

Total	
Add	3,437
New Total	
Naval District Multiplier	X
Product	
Primary Function Multiplier	X
Product	

↑
Estimate of Other Public Quarters Operation Costs

*See complete list of primary functions, Table C-2.
r = .9953, s = 24,622

Worksheet to Estimate Total Operation Costs
Substandard Housing (Type 4)

Activity/Code _____

Observed Data	Co-efficient Multiplier	Product	Co-efficient Multiplier	Product
X12 (Thousands of square feet of interior structure)	1,000		.32651	
X18 (Average yearly No. of move-outs)	1,000		.22065	
[X1] [X78] (No. of dwelling units (times) inches of snow and sleet)	10		.37365	

Naval District	Multiplier	Primary Function*	Multiplier
1	0.93333	Air Station of Facility	0.97719
5	0.89805	Auxiliary Air Station	1.02814
6	0.99405	Ammo., Ord., and Wpns	1.00631
8	0.91834	Naval Station	1.00013
11	1.12695	Public Works Center	1.00064
12	1.02132	Shipyards	0.99995
13	0.97599		
17	1.06002		
20	0.93124		

*See complete list of primary functions, Table C-2.
r = .9944, s = 8,798

Total

Add

New Total

Naval District Multiplier

Product

Primary Function Multiplier

Product

509

X

X

↑
Estimate of Substandard Housing Operation Costs

Worksheet to Estimate Total Operation Costs

All Housing Types Combined

Activity/Code _____

Observed Data	Co-efficient Multiplier	Product	Co-efficient Multiplier	Product
X10 (Thousands of gallons of sewage)	1		.80963	
X29 (No. of semi-permanent dwelling units of masonry construction)	-1,000		.48035	-
[X1] [72] (No. of dwelling units (times) [1] if the activity is not within 50 miles of coast, [2] if the activity is within 50 miles of coast)	1,000		.11708	
[X1] [X76] (No. of dwelling units (times) 7 a.m. humidity)	1		.56067	
[X1] [X78] (No. of dwelling units (times) inches of snow and sleet)	1		.59294	
[X1] [X79] (No. of dwelling units (times) inches of precipitation)	10		.21889	

District	Multiplier	Primary Function*	Multiplier
1	1.01324	Air Station of Facility	0.97319
3	0.96948	Auxiliary Air Station	0.79692
4	1.18497	Research and Test Labs	0.56872
5	0.93875	Ammo., Ord., and Wpns.	0.94410
6	1.09773	Supply Activities	0.71563
8	0.88336	Hospitals	0.65328
9	0.91396	Naval Stations	1.03781
11	1.10089	Public Works Center	1.02360
12	0.97007	School or Training Center	1.00941
13	1.22561	Shipyard	0.78366
14	0.91302	Miscellaneous	0.99433
17	1.41657		

Total Add	4,516
New Total	
Naval District Multiplier	X
Product Primary Function Multiplier	X
Product	

*See complete list of primary functions, Table C-2.

r = .9829, s = 45,589

↑
Estimate of Total Operation Costs

Example Calculation of Total Maintenance Costs Requirement

The following example is a calculation of the Total Maintenance Costs (resource requirement) for Encumbered Housing at the Naval Air Station at Brunswick, Me. for FY 1967. (Activity code no. 1450-202, file no. 001).

Looking at the Worksheet used to calculate Estimated Total Maintenance Costs for Encumbered Housing (Type 1) the following values of observed data will be required. These can be obtained, in this case, from Table C-3, "Input Data in Master Data File".

X10 = 50,103 thousands of gallons of sewage
X1 = 501 dwelling units (Encumbered Housing)
X80 = 34.4 normal monthly minimum temperature
Naval District = 1
Primary Function = Naval Air Station

The appropriate entries are made on the following worksheet and the mathematical operations are completed. The results is an estimated Total Maintenance Costs Requirement Estimate of \$95,585.

(Example)

Worksheet to Estimate Total Maintenance Costs (Including BEM)
for Encumbered Housing (Type 1)

Activity/Code Naval Air Station, Brunswick, Ms./1450-202

Observed Data		Co-efficient Multiplier	Product	Co-efficient Multiplier	Product
X10 (Thousands of gallons of sewage)	50,103	10	501,030	.12978	65,000
[X1] [X80] (No. dwelling units (times normal monthly minimum temperature)	501	34.4	10	.61615	106,187
	17,234				

Naval District	Multiplier	Primary Function*	Multiplier
1	.68006	Air Station or Facility	.93803
3	.85049	Auxiliary Air Station	.66779
5	.92751	Ammo., Ord., and Wpns.	.86871
6	1.18356	Naval Station	1.05941
8	1.25045	Public Works Center	1.02522
10	.70866	School or Training Center	.87714
11	1.09593	Miscellaneous	.99204
12	.78291		
13	.99971		
14	.94500		
20	1.65047		

Total 171,187

Subtract -21,347

New Total 149,840

Naval District Multiplier X.68006

Product 101,900

Primary Function Multiplier X.93803

Product 95,585

*See complete list of primary functions, Table C-2.

r = .9549, s = 125,250

↑
Estimate of Encumbered Housing Maintenance Costs

Table A-1. Variables Used on Work Sheets for
Total Maintenance Costs (Including BEM)

Symbol	Variable	Description of Variable
DWL UN	X1	No. dwelling units
HS POP	X2	Housing population
SQ FT	X3	Square feet
\$M B	(Y12 + (X47-X46) (16)	Total maintenance cost plus change in BEM (41)
KWH	X6	KWH of electricity
CU FT	X7	Cubic feet of gas
F OIL	X8	Gallons of fuel oil
WATER	X9	Gallons of water
SEWAGE (6)	X10	Gallons of sewage
STR EX	X11	Square feet exterior structure
STR IN	X12	Square feet interior structure
PNT EX	X13	Exterior painting
PNT IN	X14	Interior painting
ACRES	X15	Acres of grounds
S AREA	X16	Surfaced area
AC UN	X17	Average No. active units
MOVE O	X18	Average move-outs
MOVE I	X19	Average move-ins
*UTIL	X20	Percent utilization
BEM	X46	Backlog of essential maintenance
*COAST	X72	Proximity to coast
CIV OC	X69	Civilian occupancy

*Denotes a variable which was multiplied by the number of dwelling units.

Table A-2. Variables Used on Work Sheets for
Total Maintenance Costs (Including BEM)

Symbol	Variable	Description of Variable
DWL UN	X1	No. dwelling units
\$M + B	Y12 + (X47-X46)	Total maintenance cost plus change in BEM
CU YDS	X4	Cubic yards of refuse
P MAS	X21	Permanent masonry units
S MAS	X29	Semi-permanent masonry units
P FRAM	X22	Permanent frame units
S FRAM	X30	Semi-permanent units
P STUC	X23	Permanent stucco units
S STUC	X31	Semi-permanent stucco units
P OTH	X24	Other units - permanent
S OTH	X32	Other units - semi-permanent
P TOT	X25	Total permanent units
S TOT	X33	Total semi-permanent units
*PAVBD	X26	Average No. bedrooms - permanent
*SAVBD	X34	Average No. bedrooms - semi-permanent
*P BATH	X27	Average No. bathrooms - permanent
*S BATH	X35	Average No. bathrooms - semi-permanent
*MINTE	X80	Normal monthly minimum temperature
*MAXTE	X81	Normal monthly maximum temperature
*CIT PO	X74	City population
*NDHDQ	X75	Proximity to N.D. Headquarters
*7 HUM	X76	Humidity (7 a.m.)
*1 HUM	X77	Humidity (1 p.m.)
*SNOW	X78	Inches of snow and sleet
*PRECI	X79	Precipitation

*Denotes a variable which was multiplied by the number of dwelling units.

Table A-3. Variables Used On Work Sheets For Total Operation Costs

Symbol	Variable	Description of Variable
DWL UN	X1	No. dwelling units
HS POP	X2	Housing population
SQ FT	X3	Square feet
CTC	Y6	Total operation costs
KWH	X6	KWH of electricity
CU FT	X7	Cubic feet of gas
F OIL	X8	Gallons of fuel oil
WATER	X9	Gallons of water
SEWAGE	X10	Gallons of sewage
STR EX	X11	Square feet exterior structure
STR IN	X12	Square feet interior structure
PNT EX	X13	Exterior painting
PNT IN	X14	Interior painting
ACRES	X15	Acres of ground
S AREA	X16	Surfaced area
AC UN	X17	Average No. active units
MOVE O	X18	Average move-outs
MOVE I	X19	Average move-ins
*UTIL	X20	Percent utilization
CIV OC	X69	Civilian occupancy
*NIF	X70	Naval Industrial Fund
*COAST	X72	Proximity to coast

* Denotes a variable which was multiplied by the number of dwelling units.

Table A-4. Variables Used On Work Sheet For Total Operation Costs

Symbol	Variable	Description of Variable
DWL UN	X1	No. dwelling units
CTC	Y6	Total operation costs
CU YDS	X4	Cubic yards of refuse
P MAS	X21	Permanent masonry units
S MAS	X29	Semi-permanent masonry units
P FRAM	X22	Permanent frame units
S FRAM	X30	Semi-permanent frame units
P STUC	X23	Permanent stucco units
S STUC	X31	Semi-permanent stucco units
P OTH	X24	Other units - permanent
S OTH	X32	Other units - semi-permanent
P TOT	X25	Total permanent units
S TOT	X33	Total semi-permanent units
*PAVBD	X26	Average No. bedrooms - permanent
*SAVBD	X34	Average No. bedrooms - semi-permanent
*P BATH	X27	Average No. bathrooms - permanent
*S BATH	X35	Average No. bathrooms - semi-permanent
*CIT PO	X74	City population
*NDHDQ	X75	Proximity to N.D. Headquarters
*7 HUM	X76	Humidity (7 a.m.)
*1 HUM	X77	Humidity (1 p.m.)
*SNOW	X78	Inches of snow and sleet
*PRECI	X79	Precipitation
*MINTE	X80	Normal monthly minimum temperature
*MAXTE	X81	Normal monthly maximum temperature

* Denotes a variable which was multiplied by the number of dwelling units.

REFERENCES

1. NCEL ltr Ser 364, 19 Feb 1970, with Encl (1).
2. NCEL ltr Ser 892, 8 May 1970, with Encl (1).
3. Battelle Memorial Institute, Study for Allocation of Maintenance Funds, Navy Family Housing, Apr 1970, NCEL Report CR 70.014.

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13 ABSTRACT <p>This report covers an investigation at activity level of the causes of Operation & Maintenance (O&M) problems. Direct investigation in the field showed that major O&M problems with Navy family quarters are common to all activities, but because of established policies, the local Housing Manager has little control over factors causing maintenance problems. A higher level study of Life Cycle Costs of Family Housing is recommended. By using regression analysis, those factors which best measure O&M requirements were determined. Work sheets are derived which can be used to forecast O&M fund requirements, to make an equitable distribution of O&M funds, and also as a measure of effectiveness.</p>		

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