Water Conservation Study (Water and Energy)
Energy Engineering Analysis Program (EEAP) FY94S
Fort Knox, Kentucky

Final Report

Volume 1 of 3

CONTRACT #DAC01-94-D-0034
SYSTEMS CORP PROJECT #94013.03
DECEMBER 30, 1994

Louisville District,
US Army Corps
of Engineers

SYSTEMS corp
SYSTEMS ENGINEERING AND MANAGEMENT CORPORATION
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Marie Wakefield,
Librarian Engineering
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1 EXECUTIVE SUMMARY

FY94S WATER CONSERVATION STUDY (WATER AND ENERGY), FT. KNOX, KY

1.1 SYNOPSIS

Systems Corp surveyed and completed water and energy analyses for 650 representative buildings at Fort Knox, categorized as unaccompanied personnel housing, community facilities, administrative facilities, maintenance facilities, training facilities, family housing, post laundry, hospital, heating plants, cooling towers, water treatment plants and water distribution systems. The water and energy conservation opportunities (ECOs) evaluated are listed in Table 1.1.

Cost estimates were prepared using MeansData for Windows Spreadsheets, Version 2.0a. Life cycle cost analyses were performed using the Life Cycle Cost in Design (LCCID) computer program. Project descriptions and DD1391 forms were prepared for four Energy Conservation Investment Program (ECIP) projects. The total of the four projects that were developed represent $893K in annual savings and a total discounted savings of $13.4M in the twenty year life of the projects. The simple paybacks average 5.6 years and the savings to investment (SIR) for the four ECIP projects average 2.8. In addition, three Federal Energy Management Program (FEMP) projects were developed. FEMP Project 1 is the replacement of all of the steam traps in the post laundry with a payback of 0.5 years and an SIR of 40. FEMP Project 2 is heating distribution system manhole repairs with a 3.4 year payback and an SIR of 5.5. FEMP Project 3 is the installation of wells to provide irrigation water for Lindsey and Anderson Greens with a 5.1 year payback and an SIR of 2.9.

1.2 INTRODUCTION

Systems Engineering and Management Corporation (Systems/Corp) was contracted by the Louisville District of the United States Army Corps of Engineers in August 1994 to perform a water conservation study of Fort Knox, Kentucky.

1.2.1 Scope of Work

1. Evaluate selected water and energy conservation opportunities (ECOs) to determine their water and energy savings potential and economic feasibility.

2. Conduct a limited site survey of selected buildings, family housing, heating plants, cooling towers and water distribution systems to insure any methods of water conservation which are practical and have not been evaluated in any previous study have been considered and the results documented.
<table>
<thead>
<tr>
<th>PROJECT</th>
<th>INITIAL COST ($)</th>
<th>ENERGY SAVINGS (MWH/HR)</th>
<th>SIMPLE PAYBACK PERIOD (YRS)</th>
<th>SIR</th>
<th>WATER AND MAINTENANCE SAVINGS ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECIP-FH1: Family Housing Water Conservation Phase 1</td>
<td>887,700</td>
<td>374</td>
<td>5.73</td>
<td>2.61</td>
<td>106,700</td>
</tr>
<tr>
<td>ECIP-FH2: Family Housing Water Conservation Phase 2</td>
<td>992,200</td>
<td></td>
<td>5.68</td>
<td>2.61</td>
<td>125,000</td>
</tr>
<tr>
<td>ECIP-FH3: Family Housing Water Conservation Phase 3</td>
<td>980,100</td>
<td></td>
<td>6.63</td>
<td>2.24</td>
<td>98,900</td>
</tr>
<tr>
<td>ECIP-4: Water Conservation Improvements to 452 Non-Family Housing Buildings</td>
<td>1,712,500</td>
<td>3,150</td>
<td>4.12</td>
<td>3.68</td>
<td>296,600</td>
</tr>
<tr>
<td>FEMP-1: Replacement of Steam Traps in Post Laundry</td>
<td>32,900</td>
<td>6,548</td>
<td>0.46</td>
<td>39.92</td>
<td>2,200</td>
</tr>
<tr>
<td>FEMP-2: Heating Distribution System Manhole Repairs</td>
<td>247,200</td>
<td>6,935</td>
<td>3.39</td>
<td>5.48</td>
<td></td>
</tr>
<tr>
<td>FEMP-3: Golf Course Irrigation Well System</td>
<td>36,900</td>
<td>-9</td>
<td>5.13</td>
<td>2.90</td>
<td>7,603</td>
</tr>
</tbody>
</table>
1. Executive Summary

FY94S Water Conservation Study (Water and Energy), Ft. Knox, KY

3. Determine efficiency of existing systems. Determine the replacement options with the highest SIR.

4. Provide complete programming or implementation documentation for all recommended ECOs.

5. Prepare a comprehensive report to document the work performed, the results, and the recommendations.

1.2.2 Organization of the Final Report

The submitted material for this report consists of the following:

Volume I: Executive Summary, Methods and Approach, ECIP Project 1, ECIP Project 2, and ECIP Project 3.
Volume III: FEMP Project 1, FEMP Project 2, FEMP Project 3, and Appendices A-D.

1.3 Present and Historical Water Consumption

The baseline water and energy consumption and the water and energy conservation opportunities were evaluated using spreadsheets to calculate water and energy consumption. These have been included in Section 3 through 9 of this report.

The energy, water and sewage treatment costs used to calculate the savings for the project are as follows:

<table>
<thead>
<tr>
<th>Cost/MBtu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric = $0.02505/KWH or $25.05/MWH</td>
</tr>
<tr>
<td>Fuel Oil = $5.05/MBtu or $17.15/MWH</td>
</tr>
<tr>
<td>Natural Gas = $3.10/MBtu or $10.51/MWH</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cost/Kgal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water = $0.9409/KGAL or $0.249/Kliter</td>
</tr>
<tr>
<td>Sewage = $0.6292/KGAL or $0.160/Kliter</td>
</tr>
</tbody>
</table>
1 EXECUTIVE SUMMARY

FY94S WATER CONSERVATION STUDY (WATER AND ENERGY), FT. KNOX, KY

1.4 ENERGY CONSERVATION OPPORTUNITIES INVESTIGATED

Systems Corp analyzed sixteen water and energy conservation opportunities (ECOs) at Fort Knox, Kentucky. The analysis was performed utilizing water and energy models developed by Systems Corp and data collected during the field survey of the facilities at Fort Knox. Each ECO was evaluated to determine the potential water and energy savings, dollar savings, implementation costs, simple payback, life cycle cost, and savings to investment ratio (SIR). The sixteen ECOs that were evaluated are as follows:

ECO-1  Spring-Loaded Faucets
ECO-2  Faucet Aerators
ECO-2FH  Faucet Aerators in Family Housing Units
ECO-3  Flush Valves for Water Closets
ECO-3FH  Water Closets in Family Housing Units
ECO-4  Flush Valve Retrofits for Urinals
ECO-5  Water Saving Showerheads
ECO-6  Dining Facility (Kitchen) Retrofits
ECO-7  Golf Course Irrigation
ECO-8  Post Laundry Retrofits
ECO-9  Water Treatment Plants and Well Field Motors and Pumps
ECO-10  Manhole Sump Pump Repairs
ECO-11  Sensor Controls
ECO-12  Water Heater Insulation Blanket
ECO-16  Ozone Treatment of Cooling Tower Water

Systems Corp’s water and energy analysis models were used to determine the savings achieved for implementing each ECO in the facilities evaluated. MeansData for Windows Spreadsheets, Version 2.0a cost estimating software was used to estimate the implementation cost of each ECO in each facility evaluated. The U.S. Army Corps of Engineers’ Life Cycle Cost in Design, Version 1.0, Level 92, software was used to perform life cycle cost analyses and determine the SIR of each ECO for each facility evaluated.

1.4.1 ECOs Recommended
Systems Corp recommended both ECOs evaluated be implemented, but not in every area surveyed. The following is a list of the ECOs recommended to be implemented by area surveyed. The criteria for recommendation is a favorable simple payback, and savings to investment ratio (SIR).

ECO-1  Spring-Loaded Faucets  
ECO-2  Faucet Aerators  
ECO-2FH  Faucet Aerators in Family Housing Units  
ECO-3  Flush Valves for Water Closets  
ECO-3FH  Water Closets in Family Housing Units  
ECO-4  Flush Valve Retrofits for Urinals  
ECO-6  Dining Facility (Kitchen) Retrofits  
ECO-7  Golf Course Irrigation  
ECO-8  Post Laundry Retrofits  
ECO-10  Manhole Sump Pump Repairs  

1.4.2 ECOs Rejected  

ECO-9, 11, 12, and 16 were rejected due to the large investment required, the low potential savings, or the existence of a more economically feasible technology. Refer to Appendix D for The Life Cycle Cost Analyses, Cost Estimates and Calculations.

1.4.3 ECIP and FEMP Projects Developed  

Systems Corp developed four ECIP projects and three FEMP projects (see Table 1.4.3). ECIP Family Housing Project 1 consists of the replacement of water closets in 1354 family housing units with water saving, 6-liters (1.6 gallons)-per-flush water closets, and the installation of faucet aerators in 328 family housing units. ECIP Family Housing Project 2 consists of the replacement of water closets in 1602 family housing units with water saving, 6-liters (1.6 gallons)-per-flush water closets. ECIP Family Housing Project 3 consists of the replacement of water closets in 1268 family housing units with water saving, 6-liters (1.6 gallons)-per-flush water closets. ECIP Project 4 consists of the replacement of flush valves and faucets in 452 buildings with water saving flush valves, metering valve faucets and the installation of faucet aerators. FEMP Project 1 consists of the replacement of all of the steam traps in Building 18, the Post Laundry. FEMP Project 2 consists of the repairs to the heating distribution system manholes for the underground distribution systems serving boiler plants in the following buildings: Buildings 852, 1537, 1725, 1731, 1785, 1797, 2780, 5213, 5943,
1 Executive Summary

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6615 and 7203. FEMP Project 3 consists of disconnecting the existing potable water supplies and drilling two wells, one each for the Lindsey and Anderson golf courses.
This section of the report describes the method and approach used by Systems Corp to complete the study. Of primary importance to the successful completion of a project of this magnitude is organization, planning and the ability to quickly document, evaluate and manipulate large amounts of data. This data must then be reduced to useable form which allows for full development of the various projects within the available funding categories. Four Energy Conservation Investment Program (ECIP) projects and three Federal Energy Management Program (FEMP) projects were developed.

2.1 FIELD SURVEY

The field survey as performed by Systems Corp was designed to provide the necessary data required to complete the Scope of Work for this project. It was also designed to provide residual benefits to the installation by providing an organized and readily available source of information which can be used in future years. The information was transmitted in the form of field notes using standardized survey forms.

The survey forms were designed to allow notations of all data which could be utilized (not necessarily required) to calculate the energy savings gained by implementing a specific energy conservation opportunity. These forms contain data obtained from as-built drawings and old energy studies confirmed in the fields as well as data obtained only in the field.

Thorough preparation for the building survey is required to ensure the data required to perform the technical analysis is obtained. The building surveys were performed in a manner which assured the best results. A simple listing of each step of the process best describes our approach to the surveys.

1. The list of Water and Energy Conservation Opportunities (ECOs) included in the work scope were reviewed in detail.
2. Each ECO was given an identification number which is used consistently throughout this project.
3. An expanded description of each ECO was formulated to outline the possible methods for implementation of the ECO.
4. Survey forms were developed for each ECO to provide space to enter any data which might possibly be used in performing the engineering and economic analysis of the ECO.
5. The building surveys were performed. Measurements of existing flow rates were made.
6. The Systems Corp survey team met with the post Energy Officer throughout the survey on an as-needed basis.
2 METHODS AND APPROACH
FY94S WATER CONSERVATION STUDY (WATER AND ENERGY), FT. KNOX, KY

2.1.1 Energy and Water Conservation Opportunities

The Systems Corp’s Water and Energy Conservation Team gathered field data and evaluated 18 distinct energy conservation opportunities. The energy conservation opportunities are listed following table:

<table>
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<tr>
<th>TABLE 2.1.1 Energy/Water Conservation Opportunities</th>
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<tbody>
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<tr>
<td>ECO - 2</td>
</tr>
<tr>
<td>ECO - 2FH</td>
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<td>ECO - 3</td>
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<td>ECO - 3FH</td>
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<td>ECO - 4</td>
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<td>ECO - 15</td>
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<tr>
<td>ECO - 16</td>
</tr>
</tbody>
</table>
2 METHODS AND APPROACH

FY94S WATER CONSERVATION STUDY (WATER AND ENERGY), FT. KNOX, KY

2.1.2 Energy and Water Conservation Opportunities That Were Not Evaluated

Systems Corp’s Water and Energy Conservation Team surveyed all facilities before any determination of the applicability of the energy conservation opportunity was made. After completing the field survey, ECO-13, ECO-14, ECO-15 and ECO-16 were discarded.

2.1.2.1 ECO-5 Water Saving Showerheads

During the field survey, it was determined that water saving 2.5 gpm showerheads were already in place. The ECO was discarded.

2.1.2.2 ECO-13 Distribution Waterlines, Motors, Valves, Leaks, Storage Towers and Tanks, Off Peak and Capacities

All pump motors were evaluated under ECO-9. No distribution leaks were discovered during the survey. In addition, Fort Knox Directorate of Public Works, Operation and Maintenance Personnel were interviewed to learn of any likely areas where distribution water lines were suspect. The new water storage tank project plans and specifications were reviewed. The post’s electrical demand profile and water treatment plant recorder charts were reviewed to determine the impact of water pumps on electric demand charges. Comparison of the data showed that peak water demand did not coincide with peak electrical demand periods. The ECO was discarded after completing these review steps.

2.1.2.3 ECO-14 Hospital Process Cooling

ECO-14 Hospital Process Cooling pertained to the use of potable water to perform cooling of X-ray, CAT scan, dialysis or medical equipment and any associated leaks. An extensive survey of Ireland Army Community Hospital was completed with excellent cooperation and assistance from the Hospital staff. No instances were found where potable water was being used to perform process cooling. Since no water saving opportunities relating to process cooling or any associated leaks were found, ECO-14 was eliminated.

2.1.2.4 ECO-15 Vehicle Wash Facilities

ECO-15 Vehicle Wash Facilities pertained to water saving opportunities relating to vehicle washing systems. The vehicle wash facilities are located adjacent to Building 7233 and at the intersection of Wilson Road and Frazier Road. The wash systems were found to be using rain water only which is
recycled after each use. No water conservation opportunities were found, and ECO-15 was eliminated.

2.1.3 Buildings Not Evaluated

The scope of work delineates which energy conservation opportunities are to be evaluated for buildings in each category code. A real property list, sorted by category code, was appended to the scope of work. The following tables list the buildings included in the real property list for which no energy conservation opportunities were evaluated. The title of each table describes the reason that no energy conservation opportunities were evaluated for the buildings in each list.

Table 2.1.3.1 is a listing of all of the buildings that were included in the real property listing, sorted by category codes, that do not have water service.

Table 2.1.3.2 is a listing of all of the buildings that were included in the real property listing, sorted by category codes, that are abandoned or not occupied.

Table 2.1.3.3 is a listing of all of the buildings that were included in the real property listing, sorted by category codes, that no longer exist.

Table 2.1.3.4 is a listing of all the buildings that were included in the real property listing, sorted by category codes, that are not located at Fort Knox.

Table 2.1.3.5 is a listing of all the buildings that were included in the real property listing, sorted by category codes, and are non-appropriated fund facilities (AAFES).

Refer to the following tables:

Table 2.1.3.1 Buildings Without Water - No ECOs Evaluated
Table 2.1.3.2 Buildings Abandoned or Not Occupied - No ECOs Evaluated
Table 2.1.3.3 Buildings That No Longer Exist - No ECOs Evaluated
Table 2.1.3.4 Buildings That Are Not Located at Fort Knox - No ECOs Evaluated
Table 2.1.3.5 Non-Appropriated Fund Facilities - No ECOs Evaluated
TABLE 2.1.3.1 BUILDINGS WITHOUT WATER  
NO ECOs EVALUATED

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2 METHODS AND APPROACH
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2.2 CALCULATIONS

Energy calculations were performed using computerized techniques. Due to the large volume of calculations to be performed, standardized spreadsheets and procedures were developed. This assured consistent results and uniformity of quality in all of the calculations performed.

2.2.1 Baseline Water and Energy Consumption

The annual potable water production for Fort Knox from July 1993 through June 1994 was 1,421,100,000 gallons. The volume of sewage treated was 1,055,500,000. The net volumetric difference between potable water produced and sewage treated is 365,600,000 gallons more of potable water produced. Factors that affect the net differences are irrigation, evaporation, and storm water infiltration. The annual rainfall corresponding to the same period came to 50 inches. It is quite possible that the metering methods are not accurate.

The following sections will describe the method for calculating the baseline energy consumption for each of the ECOs.

2.2.1.1 Baseline Water and Energy Consumption

The baseline water and energy consumption for each ECO was calculated using a LOTUS123 spreadsheet. The water consumption was modeled using industry standards, field measurements and population data at Fort Knox. The information necessary to calculate the baseline include the following:

1. Category Codes
2. Square Footage and Age
3. Occupancy Schedule
4. Plumbing Fixture Count
5. Water Flow Measurements
6. Fuel Sources

The above information was obtained during the field survey.

2.2.2 ECO Water and Energy Consumption

The following sections describe how the water and energy savings for each ECO was calculated.
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2.2.2.1 ECO Water and Energy Consumption: ECO-1 Spring Loaded Faucets

The water and energy savings are calculated using the differential between the measured existing flow rate and the new flow rate. The new flow rate is based upon manufacturer data. American Society of Heating, Refrigerating and Air-conditioning Engineers and American Society of Plumbing Engineer standards were used to estimate frequency of demand.

2.2.2.2 ECO Water and Energy Consumption: ECO-2 Faucet Aerators

The water and energy savings are calculated using the differential between the measured existing flow rate and the new flow rate. The new flow rate was obtained from manufacturer data. The new flowrate is 50% of the existing measured flowrate. American Society of Heating, Refrigerating and Air-conditioning Engineers standards were used to calculate daily consumption. Building occupancy data was used in the calculations.

2.2.2.3 ECO Water and Energy Consumption: ECO-2FH Faucet Aerators (Family Housing)

The water and energy savings are calculated using the differential between the measured existing flow rate and the new flow rate. The new flow rate was obtained from manufacturer data; the new flowrate is 50% of the existing measured flow rate. American Society of Heating, Refrigerating and Air-conditioning Engineers standards were used to calculate daily consumption. Family housing population data was used in the calculations.

2.2.2.4 ECO Water and Energy Consumption: ECO-3 Flush Valve Retrofits for Water Closets

The water and savings are calculated using the differential between the existing flow rate and the new flow rate. The existing flush valve flow rate of 4.5 gallons per flush, or 17 liters per flush, was determined in the field. The new flush valve flow rate of 3.5 gallons per flush, or 13.2 liters per flush, is based upon manufacturer performance data. American Society of Plumbing Engineers standards were used to estimate frequency of demand and daily consumption. Building occupancy data was used in the calculations.
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2.2.2.5 ECO Water Consumption: ECO-3FH Water Closet Replacements (Family Housing)

The water and savings are calculated using the differential between the existing flow rate and the new flow rate. The existing flow rate was determined in the field to be 5 gallons per flush, or 19 liters per flush. The new flow rate was based upon manufacturer data of 1.6 gallons per flush, or 6 liters per flush. American Society of Plumbing Engineers standards were used to estimate frequency of demand. Family housing population data was used in the calculations. Five flushes per day, per occupant, were used.

2.2.2.6 ECO Water Consumption: ECO-4 Flush Valve Retrofits for Urinals

The water and savings are calculated using the differential between the existing flow rate and the new flow rate. The existing flow rate of 1.5 gallons per flush, or 5.7 liters per flush, was measured in the field. The new flow rate of 1.0 gallons per flush, or 3.8 liters per flush, is based upon manufacturer performance data. American Society of Plumbing Engineers standards were used to estimate frequency of demand. Building occupancy data was used in the calculations.

2.2.2.7 ECO Water and Energy Consumption: ECO-6 Dining Facilities (Kitchen) Retrofits

The water and energy savings are calculated using the differential between the measured existing flow rate and the new flow rate. The retrofit evaluated consisted of installing aerators on the kitchen sinks that were not used for pot filling. The aerators were assumed to decrease the flow rate by 50% per manufacturer data. American Society of Heating, Refrigerating and Air-conditioning Engineers standards were used to estimate frequency of demand.

2.2.2.8 ECO Water and Energy Consumption: ECO-7 Golf Course Irrigation

The potable water meter readings were used to determine the annual consumption. The cost to switch to a raw water well supply was calculated using calculated pump run times and brake horsepower. The calculations were based upon a well depth of 200 feet and a casing size of six inches. The estimated well pump horse power is 75 horsepower per well.

2.2.2.9 ECO Water and Energy Consumption: ECO-8 Post Laundry Retrofits

The steam loss from failed steam traps was calculated using Napier's equation and boiler plant operating logs.
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2.2.2.10 ECO Water and Energy Consumption: ECO-9 Water Treatment Plant's and Well Field's Motors and Pumps

The existing water pump and motor efficiencies were evaluated. The water pumps were found to be very efficient. However, the pump motors were not high efficiency motors. The electrical savings were calculated for replacing the existing motors with high efficiency motors.

2.2.2.11 ECO Water and Energy Consumption: ECO-10 Manhole Sump Pump Repairs (Heating) Life Cycle Cost Analyses

The energy savings were determined by calculating the differential piping heat loss between piping in a flooded manhole and a dry manhole.

2.2.2.12 ECO Water and Energy Consumption: ECO-11 Sensor Controls for Faucets

The water and energy savings are calculated using the differential between the measured existing flow rate and the new flow rate. American Society of Heating, Refrigerating and Air-conditioning Engineers standards were used to estimate frequency of demand.

2.2.2.13 ECO Water and Energy Consumption: ECO-12 Water Heater Insulation Blankets (Family Housing)

The energy savings were determined by calculating the differential in heat loss between the water heater with, and without, the insulating blanket.

2.2.2.14 ECO Water Consumption: ECO-16 Cooling Tower Water Treatment

The water savings were calculated using the differential in blowdown rate between the existing chemical water treatment system and a new ozone water treatment system. The existing blowdown rate was determined in the field and is based upon 3 cycles of concentration. The cycles of concentration for the new ozone treatment system is calculated to be 6 cycles. The savings is the differential in the annual water blowdown losses and the cost of chemicals.

2.3 ECOs REJECTED AFTER ANALYSIS

ECOs 9, 11, 12, and 16 were rejected due to insufficient savings after calculations were completed.
2.3.1 ECO-9 Water Treatment Plants and Wellfield Motors and Pumps

The water treatment plant and well field motors were evaluated as ECO-9. Savings are based on the installation of high efficiency motors. The energy savings that result are not great enough to justify replacement of all motors at this time. It is recommended to install higher efficiency motors when the existing motors need to be replaced.

The LCCID report calculation sheet and cost estimate for ECO-9 are in Appendix D.

2.3.2 ECO-11 Sensor Controls for Faucets

Sensor controls for faucets, urinals and toilets were evaluated for two barracks. It is evident that the savings do not justify the cost to install these systems. Other ECOs have higher SIR and lower payback periods so sensors were not evaluated for all buildings.

The water savings is assumed to be equal to that calculated for ECO-1, ECO-3, and ECO-4. The LCCID reports and cost estimates are in Appendix D.

2.3.3 ECO-12 Water Heater Insulation Blankets

The addition of an insulation blanket on hot water heaters in family housing units does not result in significant energy savings. Most water heaters are well insulated and additional insulation does not reduce heat loss significantly. This ECO was evaluated for two family housing units. It is evident that the payback period and SIR are very poor, therefore no other buildings were evaluated for this ECO.

The LCCID reports, calculation sheets, and cost estimates for this ECO are in Appendix D.

2.3.4 ECO-16 Cooling Tower Water Treatment

The water and chemical savings calculated for switching from chemical water treatment to ozone water treatment were insufficient to achieve a payback of less than ten years. The cooling tower operates only six months a year. If the tower operated year round, the project may have had payback of less than ten years.

The calculation sheets for this ECO are in Appendix D.
2.4 COST ESTIMATES

The cost estimates for the ECOs were obtained using a variety of sources. This section explains how each part of the cost estimate was determined.

The initial cost for each ECO is the sum of the construction costs for the project and the project costs. The construction costs include all costs in materials, labor, and contractor's overhead and profit. The project costs include supervision, inspection, and overhead (SIOH) for the project and the project design costs.

2.4.1 Construction Costs

The construction costs for each ECO were estimated using MeansData for Windows Spreadsheets, Version 2.0a, cost estimating software. Prices not available in the accompanying database were obtained using a combination of sources. These sources include the following:

- Local suppliers and vendors
- Systems Corp Estimating Data

All pricing has been adjusted, where applicable, to represent the labor costs in the Fort Knox labor market. The construction cost estimates have been prepared to include a reasonable level of detail for each ECO calculated. The construction costs include an additional contingency and 10% profit. A minimum contingency of 10% was used, higher contingencies were used on some projects.

2.4.2 Project Costs

The project costs for each ECO include the cost of supervision, inspection, and overhead required to complete the project. A value of 5.0% of the construction cost has been used for the SIOH. Also included in the project costs is the cost to design each ECO. The design cost has been included at a fixed value of 5.0% of construction cost. This approach assures consistent values have been used for the project costs, allowing for combination of ECOs into larger projects without the need to adjust these values.

2.5 ECO LIFE CYCLE COSTS

The life cycle cost analyses for the ECOs are a combination of energy costs, investment costs, maintenance costs, and replacement costs. Each of these components may, or may not, be significant.
2 METHODS AND APPROACH

FY94S WATER CONSERVATION STUDY (WATER AND ENERGY), FT. KNOX, KY

Factors in determining the life cycle cost of the project. Each of these cost components has been evaluated for each ECO to determine the contribution, if any, to the life cycle cost of the project.

The life cycle costs were calculated using the computer program Life Cycle Costing in Design (LCCID) as required in the Scope of Work.

2.5.1 Energy and Water Costs

Energy costs for each type of fuel used in the facilities included in this project were obtained from the installation and through the Defense Energy Information System (DEIS). The costs were obtained along with the amount of energy used for FY93. Average annual water, sewage and energy costs per unit were calculated. Electricity, fuel oil and natural gas are the only sources of energy related to the study.

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<tr>
<td>Electric</td>
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<table>
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<tr>
<th>Cost/Kgal</th>
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<tbody>
<tr>
<td>Water</td>
</tr>
<tr>
<td>Sewage</td>
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</table>

2.5.2 Maintenance and Replacement Costs

The maintenance and operating costs/savings for each ECO were calculated, where applicable. First considered was whether the annual recurring (maintenance and operation) non-energy costs would significantly change as a result of each ECO. These values are sometimes unjustifiably manipulated to produce the desired results for the project economic analysis. Therefore, it was typically assumed maintenance and operation activities will continue at the same rate as before the project. However,
readily identifiable differences, such as boiler maintenance, have been included. The estimated costs were obtained from the Means Facilities Maintenance and Repair Costs Data, 1994. These costs are shown on each corresponding life cycle summary sheet included in this report.

The replacement costs (non-energy non-annual recurring cost) for each ECO will be evaluated in the same manner as non-energy annual recurring cost. An example of this type of cost item is the replacement of the cartridge in spring-loaded faucets.

It is the policy of Systems Corp to be conservative when estimating these more subjective cost components—which, if improperly evaluated, could result in inappropriate project qualification and funding decisions.
This section contains the project description and the DD1391 forms for ECIP Project FH-1, Family Housing Water Conservation Phase I improvements to 328 Family Housing Units. Two lists of the buildings included in the project follow the DD1391 forms. The first list includes all buildings considered in the project in numerical order. The second list shows which buildings were used to model unsurveyed buildings. Following these lists are the LCCID report and the cost estimate for the proposed project. Calculation sheets for the individual buildings follow the project cost estimate. Below is a detailed index of the information included in this section.

DD1391 Form .......................................................... 3-2
Table 3.1 ECIP FH-1 - Family Housing ......................... 3-6
Table 3.2 Buildings Modeled bySurveyed Buildings .......... 3-9
Project LCCID Report .............................................. 3-11
Cut Sheets/Product Information .................................. 3-12
Project Cost Estimate .............................................. 3-13
Building Calculation Sheets ..................................... 3-16
DATE: 22 December 1994
PROJECT NO.: ECIP-FH1
PROJECT TITLE: Family Housing Water Conservation Phase I
INSTALLATION: Fort Knox
LOCATION: Kentucky

PRIMARY FACILITY
Water Closets and Faucet Aerators $887,000

ESTIMATED CONTRACT COST $733,636
CONTINGENCY PERCENT (10%) 73,364
SUBTOTAL 807,000
SUPERVISION, INSPECTION & OVERHEAD (5%) 40,350
DESIGN COST 40,350
TOTAL REQUEST 887,700
TOTAL REQUEST (ROUNDED) $888,000

Replace water closets in 1354 family housing units with water saving, 6 liters (1.6 gallons) per flush water closets, and install faucet aerators in 328 family housing units. All water closets will be of the flush tank type. The project will significantly reduce potable water consumption and sanitary waste production.
DATE: 22 December 1994
PROJECT NO.: ECIP-FH1
PROJECT TITLE: Family Housing Water Conservation Phase I
INSTALLATION: Fort Knox
LOCATION: Kentucky

PROJECT:
Replace water closets in 1354 family housing units with water saving, 6 liters (1.6 gallons) per flush water closets, and install faucet aerators in 328 family housing units.

REQUIREMENTS:
Fort Knox utilizes inefficient outdated water closets in its family housing units. The existing water closets consume significantly more water and generate greater quantities of sanitary waste per flush than the new standard water saving water closet. The existing inefficient systems place greater demand on the water table, water treatment plant and waste treatment plant. The U.S. Army Corp of Engineers, Louisville District, contracted an Energy Engineering Analysis Program (EEAP) Water Conservation Study of the Post. The study identified energy and water conservation opportunities. Life cycle cost analysis was performed on each opportunity to determine its discounted savings-to-investment ratio (SIR) and estimated payback period. This project has a SIR of 2.61 and a simple payback period of 5.73 years. The project exceeds the minimum requirements of an SIR greater than 1.25 and a simple payback of less than 10 years.

CURRENT SITUATION:
The family housing units at Ft. Knox have inefficient water closets and lack aerators at many sinks. The family housing units consume more water and generate more sanitary waste than is necessary. The new water closets and aerators will greatly reduce the water consumption and waste generated.

IMPACT IF NOT PROVIDED:
If this project is not implemented, 1354 family housing units will continue to consume more water and generate more waste than necessary. The U.S. Army will fail to realize an estimated $155K in annual savings (FY95$) and a total discounted savings of $2.32M during the twenty year life of the project.
ADDITIONAL:
A life cycle cost analysis was performed on the project. The project will realize water savings of over 2.6 times the initial investment cost and will pay for itself in less than 5.8 years.

Ft. Knox is not on the list of installations considered for closure or realignment.
SECTION 11 - ECONOMIC ANALYSIS DATA

11D ECONOMIC JUSTIFICATION SUMMARY
This water conservation project is recommended for funding. A life cycle cost analysis was performed on each portion of this project and on the overall project. The overall project will realize water savings of over 2.6 times the initial investment cost and will pay for itself in less than 5.8 years.
<p>| 414 B | 443 A | 1201 | 1436 A |
| 414 A | 447  | 1202 | 1436 B |
| 415 A | 448  | 1203 | 1438 B |
| 415 B | 449 B | 1204 | 1438 A |
| 416 A | 449 A | 1401 | 1439 A |
| 416 B | 450  | 1402 | 1439 B |
| 417 A | 451 A | 1403 | 1440 A |
| 417 B | 451 B | 1404 | 1440 B |
| 418 A | 452 A | 1405 | 1441 B |
| 418 B | 452 B | 1406 | 1441 A |
| 419  | 453 B | 1408 | 1442 A |
| 419 B | 453 A | 1409 | 1442 B |
| 420 B | 454 A | 1410 | 1443 B |
| 420 A | 454 B | 1411 A| 1443 A |
| 421 B | 455 A | 1411 B| 1444 A |
| 421 A | 455 B | 1412 | 1444 B |
| 422 A | 456 B | 1413 A| 1444 A |
| 422 B | 456 A | 1413 B| 1445 B |
| 423  | 457 B | 1416 A| 1446 B |
| 424  | 457 A | 1416 B| 1446 A |
| 425  | 458 B | 1417 | 1447  |
| 426  | 458 A | 1418 A| 1453 B |
| 427  | 459 A | 1419 B| 1453 A |
| 431 A | 459 B | 1419 A| 1454 B |
| 431 B | 460 B | 1420 A| 1454 A |
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| 432 B | 461 A | 1422 A| 1455 A |
| 434 B | 461 B | 1422 B| 1457 A |
| 434 A | 462 B | 1423 | 1457 B |
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| 436 A | 1120 | 1426 | 1458 A |
| 436 B | 1122 | 1427 | 1458 A |
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| 437 B | 1125 B| 1429 A| 1459 A |
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| 438 B | 1126 B| 1430 B| 1460 B |
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| 440 A | 1132 | 1432 B| 1462 B |
| 441 A | 1133 | 1433 B| 1463 A |
| 441 B | 1134 | 1433 A| 1463 B |
| 442 A | 1135 | 1434 A| 1464 B |
| 442 B | 1136 | 1434 B| 1464 A |
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| 1465 B | 4257 | 4332 B | 7511 A |
| 1466 B | 4258 | 4332 A | 7511 B |
| 1466 A | 4259 | 4333 A | 7512 A |
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| 4026  | 4262 | 4334 B | 7513 B |
| 4027  | 4263 | 4335 B | 7514 A |
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| 4030  | 4265 | 4336 B | 7515 A |
| 4031  | 4266 | 4336 A | 7515 B |
| 4032  | 4267 | 4338 B | 7516 B |
| 4033  | 4268 | 4338 A | 7516 A |
| 4034  | 4269 | 4339 B | 7518 B |
| 4035  | 4270 | 4339 A | 7518 A |
| 4036  | 4271 | 4340 B | 7518 B |
| 4037  | 4272 | 4341 B | 7519 A |
| 4038  | 4273 | 4341 B | 7519 B |
| 4039  | 4274 | 4341 A | 7520 A-H |
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| 4041  | 4277 | 4342 B | 7521 A |
| 4043  | 4278 | 4343 A | 7522 B |
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| 4046  | 4281 | 4351  | 7523 A |
| 4047  | 4282 | 4354  | 7523 B |
| 4048  | 4283 | 4356  | 7524 A-H |
| 4049  | 4284 | 4357  | 7525 A |
| 4086  | 4285 | 4358  | 7526 B |
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| 4088  | 4287 | 4360  | 7527 B |
| 4089  | 4288 | 4361  | 7527 A |
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| 4092  | 4303 A| 4363 B | 7529 A |
| 4093  | 4303 B| 4363 A | 7529 B |
| 4094  | 4305 A| 4363  | 7530 A |
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| 4099  | 4307 B| 4365 B | 7532 A |
| 4100  | 4307 A| 4367  | 7532 B |
| 4102  | 4308 A| 4369  | 7533 A |
| 4103  | 4308 B| 5054  | 7533 B |
| 4105  | 4310 A| 5314  | 7534 B |
| 4106  | 4330 B| 7480 A-H| 7534 A |
| 4107  | 4330 A| 7493 A-H| 7535 A |
| 4113  | 4331 B| 7510 A | 7535 B |
| 4114  | 4331 A| 7510 B | 7536 A |
| 7536 B | 7556 B | 7874 B | 9045 A-D |
| 7537 B | 7557 A | 7874 A | 9046 A-H |
| 7537 A | 7557 B | 7876 B | 9047 A-H |
| 7538 A | 7558 A | 7876A | 9048 A, C-H |
| 7538 B | 7558 B | 7878A | 9049 A-H |
| 7539 A | 7559 A | 7878B | 9052 A-H |
| 7539 B | 7559 B | 7801 B - 7820 B | 9053 |
| 7540 B | 7740 A-H | 7801 A - 7868 A | 9053 A, C-H |
| 7540 A | 7744 A-G | 7822 B - 7833 B | 9054 A-G |
| 7541 A | 7745 A-H | 7835 B - 7860 B | 9055 A-H |
| 7541 B | 7746 A-D | 7862 B - 7872 B | 9056 A-D |
| 7542 B | 7747 B-G | 7870 A - 7872 A | 9057 A-H |
| 7542 A | 7747 A-H | 7880 B - 7888 B | 9058 A-H |
| 7543 A | 7748 A-G | 7880 A - 7888 A | 9060 A-D |
| 7544 A | 7749 B-G | 7982 A-D | 9110 A-H |
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| 7551 B | 7760 A-H | 9032 A-H | 9142 A - 9163 A |
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| 7552 B | 7761 B-D | 9036 A-H | 9206 |
| 7553 A | 7762 A-D | 9037 A-D | 9211 |
| 7553 B | 7762 B-C | 9038 A-H | 9222 |
| 7554 A | 7770 A-D | 9039 A-H | 11127 B |
| 7554 B | 7770 B-C | 9040 A-C | 13435 B |
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| 7555 B | 7821 | 9042 A-H |
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</tbody>
</table>
1. INVESTMENT
A. CONSTRUCTION COST $ 807000.
B. SIOH $ 40350.
C. DESIGN COST $ 40350.
D. TOTAL COST (1A+1B+1C) $ 887700.
E. SALVAGE VALUE OF EXISTING EQUIPMENT $ 0.
F. PUBLIC UTILITY COMPANY REBATE $ 0.
G. TOTAL INVESTMENT (1D - 1E - 1F) $ 887700.

2. ENERGY SAVINGS (+)/COST (-)
DATE OF NISTIR 85-3273-X USED FOR DISCOUNT FACTORS OCT 1994
UNIT COST SAVINGS ANNUAL $ DISCOUNT DISCOUNTED
FUEL / MWH(1) MWH/YR(2) SAVINGS(3) FACTOR(4) SAVINGS(5)
A. ELECT $ 46.40 0. $ 0. 15.08 $ 0.
B. DIST $ .00 0. $ 0. 18.57 $ 0.
C. RESID $ .00 0. $ 0. 21.02 $ 0.
D. NAT G $ 10.51 374. $ 3931. 18.58 $ 73033.
E. COAL $ .00 0. $ 0. 16.83 $ 0.
F. PPG $ .00 0. $ 0. 17.38 $ 0.
M. DEMAND SAVINGS 0. $ 0.
N. TOTAL 374. $ 3931. $ 73033.

3. NON ENERGY SAVINGS (+)/COST (-)
A. ANNUAL RECURRING (+/-) $ 106686.
   (1) DISCOUNT FACTOR (TABLE A) 14.88
   (2) DISCOUNTED SAVING/COST (3A X 3A1) $ 1587488.
B. NON RECURRING SAVINGS (+)/COSTS (-)
   SAVINGS (+) YR DISCNT DISCOUNTED
   ITEM COST (-) OC FACTR SAVINGS (+)/
   (1) (2) (3) COST (-) (4)
1. REPLACEMENT $ 887700. 10 .74 656898.
d. TOTAL $ 887700. 656898.
C. TOTAL NON ENERGY DISCOUNTED SAVINGS (+)/COST (-) (3A2+3Bd4) $ 2244386.

4. FIRST YEAR DOLLAR SAVINGS 2N3+3A+(3Bd1/(YRS ECONOMIC LIFE)) $ 155002.
5. SIMPLE PAYBACK PERIOD (1G/4) 5.73 YEARS
6. TOTAL NET DISCOUNTED SAVINGS (2N5+3C) $ 2317419.

7. SAVINGS TO INVESTMENT RATIO (SIR)= (6 / 1G)= 2.61
   (IF < 1 PROJECT DOES NOT QUALIFY)
   **** Project does not qualify for ECIP funding; 4,5,6 for information only.

8. ADJUSTED INTERNAL RATE OF RETURN (AIRR): N/A
• Water-saving 1.5 gallon flush.
• Features Pressure-Clean™ flushometer tank system.
• Three-bolt quick connect system with factory-installed tank gasket and bolts.

K-3458 Wellworth Lite PC Toilet, vitreous china, 1.5 gallon flush. Close-coupled design with elongated bowl. Minimum roughing-in is 12" (305 mm).

Tank/bowl combination includes K-4333 bowl, K-4470 vitreous china tank with Kohler 81100 flushometer tank system, K-4471 tank cover and K-8434 chrome-plated trip lever.

IMPORTANT—For most satisfactory operation, a minimum static water pressure of 25 P.S.I. is required at the toilet supply inlet.

Recommended Seats and Supply
K-4650 Lustra™ solid plastic seat with open front and cover.
K-4652 Lustra solid plastic seat with closed front and cover.
K-4670-C Lustra solid plastic seat (K-4681-C Black Black™) with open front and check hinge.
K-7637 ¾" angle supply with stop.

Tank Locks—Add suffix “-T” to product number.

Bedpan Lugs—Add suffix “-L” to product number.

For complete color selection, see Colors section.
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<th>Line #</th>
<th>Description</th>
<th>Manhours</th>
<th>Matl</th>
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U15 MECHANICAL 7818 $449,868 $222,251 $0 $0 $672,119
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30-Dec-94  MeansData for Lotus  Page 2
Estimate: ECO - 2 & 3  Date: 15-Dec-94
Description: INSTALL AERATORS & WATER CLOSETS - FAMILY HOUSING
Project: LIMITED EEAP (WTR) Bid Date:
Location: FORT KNOX, KY  Job #: 94013.03
Sq. footage: FAM HSG - GP 1  City index: Louisville, KY

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SYSTEMS CORP Systems Engineering and Management Corporation, Knoxville, TN
## FACILITY NO.: 450 A&B
### Function: UNACCOM PERS HOUS DET FAC TYPICAL OF 58 UNITS
### Occupancy: FAMILY
### Operating Hours: 24

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**SYSTEMS CORP**

Systems Engineering and Management Corporation, Knoxville, TN
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**FACILITY NO.: 450 A&B**

**Water Rate:** 0.42 $/KL

**Energy Rate:**

**Gas Rate:** 10.51 $/MWH

**Demand Rate:**

**SYSTEMS CORP**

Systems Engineering and Management Corporation, Knoxville, TN
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**SYSTEMS CORP**

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**TOTAL:**

- **Water:** $420.33
- **Energy:** $80.96
- **Total:** $501.29

**Dollars Invested:** $60.00

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**SYSTEMS CORP**

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**TOTAL:**

- Water Rate: 0.42 $/KL
- Gas Rate: 10.51 $/MWH
- Energy Rate: 0.89 $/KWH
- Demand Rate: 43.946 kWh

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Systems Engineering and Management Corporation, Knoxville, TN
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**TOTALS:**

- **ECO1 TOTAL:** LPM: 2, Water Leaks: 0
- **ECO2 TOTAL:** LPF: 1, #FL/YR: 1, Water Leaks: 0
- **ECO3 TOTAL:** LPF: 1, #FL/YR: 1, Water Leaks: 0
- **ECO4 TOTAL:** LPM: 1, HRS/YR: 0, Water Leaks: 0
- **ECO5 TOTAL:** TEMP: 1, Water Leaks: 0
- **ECO6 TOTAL:** 1, 0
### FY94S EEAP FT. KNOX WATER CONSERVATION STUDY

**CALCULATION WORK SHEET 2**

**FACILITY NO.:** 4358  
**Water Rate:** 0.42 $/KL  
**Energy Rate:** $/KWH  
**Gas Rate:** 10.51 $/MWH  
**Demand Rate:** $/KW

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**ECO2 TOTAL:**

**ECO3 TOTAL:**

**ECO4 TOTAL:**

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**Systems Engineering and Management Corporation, Knoxville, TN**
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**ECO6 TOTAL:**

**SYSTEMS CORP**

Systems Engineering and Management Corporation, Knoxville, TN
# FY94S EEAP FT. KNOX WATER CONSERVATION STUDY

## CALCULATION WORK SHEET 2

**FACILITY NO.:** 5314 D  
**Water Rate:** 0.42 $/KL  
**Energy Rate:** [Blank] $/KWH  
**Gas Rate:** 10.51 $/MWH  
**Demand Rate:** [Blank] $/KW

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## FY94S EEAP FT. KNOX WATER CONSERVATION STUDY

### CALCULATION WORK SHEET 2

**FACILITY NO.:** 5475 D  
**Water Rate:** 0.42 $/KL  
**Energy Rate:**  
**Gas Rate:** 10.51 $/MWH  
**Demand Rate:**  

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Systems Engineering and Management Corporation, Knoxville, TN
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# FY94S EEAP FT. KNOX WATER CONSERVATION STUDY

**CALCULATION WORK SHEET 2**

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## FY94S EEAP FT. KNOX WATER CONSERVATION STUDY

**Calculation Work Sheet 1**

### Facility No.:

7869 A

### Function:

Unaccom Pers Hous Det Fac Typical of 84 Units

### Occupancy:

Family

### Operating Hours:

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**SYSTEMS CORP**

Systems Engineering and Management Corporation, Knoxville, TN
This section contains the project description and the DD1391 forms for ECIP Project FH-2, Family Housing Water Conservation Phase II improvements to 1,602 Family Housing Units. Two lists of the buildings included in the project follow the DD1391 forms. The first list includes all buildings considered in the project in numerical order. The second list shows which buildings were used to model unsurveyed buildings. Following these lists are the LCCID report and the cost estimate for the proposed project. Calculation sheets for the individual buildings follow the project cost estimate. Below is a detailed index of the information included in this section.

DD1391 Form ................................................................. 4-2
Table 4.1 - ECIP FH-2 - Family Housing .......................... 4-6
Table 4.2 - Buildings Modeled by Surveyed Buildings ........ 4-7
Project LCCID Report ...................................................... 4-8
Catalog Cut Sheets/Product Information ......................... 4-9
Project Cost Estimate ....................................................... 4-10
Building Calculation Sheets ............................................ 4-13
DATE: 22 December 1994
PROJECT NO.: ECIP-FH2
PROJECT TITLE: Family Housing Water Conservation Phase II
INSTALLATION: Fort Knox
LOCATION: Kentucky

PRIMARY FACILITY
    Water Closets $993,000

ESTIMATED CONTRACT COST $820,000
CONTINGENCY PERCENT (10%) 82,000
SUBTOTAL 902,000
SUPERVISION, INSPECTION & OVERHEAD (5%) 45,100
DESIGN COST 45,100
TOTAL REQUEST 992,200
TOTAL REQUEST (ROUNDED) $993,000

Replace water closets in 1602 family housing units with water saving, 6 liters (1.6 gallons) per flush water closets. All water closets will be of the flush tank type. The project will significantly reduce potable water consumption and sanitary waste production.
DATE: 22 December 1994
PROJECT NO.: ECIP-FH2
PROJECT TITLE: Family Housing Water Conservation Phase II
INSTALLATION: Fort Knox
LOCATION: Kentucky

PROJECT:
Replace water closets in 1602 family housing units with water saving, 6 liters (1.6 gallons) per flush water closets.

REQUIREMENTS:
Fort Knox utilizes inefficient outdated water closets in its family housing units. The existing water closets consume significantly more water and generate greater quantities of sanitary waste per flush than the new standard water saving water closet. The existing inefficient systems place greater demand on the water table, water treatment plant and waste treatment plant. The U.S. Army Corp of Engineers, Louisville District, contracted an Energy Engineering Analysis Program (EEAP) Water Conservation Study of the Post. The study identified energy and water conservation opportunities. Life cycle cost analysis was performed on each opportunity to determine its discounted savings-to-investment ratio (SIR) and estimated payback period. This project has a SIR of 2.61 and a simple payback period of 5.68 years. The project exceeds the minimum requirements of an SIR greater than 1.25 and a simple payback of less than 10 years.

CURRENT SITUATION:
The family housing units at Ft. Knox have inefficient water closets. The family housing units consume more water and generate more sanitary waste than is necessary. The new water closets will greatly reduce the water consumption and waste generated.

IMPACT IF NOT PROVIDED:
If this project is not implemented, 1602 family housing units will continue to consume more water and generate more waste than necessary. The U.S. Army will fail to realize an estimated $175K in annual savings (FY95$) and a total discounted savings of $2.59M during the twenty year life of the project.
ADDITIONAL:
A life cycle cost analysis was performed on the project. The project will realize water savings of over 2.6 times the initial investment cost and will pay for itself in less than 5.7 years.

Ft. Knox is not on the list of installations considered for closure or realignment.
22 December 1994
ECIP-FH2
Family Housing Water Conservation Phase II
Fort Knox
Kentucky

SECTION 11 - ECONOMIC ANALYSIS DATA

11D ECONOMIC JUSTIFICATION SUMMARY

This water conservation project is recommended for funding. A life cycle cost analysis was performed on each portion of this project and on the overall project. The overall project will realize water savings of over 2.6 times the initial investment cost and will pay for itself in less than 5.7 years.
| 4404 A-L | 4521 A-E | 4889 A-F | 5310 A-H |
| 4408 A-D | 4801 A-D | 4891 A-F | 5311 A-H |
| 4414 A-F | 4806 A-D | 4898 A-D | 5320 A-H - 5330 A-H |
| 4417 A-D | 4807 A-D | 4899 A-F | 5334 A-H |
| 4418 A-L | 4808 A-F | 4902 A-D | 5336 A-H |
| 4422 A-D | 4810 A-F | 4903 A-D | 5337 A-H |
| 4423 A-L | 4811 A-D | 4904 A-F | 5339 A-H |
| 4427 A-L | 4813 A-D | 4907 A-D | 5340 A-H |
| 4431 A-F | 4814 A-D | 4908 A-L | 5342 A-H |
| 4434 A-F | 4816 A-D | 4913 A-D | 5344 A-H |
| 4443 A-D | 4822 A-D | 4917 A-D | 5353 |
| 4454 A-D | 4827 A-F | 4926 A-L | 5400 A-H |
| 4455 A-D | 4829 A-L | 4930 A-D | 5406 A-D |
| 4456 | 4833 A-L | 4931 A-F | 5406 F-H - 5409 A-H |
| 4464 A-D | 4842 A, C-F | 4936 A-L | 5415 A-H |
| 4465 A-D | 4844 A-L | 4940 A-F | 5417 A-H |
| 4468 A-D | 4850 A-L | 4946 A-D | 5425 A-H |
| 4469 A-D | 4854 A-D | 4947 A-F | 5427 A-H |
| 4471 A-D - 4473 A-D | 4855 A-D | 4950 A-D | 5430 A-H |
| 4476 A-L | 4859 | 4955 A-D | 5438 A-H |
| 4480 A-L | 4859 B-D - 4861 A-D | 4957 A-L | 5441 A-H |
| 4486 A-D | 4865 A-H | 4967 A-F | 5444 A-H |
| 4488 A-L | 4868 A-F | 4969 A-K | 5446 A-H |
| 4492 A-L | 4870 | 4973 A-D | 5447 A-H |
| 4496 | 4870 A-L | 4974 A-F | 5449 A-H |
| 4496 B-D - 4498 A-D | 4874 A-D | 4976 A-D | 5450 A-H |
| 4499 A-L | 4875 A-K | 4977 A-F | 5452 A-H |
| 4503 A, C-D | 4879 A-D | 4979 A-F | 5454 A-H |
| 4504 A-L | 4880 A-F | 4981 A-F | 5455 A-H |
| 4512 A-H | 4884 A-F | 4985 A-DE | 5461 A-H |
| 4515 A-F | 4887 A-D | 4987 A-F |
### Table 4.2 Buildings Modeled by Surveyed Buildings

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<th>Buildings Surveyed and Calculated</th>
<th>Buildings Assumed Typical of Surveyed Buildings</th>
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LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: ECIP-FH2
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP) LCID FY95 (92)
INSTALLATION & LOCATION: FT KNOX REGION NO. 4 CENSUS: 3
PROJECT NO. & TITLE: ECIP-FH2 FAMILY HOUSING PROJECT 2
FISCAL YEAR 1995 DISCRETE PORTION NAME: WATER
ANALYSIS DATE: 12-27-94 ECONOMIC LIFE 20 YEARS PREPARED BY: DERRINGTON

1. INVESTMENT
   A. CONSTRUCTION COST $ 902000.
   B. SIOH $ 45100.
   C. DESIGN COST $ 45100.
   D. TOTAL COST (1A+1B+1C) $ 992200.
   E. SALVAGE VALUE OF EXISTING EQUIPMENT $ 0.
   F. PUBLIC UTILITY COMPANY REBATE $ 0.
   G. TOTAL INVESTMENT (1D - 1E - 1F) $ 992200.

2. ENERGY SAVINGS (+) / COST (-)
   DATE OF NISTIR 85-3273-X USED FOR DISCOUNT FACTORS OCT 1994
   UNIT COST SAVINGS ANNUAL $ DISCOUNT DISCOUNTED
   FUEL $/ MWH(1) MWH/YR(2) SAVINGS(3) FACTOR(4) SAVINGS(5)
   A. ELECT $ 46.40 0. $ 0. 15.08 $ 0.
   B. DIST $ .00 0. $ 0. 18.57 $ 0.
   C. RESID $ .00 0. $ 0. 21.02 $ 0.
   D. NATG $ 10.51 0. $ 0. 18.58 $ 0.
   E. COAL $ .00 0. $ 0. 16.83 $ 0.
   F. PPG $ .00 0. $ 0. 17.38 $ 0.
   M. DEMAND SAVINGS $ 0. $ 0. 14.88 $ 0.
   N. TOTAL $ 0. $ 0. $ 0.

3. NON ENERGY SAVINGS (+) / COST (-)
   A. ANNUAL RECURRING (+/-)
      (1) DISCOUNT FACTOR (TABLE A) $ 125000.
      (2) DISCOUNTED SAVING/COST (3A X 3A1) 14.88 $ 1860000.
   B. NON RECURRING SAVINGS (+) / COSTS (-)
      SAVINGS(+) YR DISCNT DISCOUNTED
      ITEM COST(-) OC FACTR SAVINGS(+) /
      (1) (2) (3) (4)
      1. REPLACEMENT $ 992200. 10 .74 734228.
   d. TOTAL $ 992200. 734228.
   C. TOTAL NON ENERGY DISCOUNTED SAVINGS (+)/COST(-) (3A2+3Bd4)$ 2594228.

4. FIRST YEAR DOLLAR SAVINGS 2N3+3A+(3Bd1/(YRS ECONOMIC LIFE))*$ 174610.
5. SIMPLE PAYBACK PERIOD (1G/4) 5.68 YEARS
6. TOTAL NET DISCOUNTED SAVINGS (2N5+3C) $ 2594228.
7. SAVINGS TO INVESTMENT RATIO (SIR)=(6 / 1G)= 2.61
   (IF < 1 PROJECT DOES NOT QUALIFY)
   **** Project does not qualify for ECIP funding; 4,5,6 for information only.
8. ADJUSTED INTERNAL RATE OF RETURN (AIRR): N/A
- Water-saving 1.5 gallon flush.
- Features Pressure-Clean™ flushometer tank system.
- Three-bolt quick connect system with factory-installed tank gasket and bolts.

**K-3458 Wellworth Lite PC Toilet**, vitreous china, 1.5 gallon flush. Close-coupled design with elongated bowl. Minimum roughing-in is 12" (305 mm).

Tank/bowl combination includes K-4333 bowl, K-4470 vitreous china tank with Kohler 81100 flushometer tank system, K-4471 tank cover and K-9434 chrome-plated trip lever.

**IMPORTANT**—For most satisfactory operation, a minimum static water pressure of 25 P.S.I. is required at the toilet supply inlet.

Recommended Seats and Supply
- K-4650 Lustra™ solid plastic seat with open front and cover.
- K-4652 Lustra solid plastic seat with closed front and cover.
- K-4670-C Lustra solid plastic seat (K-4681-C Black Black™) with open front and check hinge.
- K-7637 ¾" angle supply with stop.

Tank Locks—Add suffix "-T" to product number.

Bedpan Lugs—Add suffix "-L" to product number.

For complete color selection, see Colors section.
30-Dec-94

MeansData for Lotus

-------------------------------
Estimate: ECO - 3  Date: 15-Dec-94
Description: INSTALL WATER CLOSETS - FAMILY HOUSING
Project: LIMITED EEAP (WTR) Bid Date: 
Location: FORT KNOX, KY  Job #: 94013.03
Sq. footage: FAM HSG - GP 2  City index: Louisville, KY
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**ECO6 TOTAL:**

| Description | |
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**SYSTEMS CORP**

Systems Engineering and Management Corporation, Knoxville, TN
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SYSTEMS CORP
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**SYSTEMS CORP** Systems Engineering and Management Corporation, Knoxville, TN
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| ECO3 TOTAL: | LPF | LPF | 2 | 0 |
| ECO4 TOTAL: | LPM | LPM | 0 | 0 |
| ECO5 TOTAL: | TEMP | TEMP | 2 | 0 |
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### FY94S EEAP FT. KNOX WATER CONSERVATION STUDY

**FACILITY NO.: 5353 F**

**FUNCTION:** UNACCOM PERS HOUS DET FAC TYPICAL OF 711 UNITS

**Occupancy:** FAMILY

**Operating Hours:** 24

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**SYSTEMS CORP**

Systems Engineering and Management Corporation, Knoxville, TN
**FY94S EEAP FT. KNOX WATER CONSERVATION STUDY**

**CALCULATION WORK SHEET 2**

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**SYSTEMS CORP**

Systems Engineering and Management Corporation, Knoxville, TN
This section contains the project description and the DD1391 forms for ECIP Project FH-3, Family Housing Water Conservation Phase III improvements to 1,268 Family Housing Units. Two lists of the buildings included in the project follow the DD1391 forms. The first list includes all buildings considered in the project in numerical order. The second list shows which buildings were used to model unsurveyed buildings. Following these lists are the LCCID report and the cost estimate for the proposed project. Calculation sheets for the individual buildings follow the project cost estimate. Below is a detailed index of the information included in this section.

DD1391 Form ......................................................... 5-2
Table 5.1 ECIP FH-3 - Family Housing .......................... 5-6
Table 5.2 Buildings Modeled by Surveyed Buildings ............ 5-7
Project LCCID Report ............................................. 5-8
Catalog Cut Sheets/Product Information .......................... 5-9
Project Cost Estimate ............................................. 5-10
Building Calculation Sheets ..................................... 5-13
**DATE:** 22 December 1994  
**PROJECT NO.:** ECIP-FH3  
**PROJECT TITLE:** Family Housing Water Conservation Phase III  
**INSTALLATION:** Fort Knox  
**LOCATION:** Kentucky

**PRIMARY FACILITY**  
Water Closets  

**ESTIMATED CONTRACT COST**  
$810,000  
**CONTINGENCY PERCENT (10%)**  
81,000  
**SUBTOTAL**  
891,000  
**SUPERVISION, INSPECTION & OVERHEAD (5%)**  
44,550  
**DESIGN COST**  
44,550  
**TOTAL REQUEST**  
980,100  
**TOTAL REQUEST (ROUNDED)**  
$981,000

Replace water closets in 1268 family housing units with water saving, 6 liters (1.6 gallons) per flush water closets. All water closets will be of the flush tank type. The project will significantly reduce potable water consumption and sanitary waste production.
DATE: 22 December 1994
PROJECT NO.: ECIP-FH3
PROJECT TITLE: Family Housing Water Conservation Phase III
INSTALLATION: Fort Knox
LOCATION: Kentucky

PROJECT:
Replace water closets in 1268 family housing units with water saving, 6 liters (1.6 gallons) per flush water closets.

REQUIREMENTS:
Fort Knox utilizes inefficient outdated water closets in its family housing units. The existing water closets consume significantly more water and generate greater quantities of sanitary waste per flush than the new standard water saving water closet. The existing inefficient systems place greater demand on the water table, water treatment plant and waste treatment plant. The U.S. Army Corp of Engineers, Louisville District, contracted an Energy Engineering Analysis Program (EEAP) Water Conservation Study of the Post. The study identified energy and water conservation opportunities. Life cycle cost analysis was performed on each opportunity to determine its discounted savings-to-investment ratio (SIR) and estimated payback period. This project has a SIR of 2.24 and a simple payback period of 6.63 years. The project exceeds the minimum requirements of an SIR greater than 1.25 and a simple payback of less than 10 years.

CURRENT SITUATION:
The family housing units at Ft. Knox have inefficient water closets. The family housing units consume more water and generate more sanitary waste than is necessary. The new water closets will greatly reduce the water consumption and waste generated.

IMPACT IF NOT PROVIDED:
If this project is not implemented, 1268 family housing units will continue to consume more water and generate more waste than necessary. The U.S. Army will fail to realize an estimated $148K in annual savings (FY95$) and a total discounted savings of $2.2M during the twenty year life of the project.
ADDITIONAL:
A life cycle cost analysis was performed on the project. The project will realize water savings of over 2.2 times the initial investment cost and will pay for itself in less than 6.7 years.

Ft. Knox is not on the list of installations considered for closure or realignment.
SECTION 11 - ECONOMIC ANALYSIS DATA

11D ECONOMIC JUSTIFICATION SUMMARY

This water conservation project is recommended for funding. A life cycle cost analysis was performed on each portion of this project and on the overall project. The overall project will realize water savings of over 2.2 times the initial investment cost and will pay for itself in less than 6.7 years.
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*Surveyed building not included in this project. It is covered under Project Group 1.
LIFE CYCLE COST ANALYSIS SUMMARY

STUDY: ECIP-FH3
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP)
INSTALLATION & LOCATION: FT KNOX
REGION NOS. 4
CENSUS: 3
PROJECT NO. & TITLE: ECIP-FH3 FAMILY HOUSING PROJECT 3
FISCAL YEAR 1995
DISCRETE PORTION NAME: WATER
ANALYSIS DATE: 12-27-94
ECONOMIC LIFE 20 YEARS
PREPARED BY: DERRINGTON

1. INVESTMENT
A. CONSTRUCTION COST $ 891000.
B. SIOH $ 44550.
C. DESIGN COST $ 44550.
D. TOTAL COST (1A+1B+1C) $ 980100.
E. SALVAGE VALUE OF EXISTING EQUIPMENT $ 0.
F. PUBLIC UTILITY COMPANY REBATE $ 0.
G. TOTAL INVESTMENT (1D - 1E - 1F) $ 980100.

2. ENERGY SAVINGS (+) / COST (-)
DATE OF NISTIR 85-3273-X USED FOR DISCOUNT FACTORS OCT 1994

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3. NON ENERGY SAVINGS (+) / COST (-)

A. ANNUAL RECURRING (+/-)
(1) DISCOUNT FACTOR (TABLE A) $ 98900.
(2) DISCOUNTED SAVING/COST (3A x 3A1) $ 1471632.

B. NON RECURRING SAVINGS (+) / COSTS (-)

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C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+)/COST(-) (3A2+3Bd4) $ 2196906.

4. FIRST YEAR DOLLAR SAVINGS 2N3+3A+(3Bd1/(YRS ECONOMIC LIFE)) $ 147905.

5. SIMPLE PAYBACK PERIOD (1G/4) 6.63 YEARS

6. TOTAL NET DISCOUNTED SAVINGS (2N5+3C) $ 2196906.

7. SAVINGS TO INVESTMENT RATIO (SIR) = (6 / 1G) = 2.24
(If < 1 PROJECT DOES NOT QUALIFY)

**** Project does not qualify for ECIP funding; 4,5,6 for information only.

8. ADJUSTED INTERNAL RATE OF RETURN (AIRR): N/A
- Water-saving 1.5 gallon flush.
- Features Pressure-Clean™ flushometer tank system.
- Three-bolt quick connect system with factory-installed tank gasket and bolts.

**K-3458** Wellworth Lite PC Toilet, vitreous china, 1.5 gallon flush. Close-coupled design with elongated bowl. Minimum roughing-in is 12" (305 mm).

Tank/bowl combination includes K-4333 bowl, K-4470 vitreous china tank with Kohler 8100 flusohmeter tank system, K-4471 tank cover and K-9434 chrome-plated trip lever.

**IMPORTANT**—For most satisfactory operation, a minimum static water pressure of 25 P.S.I. is required at the toilet supply inlet.

Recommended Seats and Supply
- K-4650 Lustra™ solid plastic seat with open front and cover.
- K-4652 Lustra solid plastic seat with closed front and cover.
- K-4670-C Lustra solid plastic seat (K-4671-C Black Black™) with open front and check hinge.
- K-7637 ¾" angle supply with stop.

Tank Locks—Add suffix "-T" to product number.

Bedpan Lugs—Add suffix "-L" to product number.

*For complete color selection, see Colors section.*
Estimate: ECO - 3  Date:  15-Dec-94
Description: INSTALL WATER CLOSETS - FAMILY HOUSING
Project: LIMITED EEAP (WTR) Bid Date:
Location: FORT KNOX, KY  Job #:  94013.03
Sq. footage: FAM HSG - GP 3  City index: Louisville, KY

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30-Dec-94
MeansData for Lotus

Estimate: ECO - 3     Date: 15-Dec-94
Description: INSTALL WATER CLOSETS - FAMILY HOUSING
Project: LIMITED EEAP (WTR) Bid Date:
Location: FORT KNOX, KY    Job #: 94013.03
Sq. footage: FAM HSG - GP 3    City indx: Louisville, KY

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SUMMARY
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ECO2 TOTAL: LPF
ECO3 TOTAL: LPF
ECO4 TOTAL: LPM
ECO5 TOTAL: TEMP
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SYSTEMS CORP Systems Engineering and Management Corporation, Knoxville, TN
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SYSTEMS CORP

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- #FL/YR: 2
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- TEMP: 19
- TEMP: 9.5
- #FL/YR: 2
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**ECO6 TOTAL:**
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# FY94S EEAP FT. KNOX WATER CONSERVATION STUDY

**CALCULATION WORK SHEET 2**

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**SYSTEMS CORP**

Systems Engineering and Management Corporation, Knoxville, TN
### FY94S EEAP FT. KNOX WATR CONSERVATION STUDY

**CALCULATION WORK SHEET 1**

**FACILITY NO.:** 5568 B  
**FUNCTION:** UNACCOM PERS HOUS DET FAC  
**TYPICAL OF 188 UNITS**

**DATE:** 5 OCT 94

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**ECO6 TOTAL:**

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**SYSTEMS CORP**  
Systems Engineering and Management Corporation, Knoxville, TN
**FY94S EEAP FT. KNOX WATER CONSERVATION STUDY**

**CALCULATION WORK SHEET 2**

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**TOTAL:**

**WATER:**

**TOTAL**

**Dollars Invested:**

- **WATER:**
  - **Total:** $90.33
  - **Total Dollars Invested:** $60.00

**Annual Water Saving:**

- **Annual Energy Saving:**
  - **ELEC KW:**
  - **ELEC KWH:**
  - **GAS MWH:**

**FY94S EEAP FT. KNOX WATER CONSERVATION STUDY**

**CALCULATION WORK SHEET 2**

**SYSTEMS CORP** Systems Engineering and Management Corporation, Knoxville, TN
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Systems Engineering and Management Corporation, Knoxville, TN
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**SYSTEMS CORP**

Systems Engineering and Management Corporation, Knoxville, TN
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<th>Existing Fixture System Description</th>
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