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Accelerated Characterization of Metal Fuel Stored in the Hanford K Basins

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DISCLAIMER

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ABSTRACT

Efforts are under way to gather data on the condition of the metal fuel and associated sludge stored in the water-filled Hanford K Basins. Most of the current data gathering activities are being performed in the basins without fuel movement. These techniques include a video survey of open storage canisters, determination of water/gas levels in sealed canisters, sampling of gas and water from sealed canisters (for chemical analysis) and measurement of sludge depth and sludge volume.

I. INTRODUCTION

The two water-filled Hanford K Basins contain roughly 2,000 tons of zirconium alloy clad uranium metal fuel assemblies irradiated in N Reactor prior to 1987. Half of these fuel assemblies (in the K-East Basin) are in open top canisters made of aluminum or stainless steel and half (in the K-West Basin) are in sealed vented water-filled canisters made from the same materials. Both types of canisters are shown in Figure 1. This paper describes near term attempts to gather data on the mechanical condition and chemical state of the fuel. These on-going in-situ nondestructive examinations are intended to complement hotcell examinations[1] which are ongoing or planned for the future. These characterization data will feed decisions on interim storage, long term storage, and the environmental documentation process as the fuel is relocated.

The individual N Reactor fuel assemblies each consist of two concentric fuel elements separated by an intervening coolant channel as shown in Figure 2. Optimally 14 inner and 14 outer elements are stored in one canister. A canister consists of two identical barrels welded together with seven fuel assemblies per barrel. In practice fewer than 14 fuel assemblies are often found in one canister.

II. CHARACTERIZATION DATA

Several techniques have been, or are planned to be, employed during the conduct of examinations in the K Basins. These include:

A. Video Survey

Using an under-water camera (Figure 3a) a survey has been made of the open-top canisters which hold fuel in the K-East Basin. These data have given early assessments of the degree of cladding degradation, endcap damage, canister corrosion, fuel swelling, and canister/fuel interactions. Examples of fuel corrosion associated with a broken or detached endcaps as well as with split cladding are presented in Figure 4.

A quantitative assessment of the percentage of deteriorated fuel has been made and a significant fraction are damaged. However the majority of the fuel elements appear to be intact and uncorroded (as far as can be determined from an overhead view). Those elements which show evidence of deterioration appear to be those which sustained endcap damage during reactor discharge. Oxidation of uranium fuel by water has caused deformation and detachment of endcaps due to fuel expansion caused by formation of low density oxides relative to the original metal. A small minority of fuel elements have split cladding with major segments of missing fuel.

Corrosive and mechanical interactions between fuel and canisters are not seen. Stainless steel canisters appear to be essentially uncorroded in the K Basin water environment. The older aluminum canisters show large numbers of corrosion nodules which predate the institution of strict water chemistry control measures in the basins.

B. Water Level Measurements in Sealed Canister Vents

The closed canisters in the K-West Basin contain a venting device which allows excess gases (such as those associated with fuel corrosion) to escape. Ultrasonic measurements (Figure 3b) of the level of the gas/water interface in these devices have been used to provide indications of gas buildup due to fuel corrosion or of water intrusion due to a failure of the canister seal.

C. Gas and Water Sampling from Canisters

Strategies and equipment have been developed for sampling of gas and water from the closed canisters of fuel in the K-West Basin (see Figure 3b). Entry into the canisters will be made through valves originally designed to load canisters with water and cover gas. The samples obtained in this manner will furnish indications of fuel oxidation, fission product release and canister integrity. These data will also guide choices of fuel to be retrieved and examined in detail at the Hanford hotcells.

D. Sludge Depth Measurements

The sludge on the floor of the basins (mainly in K-East) consists of a mixture of canister/rack corrosion product, oxidized fuel, sand, and other debris of external origin. Depth measurements and qualitative properties assessments of K-East Basin sludge have been made using under water video techniques. An example of these measurements is shown in Figure 5. Large expanses of the K-East Basin are covered by a depth of only a few cm of sludge (Figure 6) with isolated accumulations of up to 18 cm deep. Small pit areas appended to the basin contain up to 100 cm deep sludge in isolated spots. Integration of the depth measurements yields a sludge volume of 37.6 m^3 for the basin proper exclusive of the sludge in the pits.

E. Characterization During Fuel Movement

It is currently envisioned that some under water fuel movement will take place in the K-East Basin perhaps as part of a limited demonstration of a path forward. Fuel and sludge from within canisters will be dumped during these activities. Various types of characterization information, which cannot be obtained from undisturbed fuel, will be acquired during this operation. Visual information on fuel integrity and sludge particle settling times will be recorded. Samples of fuel, canister material, and canister sludge will be taken for hotcell analyses.

III. CONCLUSIONS

Accelerated characterization of K Basin spent metal fuel will influence near term facility decisions and allow informed choices of fuel and sludge samples targeted for more extensive hotcell examination. The condition of the elements in the K-East Basin ranges from pristine to corroded fuel with ruptured cladding. The magnitude of the sludge mitigation campaign has been bounded through determination of sludge volume. Finally data pertinent to the choice of wet and dry storage options are being obtained from sealed canisters in the K-West Basin.

ACKNOWLEDGEMENT

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REFERENCE

1. Abrefah, J. et al., "Characterization of Hanford Spent Nuclear Fuel," DOE Spent Nuclear Fuel, American Nuclear Society, Salt Lake City, December 1994.

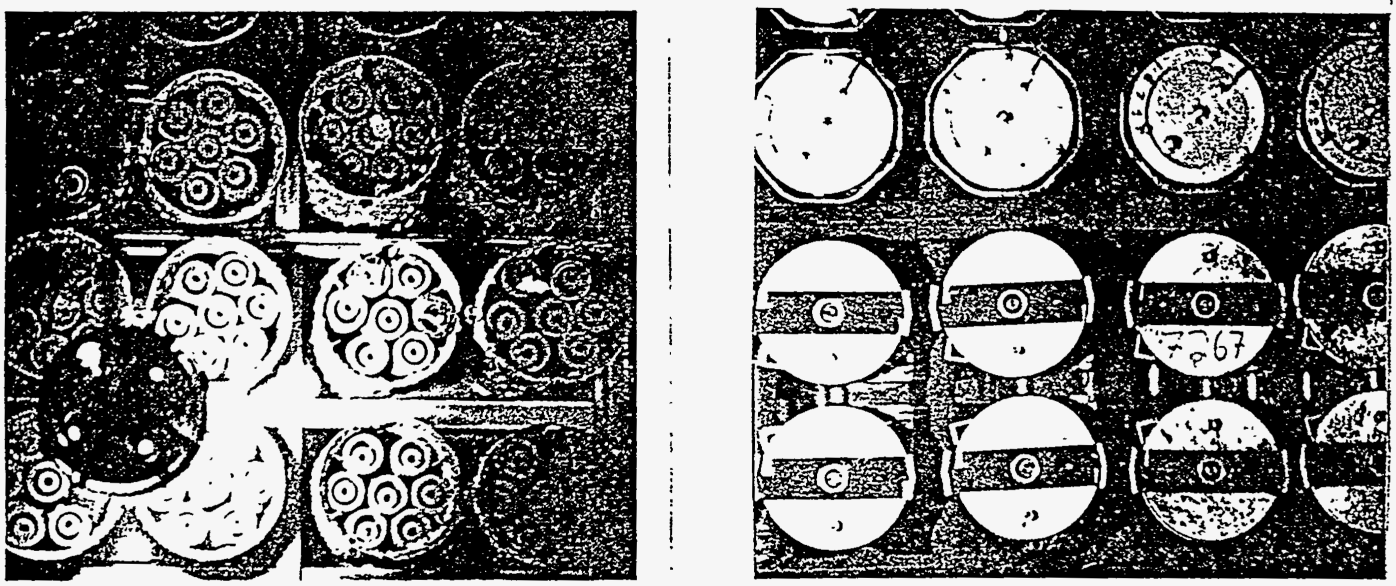


Figure 1. Open Top Canisters in K-East Basin Containing N Reactor Fuel Elements.

Closed Canisters in K-West Basin With Lids Held in Place with Locking Bars.

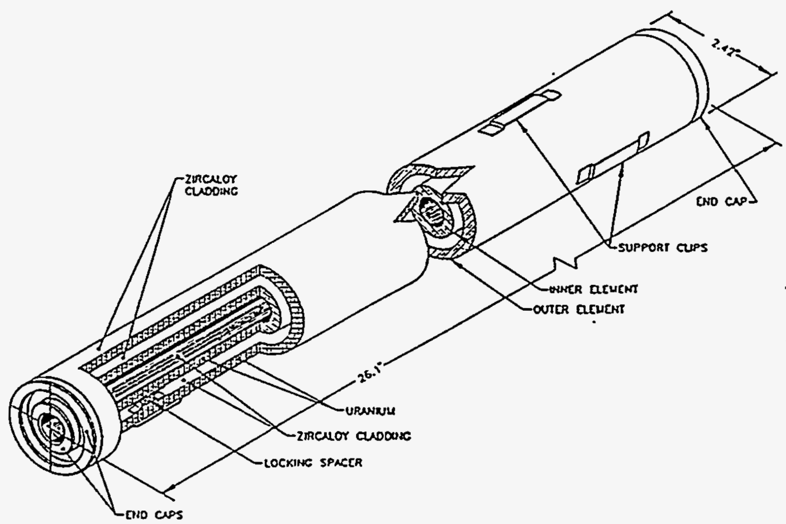
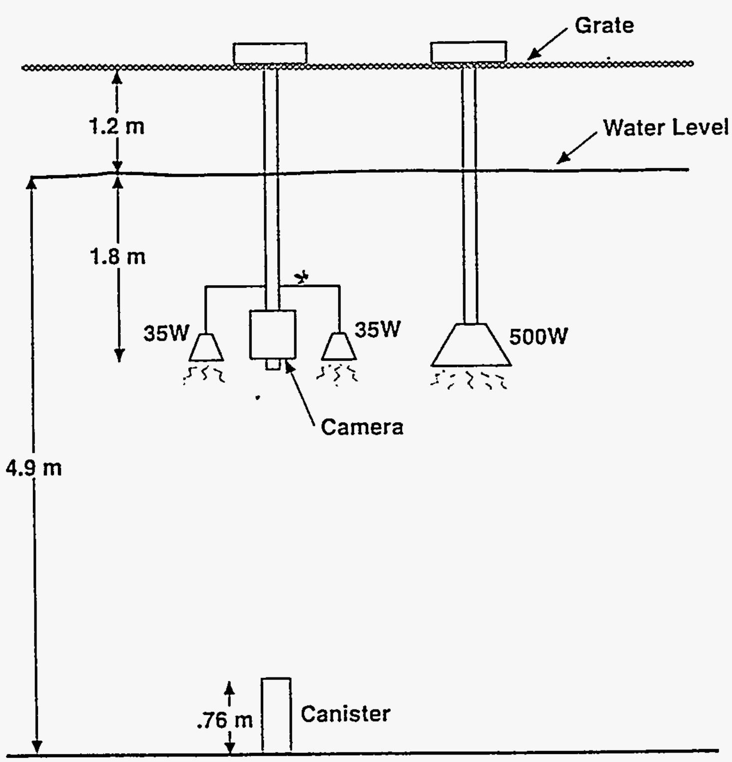
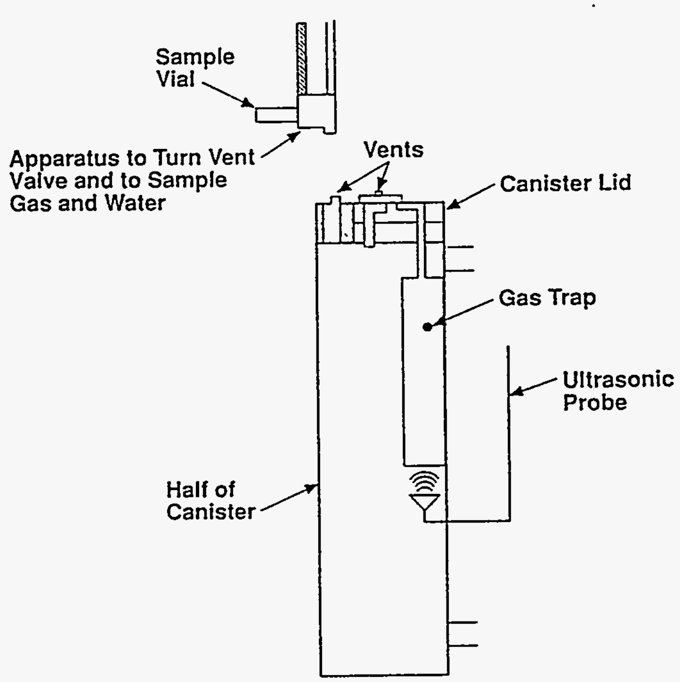


Figure 2. N Reactor Fuel Element Design.



(a)



(b)

Figure 3. Schematic Drawings of Apparatus Utilized for In-Situ Examinations.
(a) Underwater photographic survey of K-Each Basin open top canisters.
(b) Ultrasonic measurements of gas/water interface in gas trap and sampling of gas and water from sealed canisters in K-West Basin.

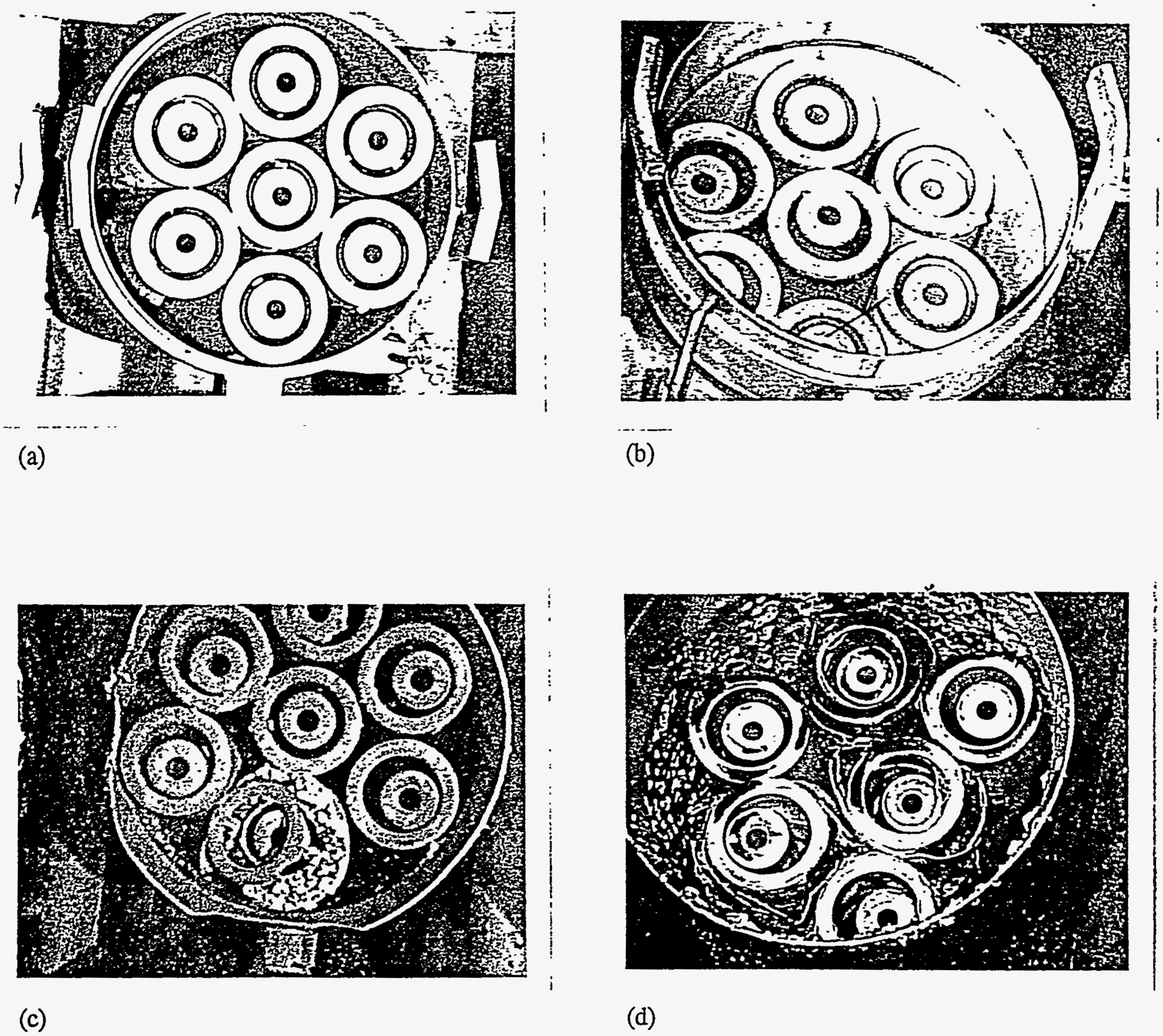
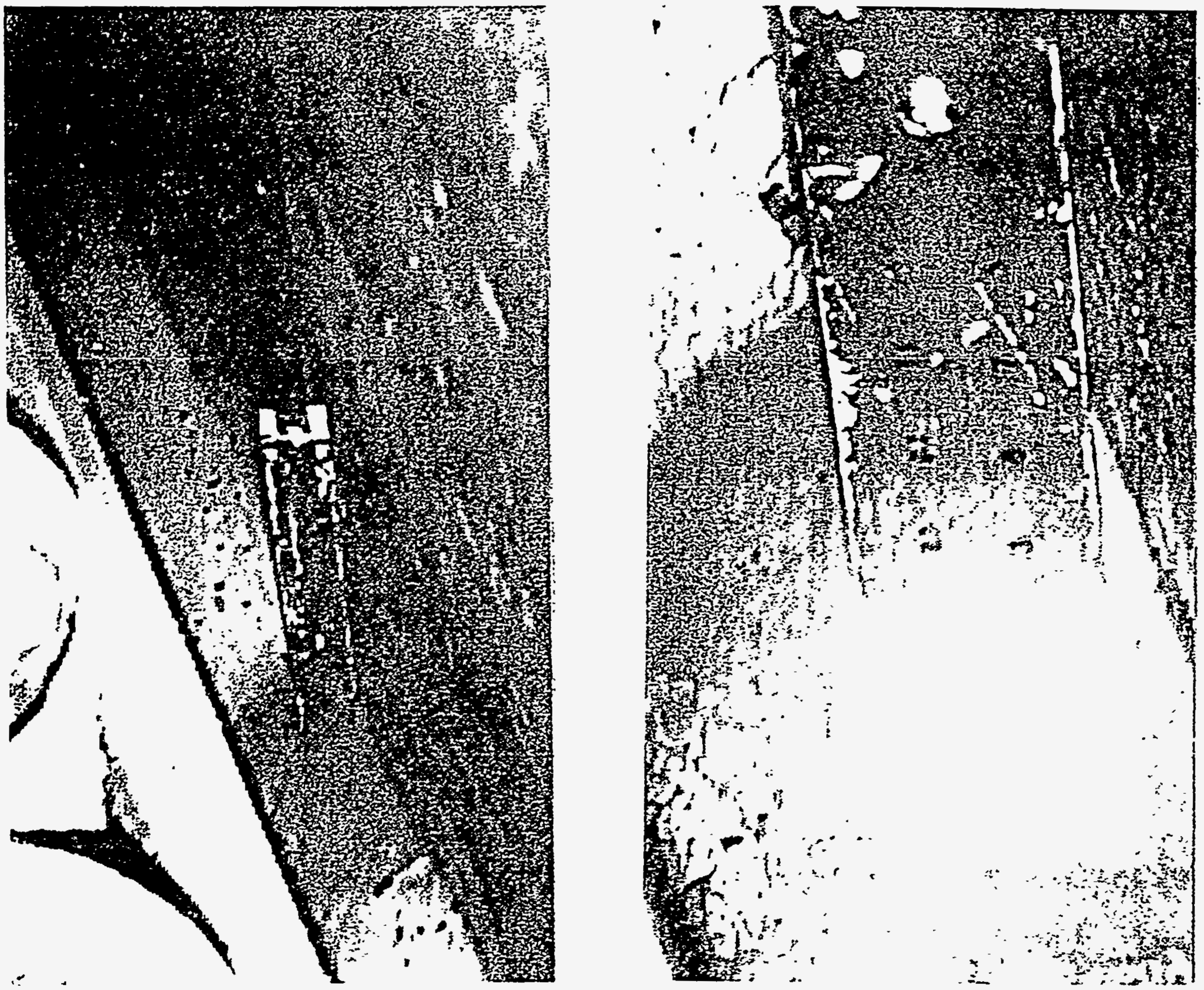


Figure 4. Underwater View of One Half of a Fuel Canister in the K-East Basin with (a) Intact Fuel and Stainless Steel Canister (b) Damaged Endcap with Some Corrosion (c) Detached Endcap with More Severe Corrosion, and (d) Split Cladding in a Corroded Aluminum Canister.



(a) (b)

Figure 5. Sludge Measurements in the K-East Basin (a) Overview of a Measurement and (b) Same Area at Higher Magnification Showing Flocculent and Crusty Nature of Some of the Sludge Layers.

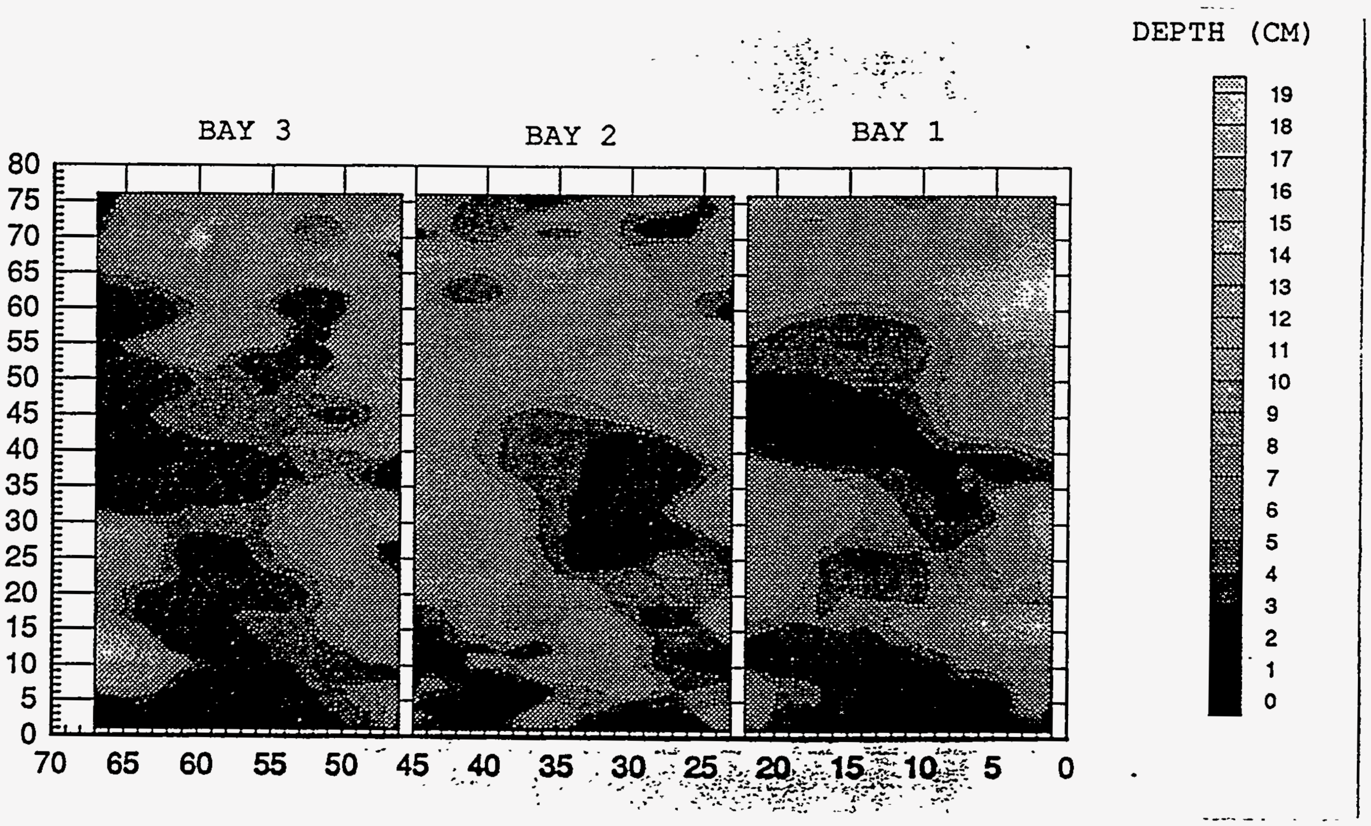


Figure 6. Contour Map of Sludge Depth in the Hanford K-East Basin.