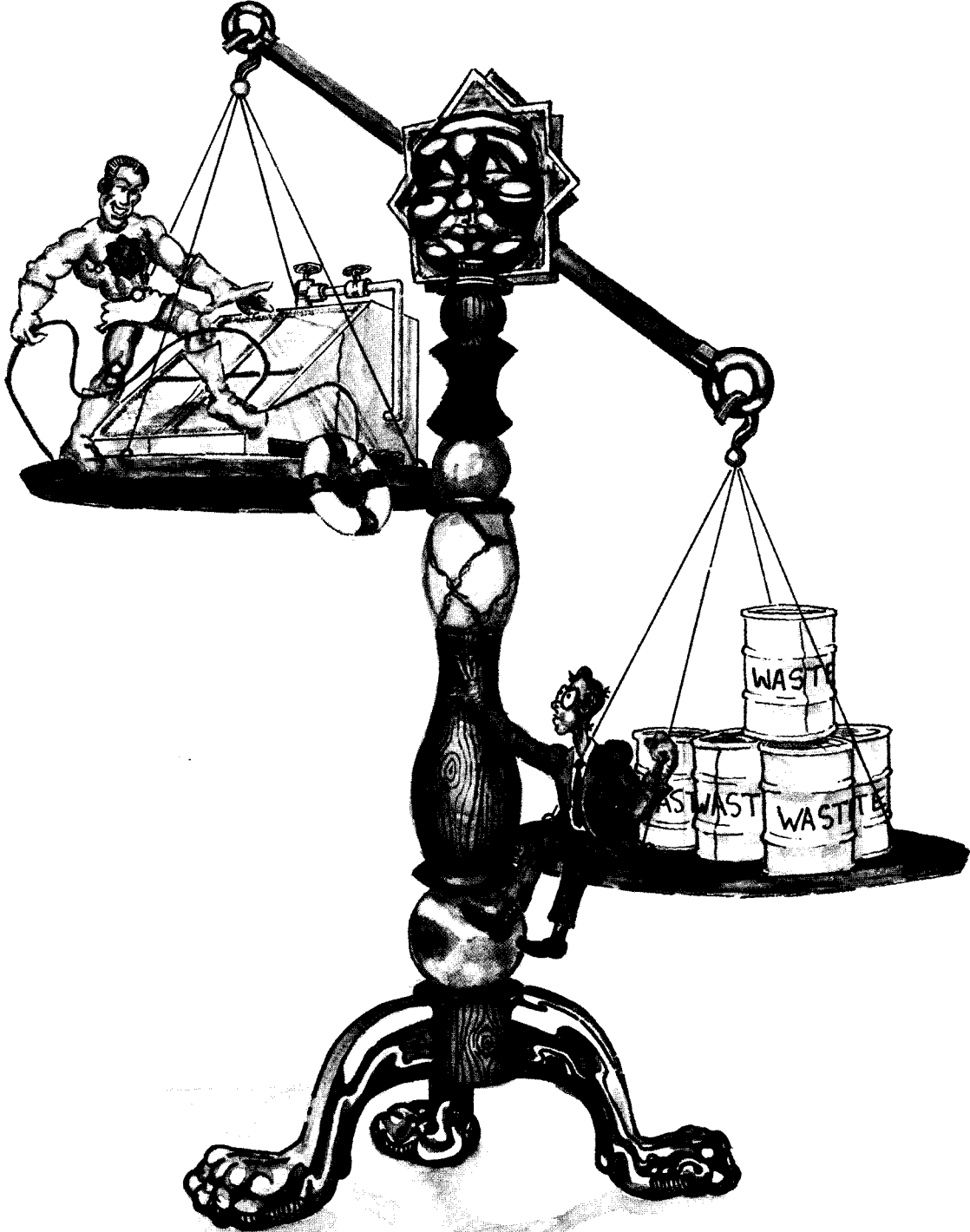


# Reducing Waste Management Costs Using Solar Evaporators



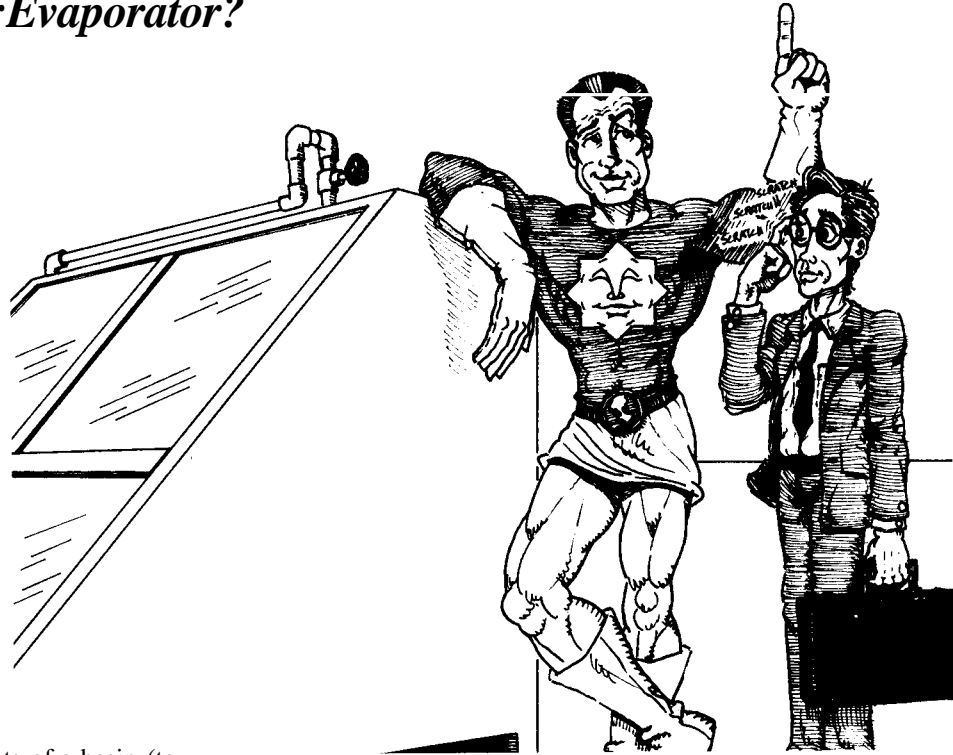
# Reducing Waste Management Costs Using Solar Evaporators

## *What is a Solar Evaporator?*

A solar evaporator is a device which uses clean, renewable solar energy to reduce the volume of liquid waste. The reduced waste volume means that you will spend less money to properly dispose of the waste. Given the costs of complying with numerous federal and state laws to protect the environment, those cost savings can be critical to the cost competitiveness of your business.

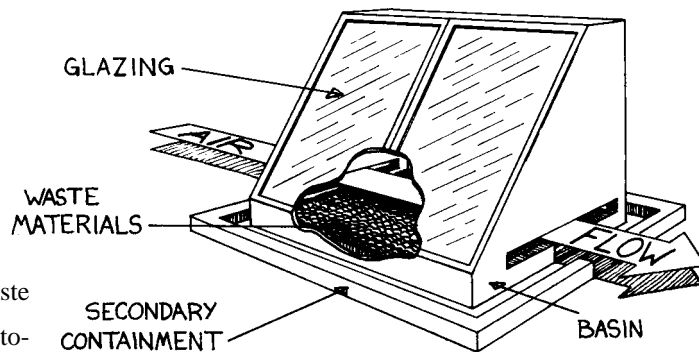
A solar evaporator consists of a basin (to hold the waste stream) covered by transparent glazing. The glazing admits solar radiation, increasing the rate of evaporation of the waste stream. The glazing also prevents rain water from further diluting the waste material. Air vents in the side of the basin allow natural air flow to enhance evaporation and remove vapors.

Because of its simple design, the solar evaporator requires little maintenance and uses no purchased energy to operate. Operation consists of moving the liquid waste material into the basin and removing the concentrated waste from the basin. This can be accomplished with automatic or manual controls, depending upon the relative location of the solar evaporator and the waste stream as well as the level of sophistication desired.

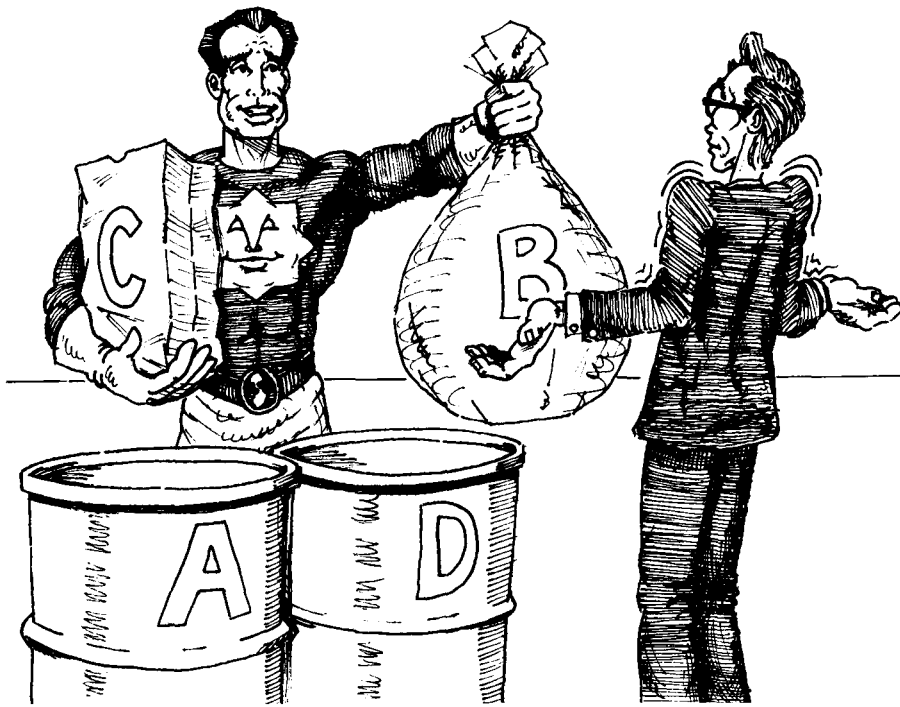


# SOLAR

EVAPORATOR



## *What types of waste can a Solar Evaporator reduce?*



A Solar evaporator can reduce the volume of aqueous water-based waste streams. The waste must be a material that remains in solution where only water will evaporate (usually an organic). This ensures that nothing harmful to the environment is released into the air as the water evaporates. The waste should not contain any mercury or arsenic.

Your state environmental agency can provide specific advice about the types of waste which you can safely treat in a solar evaporator. See Appendix A for a list of state and regional environmental agencies. Your environmental consultant should be able to provide laboratory tests to confirm the suitability of treating your particular waste in a solar evaporator.

Examples of wastes which have been treated in solar evaporators include spent metal plating solutions (low vapor-pressure salts) and aqueous machine tool coolant solutions. As production and use of CFC's (chlorofluorocarbons) for cleaning electronic circuit boards is restricted, water-based cleaners may replace them. This will provide new applications for solar evaporator technology.

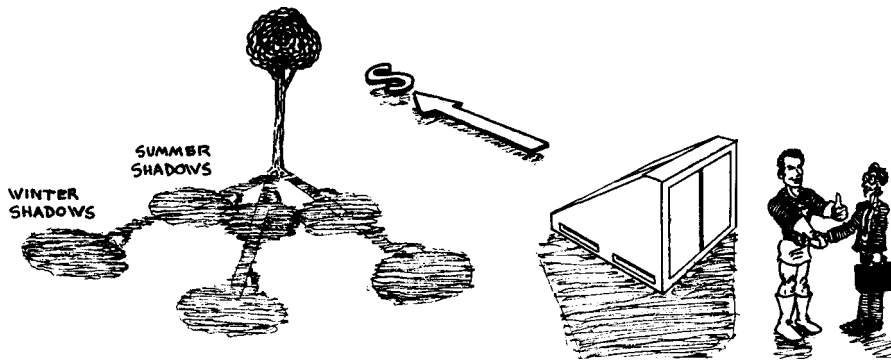
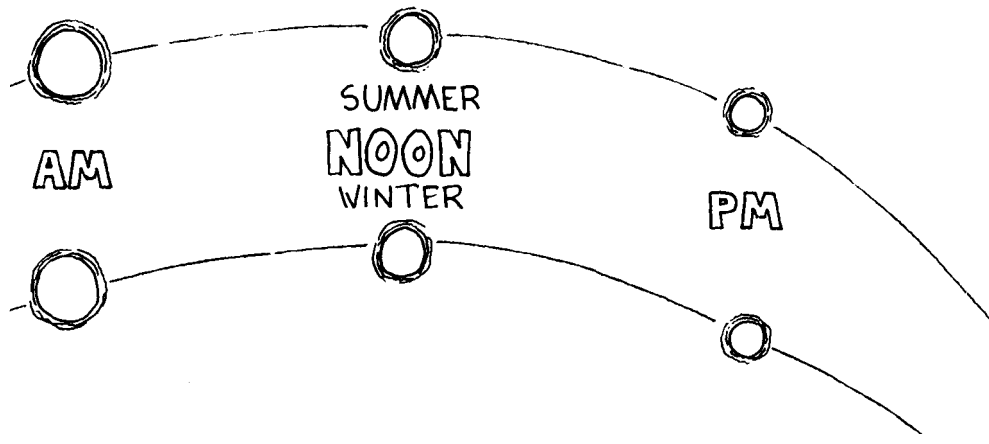
## *What laws pertain to waste minimization with solar evaporators?*

Depending upon the type of waste you are treating and the size of your operation, several federal and state laws may pertain to use of a solar evaporator. Since it is a new technology, and since the laws can be very complicated to interpret and apply to a given situation, it is important to discuss the issues with your environmental consultant and the appropriate regulatory agency.

Federal regulations include the Clean Water Act (CWA), Clean Air Act (CAA) and the Resource Conservation and Recovery Act (RCRA). The Clean Water Act is intended to protect the quality of surface water. The U.S. Environmental Protection Agency (EPA) has established limits for contaminants in direct water discharges from industry and manages their efforts in this



## *where can I put a Solar Evaporator?*



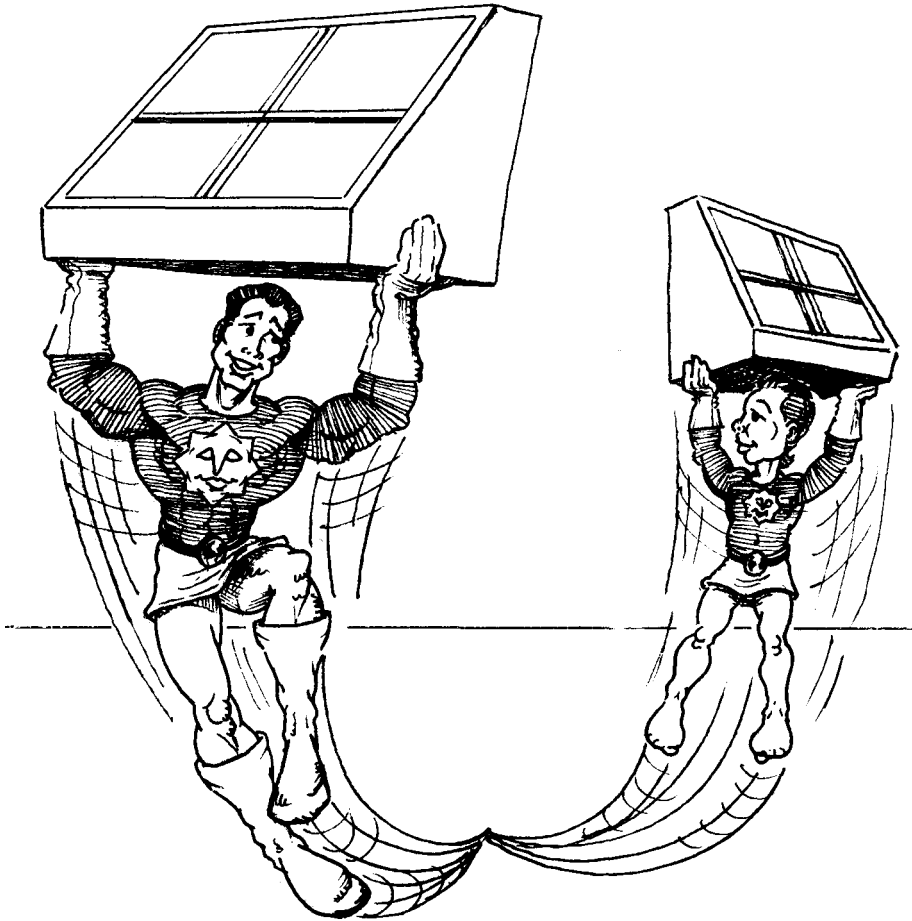
A solar evaporator needs to be placed in a location that has good exposure to the sun at all times. It should also be as close as practical to the source of the waste to minimize material handling requirements. For ease of maintenance, provide room for access to the evaporator by a fork lift or other equipment used to move drums or to clean or move the evaporator. In most cases, some type of secondary containment should be provided in case the evaporator ever leaks or material is spilled while being moved in or out of the evaporator.

To insure that the evaporator has maximum solar availability, place the evaporator in an unshaded location so that the glass front of the unit is facing due south, or within 30 degrees of due south. The sun rises in the east and traces a path through the southern sky before setting in the west. The height of the sun with respect to the horizon as it moves through the southern sky de-

pends upon the time of the year as well as the geographic location of the site.

The sun is highest on June 21 or summer solstice and is lowest on December 21 or winter solstice. Sun paths show the actual geometry of the sun's path through the sky for different geographic latitudes. They are useful for determining the effect of shading from nearby trees or buildings. By observing the shadows cast by surrounding trees, buildings or other structures, you can get a good idea of whether a particular site is suitable for a solar evaporator. To optimize performance, the evaporator should be exposed to the sun throughout the year. You may be able to get assistance in assessing the suitability of a particular site through your state energy office, a solar energy center or a consulting energy engineer.

## *How large will my Solar Evaporator need to be?*



The size of your solar evaporator will depend upon the amount of waste to be evaporated and the performance (evaporation rate) of the evaporator. Based on testing done at The University of Alabama in Huntsville, a solar evaporator in Alabama will evaporate about 20 gallons per square foot of solar collector area per year. Monthly performance varies seasonally from as much as three gallons per square foot in summer months to around one gallon per square foot in winter months. Appendix C contains a graph of monthly performance of solar evaporators in Alabama. Performance will vary based on the climate in which the evaporator is installed, but is expected to be between 15 and 25 gallons per square foot per year in most applications in the United States.

For example, assume you produce 100 gallons per month of liquid waste for a total of 1200 gallons per year. Divide 1200 gallons by the annual performance rate of 20 gallons per square foot per year to specify a collector area of 60 square feet (6 feet x 10 feet, for example). The basin of the solar evaporator plus the surge tank, if needed, should be able to accommodate a volume equal to about two months of waste production (200 gallons in our example).

Other factors that may affect the performance of a solar evaporator include the concentration and the content of the liquid being evaporated. As the concentration increases, the evaporation rate will be reduced. If the liquid contains oil, a film may form on top of the liquid which could reduce the evaporation rate.

## *How much will I save by using a Solar Evaporator?*

The amount of your savings will depend on how much you pay for conventional treatment, the cost of your solar evaporator and the performance of the unit. Results of analysis and demonstration projects of solar evaporator technology suggest that many users may recover their investment in less than two years. This means that savings in the first two years will exceed the initial cost of the solar evaporator, making it a very attractive investment.

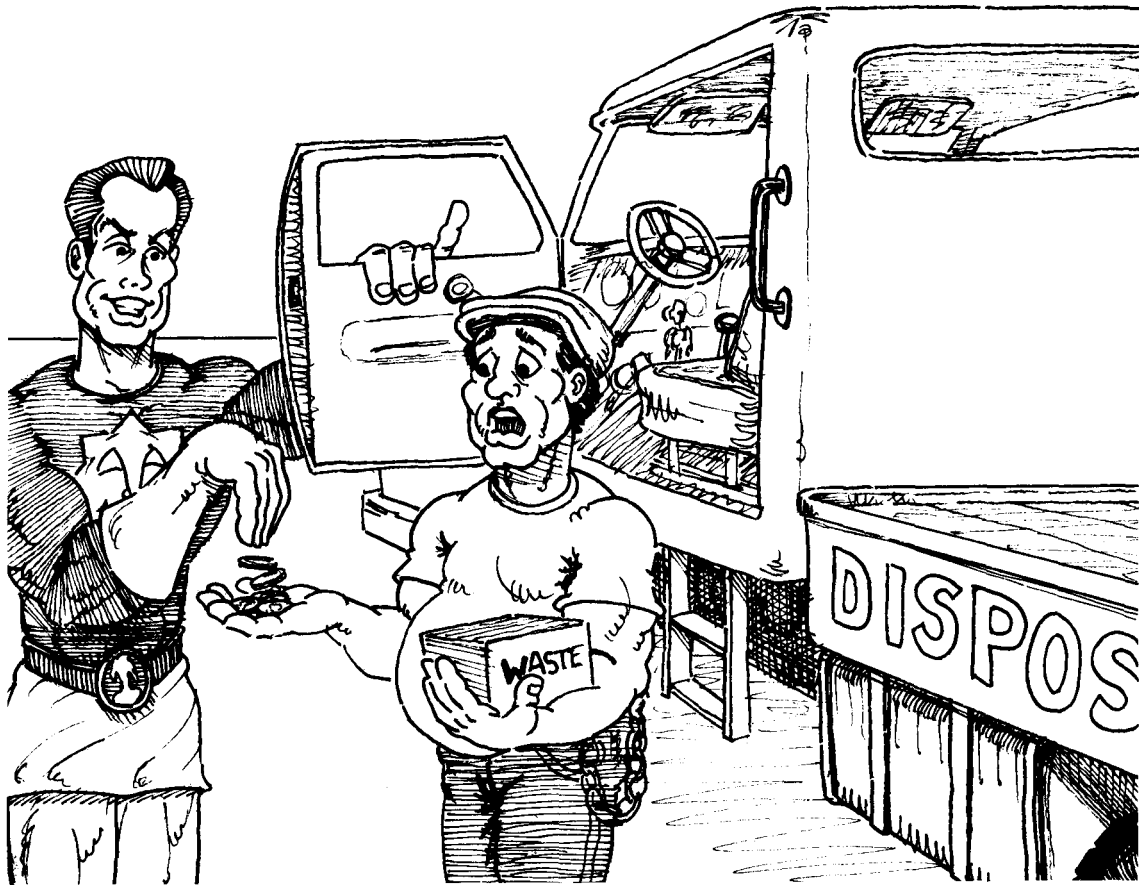
The installed cost of a solar evaporator will depend upon the materials used and any special site-specific issues affecting piping, secondary containment and installation. Early experience with prototype units suggests a cost range of \$60-120 per square foot of collector area. With commercialization of the technology, costs should drop to \$30-60 per square foot. At a cost of \$60 per square foot, our example 60 square foot solar evaporator would cost \$3600.

The disposal cost of liquid waste varies based on the material and the quantity disposed of. As a rule, small generators, those producing from 220-2200 pounds per month, pay more per gallon to dispose of material than large producers because of the relatively small quantities being handled. Where waste is shipped in 55-gallon (200 liter) drums for commercial treatment, the cost of treating one or two drums can be as high as \$7 per gallon. Let's assume you currently pay only \$2 per



gallon for disposal. In our example, you would pay \$200 per month or \$2400 per year. This would be your total potential savings from use of a solar evaporator.

While a solar evaporator requires no conventional energy to operate, you will have some related operation and maintenance costs. The evaporator will need to be monitored periodically to insure it is operating properly. The liquid waste will need to be transported to the evaporator, either manually in drums or automatically by piping with manual valve filling or float valve control. If the solar evaporator is filled automatically, there may be minor energy costs for pumps to move the liquid. Occasionally, the waste concentrate will have to be removed and properly disposed of. You may want to clean the glazing of the evaporator periodically. In general, operation and maintenance costs should be small compared to the disposal savings. Your environ-



mental consultant can estimate the costs in your particular situation.

Let's assume that operation and maintenance costs are 10% of the disposal cost savings. In our example, this would result in \$240 annual operation and maintenance costs. Subtracting \$240 from \$2400 would result in a net annual savings of \$2160.

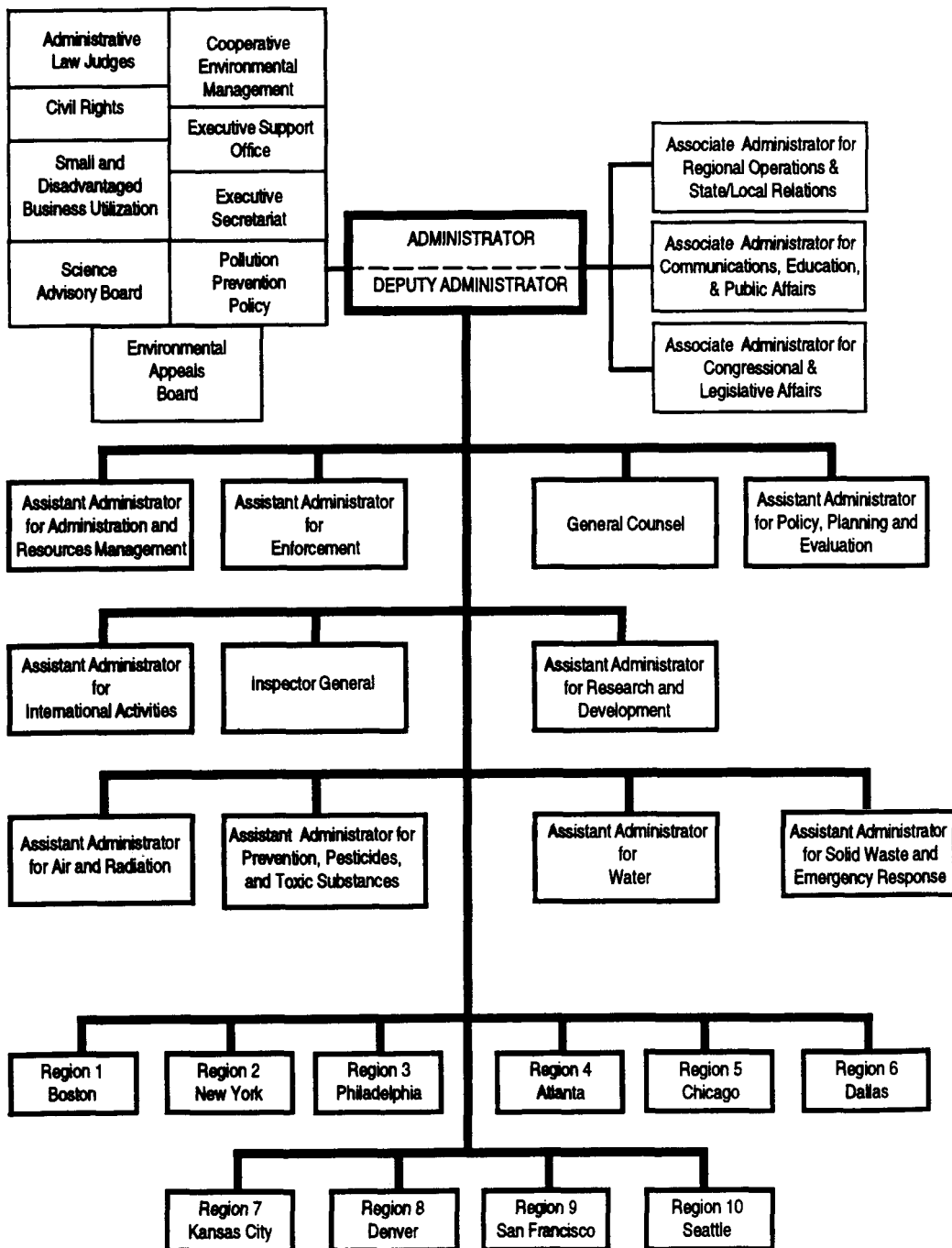
Once you determine how much the evaporator will cost and how much it will save in disposal, energy and maintenance costs, the next step is to do an economic analysis of the project. The easiest approach is to compute the simple payback. This is determined by dividing the installed cost of the evaporator by the total annual savings.

Although it does not consider the time value of money or the useful life of the project, simple payback

may be sufficient for selling management on the idea. Most businesses like to see a simple payback of 2-3 years or less for cost-saving projects. Keep in mind, however, that projects with longer payback periods may still be cost-effective. In our example, the simple payback would be \$3600 divided by \$2160 or 1.67 years.

In some cases, a more sophisticated life cycle cost analysis may be desired. Your environmental or engineering consultant, state energy office, local university or vendor may be able to help you compute life cycle cost statistics such as internal rate of return (IRR), adjusted internal rate of return (AIRR), net present value (NPV) or savings-to-investment ratio (SIR) for the project. This information may be useful in convincing a bank to provide financing for the project, if needed.

## U.S. Environmental Protection Agency



# EPA Regional Offices

## EPA Region 1

JFK Federal Building  
Boston, MA 02203  
(617) 565-3420

Connecticut, Massachusetts,  
Maine, New Hampshire,  
Rhode Island, Vermont

## EPA Region 2

26 Federal Plaza  
New York, NY 10278  
(212) 264-2657

New Jersey, New York,  
Puerto Rico, Virgin Islands

## EPA Region 3

841 Chestnut Street  
Philadelphia, PA 19107  
(215) 597-9800

Delaware, District of Columbia,  
Maryland, Pennsylvania,  
Virginia, West Virginia

## EPA Region 4

345 Courtland Street, NE  
Atlanta, GA 30365  
(404) 347-4727

Alabama, Florida, Georgia, Kentucky,  
Mississippi, North Carolina, South  
Carolina, Tennessee

## EPA Region 5

230 South Dearborn Street  
Chicago, IL 60604  
(312) 353-2000

Illinois, Indiana, Michigan,  
Minnesota, Ohio, Wisconsin

## EPA Region 6

1445 Ross Avenue  
Dallas, TX 75202-2733  
(214) 655-6444

Arkansas, Louisiana,  
New Mexico, Oklahoma, Texas

## EPA Region 7

726 Minnesota Avenue  
Kansas City, KS 66101  
(913) 551-7000

Iowa, Kansas, Missouri, Nebraska

## EPA Region 8

One Denver Place  
999 18th Street  
Denver, CO 80202-2405  
(303) 293-1603

Colorado, Montana, North Dakota,  
South Dakota, Utah, Wyoming

## EPA Region 9

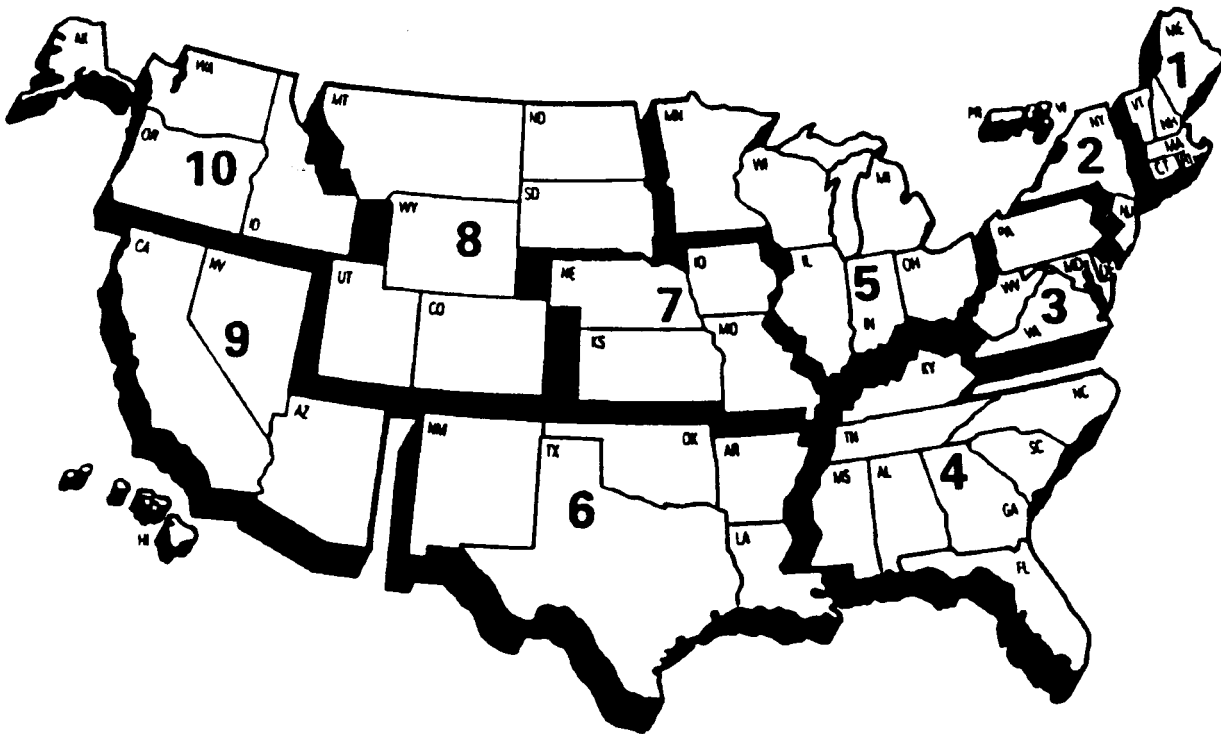
75 Hawthorne Street  
San Francisco, CA 94105  
(415) 744-1305

Arizona, California, Hawaii, Nevada,  
American Samoa,  
Guam, Trust Territories of the Pacific

## EPA Region 10

1200 Sixth Avenue  
Seattle, WA 98101  
(206) 442-1200

Alaska, Idaho, Oregon, Washington



**State Solid and Hazardous Waste Agencies  
Environmental Protection Agency  
Office of Solid Waste**

**ALABAMA**

Alabama Department of Environmental Management  
1751 Congressman W.L. Dickinson Drive  
Montgomery, AL 36130  
(205) 271-7700

**ALASKA**

Solid and Hazardous Waste Management Section  
Division of Environmental Quality  
Department of Environmental Conservation  
410 Willoughby Avenue, Suite 105  
Juneau, AK 99801-1795  
(907) 465-5150

**AMERICAN SAMOA**

Environmental Quality Commission  
Government of American Samoa  
Pogo Pogo, American Samoa 96799  
[011] (684) 633-2304

**ARIZONA**

Arizona Department of Environmental Quality  
3303 North Central Avenue  
Phoenix, AZ 85012  
(602) 207-2300

**ARKANSAS**

Arkansas Department of Pollution Control and Ecology  
8001 National Drive, P.O. Box 8913  
Little Rock, AR 72219-8913  
(501) 570-2859

**CALIFORNIA**

California Integrated Waste Management Board  
8800 Cal Center Drive  
Sacramento, CA 95826

Toxic Substances Control Division  
Department of Health Services  
400 P Street, P.O. Box 806  
Sacramento, CA 95812-0806  
(916) 322-0504

**COLORADO**

Hazardous Materials and Waste Management Division  
Colorado Department of Health  
4210 East 11th Avenue, Room 351  
Denver, CO 80220

**COMMONWEALTH OF NORTHERN MARIANA ISLANDS**

Division of Environmental Quality  
Department of Public Health and Environmental Services  
Commonwealth of Northern Mariana Islands  
P.O. Box 1304  
Saipan, TT 96950  
[011] (670) 234-6984

**CONNECTICUT**

Connecticut Department of Environmental Protection  
165 Capitol Avenue  
Hartford, CT 06106  
(203) 566-0476

Waste Engineering and Enforcement Division  
Connecticut Department of Environmental Protection  
165 Capitol Avenue  
Hartford, CT 06106  
(203) 566-5406

**DELAWARE**

Division of Aid and Waste Management  
Department of Natural Resources and Environmental Control  
89 Kings Highway, P.O. Box 1401  
Dover, DE 19903  
(302) 739-4764

**DISTRICT OF COLUMBIA**

Pesticides and Hazardous Materials Division  
Office of Consumer and Regulatory Affairs  
2100 Martin Luther King Avenue, SE, Suite 203  
Washington, DC 20020  
(202) 404-1167

Solid Waste Disposal Division  
Public Space Maintenance Administration  
2750 South Capitol Street, SE  
Washington, DC 20032

**FLORIDA**

Bureau of Hazardous Waste  
Division of Waste Management  
Department of Environmental Regulation  
2600 Blair Stone Road, Twin Towers  
Tallahassee, FL 32399-2499

**GEORGIA**

Hazardous Waste Management Branch  
Environmental Protection Division  
Department of Natural Resources  
205 Butler Street, SE, Floyd Towers East, Room 1154  
Atlanta, GA 30334  
(404) 656-2833

**GUAM**

Solid and Hazardous Waste Management Program  
Guam Environmental Protection Agency  
IT & E, Harmon Plaza, Unit D-11  
130 Rojas Street  
Harmon, GU 96911  
[011] (671) 646-8863

**HAWAII**

Department of Solid Waste  
Hawaii Department of Health  
5 Waterfront Plaza, 500 Ala Moana, Suite 250  
Honolulu, HI 96813  
(808) 586-4221

**IDAHO**

Permits and Enforcement  
Division of Environmental Quality  
1410 North Hilton Street  
Boise, ID 83706  
(208) 334-5898

**ILLINOIS**

Division of Land Pollution Control  
Illinois Environmental Protection Agency  
2200 Churchill Road, P.O. Box 19276  
Springfield, IL 62794-9276  
(217) 785-8604

## Appendix B - Sample State Ruling

{Facsimile}  
ALABAMA  
DEPARTMENT OF ENVIRONMENTAL MANAGEMENT

March 13, 1992

Mr. Steve Hillenbrand  
Waste Reduction Engineer  
Tennessee Valley Authority  
400 West Summit Hill Drive  
Knoxville, Tennessee 37902

Dear Mr. Hillenbrand

Re: Request for Interpretation  
Solar Evaporator Installations

The Alabama Department of Environmental Management (ADEM) is in receipt of TVA's request for an interpretation of the regulatory status of certain solar evaporator systems used for the treatment of aqueous hazardous wastes at generator's facilities. TVA's request dated December 9, 1991, which was followed by a meeting on January 23, 1992 between representatives of TVA, ADEM, and the University of Alabama - Huntsville, has been reviewed by the Land Division and the following conclusions have been reached:

As discussed in the January 23 meeting and in other conversations between TVA and Stephen Cobb of the Engineering Services Branch, the evaporation of aqueous hazardous waste in an evaporator (whether solar or otherwise fueled) clearly constitutes treatment of hazardous waste as defined in Rule 335-14-1-.02 of the ADEM Administrative Code. As Mr. Cobb has explained to you, treatment of hazardous waste must be conducted in a unit which is permitted under the Alabama Hazardous Waste Management and Minimization Act (AHWMMA), unless the unit qualifies for an exemption from the permit requirement. There are three exemptions which appear to be applicable to solar evaporation units. These are:

- 1) If the unit qualifies as a totally enclosed treatment unit as defined in Rule 335-14-1-.02 (See Rule 335-14-8-.01(1)(c)2.(iv)).
- 2) If the unit qualifies as a wastewater treatment unit as defined in Rule 335-14-1-.02 and is included in the facility's NPDES or SID permit as such (See Rule 335-14-8-.01(1)(c)2.(v)).
- 3) If the unit qualifies as a recycling unit as described in Rule 335-14-2-.01(6)(c).

In your December 9 request (copy attached), you presented two specific proposed applications of the solar evaporator for consideration by the Department. These were:

- A. The evaporator is hard piped from the generating process with sludges or concentrates returned to the process for re-use; and,
- B. The evaporator is located at a dead-end branch of the process and water is evaporated from the waste and the sludge or concentrate is periodically removed for treatment and/or disposal.

As discussed in the January 23 meeting, it appears that the evaporator in Option A would qualify as a recycling unit provided that the returned sludge/concentrate is utilized as a replacement for a commercial chemical product and the material is being legitimately recycled. Thus, as used in this specific application, the evaporator would not require AHWMMA permit to operate.

The evaporator in Option B will likely qualify for an exemption from permitting under the wastewater treatment unit provision provided:

- 1) The unit is designed and constructed such that it meets the definition of a tank or a tank system (See Rule 335-14-1-.02 for regulatory definitions); and,
- 2) The unit is specifically identified as a part of the wastewater treatment process in the facility's NPDES or SID permit/

permit application. Any NPDES or SID permitting issues would have to be addressed through the appropriate personnel in the ADEM Water Division.

Please note that these interpretations are based upon the information submitted by TVA on December 9, 1991. Site specific variations in the application of this technology may result in differing regulatory status of the unit and/or process. Also, it must be noted that a unit operating under an exemption from permitting, such as discussed above, must be designed, constructed, operated, and maintained in a manner which allows it to continue to qualify for said exemption. An exemption from permitting is a continual demonstration based on actual conditions, not a one-time demonstration based on theoretical design values.

During the January 23 meeting and in subsequent conversations, TVA has asked where the point of generation of the waste would be in the solar evaporation process. Review of the applicable regulations indicates that the point of generation of the waste is at the point the waste-stream exits the manufacturing process and is no longer suitable for its intended purpose without subsequent treatment and/or reclamation. Therefore, the point of generation in this system would be upstream (on the influent side) of the solar evaporator. As previously noted, the evaporation of the waste is treatment and the evaporator would have to have a AHWMMMA permit unless it is designed, constructed, operated, and maintained in a manner which enables it to qualify for one of the exemptions from permitting requirements. However, for the purposes of determining generator status, it appears that there is some question as to whether wastes which are treated in permit exempt treatment units should be counted using the influent quantity of waste or using the effluent quantity of waste. For non-exempt treatment units (e.g., surface impoundments, etc.) it is clear that the influent quantity of waste must be used in determining generator status unless the waste generated is produced in the treatment unit (e.g., treatment of a non-listed, non-characteristic wastewater which results in the production of a listed and/or characteristic sludge). This question regarding exempt units is under review by the Land Division.

Since the evaporator units as described will have air emissions, the ADEM Air Division should be consulted regarding any air permitting requirements which may be applicable. Also, the ADEM Water Division should be consulted regarding any discharges which may require water permits.

During the January 23 meeting, a question was raised regarding permit requirements for research (RD&D) evaluation of this or other hazardous waste treatment processes. As discussed in the meeting, no AHWMMMA permit is required if the material being treated is not a hazardous waste (i.e., the use of 'synthesized wastes' made from product materials for the purpose of research evaluation), or if the research using hazardous waste is conducted within the limitation of Rules 335-14-2-.01(4)(e) and (f) regarding treatability studies. If the research is conducted using hazardous waste and the treatability study exemption does not apply, then the RD&D facility must have either a full AHWMMMA permit under rule 335-14-8-.01 or a limited RD&D permit under Rule 335-14-8-.06(4) which addresses the hazardous waste research activity in question.

Should you have any questions regarding this matter, please contact, Mr. Stephen A. Cobb of the Engineering Services Branch at (205) 271-7726.

Sincerely,



**Sue R. Robertson, Chief**

Land Division

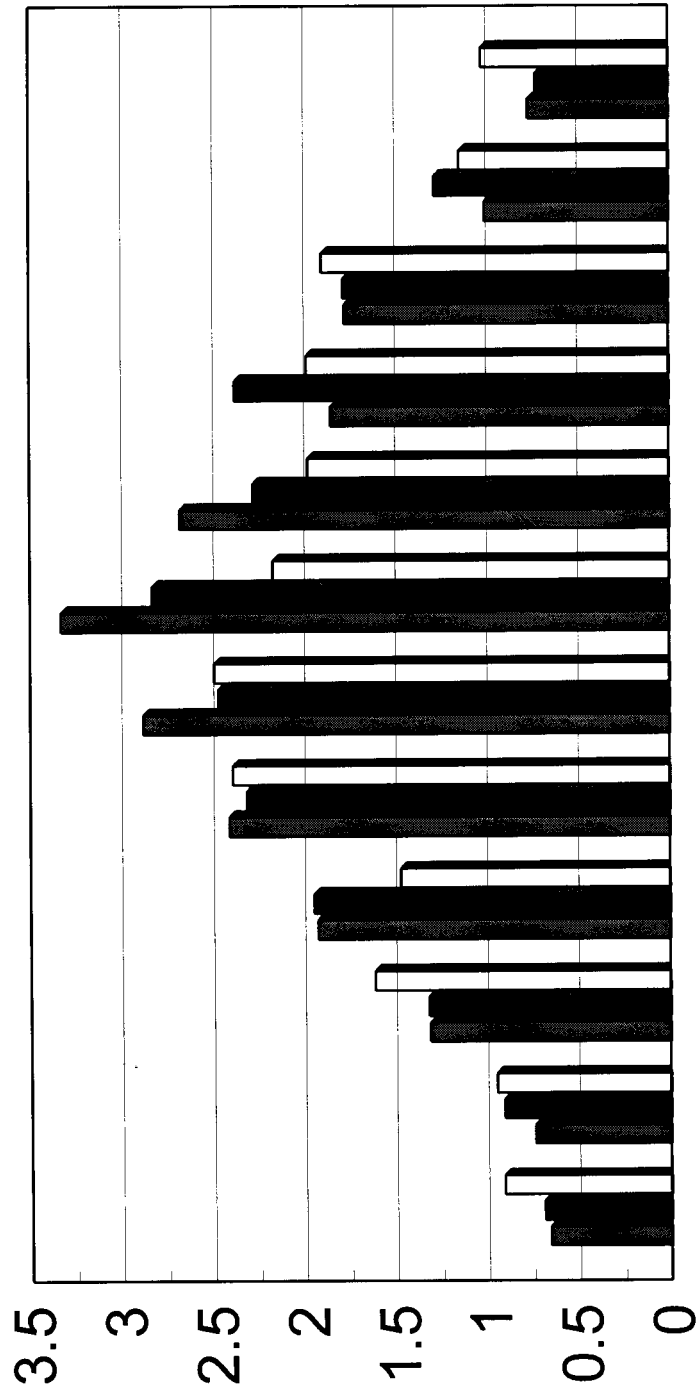
SRR/SAC:bw:#LT1134

Enclosures

cc: James S. Kutzman - EPA IV  
Gerald R. Guinn - UAH  
Steven O. Jenkins - RCRA Compliance Branch

File: ADEM Interpretations

**Solar Evaporation Rate (gallons per square foot per month)**



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Huntsville	0.66	0.74	1.32	1.93	2.42	2.88	3.33	2.68	1.85	1.78	1.01	0.77
Birmingham	0.69	0.91	1.32	1.95	2.32	2.47	2.84	2.28	2.38	1.78	1.28	0.73
Mobile	0.91	0.95	1.62	1.48	2.40	2.50	2.17	1.98	1.99	1.90	1.15	1.02

This research project has been funded, in part, by the State of Alabama through funding awarded to the Alabama Universities/TVA Research Consortium (AUTRC). Research and development of solar evaporators has been directed by Gerald R. Guinn, Ph.D., Director of the Kenneth E. Johnson Research Center (JRC) of The University of Alabama in Huntsville (UAH)

T. Kenneth Spain, P.E. of the UAH JRC compiled this manual with the input and support of many individuals. Gregory S. Trent of Huntsville, Alabama illustrated the manual. Design Services of the UAH Office of University Relations provided layout and typesetting support. Stephen J. Hillenbrand of TVA provided project oversight and invaluable input and direction to the effort. Special thanks to James M. Ransom, TVA/AUTRC Coordinator, for his support of this project.

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# UAH

The University of Alabama in Huntsville

**Johnson Research Center**

Huntsville, AL 35899

(205) 895-6361