ORNL-DWG 90Z-12431

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The Clinch River-Watts Bar Reservoir Remedial Investigation

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and
ORNL Environmental Sciences Division

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BACKGROUND INFORMATION
FOR
LOCAL OVERSIGHT COMMITTEE
NOV. 7, 1991

MARTIN MARIETTA ENERGY SYSTEMS, INC.
operating the

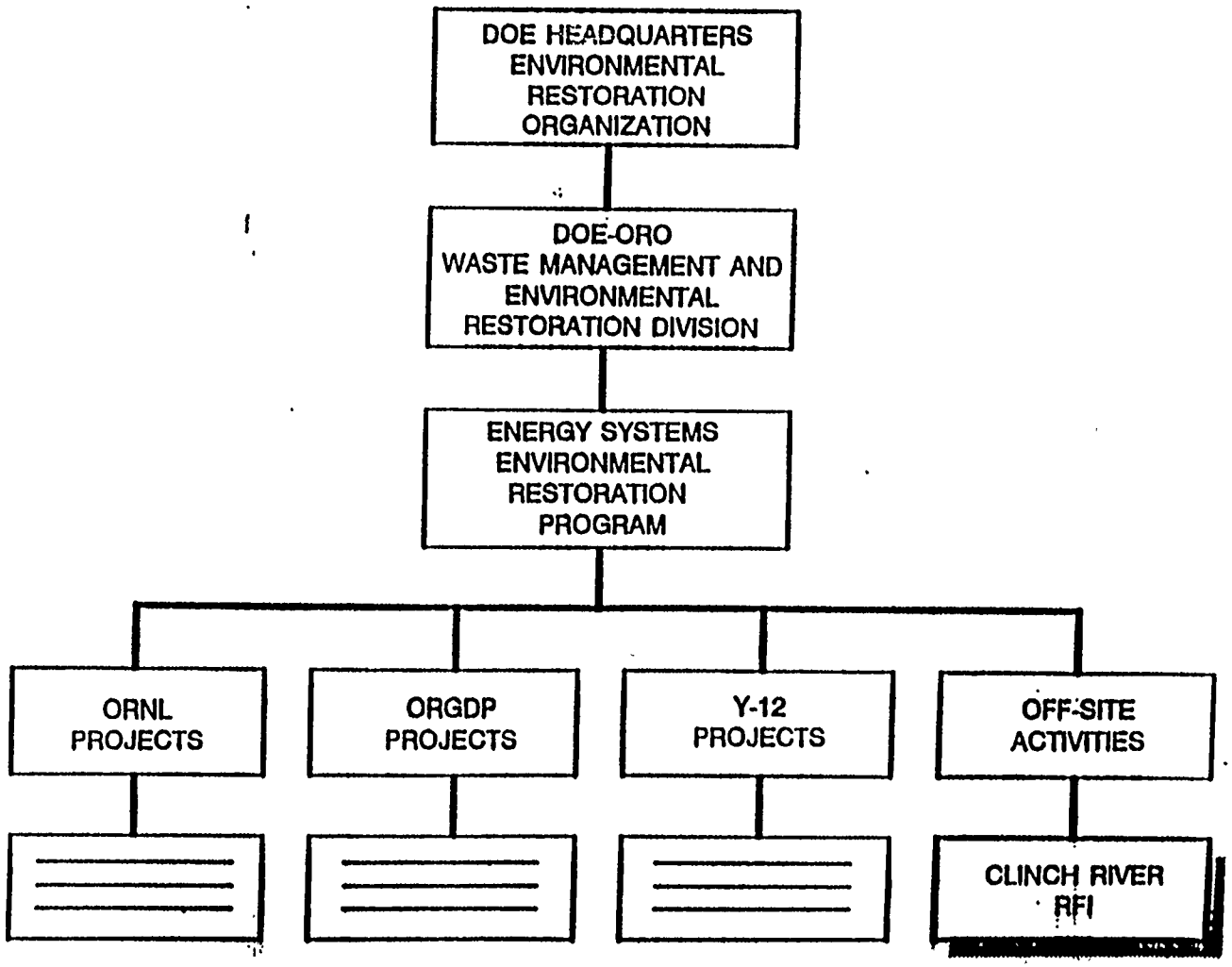
Oak Ridge National Laboratory
Oak Ridge Gaseous Diffusion Plant

Oak Ridge Y-12 Plant
Paducah Gaseous Diffusion Plant

under contract DE-AC05-84OR21400
and the
Portsmouth Gaseous Diffusion Plant
under contract DE-AC05-76OR00001
for the
U.S. DEPARTMENT OF ENERGY

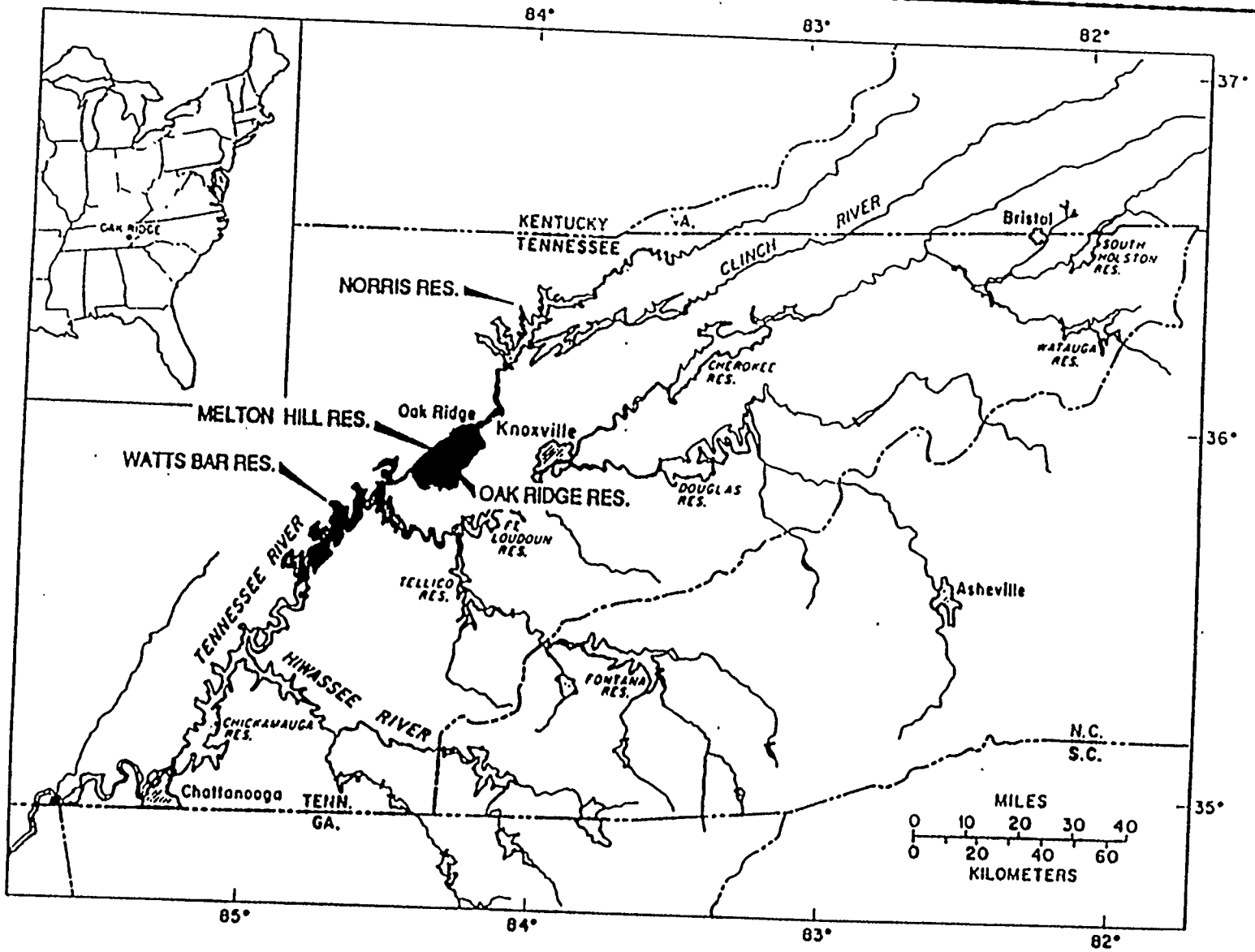
Environmental Restoration Organization

ORNL-DWG 89M-17262



ER/VU/90-93

Location of Oak Ridge Reservation, East Tennessee



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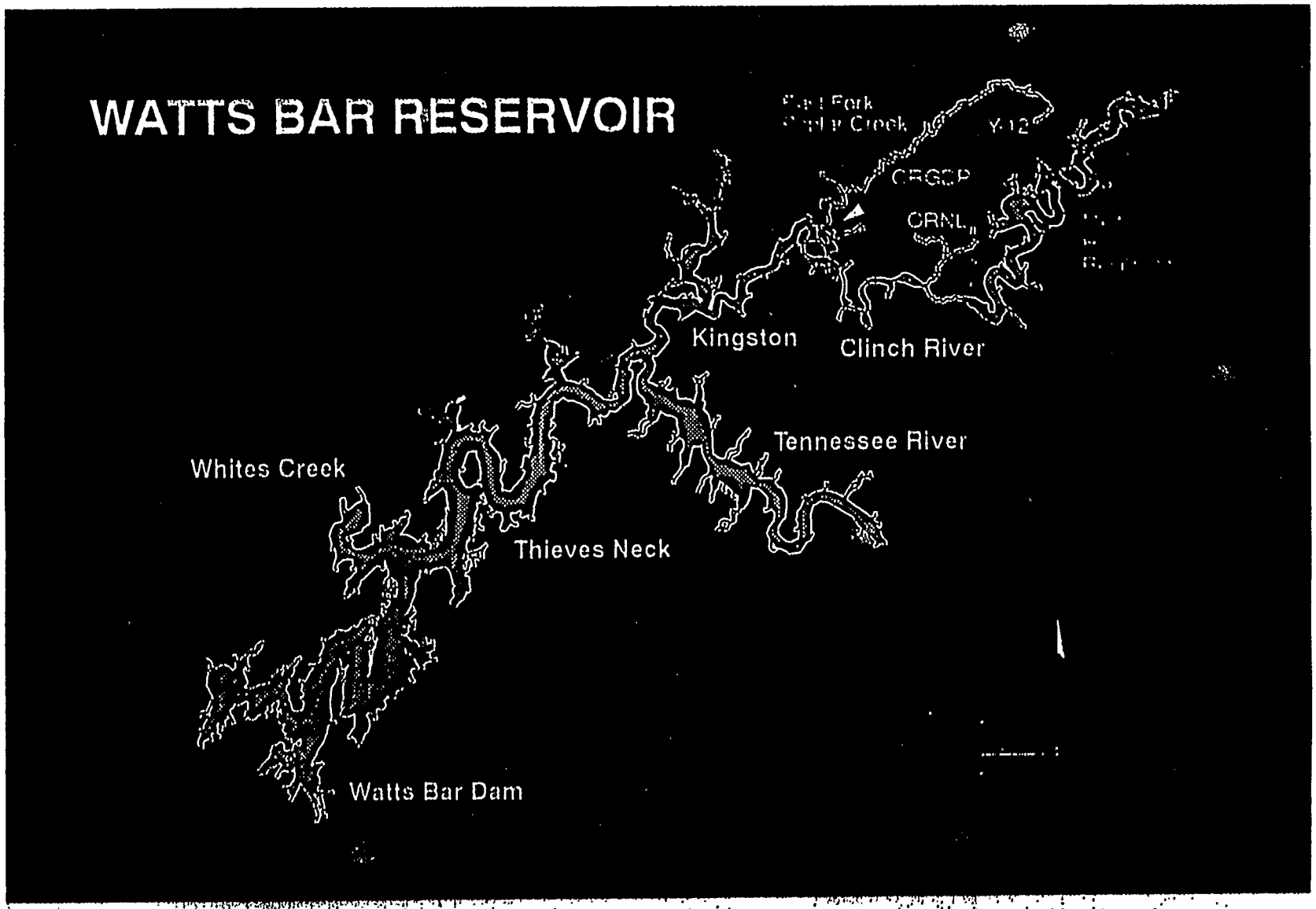
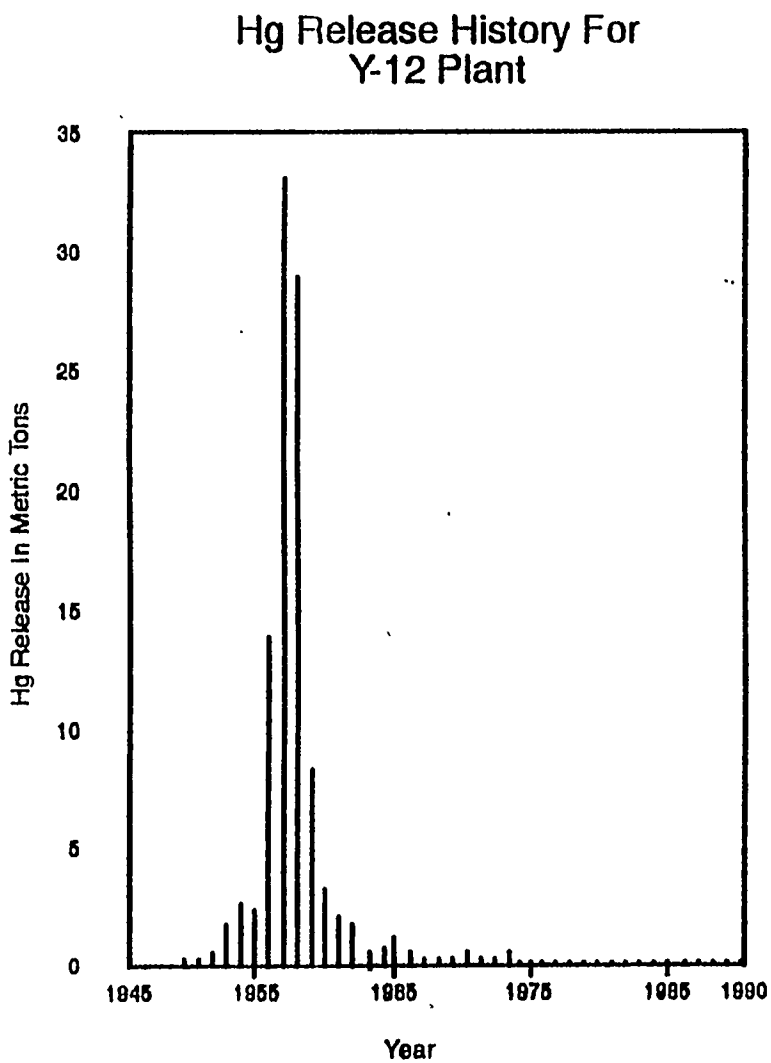
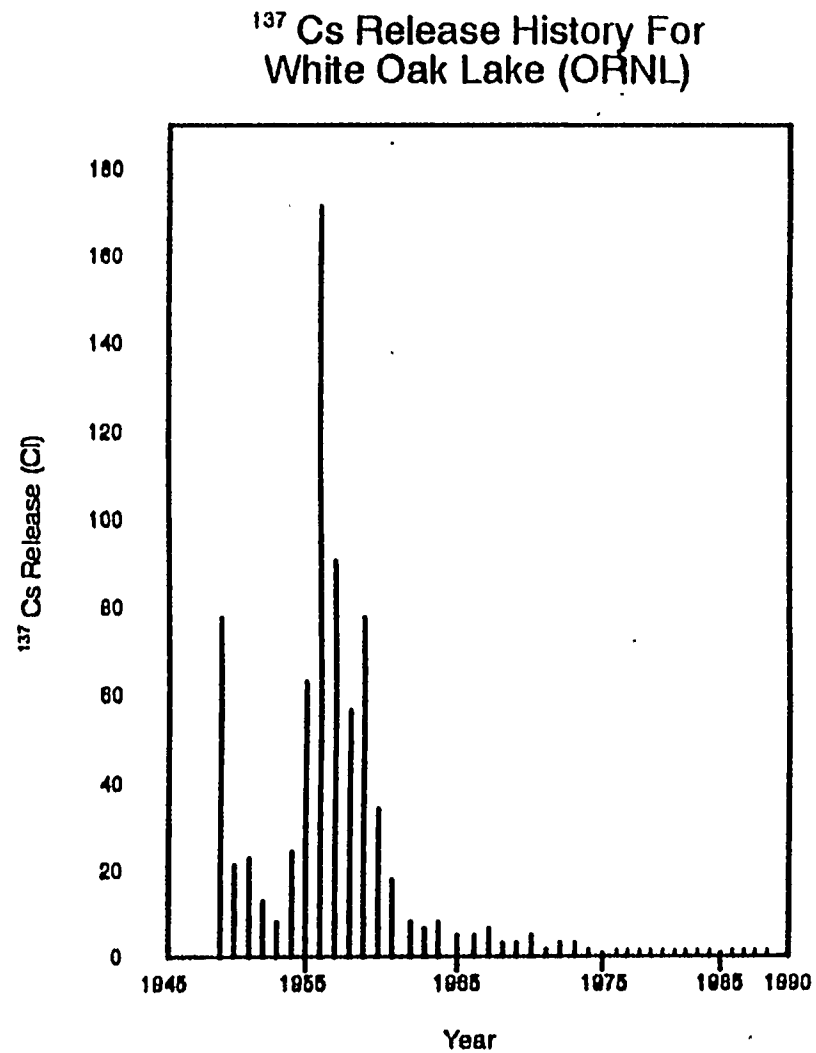

WATTS BAR RESERVOIR
Y-12
CRGCP
ORNL
Kingston
Clinch River
Tennessee River
Whites Creek
Thieves Neck
Watts Bar Dam

Background Information On

Off-Site Surface Water Contamination

Contaminant Release Histories





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Background

- Gamma Radiation Surveys (1951-1958)
  - Radioactivity was measured in sediments of the clinch river and the watts bar and Chickamauga reservoirs.

- Clinch River Study (1960-1966)
  - The radiological impact of radionuclide releases was investigated.
  - Most contaminants were transported through the Clinch River to Watts Bar.
  - Radiological dose assessments indicated low risk.

Background (continued)

- Clinch River Breeder Reactor and Other Site Studies (1970s)
  - Studies were environmental baseline for CRBR.
  - Maximum plutonium in Clinch River sediment was Found to be 2 pCi/g.
  - Mercury and PCBs were detected in game fish from Poplar Creek and Clinch River.

- 1983 Congressional Hearing
  - Hearing focused on mercury in East Fork Poplar Creek Floodplain.
  - Reports on Clinch River studies were provided.
  - Hearing resulted in the formation of Oak Ridge Task Force (comprised of TVA, DOE, USGS, TDHE, COE, and EPA members).

Background (continued)

- Oak Ridge Task Force Activities (1983 - 1989)
  - Mecury concentrations in East Fork Poplar Creek Floodplain were as high as 2400 ppm.
  - Highest mercury concentration (37 ppm) in upper Watts Bar Reservoir sediment was found 16-40 in. deep in sediment.
  - CDC/TDHE study concluded there was no immediate health risk.
  - Oak Ridge Task Force provided transition to Environmental Restoration Program (1989).

REGULATORY FRAMEWORK FOR OAK RIDGE ENVIRONMENTAL RESTORATION

- Resource Conservation and Recovery Act (RCRA)
- Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or "Superfund")
- National Environmental Policy Act (NEPA)

REGULATORY FRAMEWORK, CONTINUED

- Oak Ridge Federal Facility Compliance Agreement
  - U.S. Department of Energy
  - Tennessee Department of Health and Environment
  - U.S. Environmental Protection Agency

RCRA-CERCLA Remediation Process*

- Initiation of scoping or "homework" studies
- Development of work plan
- Initiation of site investigations and risk assessments and identification of potential remedial actions

---

*Interim remedial actions will be taken if immediate/imminent risk is discovered.

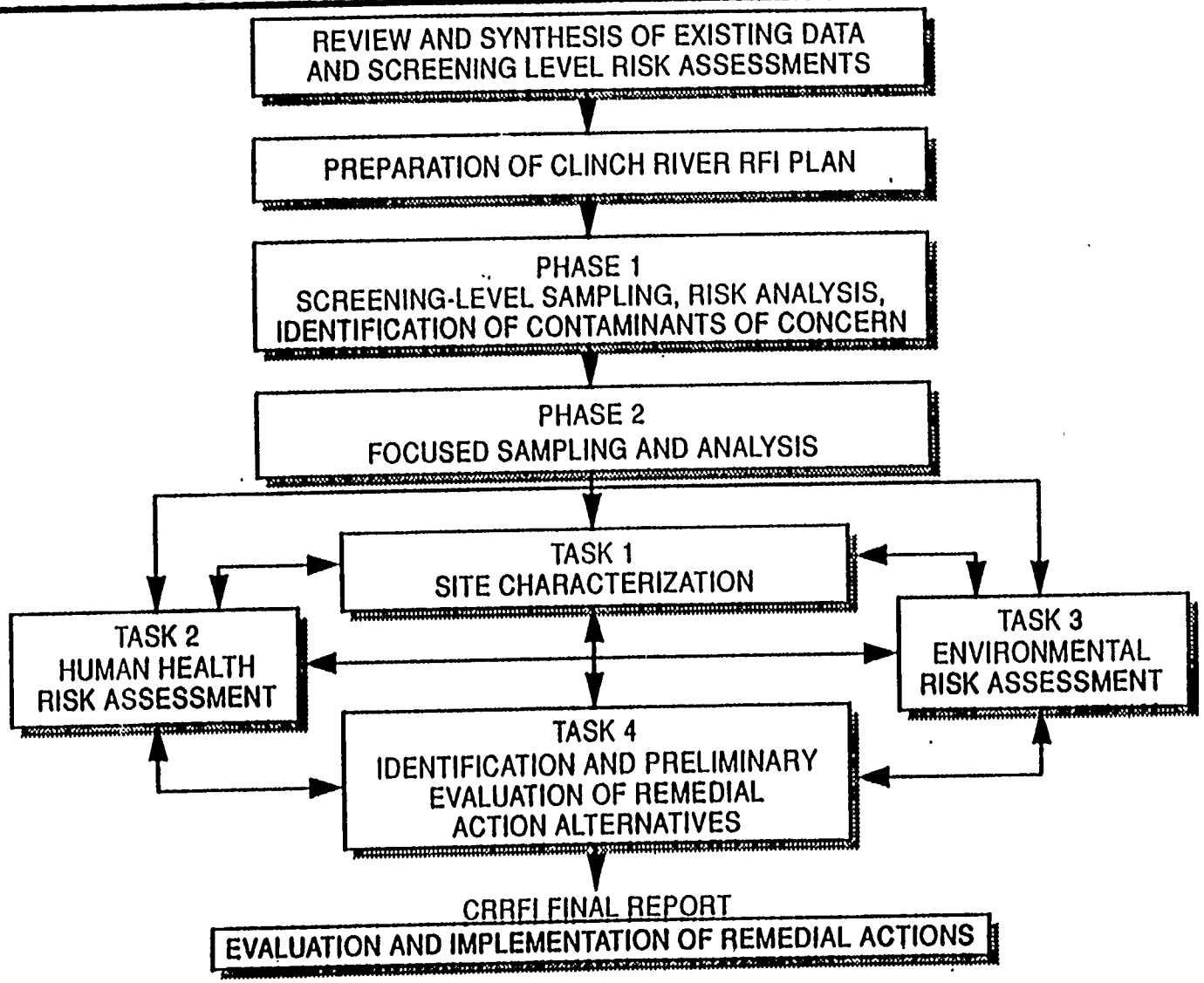
RCRA-CERCLA Remediation Process (continued)

- Evaluation of remedial action alternatives
- Selection of most appropriate remedial action(s) for reducing risk
- Implementation of selected remedial actions

Objectives of The Clinch River-Watts Bar Environmental Restoration Project

- Define the nature and extent of contamination of the off-site surface water environment downstream of the Oak Ridge Reservation
- Quantify risks to the environment and to human health and welfare posed by existing off-site contamination
- Identify and do preliminary evaluation of potential remedial actions
- Implement any remedial actions that are necessary

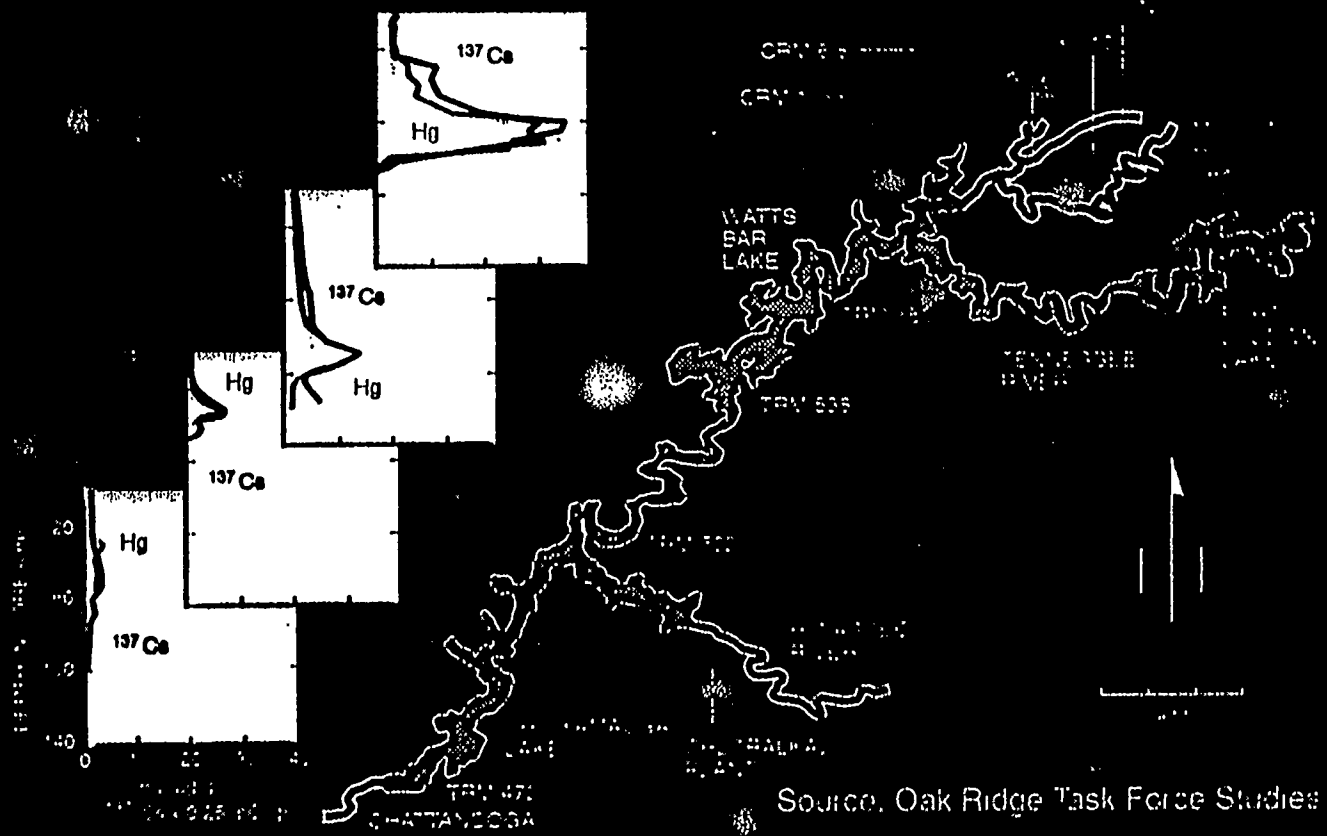
Clinch River RCRA Facility Investigation Phased Approach



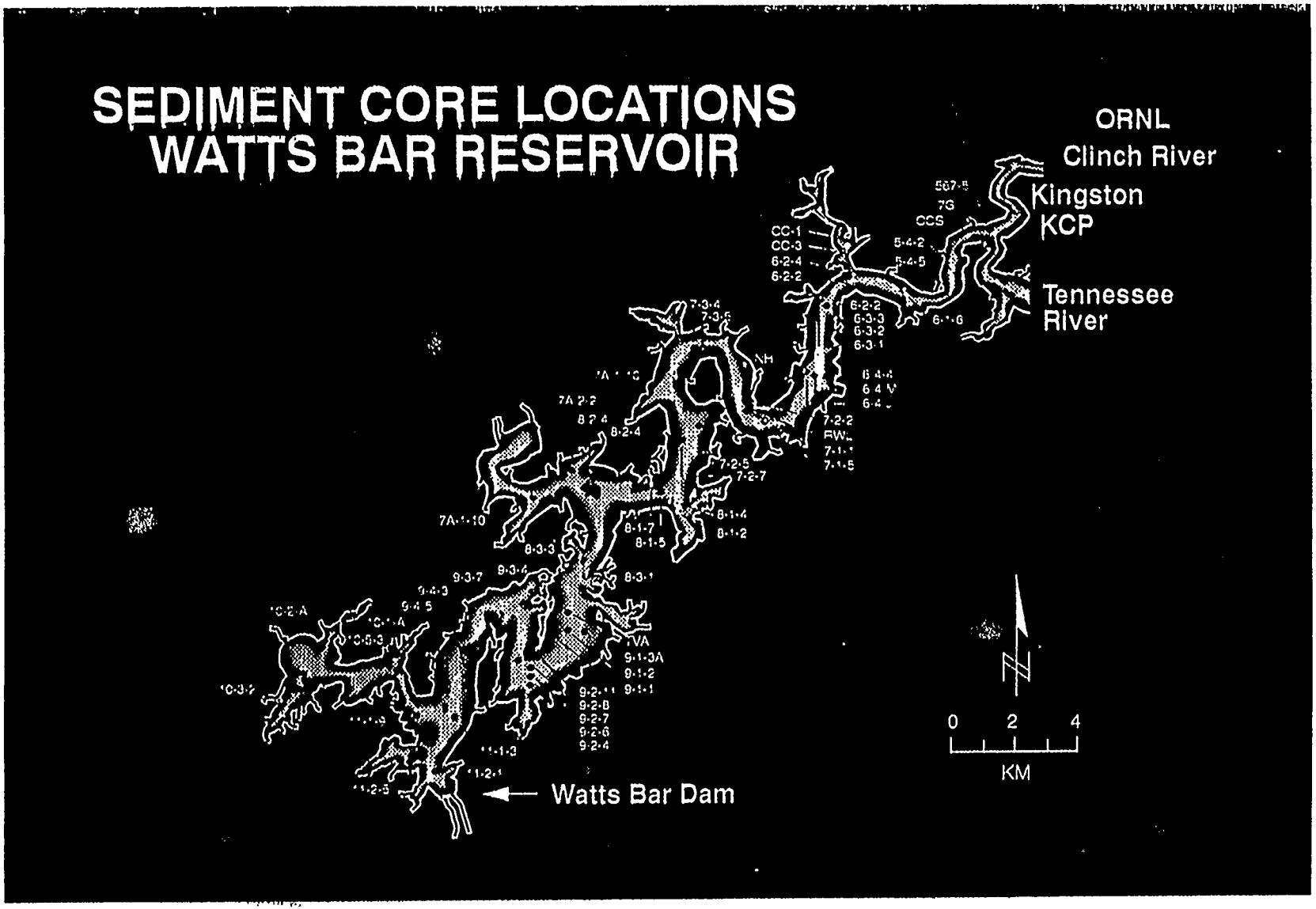
Scoping Studies That Support the Site Investigation Work Plan

- ORNL/ER-7, *Transport and Accumulation of Cesium-137 and Mecury in The Clinch River and Watts Bar Reservoir System*
- ORNL/ER-8, *Screening-Level Risk Assessment for Off-Site Ecological Effects in Surface Waters Downstream from the U.S. Department of Energy Oak Ridge Reservation*
- ORNL/ER-9, *Preliminary Screening of Contaminants in the Off-Site Surface Water Environment Downstream of the U.S. Department Of Energy Oak Ridge Reservation*

MERCURY AND ^{137}Cs PROFILES IN SEDIMENT CORES

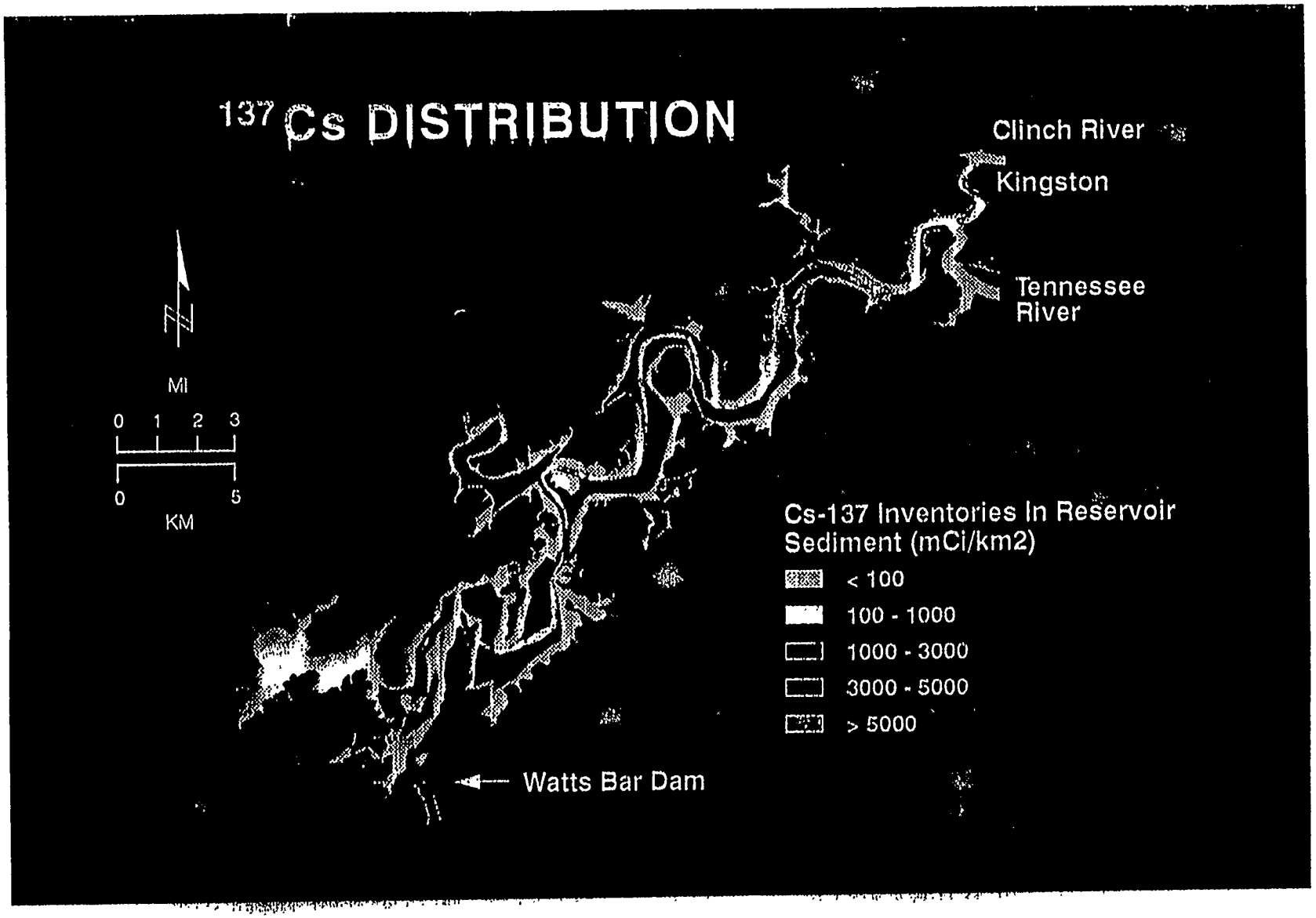


Source. Oak Ridge Task Force Studies


SEDIMENT CORE LOCATIONS
WATTS BAR RESERVOIR
ORNL
Clinch River
Kingston
KCP
Tennessee
River
Watts Bar Dam
0 2 4
KM

Distribution of Other Contaminants

- We used ^{137}Cs as an indicator of the distribution of other contaminants for these reasons:
  - ^{137}Cs release records were available from ORNL.
  - ^{137}Cs is readily measured by gamma Spectrometry.
  - Like many other contaminants, ^{137}Cs
    - Associates strongly with particles in water
    - Is removed by particle sedimentation.


137Cs DISTRIBUTION
Clinch River
Kingston
Tennessee River
MI
0 1 2 3
0 5
KM
Cs-137 Inventories In Reservoir Sediment (mCi/km2)
< 100
100 - 1000
1000 - 3000
3000 - 5000
> 5000
Watts Bar Dam

^{137}Cs and Mercury Inventories in Watts Bar Reservoir Sediments

- 290 curies of ^{137}Cs
  (~85% of total ^{137}Cs released)
- 73 tons of mercury
  (~50% of total mercury released)

Results of the Scoping Studies

- The reservoir retains sediment and particle-associated contaminants.
- The contamination of reservoir sediments by ^{137}Cs and mercury is located primarily in deep water in the old Clinch River channel.
- The highest concentrations of ^{137}Cs and mercury are isolated deep in the bottom sediment.
- Preliminary human health and environmental risk screening analyses indicate the following:
  - No short-term imminent risks
  - Further studies required on most contaminants previously reported in the Clinch River-Watts Bar Reservoir.

SCOPING STUDIES SUPPORTING SITE INVESTIGATION WORK PLAN

- ORNL/ER-7, Transport And Accumulation Of Cesium-137 And Mercury In The Clinch River And Watts Bar Reservoir System
- ORNL/ER-8 Screening Level Risk Assessment For Off-Site Ecological Effects In Surface Waters Downstream From The U.S. Department Of Energy Oak Ridge Reservation
- ORNL/ER-9, Preliminary Screening Of Contaminants In The Off-Site Surface Water Environment Downstream Of The U.S. Department Of Energy Oak Ridge Reservation

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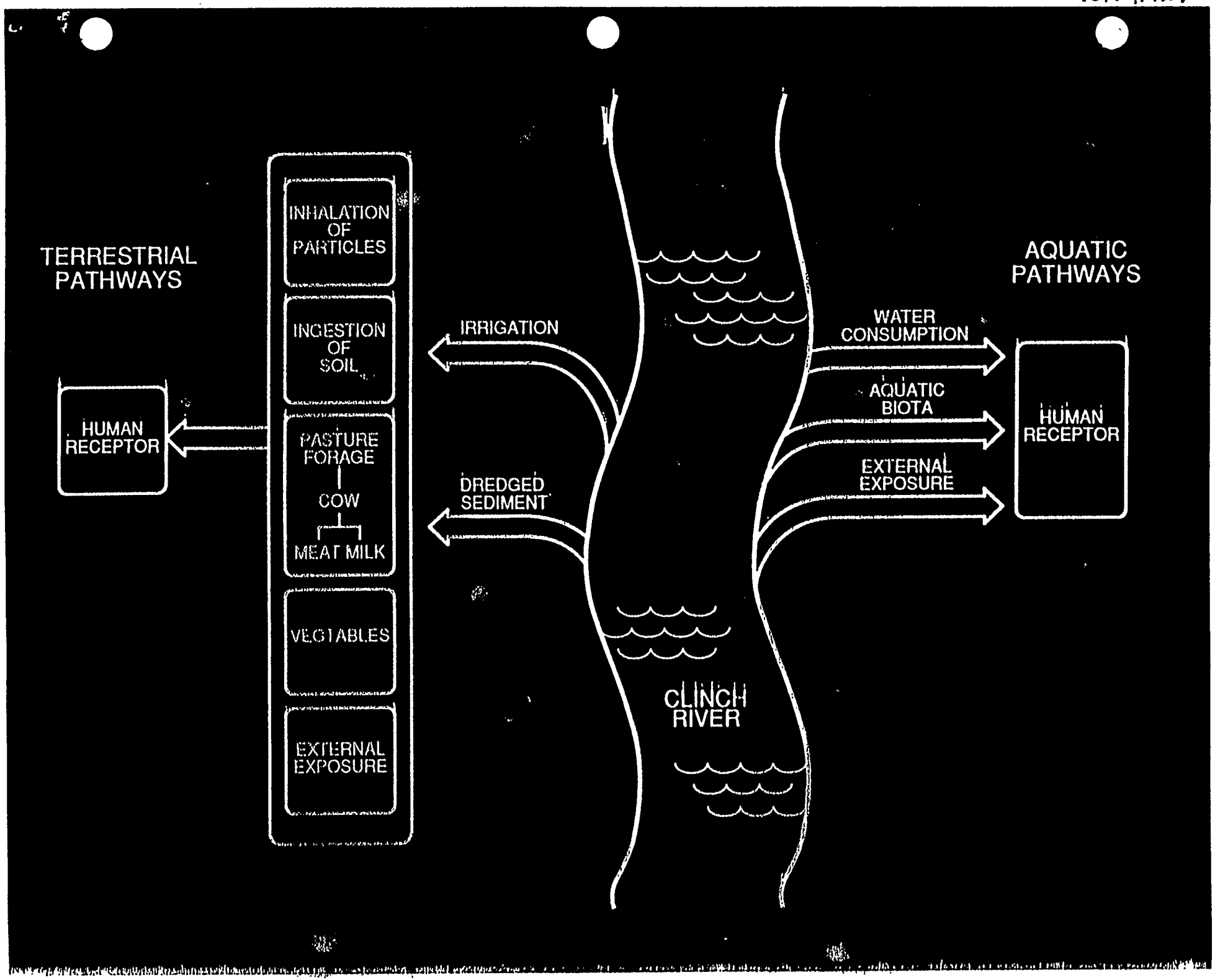
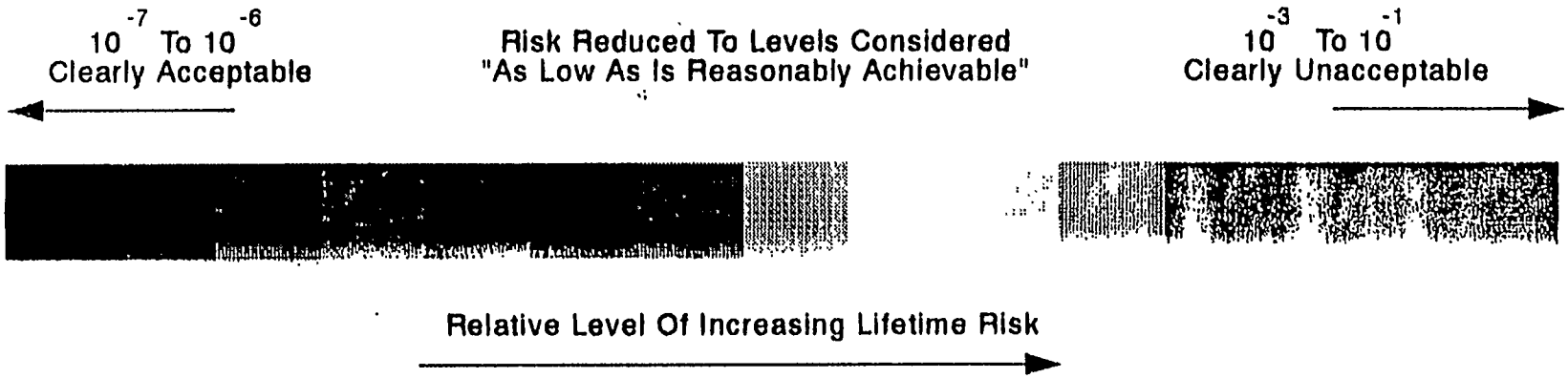

TERRESTRIAL PATHWAYS
HUMAN RECEPTOR
INHALATION OF PARTICLES
INGESTION OF SOIL
PASTURE FORAGE
COW
MEAT MILK
VEGTABLES
EXTERNAL EXPOSURE
IRRIGATION
DREDGED SEDIMENT
CLINCH RIVER
WATER CONSUMPTION
AQUATIC BIOTA
EXTERNAL EXPOSURE
AQUATIC PATHWAYS
HUMAN RECEPTOR

Acceptable Versus Unacceptable Risk



For Remedial Investigation, 10^{-3} And 10^{-6} Lifetime Risks Are Being Proposed As The Upper And Lower Bounds For Risk Screening

900374 18

Contaminants Identified in the Screening Analyses for Further Evaluation in the Clinch River RCRA Facility Investigation

Inorganics	Organics	Radionuclides
Aluminum	Anthracene	Americium-241
Antimony	Benzo (a)anthracene	***Cesium-137***
Arsenic	Bis (2-Ethylhexyl)Phthalate	***Cobalt-60***
Barium	Carbon Tetrachloride	Curium-244
Beryllium	***Chlordane***	***Europium-152, 154***
Boron	Chrysene	Plutonium-239
Cadmium	DDT	***Protactinium-234***
Chromium	4, 6-Dinitro-ortho-cresol	***Strontium-90***
Copper	Fluoranthrene	***Tritium***
Cyanide	Methylene Chloride	Uranium-238
Lead	***PCB-1254***	
Lithium	***PCB-1260***	
Manganese	Phenanthrene	
Mercury	Pyrene	
Nickel	Trans-1, 2-Dichloroethene	
Selenium	Trans-1, 3-Dichloropropene	
Silver	Vinyl Chloride	
Thallium		
Uranium		
Vanadium		
Zinc		

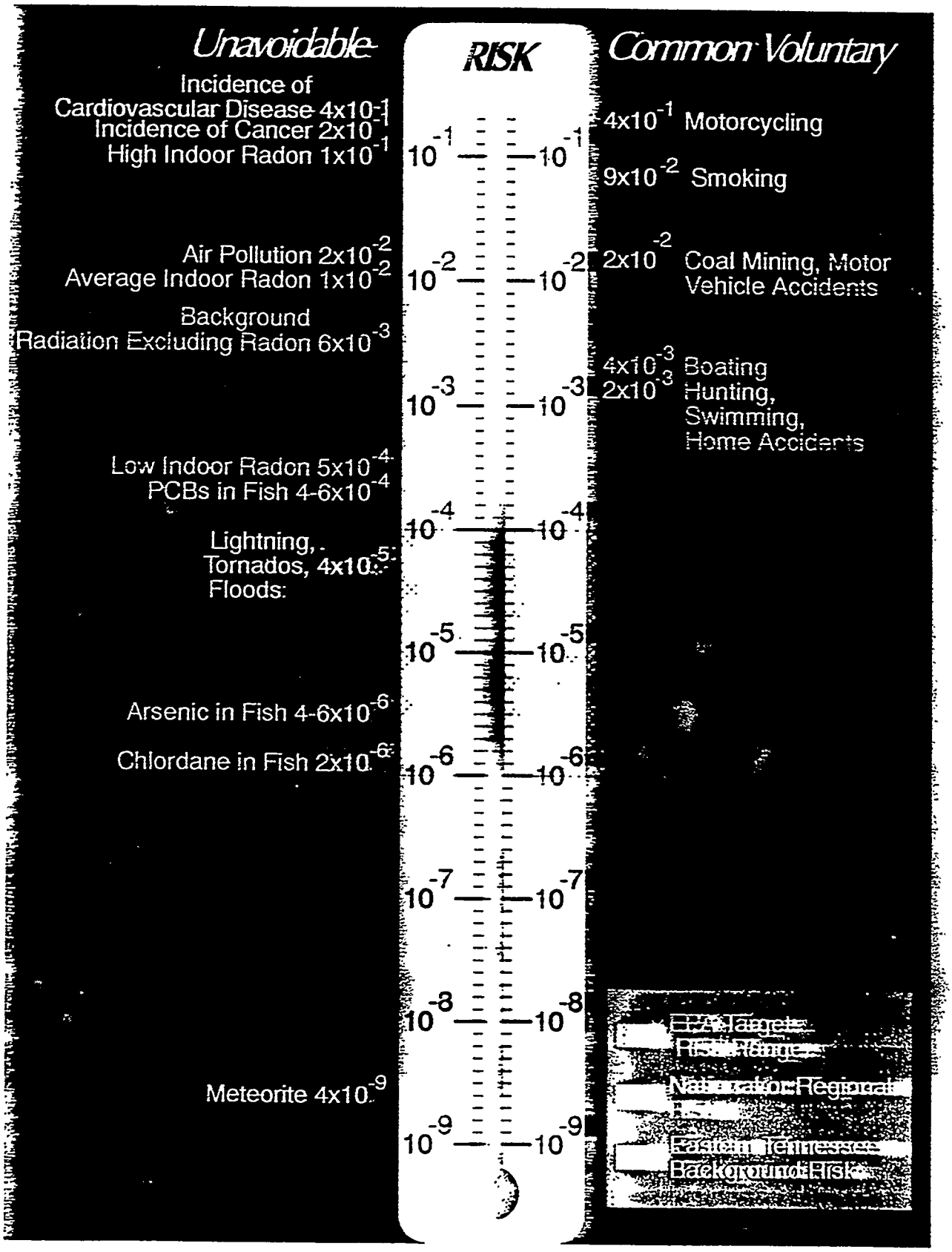
Nonconservative (realistic) assumptions

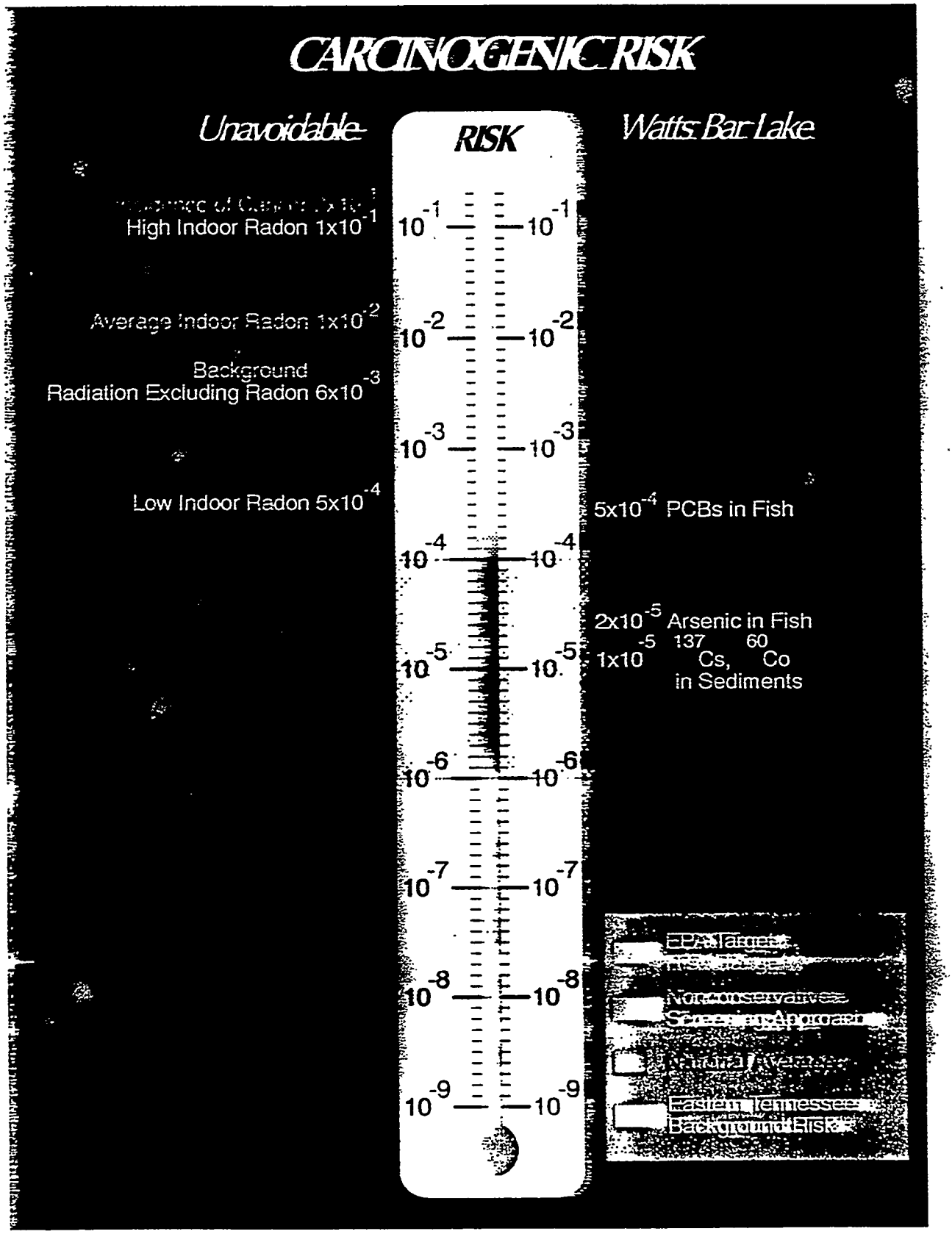
Conservative (worst-case) assumptions

CONTAMINANTS OF CONCERN IN WATTS BAR RESERVOIR

INORGANICS	ORGANICS	RADIONUCLIDES
Arsenic	PCBs[1]	Cs-137
Chromium		Co-60
Mercury		
Selenium		
Zinc		

[1] Potentially high priority contaminant via non-conservative screening.


Unavoidable
RISK
Common Voluntary
Incidence of Cardiovascular Disease 4x10-1
Incidence of Cancer 2x10-1
High Indoor Radon 1x10-1
Air Pollution 2x10-2
Average Indoor Radon 1x10-2
Background Radiation Excluding Radon 6x10-3
Low Indoor Radon 5x10-4
PCBs in Fish 4-6x10-4
Lightning, Tornados, Floods: 4x10-5
Arsenic in Fish 4-6x10-6
Chlordane in Fish 2x10-6
Meteorite 4x10-9
10-1
10-2
10-3
10-4
10-5
10-6
10-7
10-8
10-9
4x10-1 Motorcycling
9x10-2 Smoking
2x10-2 Coal Mining, Motor Vehicle Accidents
4x10-3 Boating
2x10-3 Hunting, Swimming, Home Accidents
EPA Targets
Risk Range
National or Regional
Eastern Tennessee
Background Risk

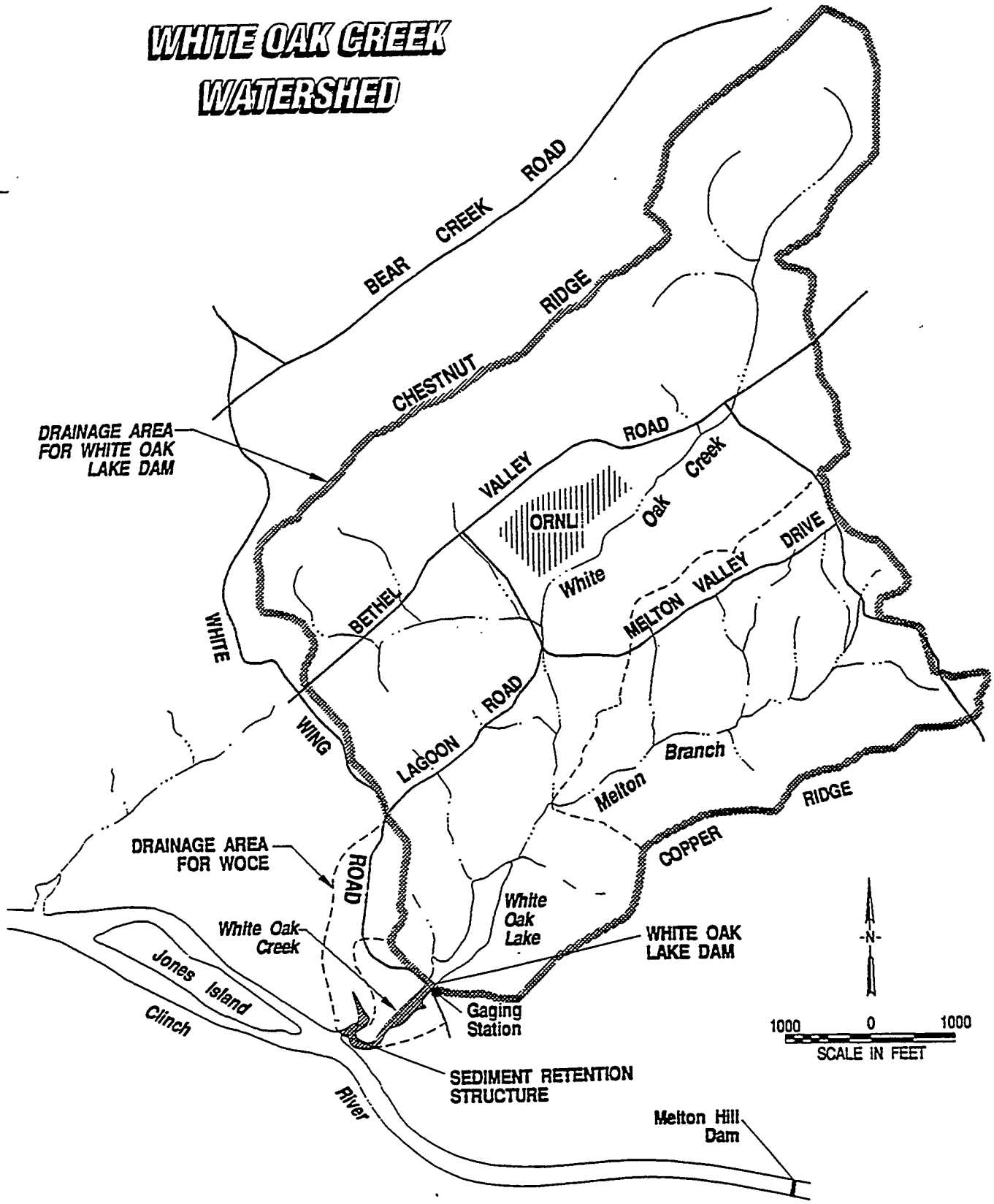

CARCINOGENIC RISK
Unavoidable
RISK
Watts Bar Lake
High Indoor Radon 1x10^-1
Average Indoor Radon 1x10^-2
Background
Radiation Excluding Radon 6x10^-3
Low Indoor Radon 5x10^-4
5x10^-4 PCBs in Fish
2x10^-5 Arsenic in Fish
1x10^-5 137Cs, 60Co
in Sediments
10^-1
10^-2
10^-3
10^-4
10^-5
10^-6
10^-7
10^-8
10^-9
Eastern Tennessee
Background Risk

Summary

- Scoping studies were conducted for two reasons:
  - To help define the spatial extent of off-site surface water contamination
  - To identify those contaminants that should be included in the comprehensive Clinch River-Watts Bar Reservoir site characterization effort.

White Oak Creek Embayment

WHITE OAK CREEK WATERSHED

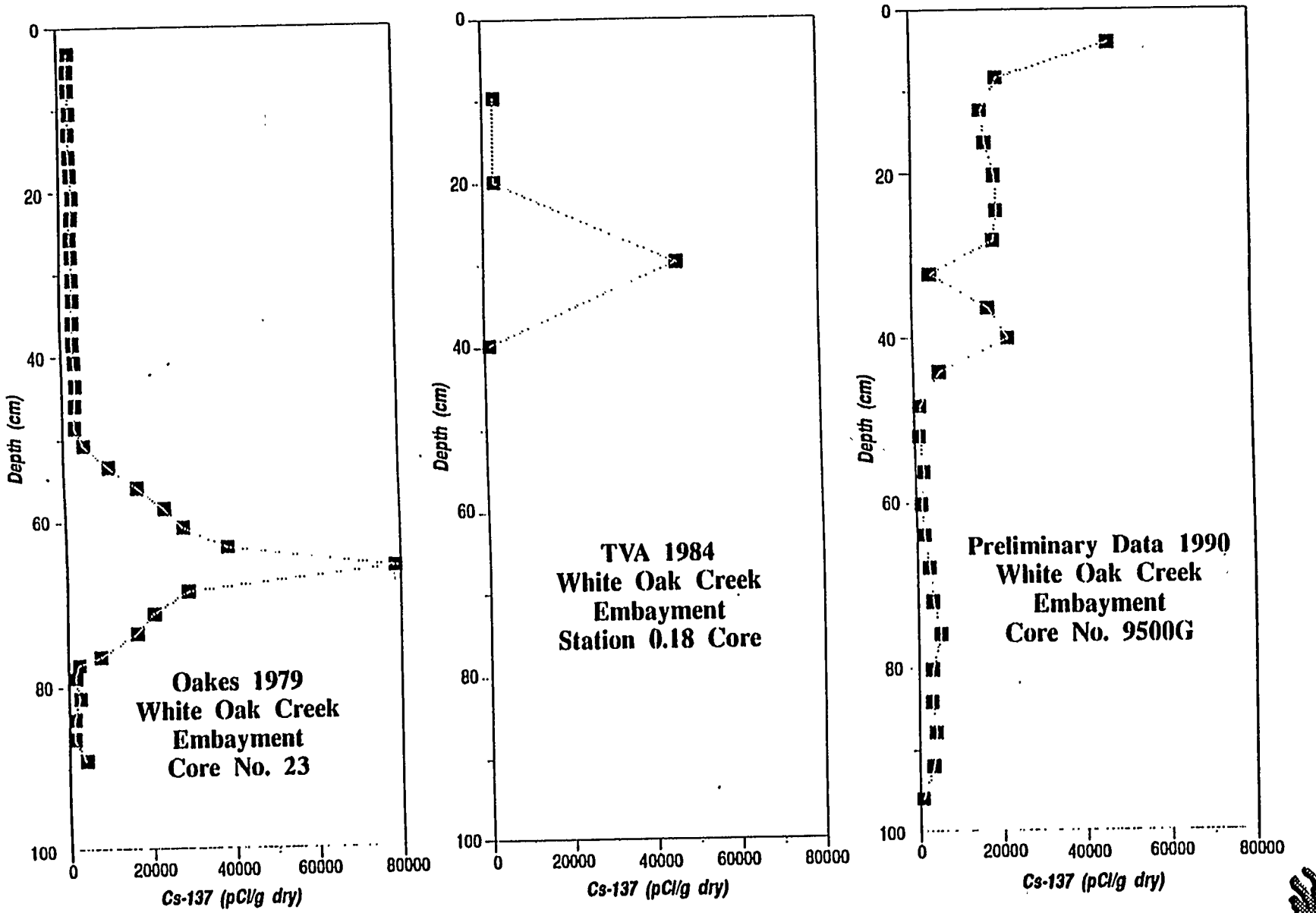


White Oak Creek Embayment

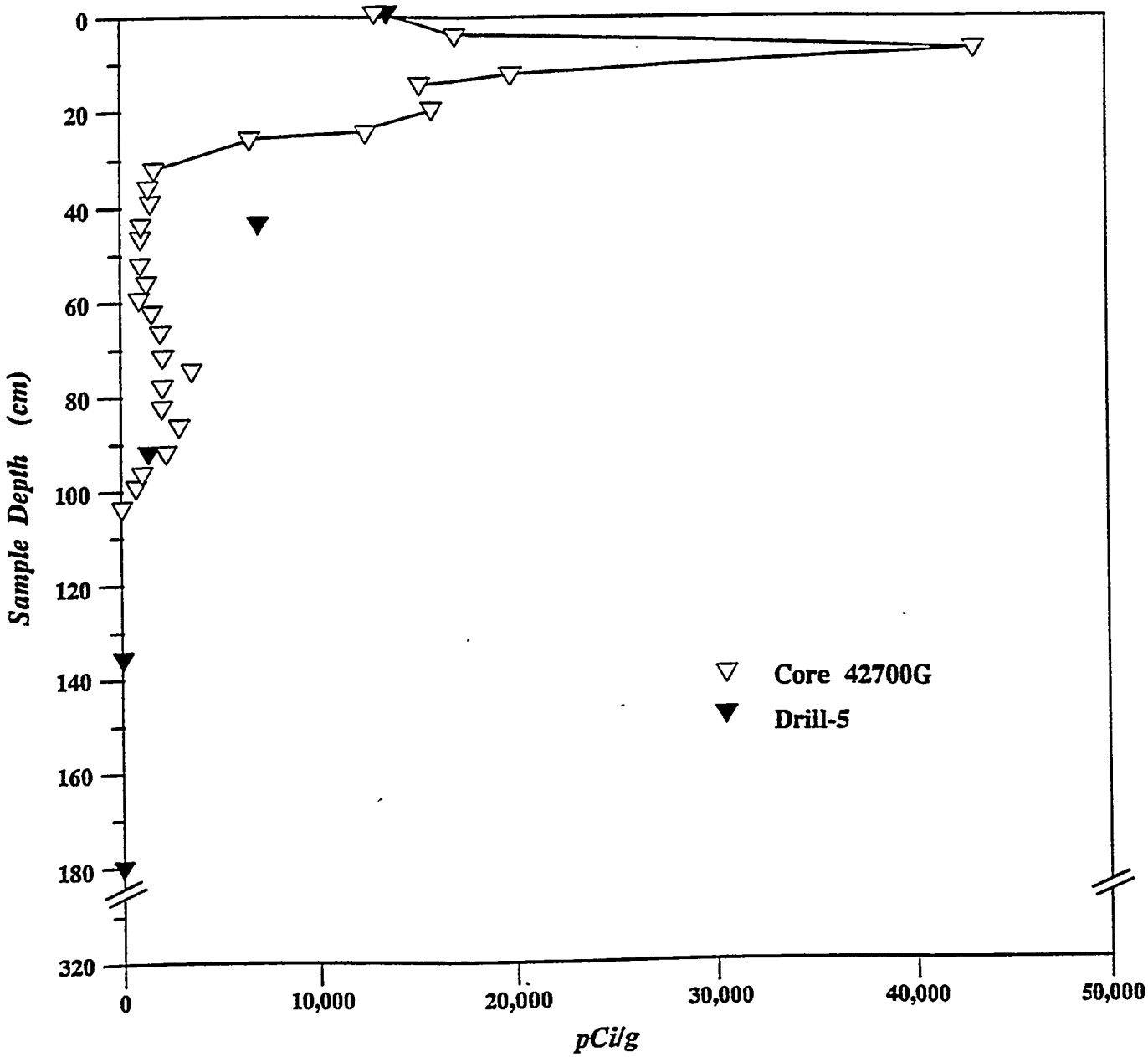
ISSUE

Higher-than-expected levels of ^{137}Cs contamination in near-surface sediments of the White Oak Creek Embayment (WOCE)

Cs-137 IN SEDIMENT CORES FROM WHITE OAK CREEK EMBAYMENT



SEDIMENT AND SOIL PROFILE OF ^{137}Cs DISTRIBUTION AT MOUTH OF WOGE



Summary of Analytical Results on WOCE Sediment and Soil

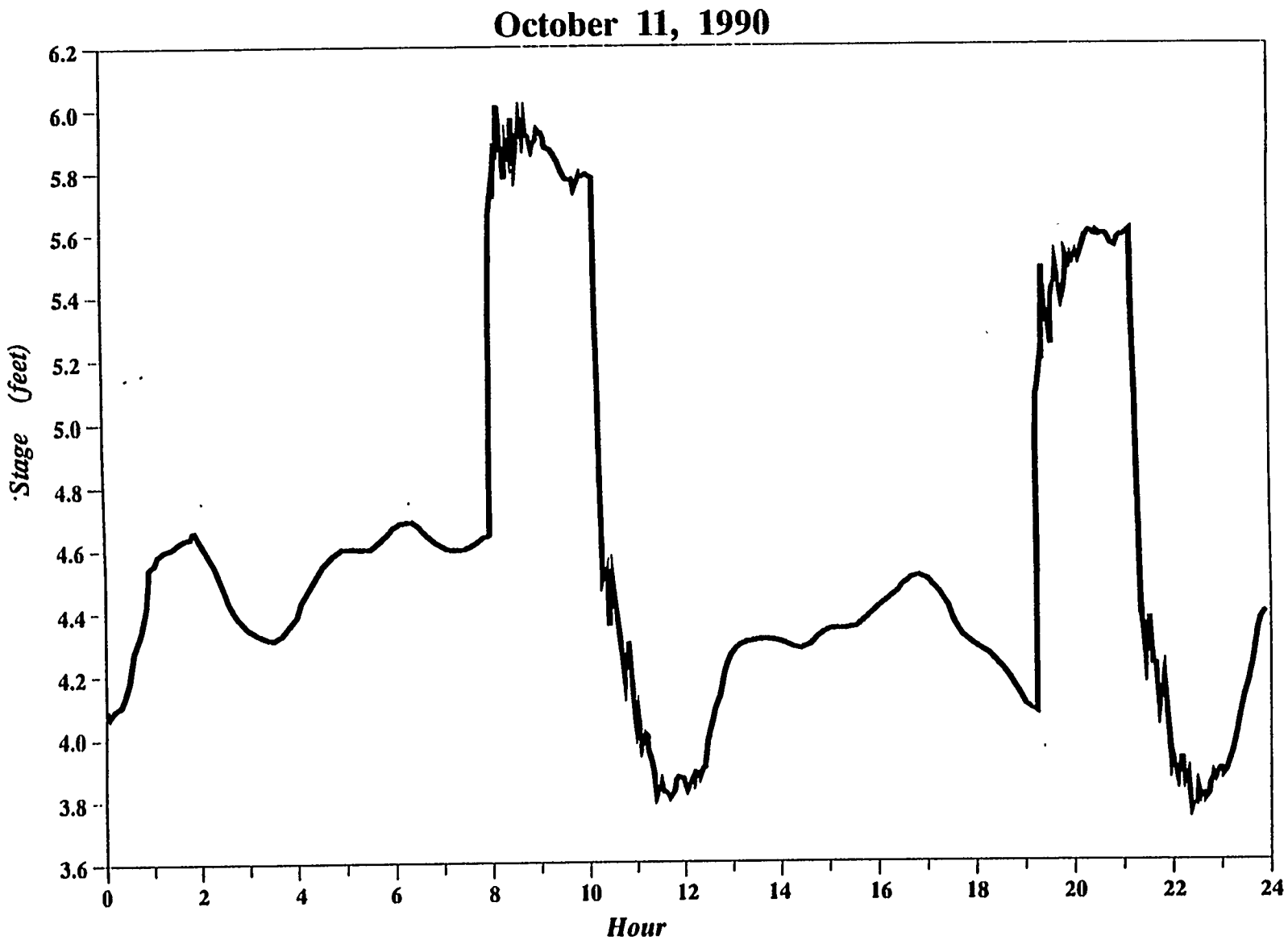
- The sediment (~upper 3 feet) in the stream channel is contaminated, primarily with ^{137}Cs; the underlying soil (~3-12 feet) is uncontaminated
- Chemical analyses of sediment for total concentrations of metals and organics show low organics, some contamination by metals (e.g., Hg, Cr, Pb)
- TCLP results show that extractable/leachable metals are low, well below guidance levels
- Therefore, the problem here is radioactive contamination, predominantly ^{137}Cs

White Oak Creek Embayment

CONCERN

The contaminated surface sediments in WOCE are of concern because they are uncontrolled; i.e., the sediments can be readily eroded from the embayment and transported downstream into the Clinch River

WHITE OAK CREEK EMBAYMENT SURFACE WATER ELEVATION



White Oak Creek Embayment

ACTION PLAN

1. Improve restriction of public access to WOCE area
2. Conduct accelerated site characterization and risk assessment efforts on the WOCE area
3. Conduct, in parallel, an assessment of potential interim corrective measures
4. Implement the most appropriate interim corrective measure to control WOCE sediment erosion to prevent transport of contaminated sediments into the Clinch River

Functional Requirements

- Contain contaminated sediments in the lower WOCE and prevent their transport into the Clinch River for a period of time consistent with the eventual remediation of up-gradient WAGs
- Minimize erosion and off-site transport of WOCE sediment by flow events in the White Oak Creek watershed and/or in the Clinch River
- Minimize the surging of water into and out of the lower portion of the WOCE
- Achieve year-round inundation of WOCE sediments to minimize risk due to direct exposure to contaminated sediment
- Minimize movement of fishes into and out of the WOCE

WOCE Project Method of Accomplishment

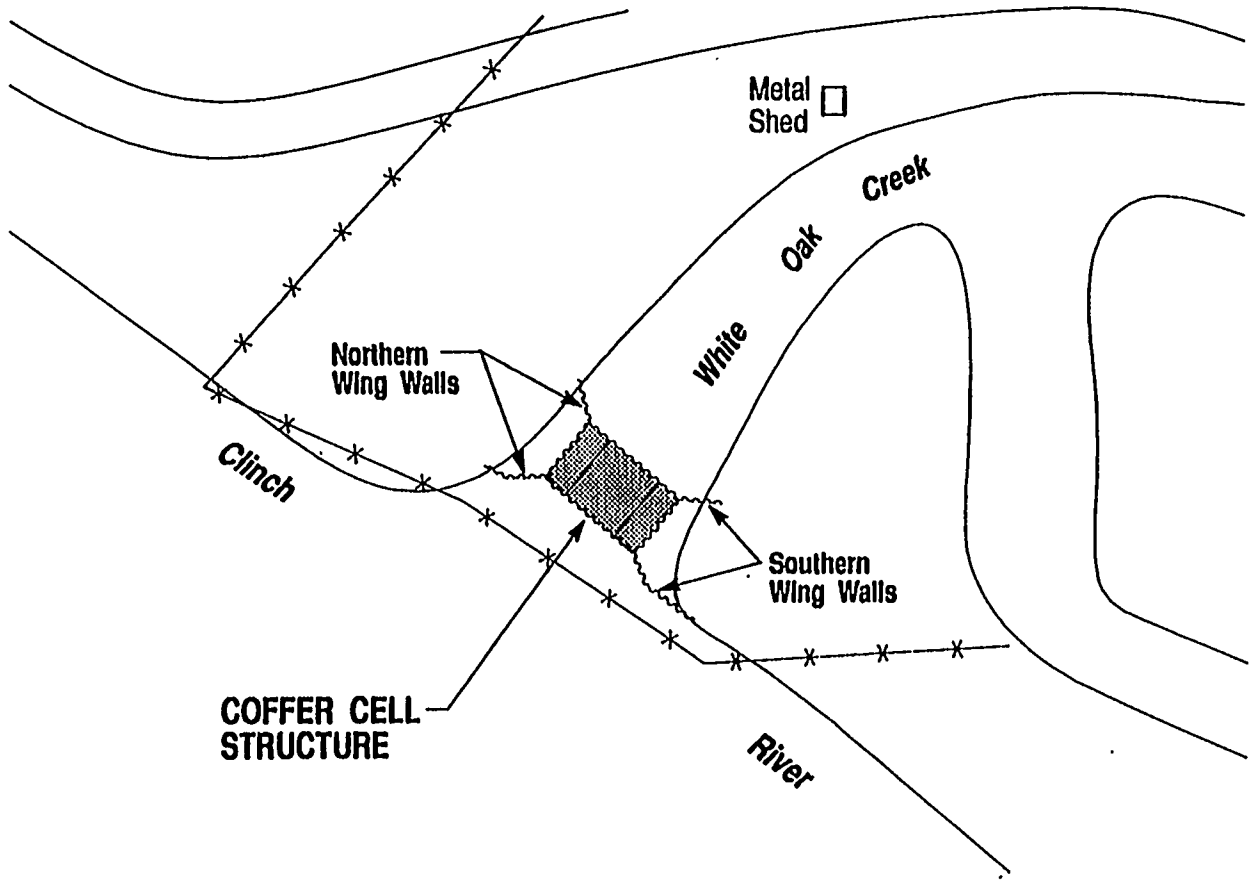
- DOE — Overall project responsibility, direction of prime contractors, NEPA documentation
- MMES — Project integration, ES&H oversight, environmental monitoring, design review, Title III, construction support
- COE — Alternatives evaluation, design, construction support
- MK-F — Construction management, construction contracting

Evaluation of Alternatives for White Oak Creek Embayment, ORNL

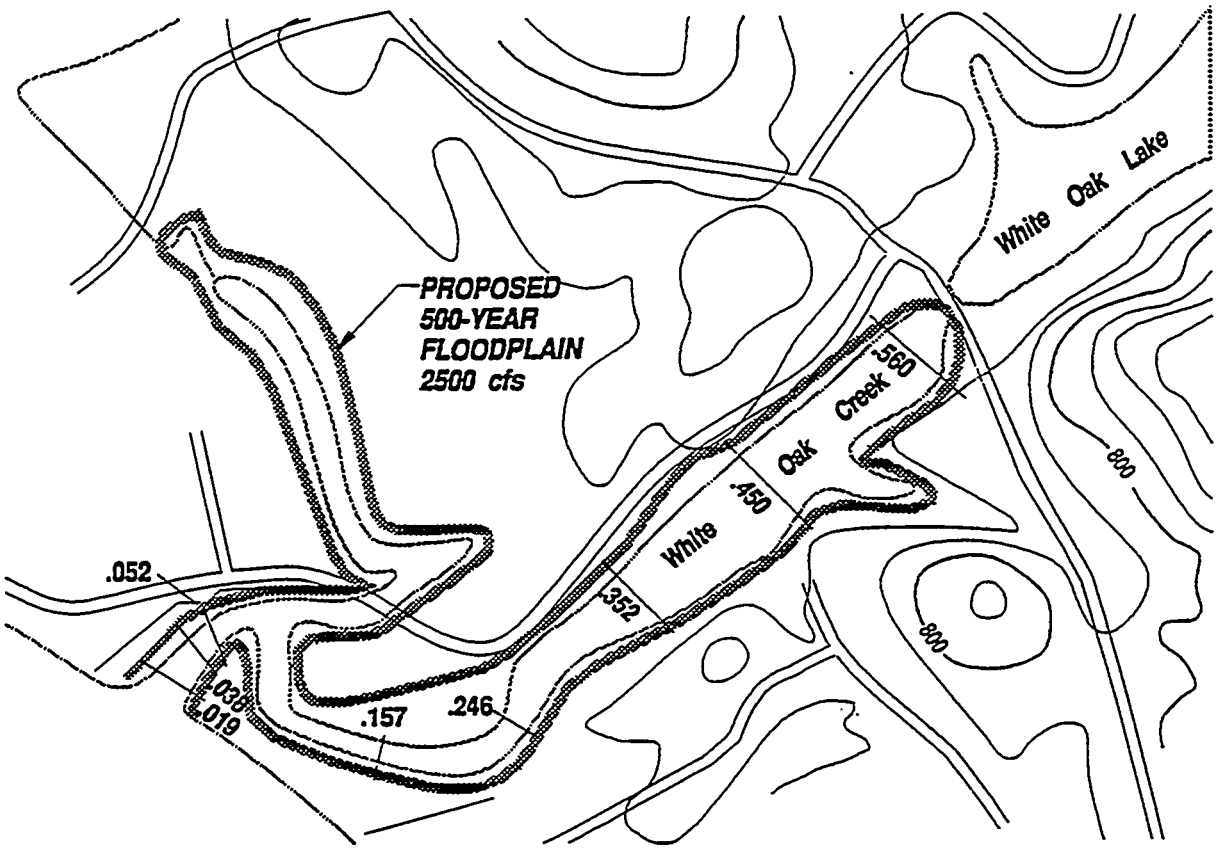
ALTERNATIVES

CERCLA CRITERIA	RETENTION APPROACHES								IN-SITU APPROACHES							No action
	Gabion structure	Rockfill structure	Rockfill/sheet pile structure	Cofferdam/rockfill structure	Sheet pile wall structure	Concrete structure	Sunken caisson structure	Silt curtain	Gabion overlay	Mat overlay	Fabriform overlay	Excavate new channel - cover old	Install pipe culvert - cover old	Dredging/removal within critical reach	Vitrification	
Implementability	N	N	N	Y	N	N	N	N	N	Y	Y	Y	Y	N	Y	Y
Long-term effectiveness and permanence				Y						N	N	N	N		N	N
Overall protection of human health and the environment				Y												N
Reduction of toxicity, mobility, and volume through treatment				Y												N
Short-term effectiveness				Y												N
Compliance with ARARs				Y												N/A
Cost				Y												Y

PLAN VIEW OF SEDIMENT RETENTION STRUCTURE



Proposed Floodplain Boundary of the 500-Year Flood Event for WOC

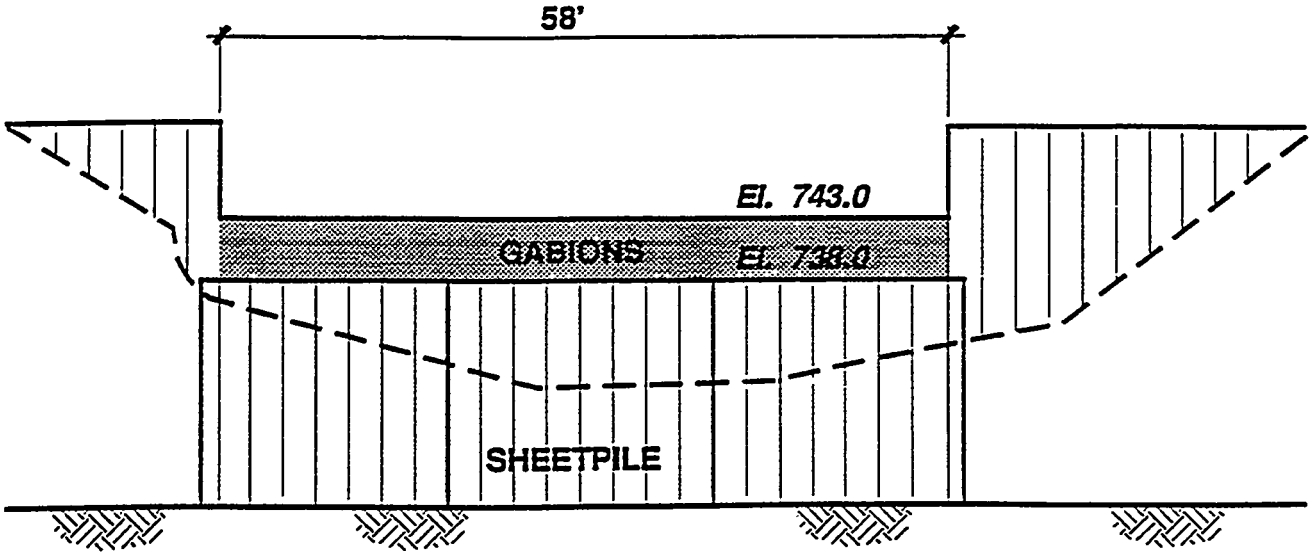


Summary of the 100- and 500-Year Flood Events for WOC Before and After Proposed Embayment Modifications

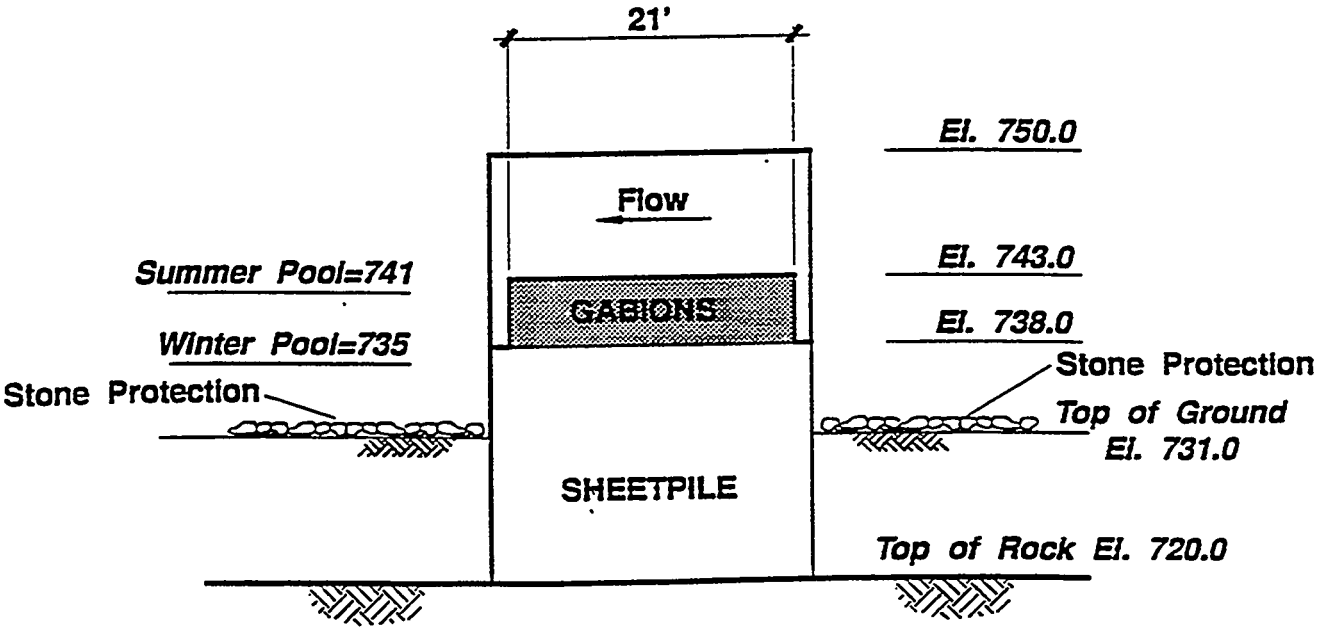
Cross-Section	EXISTING CONDITIONS		PROPOSED EMBAYMENT	
	100-yr Event*	500-yr Event**	100-yr Event	500-yr Event
0.0	741.0	741.0	748.0	749.3
0.019	741.0	741.0	748.0	749.3
0.038	741.1	741.2	748.0	749.3
0.052	741.2	741.4	748.0	749.3
0.157	741.7	742.4	748.0	749.3
0.246	742.3	743.3	748.0	749.4
0.352	742.8	744.0	748.1	749.5
0.450	742.9	744.2	748.2	749.5
0.560	743.1	744.3	748.2	749.6

* 100-year event flow rate is 1688 cfs
** 500-year event flow rate is 2500 cfs

CROSS-SECTION OF SEDIMENT RETENTION STRUCTURE



ELEVATION



SECTION

STATUS UPDATE

CLINCH RIVER-WATTS BAR RESERVOIR

REMEDIAL INVESTIGATION

Bruce L. Kimmel

Presented to the Local Oversight Committee
November 7, 1991

Purpose/Objectives of Clinch River RI Phases

Scoping Phase

- Use existing historical data to identify potential contaminants of concern
- Risk screening to
  - Immediately identify high-risk situations
  - Identify contaminants for further investigation in Phase 1

Phase-1 Investigation

- Obtain high-quality data to confirm/modify preliminary results from scoping studies
- Focus further (Phase-2) investigation on specific contaminants, sites, pathways

Purpose/Objectives of Clinch River RI Phases (cont'd)

Phase-2 Investigation

- Sampling, analysis, and data integration focused on specific contaminants, sites, pathways
- Continuing risk analysis to further focus investigation
- Identification of potential remediation alternatives
- Risk screening of potential remediation alternatives
- Site-specific sampling, analysis, prediction, risk analysis
- RI report, conclusions, recommendations

Contaminants Identified in Screening Analyses for Further Evaluation in the Clinch River RCRA Facility Investigation

Inorganics	Organics	Radionuclides
Aluminum	Chlordane*	Cesium-137*
Arsenic*	PCB-1254*	Strontium-90*
Antimony*	PCB-1260*	Cobalt-60*
Barium	Vinyl Chloride	Tritium*
Beryllium	Anthracene	Europium-152, 154*
Boron	Benzo(a)anthracene	Americium-241
Cadmium	Chrysene	Plutonium-239
Chromium	DDT	Curium-244
Copper	Fluoranthrene	Uranium-238
Cyanide	Methylene Chloride	Protactinium-234*
Lead*	Phenanthrene	
Lithium	Pyrene	
Manganese	Trans- 1,3-Dichloropropene	
Mercury	Carbon Tetrachloride	
Nickel	Trans- 1,2-Dichloroethene	
Selenium	4,6-Dinitro-ortho-cresol	
Silver	Bis(2-Ethylhexyl)Phthalate	
Thallium*		
Uranium*		
Vanadium		
Zinc		

*Potential high-priority substances identified by nonconservative screening

Contaminants of Concern in Clinch River and Watts Bar Reservoir

- Preliminary Phase-1 Results -
Human Health Risk Screening

Inorganics	Organics	Radionuclides
Arsenic	PCBs*	Cesium-137
Chromium		Cobalt-60
Mercury		
Selenium		
Zinc		

* Potentially high priority contaminant via nonconservative screening, fish ingestion pathway

All other contaminants constitute a risk only by sediment dredging and agriculture pathway

Phase-2 Planning

Approach

- Observational approach/bias for action
- Early identification and screening of potential remediation alternatives
- Progressive focus on contaminants, pathways, and sites of concern

Phase-2 Planning (cont'd)

Major Components

- Progressively focused site characterization effort
- Sources, bioaccumulation of PCBs
- Ecological assessment (risk, toxicity, physiological and reproductive effects, population- and community-level effects)
- Predictive capability for assessing contaminant transport and fate, remobilization, remediation alternatives, risk scenarios
- Preliminary identification and evaluation of potential remediation alternatives

ORNL DWG 912 106/2

Interagency Working Group on Watts Bar Reservoir Sediment Contamination

Members

- TDC, chair
- EPA-IV
- TVA
- USCOE
- DOE

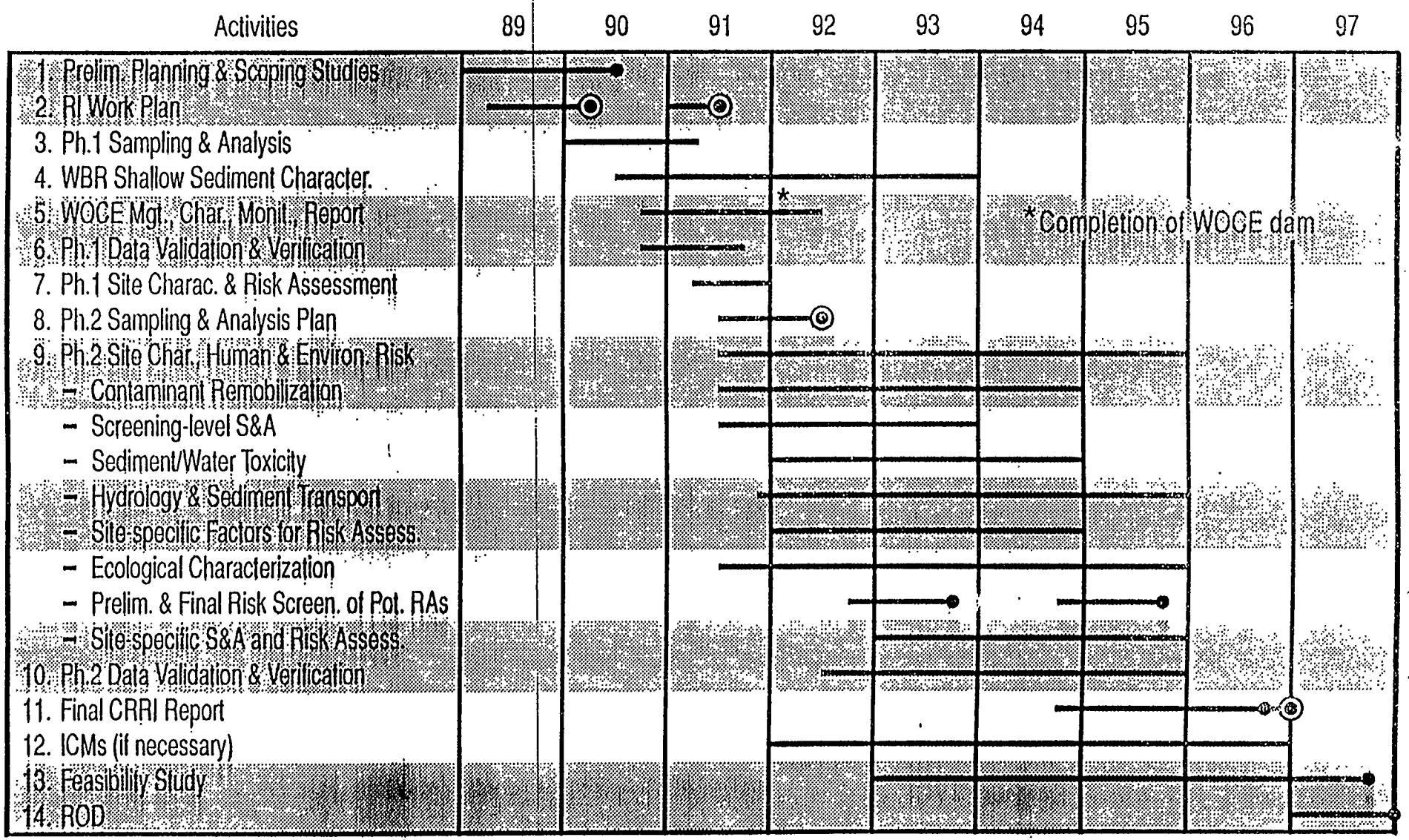
Purpose

- Examine and evaluate permit (26A) applications for activities having potential for disturbing contaminated sediments
- Ensure public safety and minimize remobilization of contaminants

TVA Assistance to DOE Efforts on the Clinch River and Watts Bar Reservoir

- Sampling at public recreation areas and water intakes on Watts Bar, Melton Hill, and Norris reservoirs
- Updating of Watts Bar sediment range cross-sections
- Modeling of water and sediment transport in the Clinch River and Watts Bar Reservoir
- Aerial photography and topographic mapping of White Oak Creek embayment
- Historical review of TVA sediment-disturbing activities

Off-Site Environmental Restoration Program



◉ Primary Milestones

● Secondary Milestones