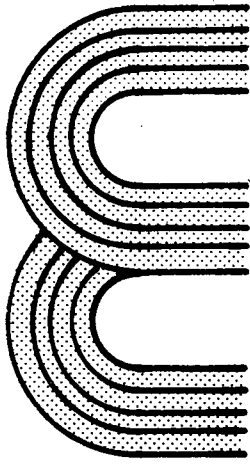


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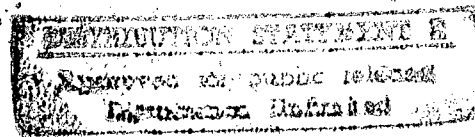
Systems Plan

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Executive Summary

Final Report

Redstone Arsenal, Alabama



February 1983

Prepared For
MOBILE DISTRICT CORPS OF ENGINEERS
MOBILE, ALABAMA
CONTRACT DACA01-77-C-0094

Prepared By
BLACK & VEATCH
CONSULTING ENGINEERS
KANSAS CITY, MISSOURI

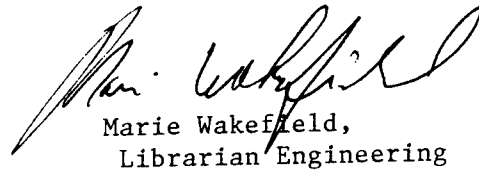


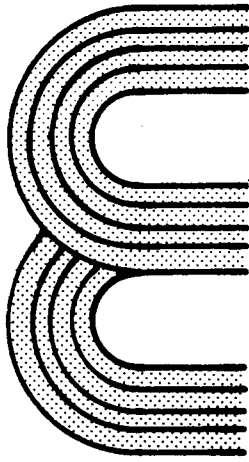
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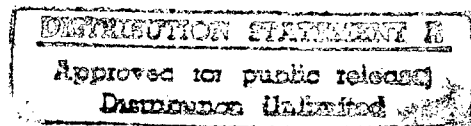
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Basewide Energy Systems Plan



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Prepared By
BLACK & VEATCH
CONSULTING ENGINEERS
KANSAS CITY, MISSOURI

EXECUTIVE SUMMARY - INCREMENTS A, B, C, D AND E

Included in this summary are the results of the Basewide Energy Systems Plan for Redstone Arsenal, Alabama. This plan includes an analysis and recommendation of energy conservation projects for the reduction of the installation's present energy consumption. The savings figures presented in this summary can only be realized after all projects have been implemented. Black & Veatch has developed projects that would meet the funding requirements for the energy conservation program. Futhermore, the recommended projects provide partial compliance with the energy conservation requirement for the installation as outlined in the Army Facilities Energy Plan. This summary presents data on the following:

- Energy use model
- Source energy reductions due to energy conservation techniques for buildings and their systems
- Application of solar energy to reduce fossil fuel consumption
- Savings utilizing central energy monitoring and control systems (EMCS)
- Use of solid waste as an alternate energy source
- The analysis of Total Energy/Selective Energy (TE/SE) systems

Tables 1 and 2 located in the Appendix present information pertaining to the physical descriptions and energy consumption of 35 typical buildings used to verify historical energy consumption in the development of the basewide energy use model. This model was then utilized as the foundation for energy conservation project analyses and recommendations. Table 3 in the Appendix summarizes the daily personnel occupancy for each typical building. Tables 1, 2 and 3 also provide information which was used to estimate source energy consumption for similar buildings within the designated groupings.

Table 4, in the Appendix, indicates the annual source energy consumed by each of the building groups used in the basewide energy use model. The estimated annual source energy consumption for all building groups calculated by the energy use model for base year 1975 was 5,196,492 mega-Btu per year. The energy use model was accurate in its prediction of the annual source energy consumption at Redstone Arsenal. The model was within 1 percent of the historical source energy consumption for FY75 shown below.

Annual Source Energy Consumption for FY75 Btu x 10 ⁶	
Electricity	2,998,747
Natural Gas	774,039
Fuel Oil No. 2	139,381
Fuel Oil No. 5	<u>1,293,239</u>
TOTAL	5,205,406

Figure 1 illustrates a percentage breakdown of the annual source energy consumption from Table 4.

The total estimated source energy savings due to implementation of all feasible energy conservation projects developed within Increments A, B, C, D and E of this study is 843,810 mega-Btu per year. These projects consisted of various architectural improvements, and mechanical and electrical system modifications and are summarized in Tables 5 and 6 in the Appendix.

Table 5 lists the project number, percent of basewide reduction, and the source energy savings for the indicated building types. Figure 2 illustrates the combined effect of the recommended energy saving improvements, as compared to the FY75 source energy consumption. The estimates of 843,810 mega-Btu per year indicates a savings of approximately 16 percent over the base year (1975). Further explanation of the historical energy consumption, basewide energy model, and energy conservation analysis can be found in the Energy Use Survey. Figure 3 illustrates the allocation of the energy conservation projects savings for significant building groups.

Table 6 was developed to give a prioritized schedule, in order of fiscal year, for implementing the recommended energy conservation projects.

Utilizing solar energy, a renewable energy source, to reduce dependence on nonrenewable energy sources at Redstone Arsenal revealed

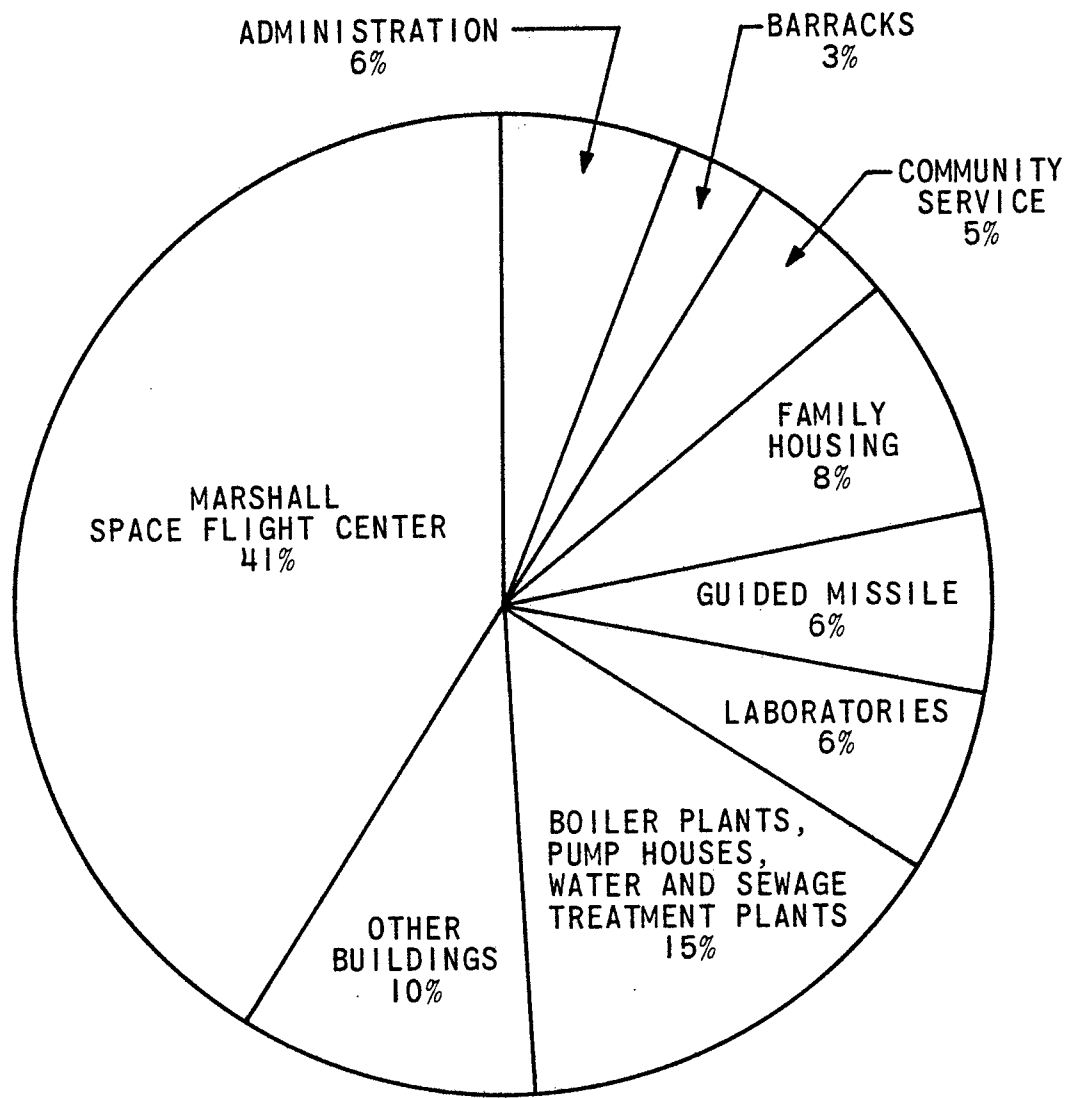


FIGURE 1
REDSTONE ARSENAL
BASEWIDE SOURCE ENERGY CONSUMPTION
 (BASE YEAR 1975)

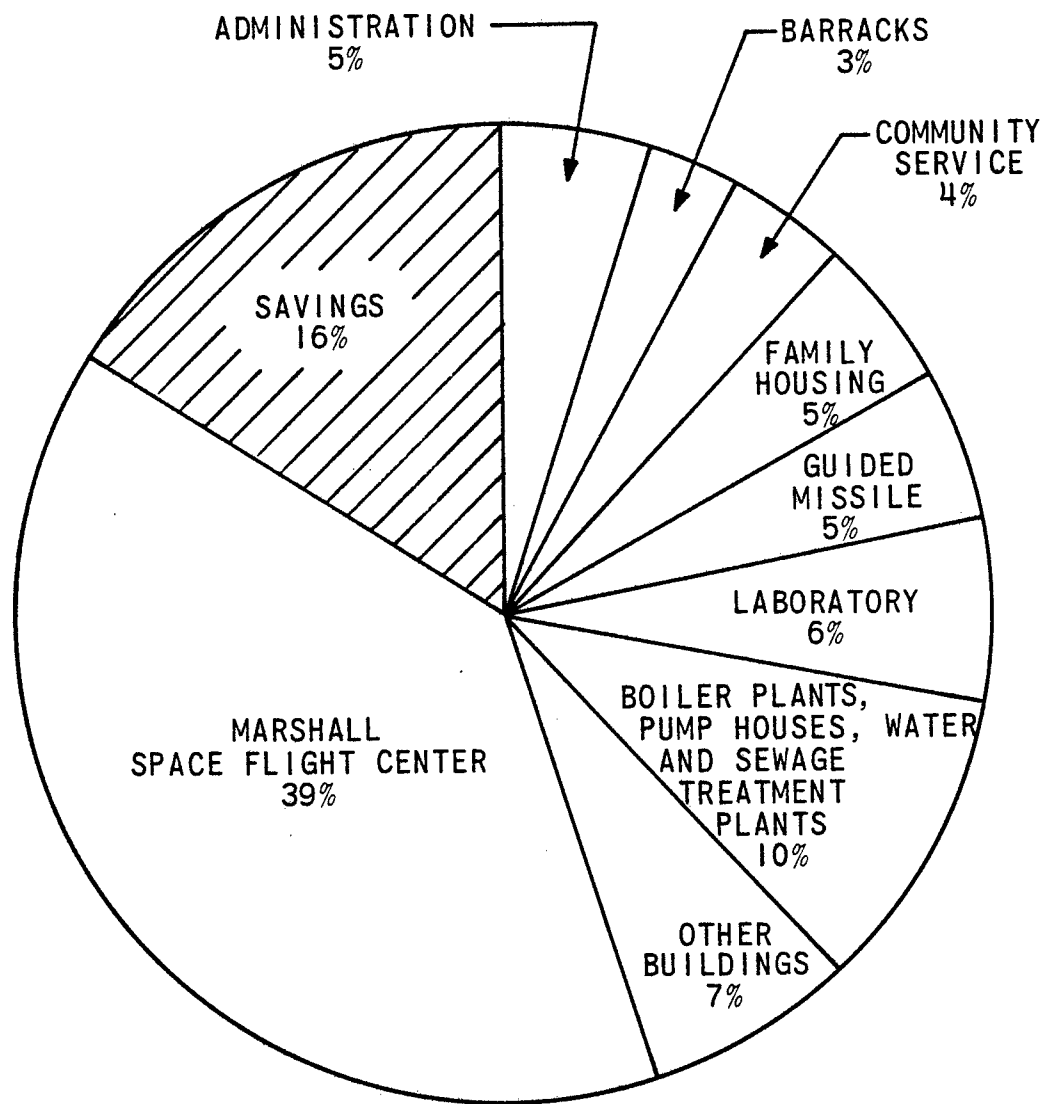
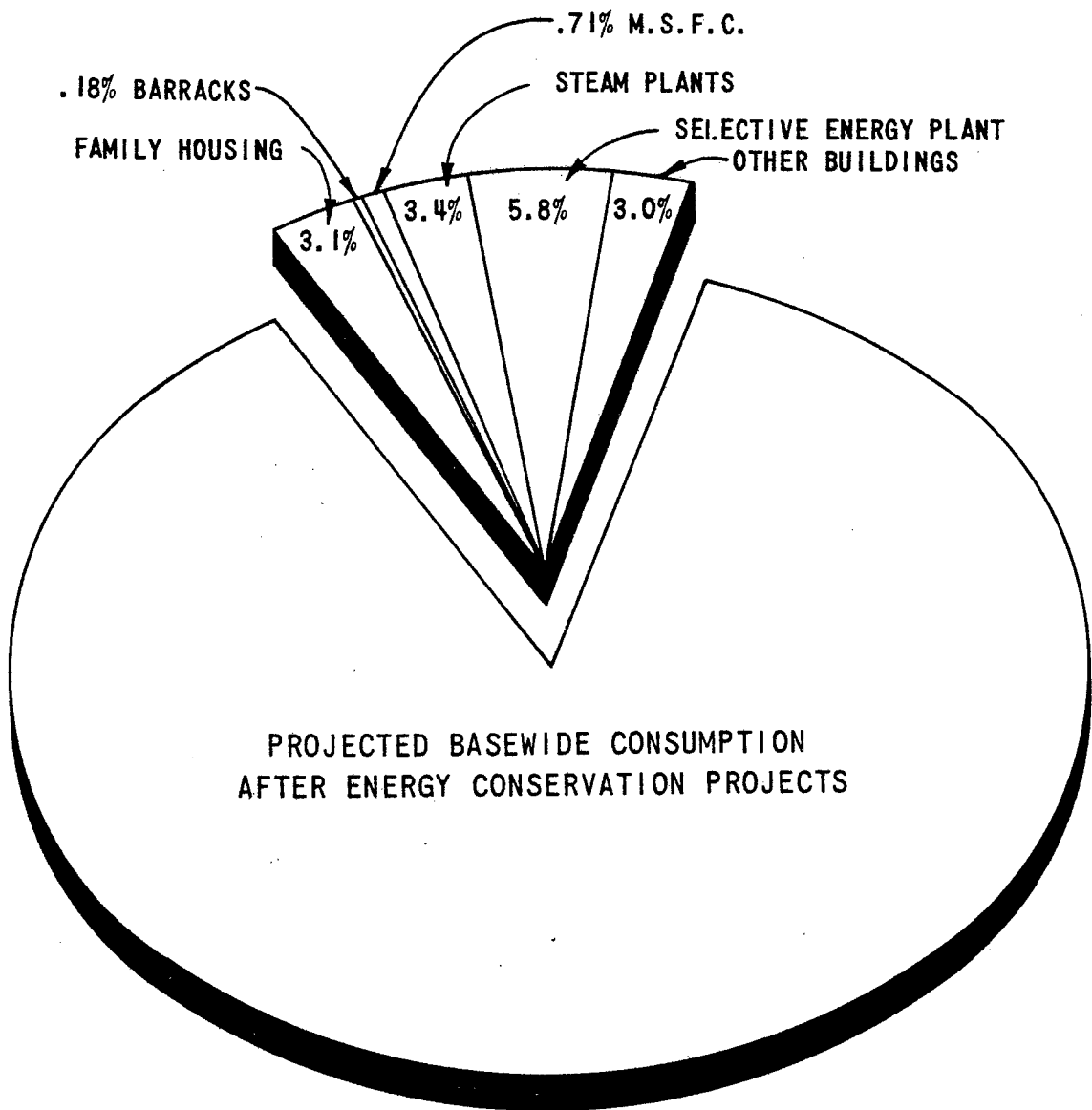


FIGURE 2
REDSTONE ARSENAL
BASEWIDE SOURCE ENERGY CONSUMPTION
AFTER ENERGY CONSERVATION PROJECTS
 (BASE YEAR -1975)



PROJECTED BASEWIDE CONSUMPTION
AFTER ENERGY CONSERVATION PROJECTS

ALLOCATION OF ENERGY
CONSERVATION PROJECTS SAVINGS
FOR SIGNIFICANT BUILDING GROUPS

FIGURE 3

that the concepts investigated would be economically impracticable. Eight concepts were evaluated and are presented in the report in Volume I entitled Solar Energy Applications.

The report on Energy Monitoring and Control Systems (EMCS) study includes recommendations for the installation of an FM radio control system. This system controls residential air-conditioning units and is estimated to save 34,217 mega-Btu per year. This project is scheduled for FY83. Additional modifications to the existing EMCS system could not be justified. Additional information is provided in the EMCS report in Volume I.

Assistance was given in evaluating the use of solid waste for reducing source energy consumption at Redstone Arsenal. This project, which was recommended by others, provides for the installation of a solid waste-burning incinerator facility to provide steam to the existing steam distribution system. This facility which is presently under construction was found to be in accordance with similar facilities recommended for other installations. The facility will provide an estimated savings of 285,658 mega-Btu per year.

The analysis of Total Energy/Selective Energy (TE/SE) systems has resulted in a Selective Energy plant programmed for FY84. This plant would burn coal and provide steam to an expanded steam distribution system while generating 23 percent of the total electrical power required by Redstone Arsenal. Oil and natural gas consumption of the installation would be reduced by 53 percent. The total annual source energy savings

would be 303,342 mega-Btu per year. Detailed descriptions of the TE/SE systems analyzed are included in the Total Energy, Selective Energy and Central Boiler Plants report in Volume I.

EXECUTIVE SUMMARY - INCREMENTS F AND G

This is a summary of the two phases of work, Increments F and G, that were completed in December, 1982.

The purpose of Increment F of the Basewide Energy Systems Plan is to identify and develop recommendations that can be used by Redstone Arsenal in preparing its energy management plan. Increment G identifies maintenance, repair and minor construction projects for the purpose of conserving energy. These are energy conservation projects that did not meet ECIP criteria or did not fit the ECIP program at the time that Increments A, B, C, D and E of the study were completed.

The average costs of energy for FY81 are given in Table 7 in the Appendix. These costs have been used as the basis for determining the dollar savings due to energy conservation.

Recommended projects developed within the scope of Increments F and G are summarized in Tables 8 and 9 respectively (See Appendix). Projects are prioritized by their E/C ratio. The E/C ratio is defined as the ratio of yearly energy savings in million Btu to the cost estimate in thousands of dollars. Any project showing a payback of 15 years or less and a Benefit-to-Cost ratio (B/C) greater than 1.0 is recommended. Material and labor cost estimates are representative of April, 1981 prices.

Five projects were put into 1391 format to be submitted by Redstone Arsenal for possible ECIP funding.

Three projects involve work in Family Housing. The first, Reduce Infiltration in Family Housing, involves caulking the soleplate and other cracks in all units. The second project, Vent Dampers, involves installing thermally actuated vent dampers in flues of gas-fired furnaces. The third project, Sliding Glass Storm Doors, involves installing aluminum storm doors on all units with sliding glass doors.

The fourth project, Exterior Insulation and Window Reduction, involves reducing window areas and installing exterior insulation on eight buildings on post.

The fifth and final project developed for possible ECIP funding, Electrical Distribution System Improvements, involves changing the voltage of the electrical distribution system to reduce line losses.

The ECIP documentation for these projects appear in Appendix B of Volume IV.

The total estimated source energy savings due to implementation of all the recommended projects in Increment F is 319,100 mega-Btu per year. The total estimated savings due to implementation of all recommended projects in Increment G is 219,300 mega-Btu per year.

Conclusion

The projected future energy savings at Redstone Arsenal due to the scheduled ECIP projects developed under Increments A, B, C, D and E, construction of the Solid Waste Incinerator Facility, and Selective Energy Plant and recommended projects from Increments F and G is shown in Figure 4. Table 10, in the Appendix, lists the individual projects comprising the "Scheduled ECIP project" section of Figure 4.

Figure 5 represents a forecast of future energy costs at Redstone Arsenal. The graph compares how costs could escalate if no energy conservation projects are implemented versus energy costs if all cost effective projects are implemented. The energy conservation projects are assumed to be implemented in the following three phases:

- Phase I - Scheduled ECIP projects
- Phase II - Solid Waste Incinerator Facility
and Selective Energy Plant
- Phase III - Increments F and G projects

Figure 5 does not account for new building construction.

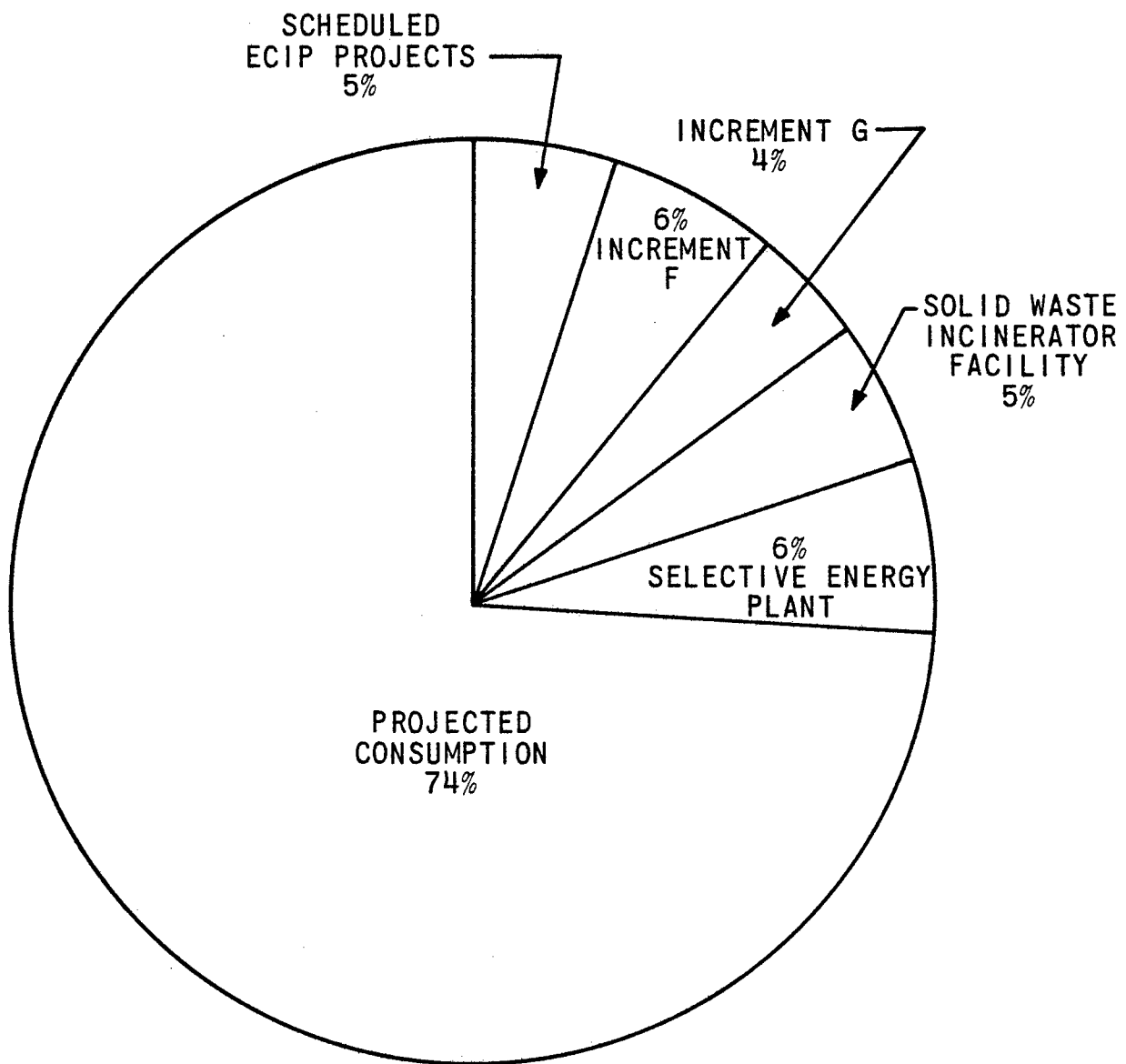


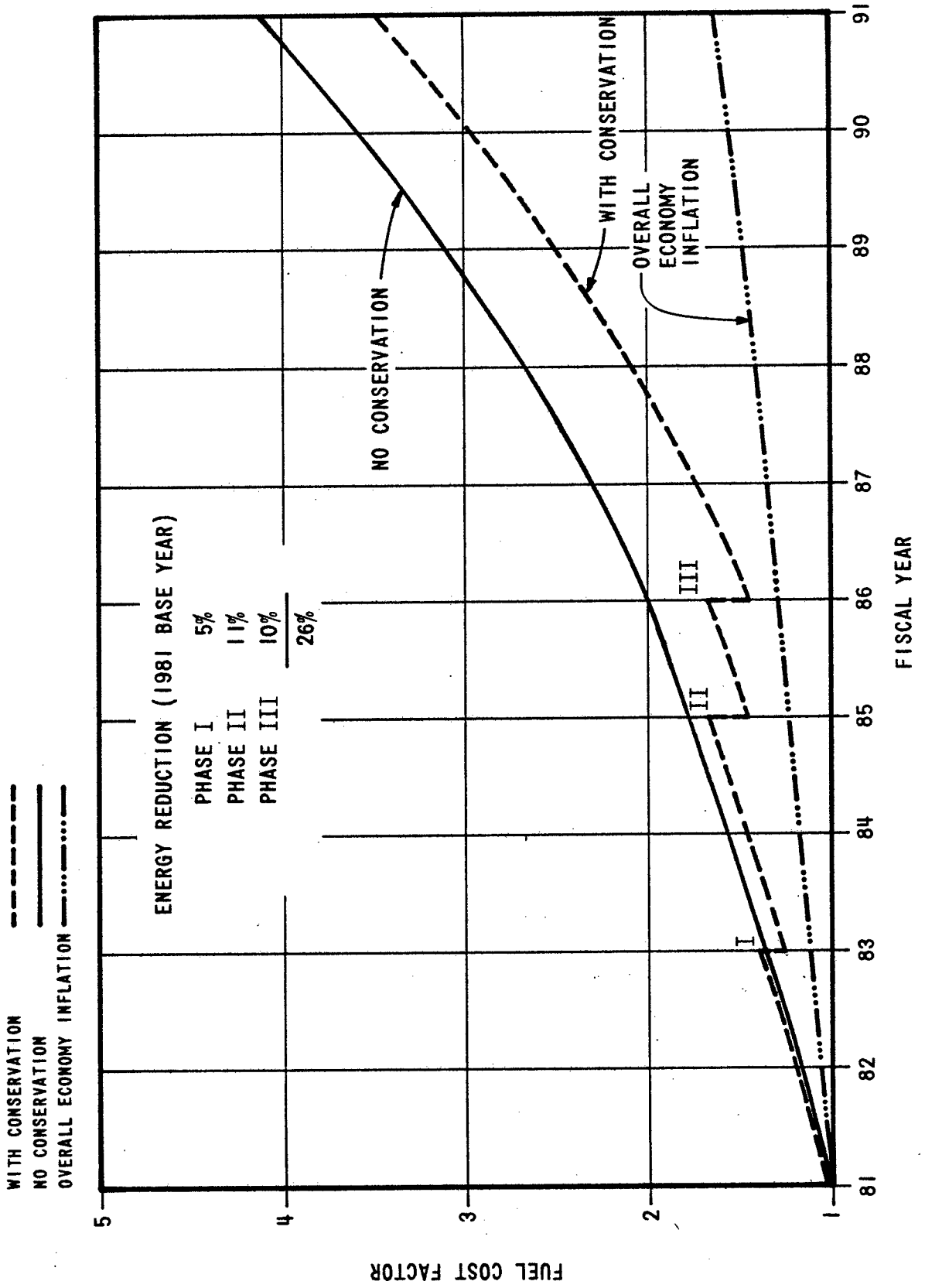
FIGURE 4

REDSTONE ARSENAL

BASEWIDE SOURCE ENERGY CONSUMPTION

(BASE YEAR 1981)

FIGURE 5
EFFECT OF ESCALATION AND ENERGY
CONSERVATION ON FUEL COST



APPENDIX A

TABLES

TABLE I
TYPICAL BUILDING CONSTRUCTION DATA
REDSTONE ARSENAL

GROUP NO.	BLDG NO.	BUILDING DESCRIPTION	NO. FLS.	CONSTRUCTION										"U" VALUES				BUILDING SQUARE FOOT	COOLING SYSTEM	HEATING SYSTEM	FUEL	PEAK TRNS. LOAD MBH	DOMESTIC CAP. (GAL)	HOT WATER
				ROOF	WALL	FLOOR	WINDOW	DOOR	ROOF	WALL	FLOOR	WINDOW	DOOR	WINDOW SQ. FT.	SYSTEM	SYSTEM	SYSTEM							
A-1	3217	OFFICES	1	ASPHALT SHINGLES	CMU	SLAB ON GRADE	SINGLE CLEAR GLASS	WOOD, SOLID	WOOD, SOLID	.27	.81	.—	1.13	.89	1.06	.87	2623	CENTRAL	BP 3624	GAS/OIL	38.9	137.0	40	ELEC.
A-2	7172	OFFICES	1	ASPHALT SHINGLES	CLAPBOARD WOOD FRAME	LINOLEUM VERTED CR. SP	SINGLE CLEAR GLASS	WOOD, SOLID	WOOD, SOLID	.07	.25	.86	1.13	.89	1.06	.87	18296	CHILLER, CENT. & MIN. U.	BOILER UNIT HTS.	OIL/ELEC	99.3	367.9	52	ELEC.
A-3	3649	OFFICES	2	BUILT-UP	CMU	SLAB ON GRADE	SINGLE CLEAR GLASS	METAL, HOLLOW	METAL, HOLLOW	.08	.51	.—	1.13	.89	1.06	.87	6019	CENTRAL	BP 4725	OIL	33.6	135.5	70	GAS
B-1	3933	BARRACKS	3	BUILT-UP	BRICK ON CONC. BLOCK	TILE, VERTED CRWL SPACE	SINGLE CLEAR GLASS	WOOD, SOLID	WOOD, SOLID	.10	.29	.87	1.13	.89	1.06	.87	41866	CENTRAL	BP 3624	OIL	173.5	863.0	200	STEAM
CS-1	3479	CAFETERIA & PK	1	ASPHALT & MINERAL SHINGLES	CONCRETE BLOCK	SLAB ON GRADE	SINGLE CLEAR GLASS	WOOD, SOLID	WOOD, SOLID	.05	.32	.—	1.13	.89	1.06	.87	9903	CENT. & MIN. U.	BP 3624 UNIT HTS.	OIL/ELEC	70.6	220.8	100	ELEC.
CS-2	3639	GAS STATION	1	ASPHALT SHINGLES	CLAY TILE	SLAB ON GRADE	SINGLE CLEAR GLASS	WOOD, SOLID	WOOD, SOLID	.60	.29	.—	1.13	.89	1.06	.87	1260	NONE	BP 3624	GAS/OIL	—	23.7	—	NONE
CS-3	376	CHAPEL	1	ASPHALT SHINGLES	BRICK ON CMU	SLAB ON GRADE	SINGLE CLEAR & DOUBLE	WOOD, SOLID	WOOD, SOLID	.11	.4	.—	1.13	.89	1.06	.87	22678	CHILLER	BOILER	GAS	183.2	443.8	60	GAS
CS-4	7115	LAUNDRY	1	ASPHALT SHINGLES	CLAY TILE	SLAB ON GRADE	SINGLE CLEAR GLASS	WOOD, SOLID	WOOD, SOLID	.45	.37	.—	1.13	.89	1.06	.87	3461	NONE	BP 7105	GAS	—	132.0	N/A	—
CS-5	3707	BOWLING ALLEY	1	BUILT-UP	BRICK ON CONC. BLOCK	SLAB ON GRADE	SINGLE CLEAR GLASS	METAL, HOLLOW	METAL, HOLLOW	.20	.30	.—	1.13	.89	1.06	.87	13187	PACKAGED	FURNACE & DUCT HTS.	GAS/OIL	77.2	266.1	80	GAS
CS-6	4813	FIRE STATION	1	BUILT-UP	CONCRETE BLOCK	SLAB ON GRADE	SINGLE CLEAR GLASS	METAL, HOLLOW	METAL, HOLLOW	.10	.44	.—	1.13	.89	1.06	.87	2659	PACKAGED	SPACE HEATER	OIL	12.5	109.2	52	ELEC
E-1	4722	ELECTRONICS SHOP	1	METAL	CLAY TILE	SLAB ON GRADE	SINGLE CLEAR GLASS	WOOD, SOLID	WOOD, SOLID	.05	.37	.—	1.13	.89	1.06	.87	31970	CENTRAL	BP 4725	GAS	125.1	515.4	15	GAS
FH-1	40	SINGLE FAMILY HOUSING	1	ASPHALT SHINGLES	WOOD SIDING	SLAB ON GRADE	SINGLE CLEAR GLASS	WOOD, SOLID	WOOD, SOLID	.07	.22	.—	1.13	.89	1.06	.87	1988	CENTRAL	FURNACE	GAS	12.7	45.2	40	GAS
FH-2	229	MULTI-FAMILY HOUSING	2	ASPHALT SHINGLES	WOOD SIDING & BRICK	SLAB ON GRADE	SINGLE CLEAR GLASS	WOOD, SOLID	WOOD, SOLID	.25	.18	.—	1.13	.89	1.06	.87	648	CENTRAL	FURNACE	GAS	36.2	173.6	240	GAS
FH-3	451	SINGLE FAMILY HOUSING	1	ASPHALT SHINGLES	BRICK	SLAB ON GRADE	SINGLE CLEAR GLASS	WOOD, SOLID	WOOD, SOLID	.04	.37	.—	1.13	.89	1.06	.87	1603	CENTRAL	FURNACE	GAS	12.6	43.7	40	GAS
FH-4	472	RUPLEX FAMILY HOUSING	2	ASPHALT SHINGLES	WOOD SIDING	SLAB ON GRADE	SINGLE CLEAR GLASS	WOOD, SOLID	WOOD, SOLID	.05	.07	.—	1.13	.89	1.06	.87	504	CENTRAL	FURNACE	GAS	16.0	55.2	80	GAS
FH-5	1364	RUPLEX FAMILY HOUSING	1	ASPHALT SHINGLES	WOOD PANELING	SLAB ON GRADE	SINGLE CLEAR GLASS	WOOD, SOLID	WOOD, SOLID	.25	.20	.—	1.13	.89	1.06	.87	380	CENTRAL	FURNACE	GAS	22.0	89.5	100	GAS
FH-6	1416	MULTI-FAMILY HOUSING	2	BUILT-UP	WOOD SIDING	SLAB ON GRADE	SINGLE CLEAR GLASS	WOOD, SOLID	WOOD, SOLID	.31	.07	.—	1.13	.89	1.06	.87	422	CENTRAL	FURNACE	GAS	22.2	83.1	160	GAS
FH-7	7130	SINGLE FAMILY HOUSING	1	ASPHALT SHINGLES	WOOD SIDING LATH & PLASTER	WOOD, CLOSED CRWL SPACE	SINGLE CLEAR GLASS	WOOD, SOLID	WOOD, SOLID	.04	.31	.34	1.13	.89	1.06	.87	1590	CENTRAL	FURNACE	GAS	15.4	90.4	52	ELEC.
FH-8	485	SINGLE FAMILY HOUSING	1	ASPHALT SHINGLES	WOOD SHAKE SIDING	SLAB ON GRADE	SINGLE CLEAR GLASS	WOOD, SOLID	WOOD, SOLID	.05	.07	.—	1.13	.89	1.06	.87	1926	CENTRAL	FURNACE	GAS	8.0	36.5	50	GAS
FH-9	1262	MULTI-FAMILY HOUSING	1	ASPHALT SHINGLES	ALUMINUM SIDING & PANELING	SLAB ON GRADE	SINGLE CLEAR GLASS	WOOD, SOLID	WOOD, SOLID	.05	.07	.—	1.13	.89	1.06	.87	5287	CENTRAL	FURNACE	GAS	26.2	91.9	120	GAS
GH-1	7819	OFFICE & WORKSHOP	1	METAL	METAL	SLAB ON GRADE	SINGLE CLEAR GLASS	METAL, SOLID	METAL, SOLID	.08	.06	.—	1.13	.89	1.06	.87	1500	CENTRAL	AHU	ELEC.	5.0	22.1	40	ELEC.
GH-2	7596	MISSILE ASSEMBLY	1	BUILT-UP	RIGID INSUL., CONC. CONCRETE	SLAB ON GRADE	SINGLE CLEAR GLASS	WOOD, SOLID	WOOD, SOLID	.6	.54	.—	1.13	.89	1.06	.87	5300	WINDOW UNITS	BP 7579	GAS	111.9	382.3	50	GAS
LA-1	5671	TRAINING FACILITY	2	ASPHALT, METAL, BUILT-UP	ASBESTOS, WOOD, CLAY TILE	SLAB ON GRADE	SINGLE CLEAR GLASS	METAL, SOLID	METAL, SOLID	.12	.10	.09	1.13	.89	1.06	.87	13269	PACKAGED MIN. U.	BP 4725	GAS/OIL	41.6	479.5	100	STEAM
LA-2	7360	MOTOR LANDING BUILDING	1	ASBESTOS & CMU	ASBESTOS	SLAB ON GRADE	SINGLE CLEAR GLASS	METAL, SOLID	METAL, SOLID	.91	.91	.—	1.13	.89	1.06	.87	2218	NONE	BP 4725	OIL	—	472.4	40	GAS
MA-1	3650	ELECTRONICS REPAIR SHOP	2	ASPHALT SHINGLES	CONCRETE BLOCK	SLAB ON GRADE	SINGLE CLEAR GLASS	WOOD, SOLID	WOOD, SOLID	.29	.53	.—	1.13	.89	1.06	.87	9870	PACKAGE	UNIT HEATERS	GAS/OIL	92.1	330.4	80	GAS
MA-2	7108	MAINT. & OPER. CREW	1	METAL	CLAY TILE	SLAB ON GRADE	SINGLE CLEAR GLASS	WOOD, SOLID	WOOD, SOLID	.71	.37	.—	1.13	.89	1.06	.87	640	WINDOW UNIT	1.5 BP 4725	GAS	3.8	56.7	10	STEAM
ME-1	3493	HEALTH CLINIC	1	BUILT-UP	CONCRETE BLOCK, BRICK	SLAB ON GRADE	SINGLE CLEAR GLASS	METAL, HOLLOW	METAL, HOLLOW	.04	.29	.—	1.13	.89	1.06	.87	4956	CENTRAL	BP 3624	GAS	17.4	71.5	50	GAS
S-1	7558	ADMINISTRATION & STORAGE	1	ASPHALT SHINGLES	CONC. BLOCK & CLAY TILE	CONCRETE, CLOSED CR. SP	SINGLE CLEAR GLASS	WOOD, SOLID	WOOD, SOLID	.52	.49	.89	1.13	.89	1.06	.87	335.6	WINDOW UNITS	BP 7579	OIL	40.5	178.3	45	GAS
S-2	3643	WAREHOUSE RECORD STORAGE	1	ASPHALT SHINGLES	CLAY TILE	SLAB ON GRADE	SINGLE CLEAR GLASS	WOOD, SOLID	WOOD, SOLID	.15	.37	.—	1.13	.89	1.06	.87	2465	WINDOW UNITS	BP 3624	OIL	7.0	28.9	40	ELEC.

TABLE 2
TYPICAL BUILDING ENERGY CONSUMPTION DATA
REDSTONE ARSENAL

GROUP NO.	BLDG	BUILDING DESCRIPTION	ANNUAL ENER. SOURCE CONSUMPTION BTU x 10 ⁶			ELEC'L ENERGY CONSUMPTION		BTU x 10 ³ FT ²
			FUEL	ELEC.	TOTAL	KW	KWH/YR	
A-1	3217	OFFICES	168	456	624	32	39276	221.0
A-2	7172	OFFICES	730	2397	3127	142	206571	170.9
A-3	3649	OFFICES	464	1080	1544	32	93071	256.5
B-1	3433	BARRACKS	6184	4528	10712	182	390327	258.2
CS-1	3479	CAFETERIA & PX	303	3540	3843	210	305142	404.4
CS-2	3639	GAS STATION	1	190	191	7	16410	151.6
CS-3	376	CHAPEL	2140	2226	4366	147	191860	190.8
CS-4	7115	LAUNDRY	15600	1911	17511	78	164730	5059.5
CS-5	3707	BOWLING ALLEY	421	5582	6003	251	481164	445.1
CS-6	4813	FIRE STATION	200	260	460	13	22427	173.0
E-1	4722	ELECTRONICS SHOP	1270	3623	4893	196	312293	153.0
FH-1	40	SINGLE FAMILY HOUSING	236	208	444	8	17933	223.3
FH-2	229	MULTI-FAMILY HOUSING	1135	691	1826	33	59558	241.8
FH-3	451	SINGLE FAMILY HOUSING	257	155	412	5	13349	257.0
FH-4	472	DUPLEX FAMILY HOUSING	427	379	806	14	32643	237.7
FH-5	1364	DUPLEX FAMILY HOUSING	537	260	797	11	22423	329.2
FH-6	1416	MULTI-FAMILY HOUSING	626	478	1104	18	41164	242.2
FH-7	7130	SINGLE FAMILY HOUSING	209	308	517	16	26511	325.2
FH-8	485	SINGLE FAMILY HOUSING	240	185	425	8	15923	220.7
FH-9	1262	MULTI-FAMILY HOUSING	618	579	1197	24	49881	226.4
GM-1	7819	OFFICE & WORKSHOP	0	705	705	39	60777	470.0
GM-2	7596	MISSILE ASSEMBLY	1723	627	2350	27	54020	443.4
LA-1	5671	TRAINING FACILITY	1000	3341	4341	211	288010	327.2
LA-2	7360	MOTOR LANDING BUILDING	969	771	1740	28	66480	785.9
MA-1	3650	ELECTRONICS REPAIR SHOP	698	908	1606	48	78304	162.7
MA-2	7108	MAINT. & OPER. CREW	188	672	860	15	57908	1343.8
ME-1	3493	HEALTH CLINIC	178	1000	1178	46	86240	237.7
S-1	7558	ADMINISTRATION & STORAGE	464	304	768	25	26180	200.9
S-2	3643	WAREHOUSE RECORD STORAGE	72	118	190	24	10141	77.1

TABLE 3
BUILDING OCCUPANCY
REDSTONE ARSENAL

GROUP NO.	BLDG.	BUILDING DESCRIPTION	NORMAL PEAK POPULATION	OCCUPANCY
A-1	3217	OFFICE	28	WEEKDAYS - 7:00 A.M. TO 4:00 P.M.
A-2	7172	OFFICE	115	WEEKDAYS - 7:55 A.M. TO 4:25 P.M.
A-3	3649	OFFICE	30	1/2 OF BLDG. OPEN 24 HOURS 1/2 OF BLDG. OPEN 8 HOURS
B-1	3433	BARRACKS	344	OPEN 24 HOURS
CS-1	3479	CAFETERIA & P.X.	50	MONDAY TO SATURDAY - 10:00 A.M. TO 6:00 P.M.
CS-2	3639	GAS STATION	2	WEEKDAYS - 6:30 A.M. TO 2:45 P.M. WEEKENDS - 7:00 A.M. TO 9:00 A.M.
CS-3	376	CHAPEL	510	WEEKDAYS - 9:00 A.M. TO 3:00 P.M. SUNDAY - 9:30 A.M. TO 12:00 NOON
CS-4	7115	LAUNDRY	4	WEEKDAYS - 6:30 A.M. TO 4:00 P.M.
CS-5	3707	BOWLING ALLEY	110	SUNDAY - 1:00 P.M. TO 12:00 MIDNIGHT; MONDAY - 5:00 P.M. TO 12:00 MIDNIGHT TUESDAY TO SATURDAY - 9:00 A.M. TO 12:00 MIDNIGHT
CS-6	4813	FIRE STATION	10	OPEN 24 HOURS
E-1	4722	ELECTRONICS SHOP	80	WEEKDAYS - 6:30 A.M. TO 5:00 P.M.
FH-1	40	SINGLE FAMILY HOUSING	4	OPEN 24 HOURS
FH-2	229	MULTI-FAMILY HOUSING	32	OPEN 24 HOURS
FH-3	451	SINGLE FAMILY HOUSING	4	OPEN 24 HOURS
FH-4	472	DUPLEX FAMILY HOUSING	8	OPEN 24 HOURS
FH-5	1364	DUPLEX FAMILY HOUSING	8	OPEN 24 HOURS
FH-6	1416	MULTI-FAMILY HOUSING	16	OPEN 24 HOURS
FH-7	7130	SINGLE FAMILY HOUSING	4	OPEN 24 HOURS
FH-8	485	SINGLE FAMILY HOUSING	4	OPEN 24 HOURS
FH-9	1262	MULTI-FAMILY HOUSING	16	OPEN 24 HOURS
GM-1	7819	OFFICE & WORKSHOP	10	7 DAYS A WEEK - 8:00 A.M. TO 4:30 P.M.
GM-2	7596	MISSILE ASSEMBLY	16	WEEKDAYS - 8:00 A.M. TO 4:30 P.M.
LAB-1	5671	TRAINING FACILITY	11	WEEKDAYS - 7:00 A.M. TO 4:30 P.M.
LAB-2	7360	MOTOR LOADING BUILDING	28	WEEKDAYS - 7:00 A.M. TO 5:00 P.M.
MAINT. 1	3650	ELECTRONIC REPAIR SHOP	20	WEEKDAYS - 7:00 A.M. TO 3:30 P.M.
MAINT. 2	7108	MAINTENANCE OPERATION CREW	13	OPEN 24 HOURS
MED-1	3493	HEALTH CLINIC	50	WEEKDAYS - 6:30 A.M. TO 3:30 P.M.
S-1	7558	ADMINISTRATION & STORAGE	20	WEEKDAYS - 7:30 A.M. TO 4:00 P.M.
S-2	3643	WAREHOUSE RECORD STORAGE	3	WEEKDAYS - 8:00 A.M. TO 3:30 P.M.
T-1	3341	TRAINING OFFICE	42	WEEKDAYS - 7:00 A.M. TO 3:30 P.M.
T-2	3465	ADMINISTRATION & TRAINING	71	WEEKDAYS - 6:30 A.M. TO 3:30 P.M.
U-1	4637	SEWAGE TREATMENT	2	OPEN 24 HOURS - 7 DAYS A WEEK
U-2	8038	WATER TREATMENT	10	OPEN 24 HOURS - 7 DAYS A WEEK
U-3	—	PUMP HOUSE	—	—
U-4	7105	BOILER PLANTS	1	OPEN 24 HOURS - 7 DAYS A WEEK

TABLE 4

Building Group Source Energy Consumption

<u>Group</u>	<u>Description</u>	<u>Group Sq. Ft.</u>	<u>Total Source Consumption Btu's x 106</u>
A	Administrative	1,509,406	332,894
B	Barracks	533,675	137,756
CS	Community Service	426,867	265,937
E	Electronics	40,469	6,214
FH	Family Housing	1,513,308	379,730
GM	Guided Missile	706,161	330,667
LA	Laboratory	593,236	344,470
MA	Maintenance	269,645	281,730
ME	Medical	103,587	24,620
S	Storage	1,052,809	86,124
T	Training	681,117	88,169
U-1	Waste Water Treatment	5,315	7,053
U-2	Water Treatment	19,167	749,621
U-3	Pump Houses	4,993	674
U-4	Boiler and A/C Plant	44,858	4,838
Z	Electric Only (includes outdoor lighting)	646,184	53,510
MSFC	George C. Marshall Space Flight Center		2,102,485
		Total	5,196,492

TABLE 5
ENERGY CONSERVATION PROJECTS
SOURCE ENERGY SAVINGS - REDSTONE ARSENAL, ALABAMA

BUILDING TYPE	ENERGY SAVINGS BTU x 1,000,000	% BASEWIDE REDUCTION FY '75	PROJECT NUMBER
FAMILY HOUSING	34,217 74,564 <u>54,368</u> 163,149	.66 1.43 <u>1.04</u> 3.13	RSA-B- 3 RSA-B- 5 RSA-B-10
BARRACKS	9,269	.18	RSA-B- 4
GEORGE MARSHALL	37,100	.71	RSA-B-14
STEAM PLANTS	63,100 98,160 <u>15,792</u> 177,052	1.21 1.89 <u>.30</u> 3.40	RSA-B- 6 RSA-B- 9 RSA-B-13
SELECTIVE ENERGY PLANT	303,342	5.83	RSA-B-15
OTHER BUILDINGS	27,385 <u>126,513</u> 153,898	.53 <u>2.43</u> 2.96	RSA-B- 2 RSA-B-12
TOTAL	843,810	16.21	

TABLE 6

ENERGY CONSERVATION PROJECTS DEVELOPED SCHEDULE - REDSTONE ARSENAL, ALABAMA

PROJECT TITLE	PROJECT NUMBER	RECOMMENDED FISCAL YEAR	COST \$ x 1000	E/C RATIO	ENERGY SAVINGS BTU x 1,000,000	YEARS PAYBACK	B/C RATIO
RELAMPING FLUORESCENT FIXTURES	RSA-B-2	1980	363	75.49	27,385	3.3	2.48
FM RADIO CONTROL SYSTEM	RSA-B-3	1980	380	90.1	34,217	6.7	1.86
INSULATED PANELS, STORM WINDOWS, AND WEATHERSTRIP DOORS IN PERMANENT BARRACKS	RSA-B-4	1980	318	29.16	9,269	9.53	1.94
STORM WINDOWS, WEATHERSTRIP DOORS, AND KITCHEN LIGHTING FIXTURE IN FAMILY HOUSING	RSA-B-5	1980	1673	47	74,564	7.7	2.4
TOTAL			2734		145,435		
UPGRADE INSULATION ON STEAM AND CONDENSATE LINES	RSA-B-6	1981	2618	24.1	63,100	9.6	1.3
FAMILY HOUSING EQUIPMENT MODIFICATION	RSA-B-10	1981	1136	50.42	54,368	6.99	2.65
STEAM PLANT MODIFICATION	RSA-B-9	1981	1116	87.9	98,160	3.3	5.98
TOTAL			4870		215,628		
INSULATION AND WINDOW REPLACEMENT	RSA-B-12	1982	3904	32.4	126,513	7.11	
UPGRADE INSULATION ON LOW PRESSURE STEAM AND CONDENSATE LINES	RSA-B-13	1982	230	68.53	15,792	3.78	3.28
UPGRADE INSULATION ON GEORGE C. MARSHALL SPACE FLIGHT CENTER STEAM AND CONDENSATE LINES	RSA-B-14	1982	1144	32.42	37,100	7.99	1.56
TOTAL			5278		179,405		
SELECTIVE ENERGY PLANT	RSA-B-15	1983	60200	N/A	303,342	14.34	1.60
TOTAL			60200		303,342		

TABLE 7

Average Energy Costs
 FY81
 Redstone Arsenal

Electricity	
Demand	\$5.99/kW
kWh (without demand)	\$0.0232/kWh
kWh (including demand)	\$0.0373/kWh
Natural Gas	
Post	\$3.74/Mcf
Family Housing	\$4.06/Mcf
Fuel Oil	
No. 2	\$1.11/gal
No. 5	\$0.85/gal

TABLE 8
Redstone Arsenal
Summary of Recommended Projects
Increment F

Project	Location(s)	Energy Savings/Year MMBtu	Dollar Savings/Year	Payback Years	E/C	B/C	Contract Cost	In-House Cost		Reference Pages Narr. Calcs.
								Material	Manhours	
Reduction of Ventilation Air Quantities	23 Buildings	58,701	\$363,025	0.02	11,977	1,710	\$4,901	\$1,560	105 - A/C Mechanic	9 A2
Seal Roof Penetrations	Bldg. 7571 and 8027	416.8	3,107	0.03	5,022	895.5	83	35	2 - Carpenter	28 A15
Seal Wall Penetrations	6 Buildings	1,445	7,579	0.05	3,724	586	388	100	6 - Carpenter 2 - Laborer	40 A24
Flow Control Showerheads*	Post	39.1	205	0.08	2,393	423	16.34	11.82	0.5 - Laborer	11 A3
Water Restrictors - Hot Water* Post	Post	10.5	79.92	0.12	1,423	203	9.23	5.78	0.20 - Laborer	33 A19
Lower Domestic Hot Water Temperature	Post	8,751.6	44,403	0.18	1,080	158	8,107	0	468 - Laborer	45 A28
Receptacle Insulation	Family Housing	12,751	65,757	0.24	795.8	112.6	16,023	2,914	757 - Laborer	17 A7
Flow Control Showerheads	Family Housing	18,000	137,340	0.19	687	129.3	26,201	15,117	640 - Laborer	11 A3
Filter Maintenance	Family Housing	17,462	39,342	0.46	531	40	32,872	0	1,758 - Laborer	17 A6
Seal Rooftop Ventilators in Winter	Buildings 3777, 8027	640	3,828	0.32	517	85	1,238	963	9 - Carpenter	41 A25
Turn Off Compressor Sump Heater	Family Housing	3,096	5,425	0.59	400	29	7,733	0	469 - Laborer	27 A14

*All figures are on a per unit basis.
N/A - Not Applicable.

TABLE 8 (Cont'd)
Redstone Arsenal
Summary of Recommended Projects
Increment F

Project	Location(s)	Energy Savings/Year MMBtu	Dollar Savings/Year	Payback Years	E/C	B/C	Contract Cost	In-House Cost		Reference Pages Marr. Calcs.
								Material	Manhours	
Furnace Derating	Family Housing	4,970	\$28,180	0.45	392	67	\$12,695	0	391 - A/C Mechanic	47 A29
Weatherstrip Doors	Family Housing	14,862	76,643	0.55	369	52	40,269	\$11,767	1,646 - Laborer	44 A27
Weatherstrip Doors	Post	66,201	327,963	0.57	352	49	188,198	99,900	5,096 - Laborer	44 A27
Filter Maintenance	Post	997	937	0.8	302	19.2	3,300	0	150 - Laborer	17 A6
Insulate Water Heaters	Family Housing	4,947	28,010	0.66	267	45	18,540	8,349	586 - Laborer	42 A26
Duct Insulation in Unconditioned Spaces	3 Buildings	755.4	3,735	1.2	176.5	24.3	4,279	2,973	75 - Laborer	20 A8
Insulate Water Heaters	Post	59.5	253	1.8	132	12	451	227	13 - Laborer	42 A26
Lower Thermostat Setting and Night Setback	Family Housing	35,200	199,584	1.3	96	23	263,060	225,610	1,172 - Electrician	29 A16
Reduce Infiltration	Family Housing	25,502	131,513	2.6	75.2	10.6	339,039	125,824	16,203 - Laborer	15 A5
Window Insulation	Bldg. 3474	80.2	385	2.8	73.2	9.4	1,096	488	35 - Laborer	13 A4
Window Insulation	Bldg. 4813	5.9	28	2.8	73.2	9.4	80	26	3 - Laborer	13 A4
Window Insulation	Bldg. 4814	46.9	225	2.8	73.2	9.4	641	282	21 - Laborer	13 A4

*All figures are on a per unit basis.
N/A - Not Applicable.

TABLE 8 (Cont'd)
Redstone Arsenal
Summary of Recommended Projects
Increment F

Project	Location(s)	Energy Savings/Year MMBtu	Dollar Savings/Year	Payback Years	E/C	B/C	Contract Cost	In-House Cost		Reference Pages Narr. Calcs.
								Material	Manhours	
Remove Warehouse Doors	Bldg. 5437	175.6	\$867	3.6	57	6.9	\$3,081	\$ 2,800	6 - Carpenter 4 - Laborer 2 - Painter	37 A22
Replace Oversized Water Heater	Bldg. 5421	16.6	99	3.1	54.2	11.3	306	212	2 - Plumber 1 - Electrician	23 A11
Replace Incandescent Lighting with Fluorescent	Post	441	2,293	3.6	53.7	5.5	8,207	5,782	76 - Electrician	21 A9
Solar Film (Per Square Foot)	Post	.0993	0.42	4.5	53	4.7	1.88/ft ²	N/A	N/A	25 A13
Insulate Warehouse Roof	Bldg. 5669	500	2,615	4.5	42.2	6.7	11,803	8,328	203 - Laborer	22 A10
Window Insulation	5 Buildings	1,533	11,482	3.2	41.3	7.4	37,105	16,520	298 - Laborer	13 A4
Vent Dampers	Family Housing	5,960	33,793	7.5	24	4	252,068	157,929	2,930 - A/C Mechanic	31 A18
Replace Incandescent Lighting with Fluorescent	Family Housing	2,430	9,180	12.2	21.8	1.4	111,530	55,794	1,758 - Electrician	21 A9
Electronic Ignitions on Furnaces	Family Housing	6,488	35,299	11.1	16.5	2.6	392,358	317,086	2,344 - A/C Mechanic	30 A17
Water Restrictors - Cold Water	Post	0	25	0.37	N/A	25	9.23	5.78	0.20 - Laborer	33 A19
Flush Valve Restrictors	Post	0	54,857	0.70	N/A	9.5	38,404	23,290	880 - Laborer	34 A20

*All figures are on a per unit basis.
N/A - Not Applicable.

TABLE 8 (Cont'd)
 Redstone Arsenal
 Summary of Recommended Projects
 Increment F

Project	Location(s)	Energy Savings/Year MMBtu	Dollar Savings/Year	Payback Years	E/C	B/C	Contract Cost	In-House Cost		Reference Pages Narr. Calcs.
								Material	Manhours	
Toilet Tank Dams	Family Housing	0	\$14,140	0.84	N/A	11	\$11,820	\$7,393	256 - Laborer	35 A21
Toilet Tank Dams*	Post	0	7.28	1.01	N/A	9	7.37	5.78	0.20 - Laborer	35 A21

*All figures are on a per unit basis.
 N/A - Not Applicable.

TABLE 9
Redstone Arsenal
Summary of Recommended Projects
Increment G

Project	Location (s)	Energy Savings/Year MMBtu	Dollar Savings/Year	Payback Years	E/C	B/C	Contract Cost	In-House Cost		Reference Pages
								Material	Manhours	
Boiler Combustion Performance Improvement	5 Buildings	8,948	\$56,121	0.30	528	92.8	\$16,935	N/A	N/A	17 B5
Heat Recovery	Bldg. 3624 & 4725	46,086	241,030	0.38	509	80	90,580	N/A	N/A	17 B5
Automatic Chiller Condenser Tube Cleaning	Bldg. 5201	6,880	39,010	0.46	405.2	68.6	16,981	N/A	N/A	7 B2
Pipe Insulation	9 Buildings	438	2,291	0.80	240.4	37.8	1,882	\$ 959	28-Laborer	37 B14
Automatic Chiller Condenser Tube Cleaning	Bldg. 5400	17,017	79,287	0.95	239.1	27	71,183	N/A	N/A	7 B2
Thermostatic Steam Valves	7 Buildings	867	4,534	0.99	193.4	30.4	4,482	2,284	70 Plumber	25 B6
Automatic Chiller Condenser Tube Cleaning	Bldg. 3305	10,922	61,928	1.2	145.2	24.6	75,217	N/A	N/A	7 B2
Automatic Chiller Condenser Tube Cleaning	Bldg 7120	2,580	14,629	1.3	144.1	24.4	17,899	N/A	N/A	7 B2
Automatic Chiller Condenser Tube Cleaning	Bldg. 7290	2,290	9,733	1.7	139.4	12.5	16,423	N/A	N/A	7 B2
Automatic Chiller Condenser Tube Cleaning	Bldg. 4500	2,290	9,733	1.7	139.4	12.5	16,423	N/A	N/A	7 B2
Automatic Chiller Condenser Tube Cleaning	Bldg. 5250	5,460	\$30,958	1.7	111.0	18.8	\$49,180	N/A	N/A	7 B2

N/A Not Applicable

TABLE 9 (Cont'd)
 Redstone Arsenal
 Summary of Recommended Projects
 Increment G

Project	Location (s)	Energy Savings/Year MMBtu	Dollar Savings/Year	Payback Years	E/C	B/C	Contract Cost	In-House Cost		Reference Pages	
								Material	Manhours	Narr.	Calcs.
Automatic Chiller Condenser Tube Cleaning	Bldg. 4489	1,721	9,758	1.7	103.9	17.6	16,558	N/A	N/A	7	B2
Automatic Chiller Condenser Tube Cleaning	Bldg. 4505	1,655	9,384	2.2	83.5	14.2	19,803	N/A	N/A	7	B2
Automatic Chiller Condenser Tube Cleaning	Bldg. 4488	3,310	18,768	2.3	77.6	13.1	42,665	N/A	N/A	7	B2
Automatic Chiller Condenser Tube Cleaning	Bldg. 3495	1,241	7,036	2.7	69.3	11.7	17,899	N/A	N/A	7	B2
Automatic Chiller Condenser Tube Cleaning	Bldg. 4484	1,241	7,036	2.7	69.3	11.7	17,899	N/A	N/A	7	B2
Fluorescent Lighting Load Reduction	Post	33,347	187,121	2.6	69.1	9.4	482,721	355,896	4,029-Electrician	10	B3
Ceiling Fans	Bldg. 7104	116	621	2.9	64.6	10.7	1,796	753	33-Electrician	14	B4
Automatic Chiller Condenser Tube Cleaning	Bldg. 3438	828	4,695	3.6	48.8	8.3	16,981	N/A	N/A	7	B2
Ceiling Fans	Bldg. 4762	565	3,101	3.8	48.5	8.5	11,656	5,998	177-Electrician	14	B4
Automatic Chiller Condenser Tube Cleaning	Bldg. 5681	706	3,001	5.1	46.0	4.2	15,364	N/A	N/A	7	B2
Automatic Chiller Condenser Tube Cleaning	Bldg. 5687	662	2,814	5.4	43.4	4.1	15,241	N/A	N/A	7	B2

N/A Not Applicable

TABLE 9 (Cont'd)
 Redstone Arsenal
 Summary of Recommended Projects
 Increment 6

Project	Location (s)	Energy Savings/Year MMBtu	Dollar Savings/Year	Payback Years	E/C	B/C	Contract Cost	In-House Cost		Reference Pages
								Material	Manhours	
Ceiling Fans	Bldg. 7571	59	323	4.8	38.1	6.6	1,549	770	24-Electrician	14 B4
Storm Windows	8 Buildings	360.5	2,043	7.0	25.2	3.3	14,294	10,661	120-Carpenter	35 B13
Ceiling Fans	6 Buildings	4,724	27,418	7.2	24.1	4.7	196,356	106,654	2,799-Electrician	14 B4
Storm Windows	8 Buildings	1,779	10,442	7.2	23.5	3.2	75,603	56,200	637-Carpenter	35 B13
Insulated Panels	10 Buildings	1212.6	5,981	8.8	23.2	3.2	52,337	31,980	879-Carpenter	27 B8
Storm Windows	Bldg. 112	196.8	942	9.4	22.2	2.8	8,871	6,594	75-Carpenter	35 B13
Electrical Distribution System Improvements	Post	46,506	198,116	10.76	20.8	2.0	2,232,100	N/A	N/A	39 B16
Install Dropped Acoustical Ceiling	Bldg. 5451	175	863	11.3	17.9	2.5	9,761	6,084	120-Carpenter	29 B9
Sliding Glass Storm Doors	Family Housing	3,563	18,142	11.1	17.7	2.4	201,393	176,400	800-Carpenter	32 B11
Ceiling Fans	Bldg. 1500	121.5	694	10.2	17.1	1.5	7,111	5,203	60-Electrician	14 B4
Exterior Insulation and Window Area Reduction	8 Buildings	6,279.7	39,286	11.1	14.4	2.0	437,252	325,033	3,685-Carpenter	33 B12
Exterior Insulation and Window Area Reduction	12 Buildings	3,002	19,900	13.5	11.2	1.6	268,503	199,597	2,263-Carpenter	33 B12
Exterior Insulation and Window Area Reduction	8 Buildings	2,029.5	13,594	14.9	10.0	1.5	202,834	158,985	1,440-Carpenter	33 B12

N/A Not applicable

TABLE 10
 REDSTONE ARSENAL
 SCHEDULED ECIP PROJECTS SINCE FY75

<u>Project</u>	<u>FY</u>	<u>Annual Energy Savings (10⁶ Btu)</u>
FM Radio Control System (FH)	80	34,217
Storm Windows and Doors (FH)	80	30,742
Improvement to Permanent Barracks	81	9,269
Add Economizers to Boilers in Building 3624	81	27,274
Oxygen Monitoring and Controls	81	25,692
Upgrade Insulation on Steam and Condensate Lines	82	115,992
Construction of Condensate Lines - 5600 Area	82	25,789
Waste Heat Recovery (FH)	83	22,901