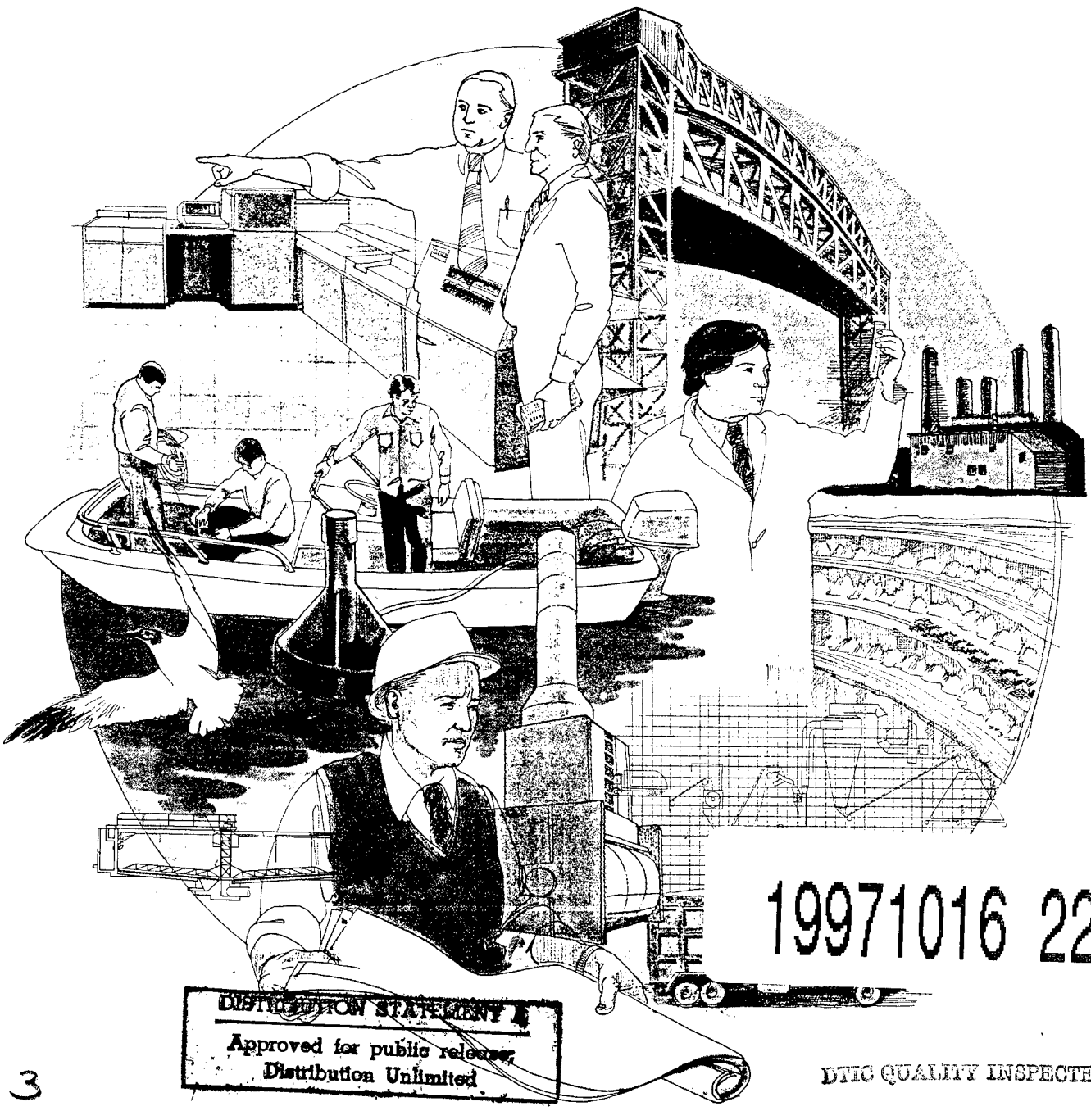
WESTON
MANAGERS DESIGNERS/CONSULTANTS



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DEPARTMENT OF THE ARMY
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FINAL REPORT

EXECUTIVE SUMMARY

INCREMENT A AND B STUDY

AT

ABERDEEN PROVING GROUNDS, MARYLAND

Prepared for:

Department of the Army
Norfolk District, Corps of Engineers
Norfolk, Virginia 23510

Under Contract No. DACA-65-84-C-0105

March 1988

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W.O. #0335-72-01/02

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SECTION 1

EXECUTIVE SUMMARY

1.1 INTRODUCTION

This report presents the results of the Energy Engineering Analysis Program conducted by Roy F. Weston, Inc. at the Aberdeen and Edgewood Areas of Aberdeen Proving Grounds under Contract No. DACA-65-84-C-0105. The study includes identification and evaluation of specific energy conservation opportunities that are applicable to the 44 buildings at Aberdeen and Edgewood.

The Increments of Work to be provided as stated in the Scope of Work:

Increment A - Projects involving modifying, improving or retrofitting existing buildings to make them more energy efficient.

Increment B - Energy conservation investigations of utilities and energy distribution systems, and energy monitoring and control systems (EMCS).

The study involved field surveying the various buildings to find out the present operating conditions and schedules, and to identify energy conservation opportunities that may be applicable. Detailed calculations were performed to evaluate the opportunities and package them into QRIP/PECIP projects.

1.2 HISTORICAL ENERGY CONSUMPTION

The annual fuel consumption at Aberdeen and Edgewood for FY 1985 (October 1984 to September 1985) was:

- Annual Electric Consumption at Aberdeen - 86,823,988 kWh
- Annual Electric Consumption at Edgewood - 60,406,319 kWh
- Total Electric Consumption at Base - 147,230,307 kWh
- Annual Fuel Oil Consumption at Aberdeen - 5,284,904 Gallons
- Annual Fuel Oil Consumption at Edgewood - 7,649,696 Gallons

- Total Fuel Oil Consumption at Base - 12,934,600 Gallons

The average fuel oil cost for FY 1985 was 0.95 per gallon.

The latest electric consumption and cost data available for the Aberdeen and Edgewood areas is for the year beginning in October of 1984 and continuing through September of 1985. Electricity is supplied to the base by four utility companies - Baltimore Gas and Electric Company, Delmarva Power Company, Conowingo Power Company and Choptank Electric Cooperative, Inc. In FY 1985 a total of 147,230,307 kWh of electricity was consumed at Aberdeen and Edgewood, costing $7,398,316.22. This results in an average electric cost of $0.05/kWh which was used in this report.

For FY 1984 (October 1983 to September 1984) the total consumption of fuel oil and electricity was:

- Annual Electric Consumption at Aberdeen - 82,884,291 kWh
- Annual Electric Consumption at Edgewood - 58,579,513 kWh
- Total Electric Consumption at Base - 141,463,804 kWh
- Annual Fuel Oil Consumption at Aberdeen - 6,319,126 Gallons
- Annual Fuel Oil Consumption at Edgewood - 8,953,330 Gallons
- Total Fuel Oil Consumption at Base - 15,272,456 Gallons

Fuel oil consumption for FY 1985 was 18.1% lower than for FY 1984 and electric consumption for FY 1985 was 4.1% higher than for FY 1984.

In comparison fuel oil consumption for FY 1984 was 10.76% higher than for FY 1983 and electric consumption was up 6.59% over FY 1983.

1.3 SPECIAL INSTRUCTIONS

Since the scope of work was written for a base-wide study and this study includes only a few buildings at the base, some items were deleted from the scope of work. This includes:

(i)	Paragraph 2.5	Future Population
(ii)	Paragraph 6.2.4	Information on Meters
(iii)	Paragraph 6.3.1	Distribution Systems
(iv)	Paragraph 6.3.4	EMCS Study, which was deleted from the scope of work by the post.

It was established that three buildings will be computer modelled, using the Carrier E20-II program. These are buildings 2353, E1930 and E5185, which have the highest annual energy savings.

The "expected lives" of the buildings used for the life cycle cost analysis were obtained from the Building Information Schedules (BIS) and verified by the post.

1.4 FINDINGS

The work done was performed in two phases. The first phase involved site visits and data collection on the various buildings. The data collected included drawings and building information schedule (BIS). Site visits were performed to collect information on cooling and heating equipment, lighting type, lighting levels, operating schedules and function of the building. Conversations and interviews were conducted with the building administrators to gain an insight into the operation of the building and to help in identifying energy conservation opportunities (ECO's). All information collected was used to identify the various ECO's applicable. The second phase involved evaluation of the various energy conservation opportunities and life cycle cost analysis.

A list of Energy Conservation Opportunities (ECO's) to be investigated is contained in Table 1-1. This list along with previous energy conservation retrofit experience, and observations and data obtained from site visits provided a basis for a list of ECO's to be quantitatively analyzed. The opportunities involved are:

- Wall Insulation
- Window Weatheriztion
- Weatherstripping
- Upgrading EMCS
- Infrared Heaters
- Destratification
- Return Condensate
- Reduce Lighting Levels
- High Efficiency Lighting

- Improve Power Factor
- Revise/Repair HVAC Controls
- Low Leakage Rolling Doors
- Light Motion Sensors
- Centralized Chiller Plant
- Expand EMCS to Include Night Setback

After analysis of the above ECO's, life cycle cost analysis was performed to calculate their SIR values. Tables 1.2 and 1.3 summarize the results of the ECO's evaluated for the Aberdeen and Edgewood areas. Projects having SIR value less than 1.2 are not recommended per directions from the post. The tables show the total savings for projects having SIR greater than 1 and 1.2.

Legend

- ● Retrofit to be Investigated by WESTON
- ▲ Retrofit Implemented or Being Implemented by Post
- ■ Retrofit Investigated by WESTON for Boiler Plant/Chiller Plant Study
- △ Retrofit Investigated by JRB Assoc.
- E Current ECIP Project

Location: Aberdeen Proving Grounds, Edgewood Area

ENERGY CONSERVATION OPPORTUNITIES

Building No.	Building Envelope													Heating										Remarks
	Wall Insulation	Roof/Ceiling Insulation	Storm Windows/Double Glazing	Reduce Glass Area	Weatherstripping/Caulking	Insulation Panels	Solar Films	Vestibules	Low Leakage Rolling Doors	Plastic Strip Doors	Air Curtains	Radiator Controls	Night Setback	Infra-Red Heaters	Destratification	Decentralize DHW Heaters	Boiler Trim Controls	Revise Boiler Controls	Insulate Steam Lines	Return Condensate	DHW Heat Pumps	Shower Flow Restrictor	Shutdown Hot Water Heater	
E1930	●			●		●			△		▲			●				▲						
E2100		E	△	●		●					▲					■	■	▲	■					
E2101																								Building Being Renovated
E3081						●				▲	▲	●						▲						
E3100		△	▲	●		●					▲							▲						
E3160						●					▲							▲						
E3220			▲			●					▲							▲						
E3222						●					▲							▲						
E3226						●					▲							▲						
E3244						●					▲							▲						
E3300			▲			●					▲							▲						
E3550		E		●		●			△		▲							▲						Very Sensitive Area
E3580				●		●					▲							▲						
E3725																								Sentry Station
E3728																								Building Being Renovated
E5100		E	▲			●					▲							▲	E					Being Renovated

TABLE 1.1 **ENERGY CONSERVATION OPPORTUNITIES MATRIX**

Legend

- ● Retrofit to be Investigated by WESTON
- ▲ Retrofit Implemented or Being Implemented by Post
- ■ Retrofit Investigated by WESTON for Boiler Plant/Chiller Plant Study
- △ Retrofit Investigated by JRB Assoc.
- E Current ECIP Project

Location: Aberdeen Proving Grounds, Edgewood Area

Building No.	Centralized CHW Plant	Convert to VAV System	Occ./Unocc. Control	Programmed Start/Stop	Duty Cycling	Demand Limiting	Economizer Cycle	Heat Reclaim From Hot Ref. Gas	Reduce Lighting Level	High Efficiency Lighting	High Efficiency Motor	Improve Power Factor	FM Radio Controls	Repl. Ineff. Kitchen Light	Optimize Transformer LDG.	Revise/Repair HVAC Controls	Reduce Street Light	EMCS	Heat Recovery-Commissary	Improve Exhaust System	Thermal Barriers for Food Cases	Remarks
	ENERGY CONSERVATION OPPORTUNITIES																					
	Air-Conditioning									**Lighting and Electrical**											**Misc.**	
E1930										●												
E2100										●												
E2101																						
E3081			●	●	▲		▲		●		●											
E3100									●		●											
E3160									●		●						▲					
E3220											●											
E3222	●									●	●				●		▲					
E3226			●	●							●						▲					
E3244											●											
E3300											●				●							Very Sensitive Area
E3550										●	●											
E3580											●											
E3725																						Sentry Station
E3728																						
E5100											●					▲						Being Renovated

TABLE 1.1 **(CONTINUED)**

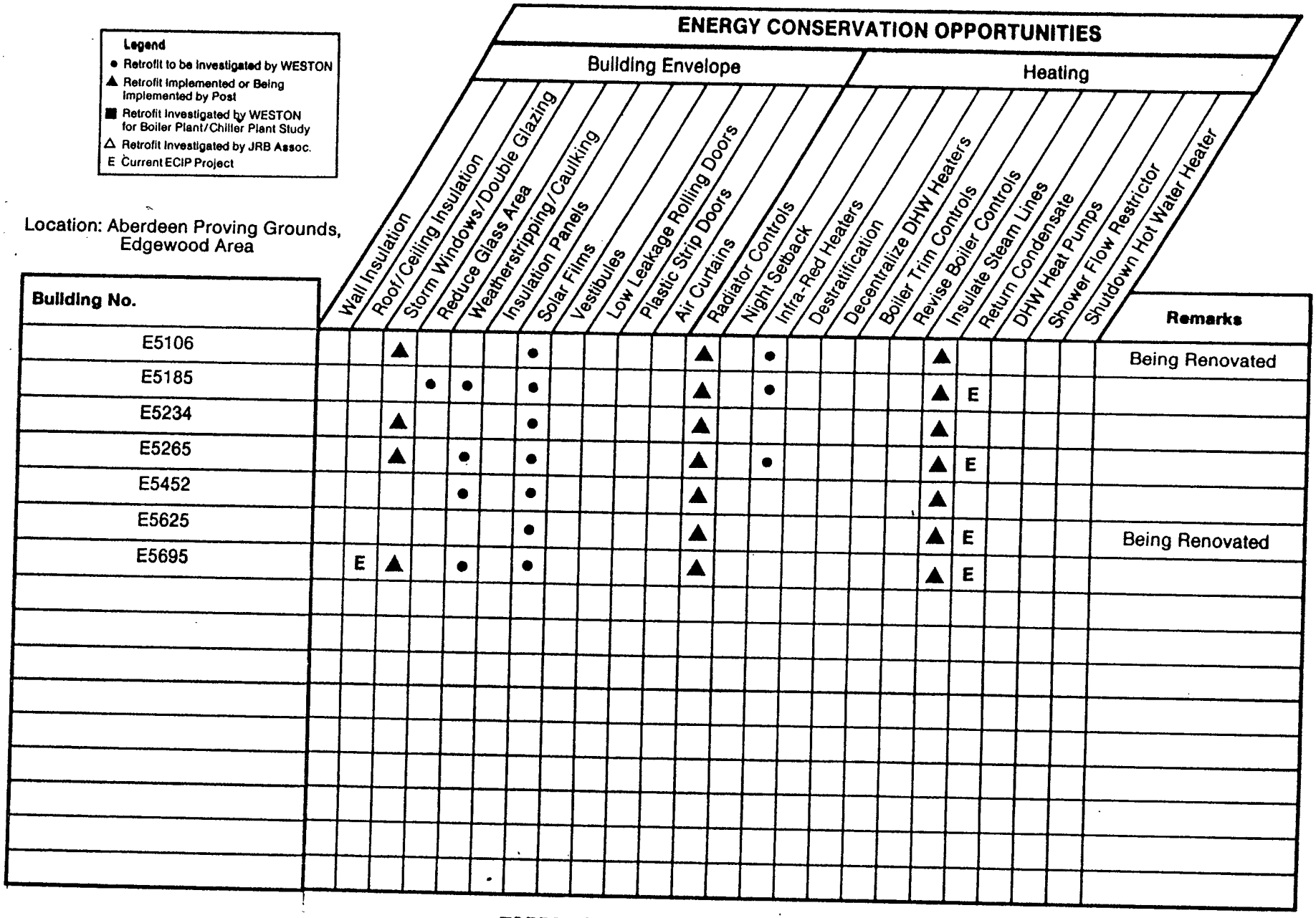


TABLE 1.1 **(CONTINUED)**

Legend
- ● Retrofit to be Investigated by WESTON
- ▲ Retrofit Implemented or Being Implemented by Post
- ■ Retrofit Investigated by WESTON for Boiler Plant/Chiller Plant Study
- △ Retrofit Investigated by JRB Assoc.
- E Current ECIP Project

Location: Aberdeen Proving Grounds, Edgewood Area

Building No.	ENERGY CONSERVATION OPPORTUNITIES: Air-Conditioning — Centralized CHW Plant	Convert to VAV System	Occ./Unocc. Control	Programmed Start/Stop	Duty Cycling	Demand Limiting	Economizer Cycle	Heat Reclaim From Hot Ref. Gas	Lighting and Electrical — Reduce Lighting Level	High Efficiency Lighting	High Efficiency Motor	Improve Power Factor	FM Radio Controls	Repl. Ineff. Kitchen Light	Optimize Transformer LDG.	Revise/Repair HVAC Controls	Reduce Street Light	EMCS	Misc. — Heat Recovery-Commissary	Improve Exhaust System	Thermal Barriers for Food Cases	Remarks
E5106										●				●								Being Renovated
E5185				▲		△				●						▲						
E5234										●												
E5265									●	●												
E5452				△		△			●	●												
E5625										●												Being Renovated
E5695	●									●				●								

TABLE 1.1 **(CONTINUED)**

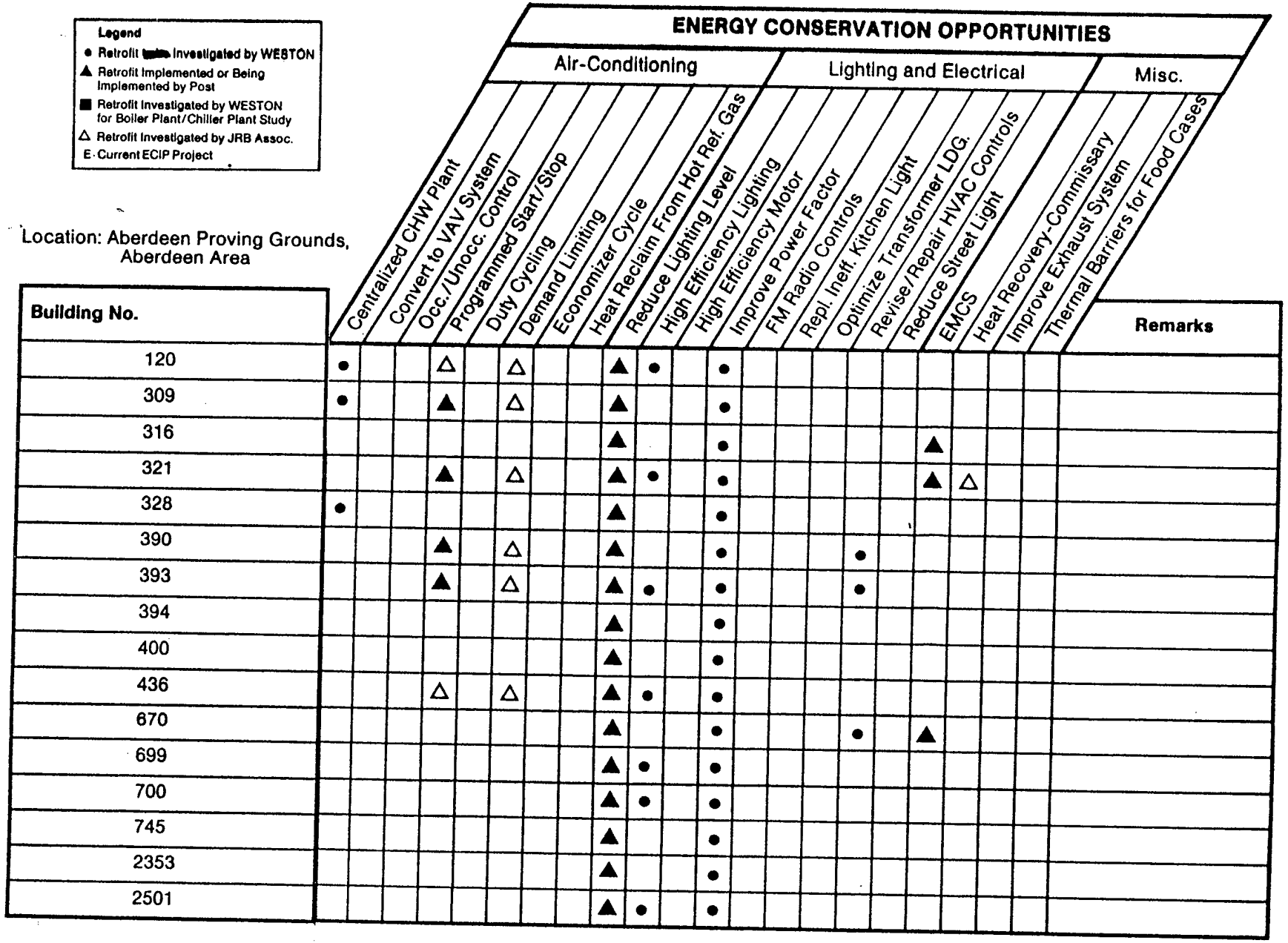
along with Edgewood also.

Legend
- ● Retrofit investigated by WESTON
- ▲ Retrofit implemented or Being Implemented by Post
- ■ Retrofit investigated by WESTON for Boiler Plant/Chiller Plant Study
- △ Retrofit Investigated by JRB Assoc.
- E Current ECIP Project

Location: Aberdeen Proving Grounds, Aberdeen Area

Building No.	Wall Insulation	Roof/Ceiling Insulation	Storm Windows/Double Glazing	Reduce Glass Area	Weatherstripping/Caulking	Insulation Panels	Solar Films	Vestibules	Low Leakage Rolling Doors	Plastic Strip Doors	Air Curtains	Radiator Controls	Night Setback/Time Clocks	Infra-Red Heaters	Destratification	Decentralize DHW Heaters	Boiler Trim Controls	Revise Boiler Controls	Insulate Steam Lines	Return Condensate	DHW Heat Pumps	Shower Flow Restrictor	Shutdown Hot Water Heater	Remarks
	Building Envelope													Heating										
120			▲				●					▲	▲						▲						
309			●				●					▲							▲						
316		E					●					▲							▲						
321		△	▲				●					▲		●					▲						
328			▲		●		●					▲							▲						
390					●		●					▲							▲						
393					●		●					▲							▲						
394					●		●					▲	E						▲						
400			▲				●					▲							▲						
436				●			●			△		▲	▲						▲						
670				●			●		●	△		▲							▲						
699							●					▲							▲						
700							●					▲							▲						
745							●					▲							▲						
2353		△	△				●					▲		●					▲						
2501							●					▲			■	■	▲	■							

Table 1.1 **ENERGY CONSERVATION OPPORTUNITIES MATRIX**



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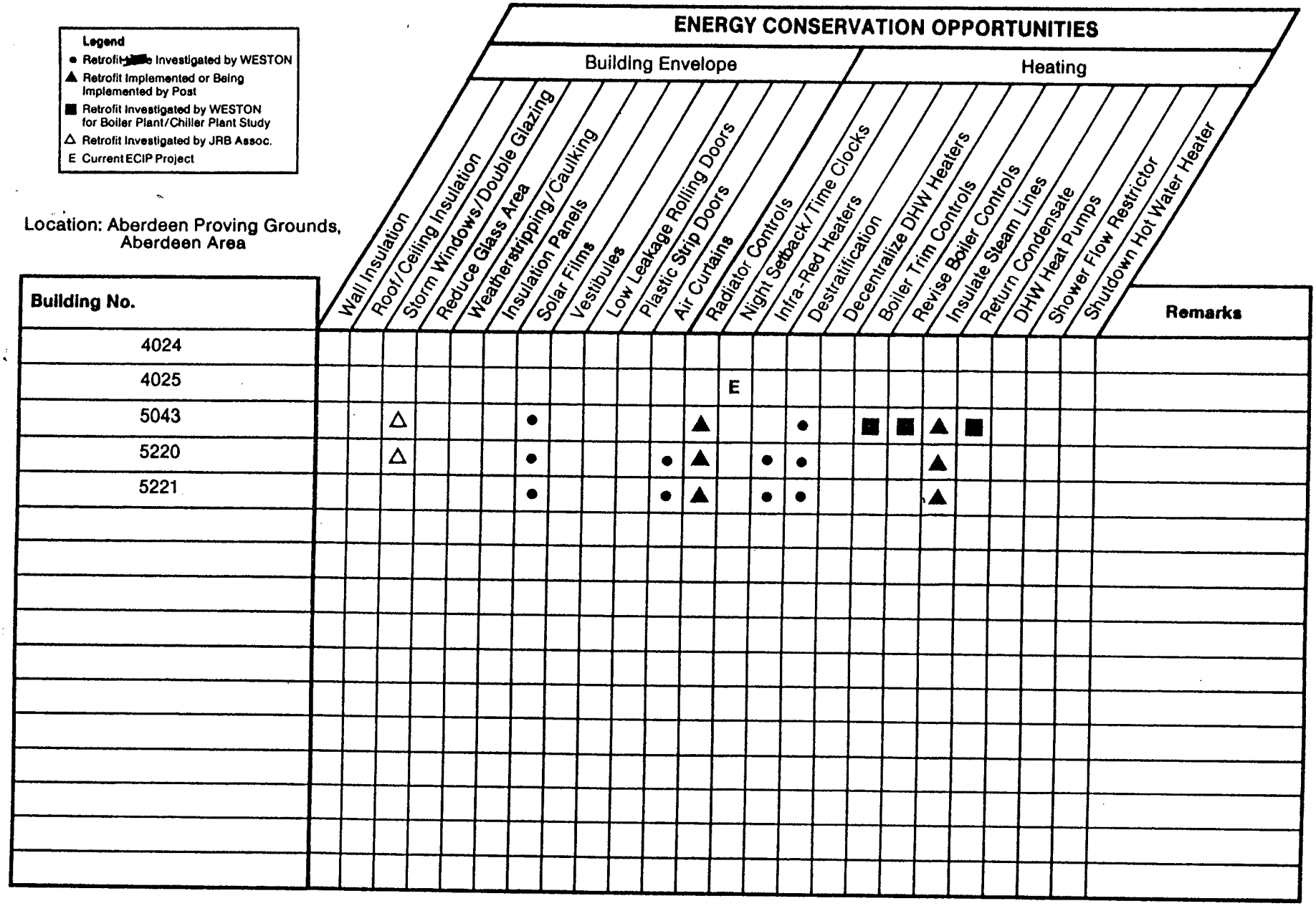

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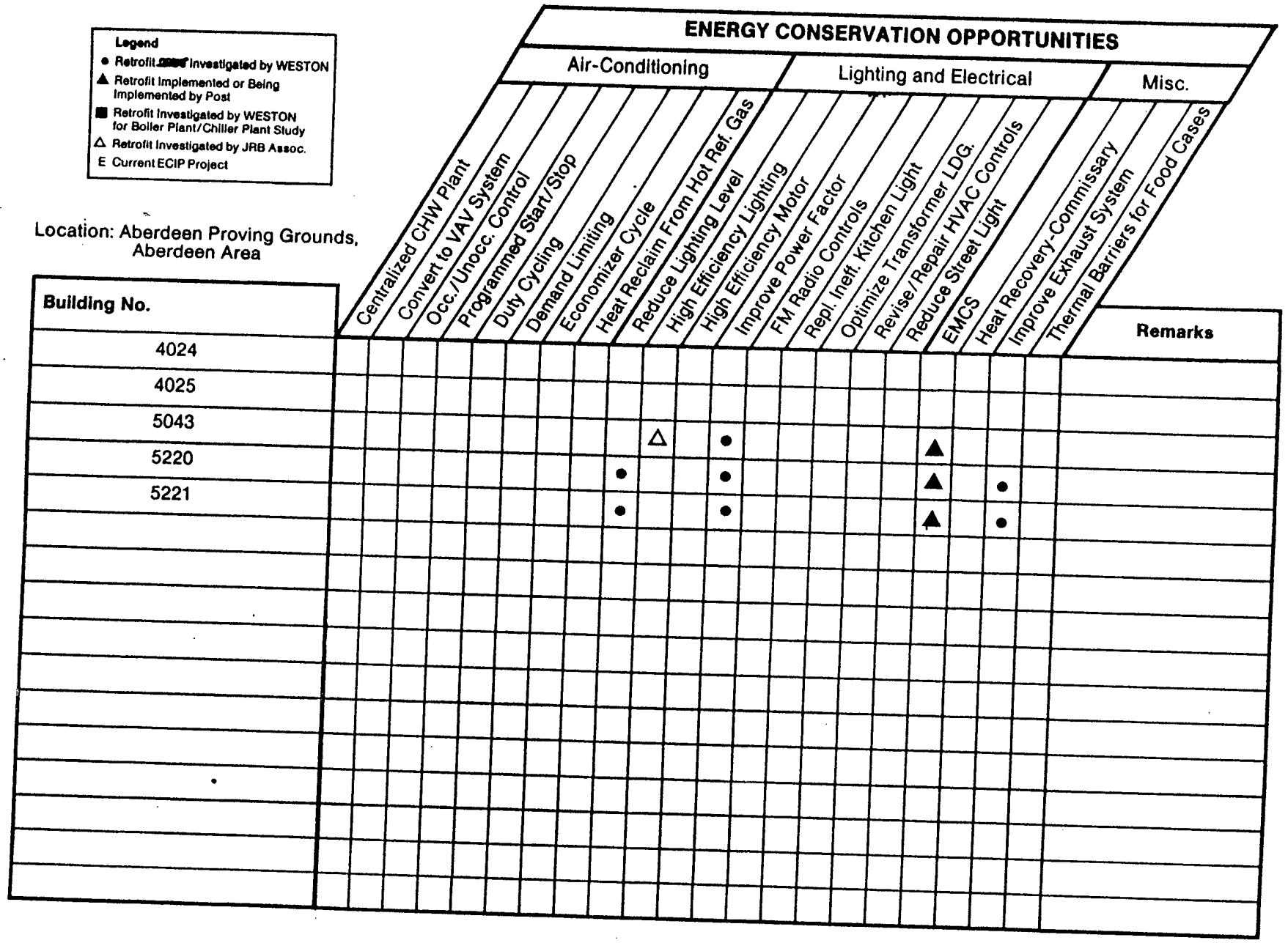


Table 1.1 **(CONTINUED)**

TABLE 1-2

SUMMARY OF EVALUATED ECO'S - ABERDEEN AREA

Opportunity	Annual Energy Savings: Electricity (MBTU)	Fuel Oil (MBTU)	Total (MBTU)	Annual Non-Energy Cost Savings ($)	Unescalated Current Working Estimate ($)	Simple Payback (Yrs)	SIR
ECO 2.1: Install Light Motion Sensors In Building 393	1,039.44	---	1,039.44	4,480	10,600	2.4	2.7
ECO 2.2: Install Thermostat and Control Valve in Bldg. 670	----	124.4	124.4	860	484	0.56	12.7
ECO 2.4: Window Weatherization(#436,670)	----	265.50	265.50	1,835	8,457	4.60	1.23
ECO 2.5: Insulated Low Leakage Rolling Doors							
15 x 18 Door	----	45.75	45.75	316	9,693	30.70	0.23
(2)10 x 12 Door	-----	38.26	38.26	264	8,220	31.10	0.11
ECO 2.6: Infrared Heaters	(No cost savings even though there is energy savings.)						

TABLE 1-2 (CONTINUED)

SUMMARY OF EVALUATED ECO'S - ABERDEEN AREA

Opportunity	Annual Energy Savings Electricity (MBTU)	Fuel Oil (MBTU)	Total (MBTU)	Annual Non-Energy Cost Savings ($)	Unescalated Current Working Estimate ($)	Simple Payback (Yrs)	SIR
ECO 2.7: Destratification of High Bay Areas							
Building 2353:	-65.2	542.90	477.70	3,470	8,214	2.40	2.98
Building 5943:	-214.1	635.10	421.00	3,467	23,770	6.90	1.01
Building 5220:	-46.6	210.20	163.60	1,250	5,867	4.70	2.37
Building 5221:	-46.6	210.20	163.60	1,250	5,867	4.70	2.37
ECO 2.9: Centralized Chiller Plant (Building 120)	531.5	----	531.50	2,290	80,000	34.90	---
ECO 2.10: Reduced Lighting Levels							
Building 5220:							
Office No. 1	6.03	----	6.03	26	54	2.10	4.35
Office No. 2	6.03	----	6.03	26	54	2.10	4.35
Building 5221:							
Office No. 1	6.03	----	6.03	26	54	2.10	4.35
Office No. 2	6.03	----	6.03	26	54	2.10	4.35

TABLE 1-2 (CONTINUED)

SUMMARY OF EVALUATED ECO'S - ABERDEEN AREA

Opportunity	Annual Energy Savings Electricity (MBTU)	Fuel Oil (MBTU)	Total (MBTU)	Annual Non-Energy Cost Savings ($)	Unescalated Current Working Estimate ($)	Simple Payback (Yrs)	SIR
ECO 2.11: Replace Incandescent with Fluorescent Lighting	71.70	----	71.70	744	1,031	1.40	1.88
ECO 2.12: Replace Fluorescent with Energy-saving Fluorescent	388.70	----	388.70	1,675	932	0.56	4.91
ECO 2.13: Replace Incandescent with HPS Lighting							
Building 699	65.63	----	65.63	283	1,630	5.8	5.4
Building 700	51.53	----	51.53	222	2,685	12.1	0.7
Building 2353	535.64	----	535.64	2,309	9,782	4.2	4.37
ECO 2.14: Upgrade HVAC Controls in Building 393	----	78.0	78.0	539	399	0.74	9.65
ECO 2.15: Expand EMCS to Include Night Setback							
Building 394	----	1,428.35	1,428.35	9,870	3,200	0.33	34.30
Building 4025	----	244.56	244.56	1,552	3,970	2.60	4.15
Totals (SIR>1.2)	2,020.84	3,104.10	5,124.94	30,221	60,649		
Totals (SIR>1)	1,806.74	3,739.20	5,145.94	33,688	84,419		

TABLE 1-3

SUMMARY OF ECO'S EVALUATED - EDGEWOOD AREA

Opportunity	Annual Energy Savings Electricity (MBTU)	Fuel Oil (MBTU)	Total (MBTU)	Annual Savings ($)	Unescalated Current Working Estimate ($)	Simple Payback (Yrs)	SIR
ECO 2.1: Wall Insulation							
Applied to Plastic Wall (Building E1930)	----	241.50	241.50	1,669	3,139	1.90	8.82
Applied to Clay Tile Wall (Building E1930)	----	227.90	227.90	1,575	13,526	8.60	1.93
ECO 2.2: Window Weatherization	----	1,924.40	1,924.40	13,298	61,747	4.60	1.22
ECO 2.5: Replace incandescent with Fluorescent Lighting	19.8	----	19.80	205	285	1.40	1.87
ECO 2.8: Destratification of High Bay Areas	-31.1	300.80	269.70	1,944	3,520	1.80	6.17
*ECO 2.10: Condensate Return	-338.7	13,412.40	13,073.70	91,220	714,000	7.80	2.10
ECO 2.12: Reduced Lighting Levels	71.7	----	71.70	309	518	1.70	7.02
Total (SIR>1.2 or SIR>1)	-278.3	16,107.00	15,828.70	110,220	796,735		

*Note 1: This ECO was evaluated in an earlier study by JRB Associates. WESTON has updated numbers to utilize existing fuel costs.

Three buildings were modelled using the Carrier E20-II operating Cost Analysis program to predict the existing annual operating costs of the buildings HVAC and non-HVAC energy consuming systems.

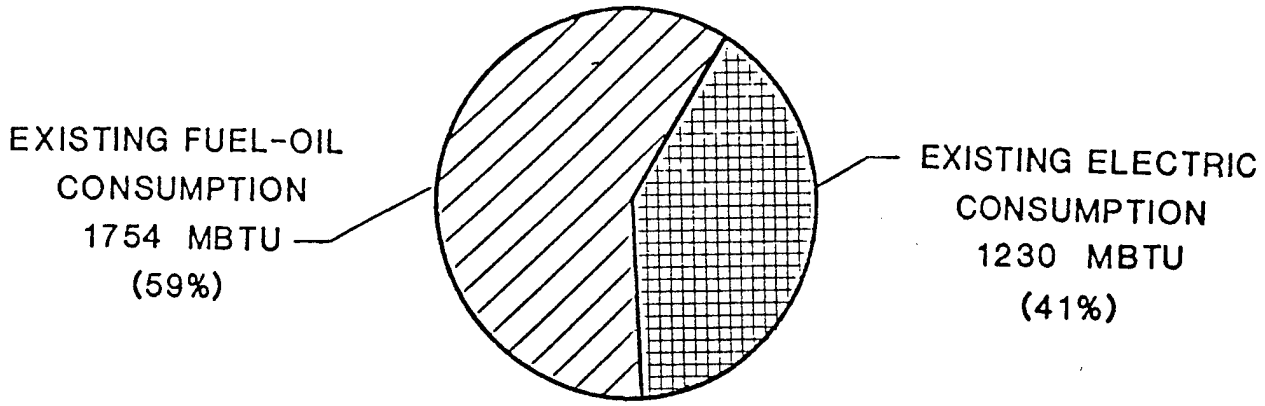
Comparing this with the annual energy savings per building, gives the percent energy savings for each building. The results are summarized below:

Bldg. No.	Total Savings Energy (MBTU)	Total Savings Cost ($)	Computed Annual Operating Cost ($)	Percent Cost Savings (%)
2353	1013.3	5,779	17,417	33.2
E1930	739.1	5,188	109,229	4.7
E5185	1,924.4	13,298	83,662	15.9

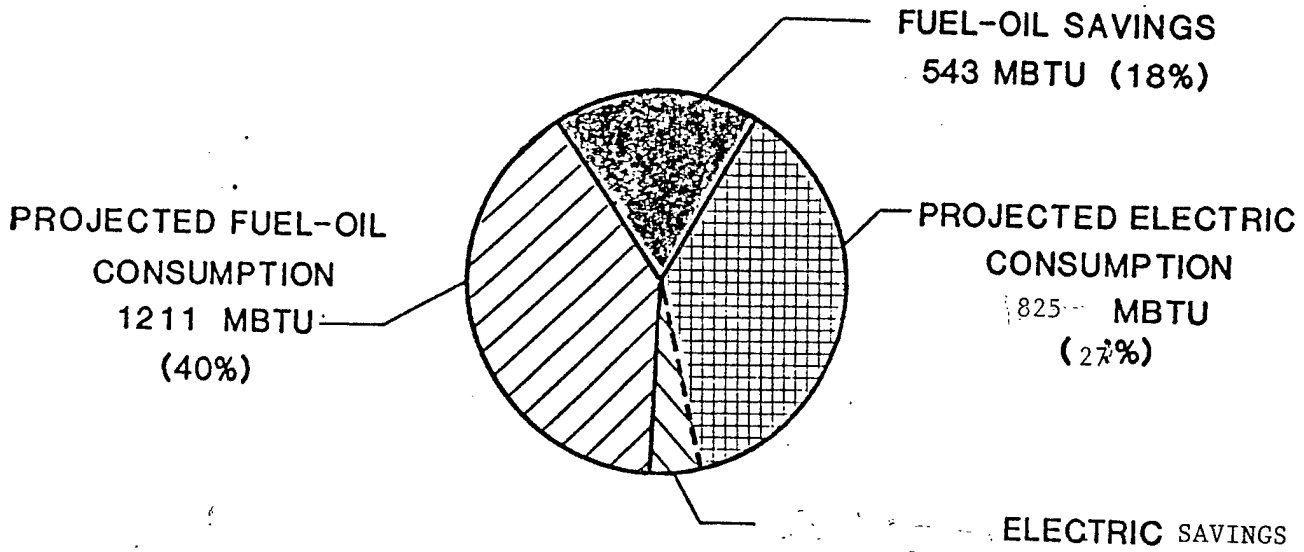
Figures 1-1 through 1-3 present the existing and projected annual energy consumption for Buildings 2353, E1930 and E5185. The existing consumption figures show the percent energy used for electricity and fuel-oil. The projected consumption shows the future fuel-oil and electric consumption and savings if the recommended ECO's for that building are implemented.

FIGURE 1-1

EXISTING AND PROJECTED ANNUAL ENERGY CONSUMPTION FOR BUILDING 2353 (BASE = FY 1985)



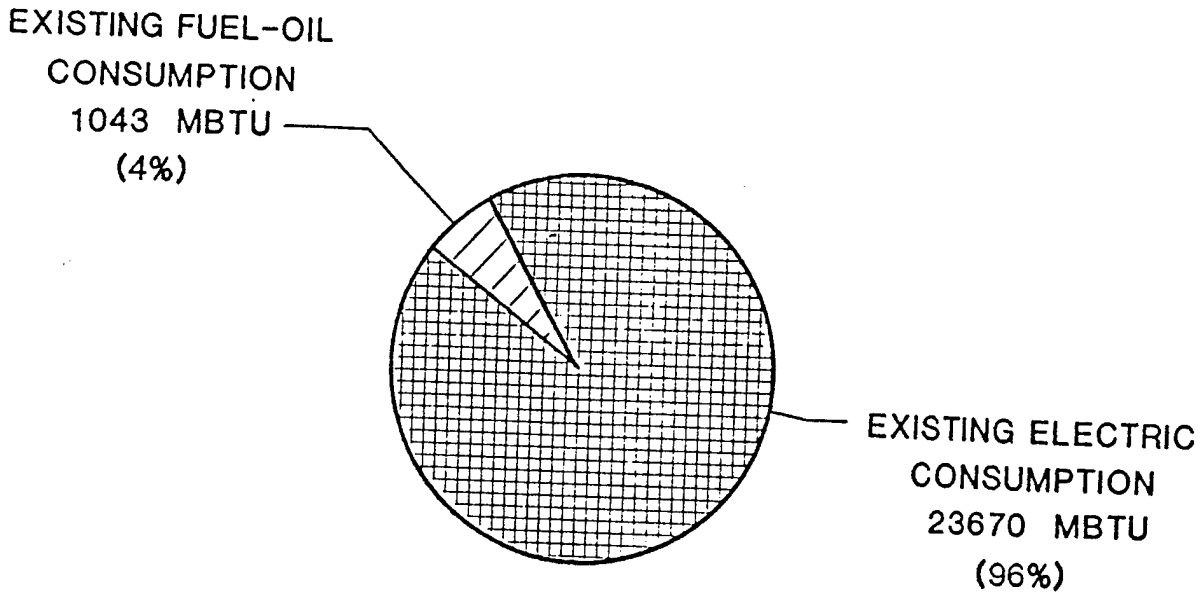
A. EXISTING



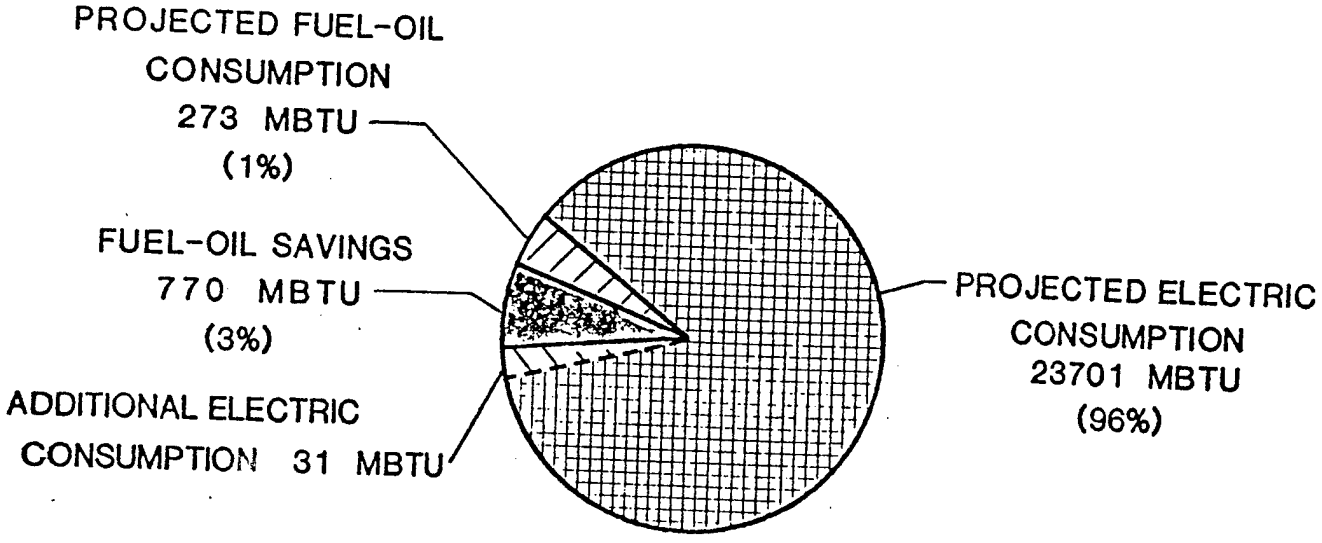
B. PROJECTED

FIGURE 1-2

EXISTING AND PROJECTED ANNUAL ENERGY CONSUMPTION FOR BUILDING E1930 (BASE = FY 1985)



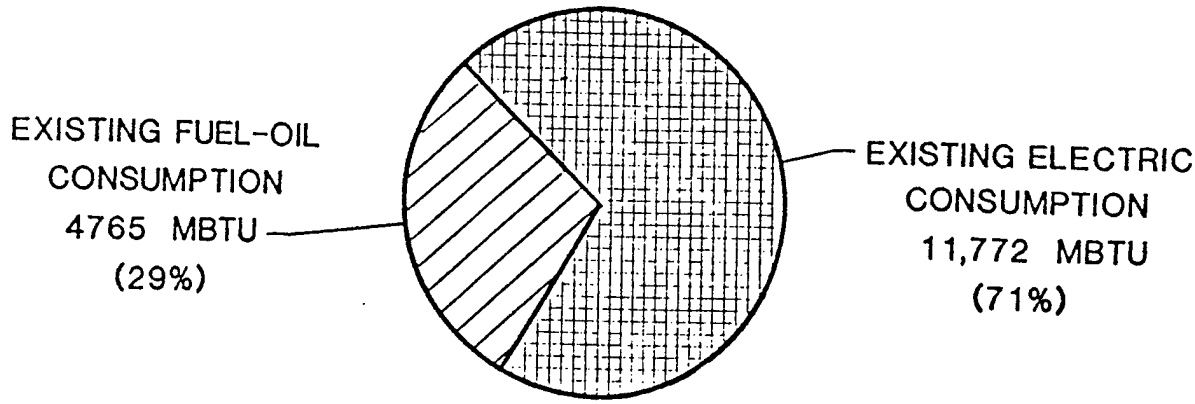
A. EXISTING



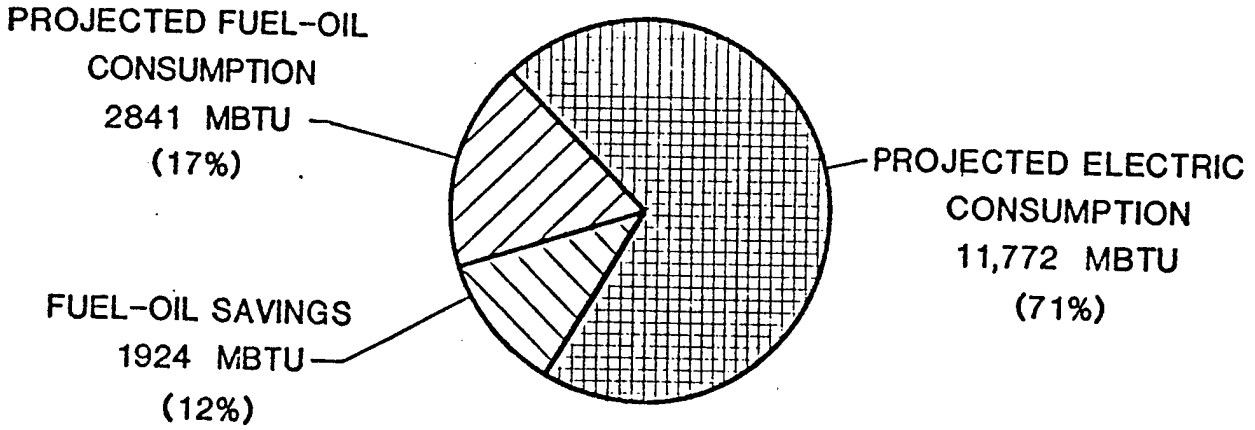
B. PROJECTED

FIGURE 1-3

EXISTING AND PROJECTED ANNUAL ENERGY CONSUMPTION FOR BUILDING E5185 (BASE = FY 1985)



A. EXISTING



B. PROJECTED

1.5 RECOMMENDED PROJECTS

Projects having SIR greater than 1.2 are grouped into one QRIP project, one PECIP project and one locally funded project. Two projects not included in the documentations are night setback and condensate return. Both these projects were documented as ECIP projects in an earlier study.

The projects recommended are:

PECIP Project #1: Miscellaneous building envelope and controls projects.

QRIP Project #1: Miscellaneous lighting projects.

Locally Funded Project: Wall insulation (Clay wall) - Building E1930

Table 1-4 through 1-6 summarize the PECIP, QRIP and locally funded projects. The total savings resulting from the various projects are:

- Total Annual Energy Savings = 1742.54 MBTU Electricity and 19211.1 MBTU Fuel-Oil
- Total Investment Required = $857,384
- Total Annual Savings = $140,441
- Simple Payback Period = 6.1 years.

TABLE 1-4

PECIP PROJECT 1: MISCELLANEOUS BUILDING ENVELOPE AND CONTROL PROJECTS

Opportunity	Annual Energy Savings Electricity (MBTU)	Fuel Oil (MBTU)	Total (MBTU)	Annual Savings ($)	Unescalated Current Working Estimate ($)	Simple Payback (Yrs)	SIR
Window Weatherization							
- Aberdeen (ECO 2.4)	----	265.4	265.5	1,835	8,457	4.6	1.23
- Edgewood (ECO 2.2)	----	1,924.4	1,924.4	13,298	61,747	4.6	1.22
Destratification:							
- Aberdeen (ECO 2.7)							
Bldg. 2353	-65.2	542.9	477.7	3,470	8,214	2.4	2.98
Bldg. 5220	-46.6	210.2	163.6	1,250	5,867	4.7	2.37
Bldg. 5221	-46.6	210.2	163.6	1,250	5,867	4.7	2.37
- Edgewood (ECO 2.8)	-31.1	300.8	269.7	1,944	3,520	1.8	6.17
Wall Insulation:							
- Edgewood (ECO 2.1) E1930 Plastic Wall	----	241.5	241.5	1,669	3,139	1.9	8.82
Install Thermostat and Control Valve in Bldg. 670 (ECO 2.2)	----	124.4	124.4	860	484	0.56	12.7
Upgrade Controls in Bldg. 393 (ECO 2.14)	----	78.0	78.0	539	399	0.74	9.65
Totals	-189.5	3,897.9	3,708.4	26,115	97,694	3.74	

PECIP Criteria: Cost > $3,000
Payback < 4 years

TABLE 1-5

QRIP PROJECT 1: MISCELLANEOUS LIGHTING PROJECTS

Opportunity	Annual Energy Savings Electricity (MBTU)	Fuel Oil (MBTU)	Total (MBTU)	Annual Savings ($)	Unescalated Current Working Estimate ($)	Simple Payback (Yrs)	SIR
Reduce Lighting Levels:							
- Aberdeen (ECO 2.10)	24.12	---	24.12	104	216	2.1	4.35
- Edgewood (ECO 2.12)	71.70	---	71.70	309	518	1.7	7.02
Replace Incandescent with Fluorescent Light							
- Aberdeen (ECO 2.11)	71.70	---	71.70	744	1,031	1.4	1.88
- Edgewood (ECO 2.5)	19.8	---	19.8	205	285	1.4	1.87
Replace Standard Fluorescent with Energy-Saving Fluorescent							
- Aberdeen (ECO 2.12)	388.7	---	388.7	1,675	932	0.56	4.91
Replace Incandescent	65.63	---	65.63	283	1,630	5.8	5.4
with HPS Lighting -Aberdeen (ECO 2-13)	535.64	---	535.64	2,309	9,782	4.2	4.37
Install Light Motion Sensors in Bldg. 393	1,039.44	---	1,039.44	4,480	10,600	2.4	2.7
Totals	2,216.73	---	2,216.73	10,109	25,264	2.5	

EDTE/OMA QRIP Criteria: Cost < $100,000
Payback < 2 years

TABLE 1-6

LOCALLY FUNDED PROJECT - WALL INSULATION (CLAY WALL) FOR BUILDING E1930

Opportunity	Annual Energy Savings			Annual Savings ($)	Unescalated Current Working Estimate ($)	Simple Payback (Yrs)	SIR
	Electricity (MBTU)	Fuel Oil (MBTU)	Total (MBTU)				
Wall Insulation (Clay Wall) Building E1930	----	227.9	227.9	1,575	13,526	8.60	1.93