ENVIRONMENTAL ASSESSMENT METHODOLOGY FOR FOSSIL ENERGY PROCESSES

by

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Abstract

IERL/RTP is conducting a number of programs involving environmental assessment and control technology development for both energy and industrial processes. However, this report focuses on one particular aspect; i.e., the status of some IERL/RTP efforts to develop Environmental Assessment Methodology, especially as it relates to the Federal Interagency Energy/Environment R&D Program.

For purposes of brevity in presentation of a large number of concepts relating to formulation of Environmental Assessment Methodology, this paper is formatted as a series of figures or tables which outline the essential features of Environmental Assessment Methodology being developed for fossil energy processes. It should be noted that the approaches indicated are developing and therefore subject to substantial change, but certain components are better established than others.

The efforts to develop Environmental Assessment Methodology involve several participating environmental assessment contractors who, as a part of their overall activities, have been assigned tasks to develop one or more of the specialized environmental assessment methodology components. The various components when complete will constitute the overall environmental assessment methodology protocol. This methodology is needed on a reasonably near-term basis to eliminate large gaps, inefficiencies and proliferation of techniques for evaluating or comparing environmental effectiveness. However, the potential value and usefulness of the approaches developed have such significance for the Agency that it would be undesirable to proceed in other than a logical and orderly fashion. An Environmental Assessment Steering Committee is in operation (see Appendix A for members) to support certain methodology tasks and provide review and consultation on others.

ACKNOWLEDGMENTS

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SUMMARY AND CONCLUSIONS

Environmental assessment and control technology development programs are underway as part of the Interagency Energy/Environment R&D Program. The Industrial Environmental Research Laboratory at the Research Triangle Park, North Carolina, is conducting work in the fossil energy area in connection with this effort. The environmental assessment work underway is organized on an industry basis and provides for a multipollutant, multimedia analysis of problems and solutions in support of the standards setting and regulatory functions of EPA. Substantial need exists for environmental assessment methodology to support this rather ambitious undertaking.

This presentation outlines a number of the approaches or components comprising the environmental assessment methodologies. The approaches, because of their complexity in dealing totally with such entities as complex effluents, are only partially developed at this time. However, enough progress has been made to illustrate the overall approach and several facets which are important components. These include:

1. Gathering and analyzing of existing process data on energy systems.
2. Phased (Levels 1, 2, and 3) comprehensive chemical/biological testing of process effluents.
3. Techniques for defining when and which more costly detailed chemical analysis is needed.
4. Compiling and organizing information on control/disposal approaches.
5. Control assays to provide standardized laboratory procedures to be used in conjunction with Level 1 sampling and analysis to define the best potential control options.
6. Use of existing health and ecological effects and other data to define Multimedia Environmental Goals (MEG's).
7. Source analysis models to evaluate environmental alternatives by utilizing MEG's to determine potential degree-of-hazard or toxic unit discharge rate for a given control option or plant.
8. Formats for information to be included in standards of practice manuals which provide part of the research documentation from the Office of Research and Development as input to EPA's program offices. Such manuals will consist of an integrated, multimedia, industry-oriented, single-package review of the environmental requirements, guidelines, and best control/disposal options.

The methodologies being developed as a part of the environmental assessment program are of extreme importance to the Agency in that they represent prototype approaches to multimedia, multipollutant problem identification and control effectiveness evaluation for complex effluents. They are prototypes of potential future regulatory approaches that can handle the whole problem and are aimed at preventing problems before they occur. Hopefully they will allow resolution of existing problems on other than a one-pollutant-at-a-time basis, a basis which is fraught with endless studies, only partially effective results, and high cost at all levels of implementation.

ENVIRONMENTAL ASSESSMENT

- Current Process Technology Background
- Environmental Data Acquisition
- Current Environmental Background
- Environmental Objectives Development
- Control Technology Assessment
- Environmental Alternatives Analysis

CONTROL TECHNOLOGY DEVELOPMENT

- Gas Treatment
- Liquids Treatment
- Solids Treatment
- Final Disposal
- Process Modification
- Combustion Modifications
- Fuel Cleaning
- Fugitive Emissions Control
- Accidental Release Technology

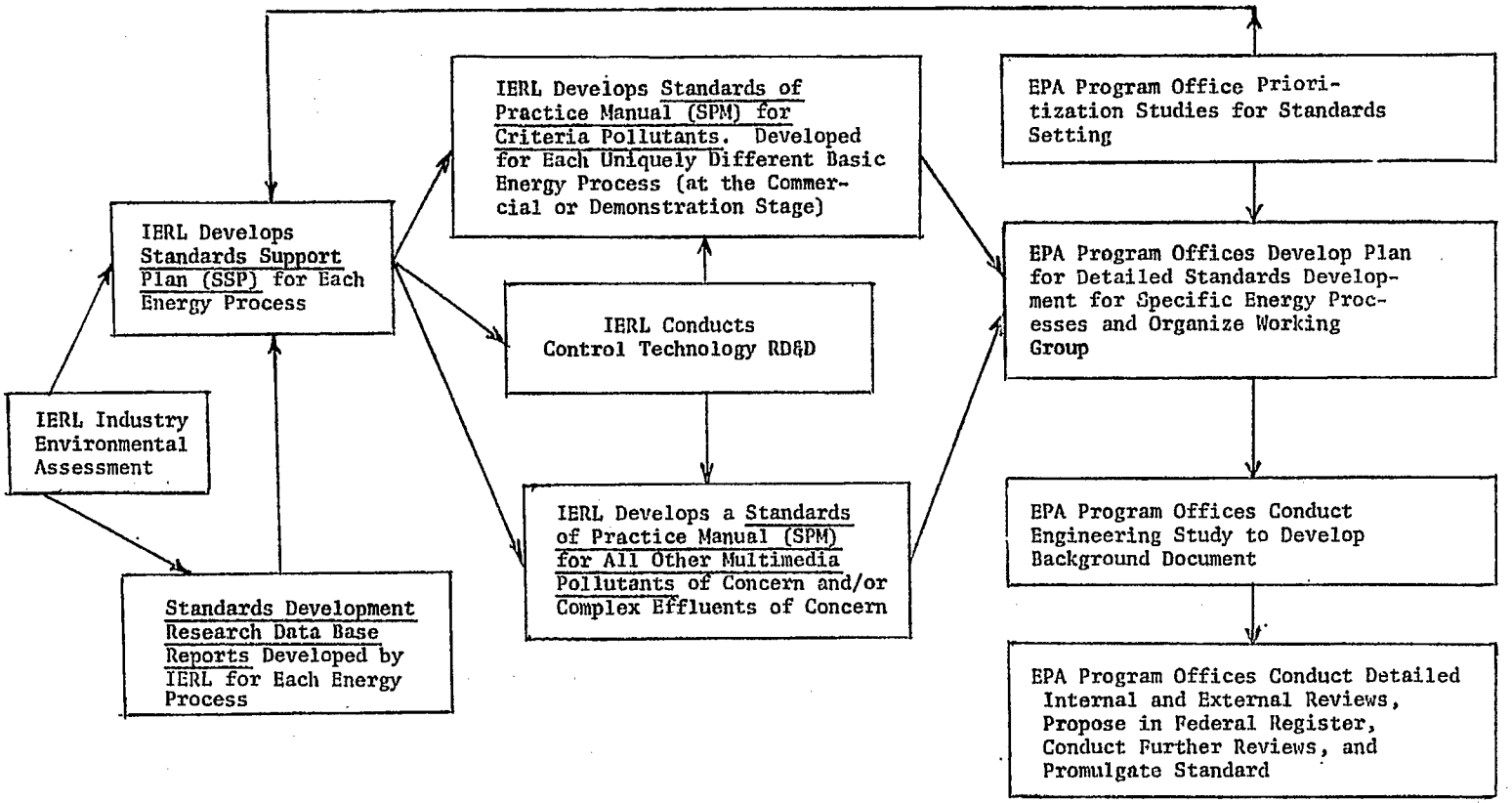
TECHNOLOGY AREAS

- Conventional Combustion
- Nitrogen Oxide/Combustion Modification Control
- Fluid Bed Combustion
- Advanced Oil Processing
- Coal Cleaning
- Synthetic Fuels

OUTPUT OBJECTIVES FOR ENVIRONMENTAL ASSESSMENT

- Defined Research Data Base for Standards
- Quantified Control R&D Needs
- Quantified Control Alternatives
- Quantified Media Degradation Alternatives
- Quantified Nonpollutant Effects and Siting Criteria Alternatives

IERL/RTP STANDARDS DEVELOPMENT SUPPORT R&D



PRIMARY USERS OF PROGRAM ACTIVITIES/RESULTS

- EPA
  - IERL/RTP (several inputs to internal program)
  - OEMI/OR&D (inputs for planning, integrated assessments, OMB, Congress)
  - Health and Ecological Effects Groups (samples, source characterization, ecological testing needs, pollutant effects data needs, test facilities)
  - Environmental Sciences (analytical needs, pollutant transport/transformation study needs, test facilities, samples)
  - Policy and Planning (development of basis for technology/environmental alternatives and costs)
  - Regional Offices (information on problems and control options on a multimedia basis; technical assistance)
  - Enforcement (control information)

- STATE AND LOCAL REGULATORY
  - Multimedia integration of industry environmental considerations

- NIOSH
  - Information
  - Samples
  - Sharing of Data Acquisition Burden
  - Common Control Technology Identification

- DOE
  - Environmental Input to On-going Program
  - Independent Environmental Review of DOE's Technology Development
  - Environmental Assessment Methodology
  - Control Technology Recommendations
  - Design Reviews
  - Proposal Reviews

- FEA
  - Energy Related Aspects of Environmental Control Approaches

- NAS
  - Environmental Inputs to National Academy of Sciences/National Academy of Engineering Studies

- ENVIRONMENTAL GROUPS
  - Environmental Alternatives and Control Option Information

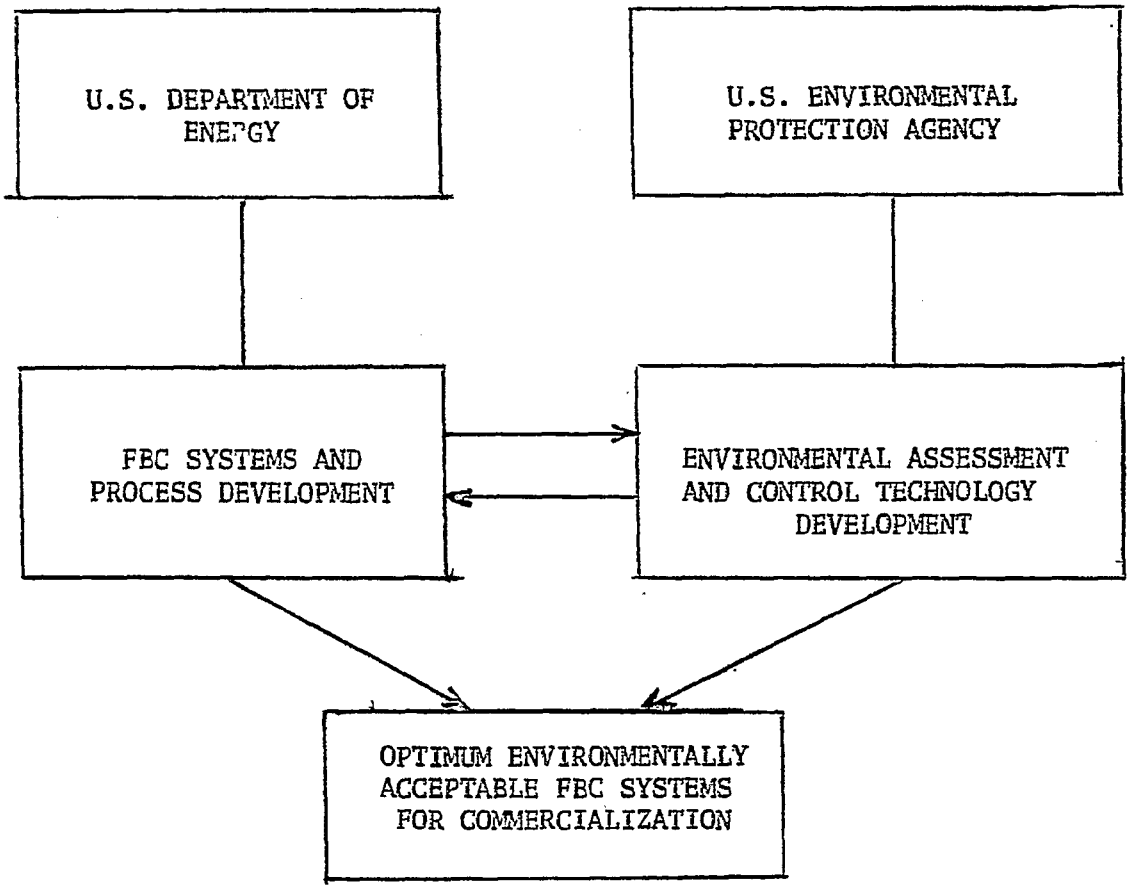
- INDUSTRY
  - Process Developers
  - Control Technology Developers/Suppliers
  - Environmental Engineers/Consultants
  - Coal and Oil Processors/Users
  - Equipment Suppliers/Servicers

- GENERAL PUBLIC
  - Guidelines for Direct Use of Individuals
  - Information on Problems/Control

STATE OF DEVELOPMENT/COMMERCIALIZATION AFFECTS APPROACH TO ENVIRONMENTAL ASSESSMENT AND CONTROL TECHNOLOGY DEVELOPMENT

- Existing Energy Technologies
  - Commercial/Private Sector Capacity

- Emerging Energy Technologies
  - ERDA/Department of Energy Developments
  - Private Sector Developments



EMERGING TECHNOLOGIES--PARALLEL EFFORTS IN PROCESS DEVELOPMENT AND ENVIRONMENTAL ASSESSMENT

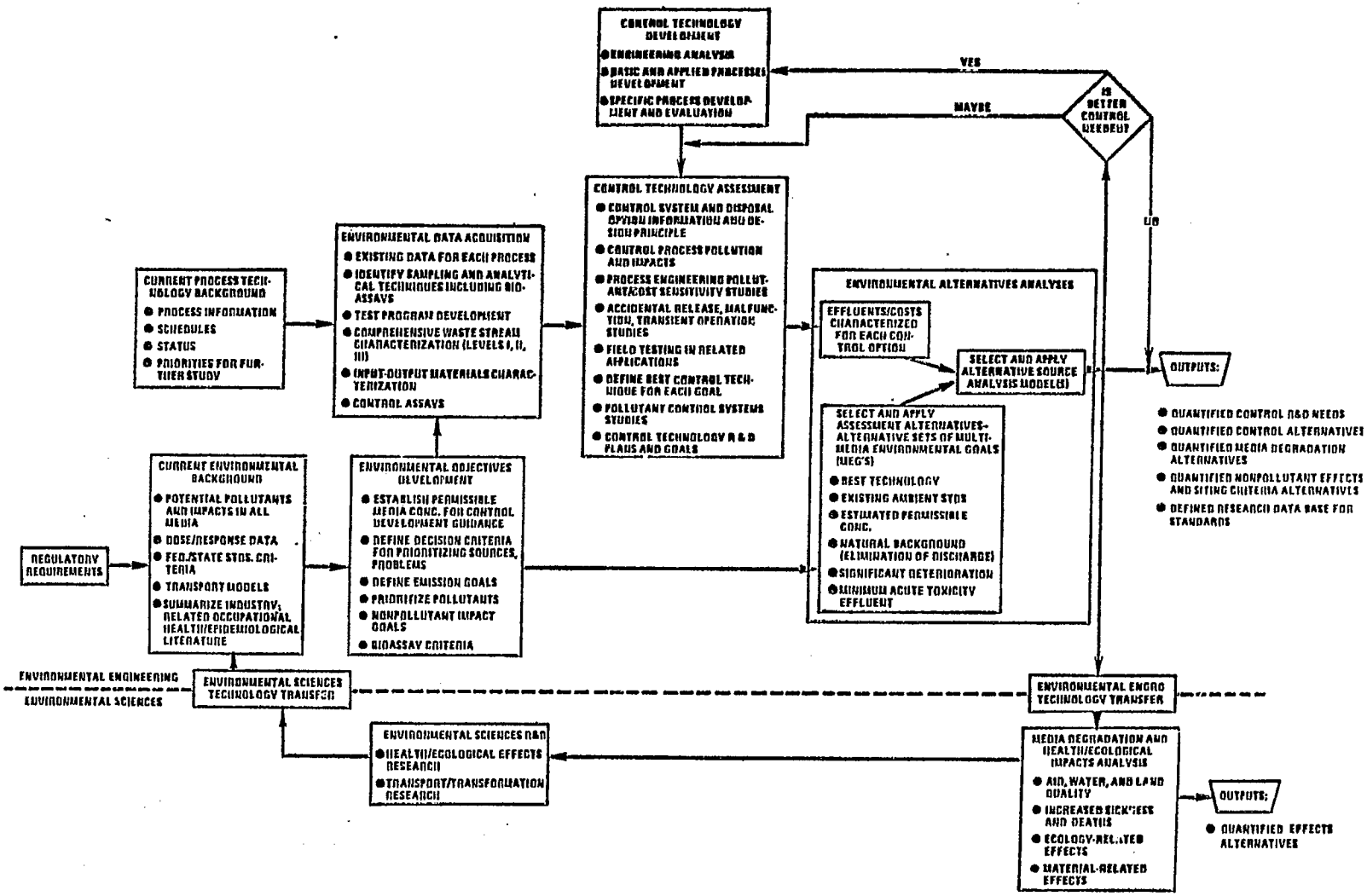
(Example for Fluidized Bed Combustion)*

*Ref. Murthy, K. and H. Nack, "Progress in EPA's Fluidized Bed Combustion Environmental Assessment and Control Technology Development Program," Presented at the Fluidized-Bed Combustion Technology Workshop, Reston, Virginia (April 1977).

ENVIRONMENTAL ASSESSMENT DEFINITION

An environmental assessment, as defined for IERL/RTP studies of fossil energy processes, is a continuing iterative study aimed at:

1. Determining comprehensive multimedia environmental loadings and environmental control costs, from the application of existing and best future definable sets of control/disposal options, to a particular set of sources, processes, or industries; and
2. Comparing the nature of these loadings with existing standards, estimated multimedia environmental goals, and bioassay specifications as a basis for prioritization of problems/control needs and for judgment of environmental effectiveness.



Environmental assessment/control technology development diagram.

ENVIRONMENTAL ASSESSMENTS SERVE AS PARTIAL INPUT TO INTEGRATED ASSESSMENTS

- The Purpose of the Integrated Assessment for Coal-Based Energy Technologies Is:
  - To identify, describe, compare, and quantify where possible the range and magnitude of biophysical, socio-economic, and energy impacts of alternative mixes, rates, levels, and timing of the development and deployment of coal-based energy technologies, supply systems, and end uses.
  - To identify and comparatively analyze technological and institutional methods of avoiding or mitigating undesirable impacts.
  - To recommend alternative policies that will achieve the best balance of environmental quality, energy efficiency, economic costs, and social benefits, and to propose strategies for policy implementation.

GENERAL STATUS OF ENVIRONMENTAL ASSESSMENT METHODOLOGY

- Developing (partly established, partly conceptual)
- Environmental Assessment Methodology assignments made to specific E. A. contractors
- Because of timing, methodology developed in parallel with preliminary environmental assessment
- First compilation of methodology to be available near end of 1977.

ENVIRONMENTAL ASSESSMENT

- Current Process Technology Background
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- Current Environmental Background
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- Environmental Alternatives Analysis

CURRENT PROCESS TECHNOLOGY BACKGROUND

Process Assessment Criteria include such factors as:

- Commercial status
- Existing capacity
- Schedules for construction, development, etc.
- Priorities
- Quantities and types of residual emissions
- Projected process costs
- Energy efficiency and form of energy. (This was considered a cost factor with independent significance.)
- Applicability; i.e., the extent of projected markets
- Rate of availability; i.e., how fast technology can be brought to commercial availability and applied
- Probability of success in development (includes a variety of considerations; e.g., the scale on which the process has been operated; the magnitude of the investment for commercial plants; how it will fare in the competition among technologies)

ENVIRONMENTAL DATA ACQUISITION

Unit Operations Organization for Study of Pollutant Sources (Examples)

- Raw Material Storage
  - Windblown dusts
  - Water runoff
  - Leakage and venting
- Transportation
  - Windblown dusts
  - Open conveyor
  - Transport liquids (water, organics)
  - Other handling losses
  - Vehicular transport
- Raw Material Preparation
  - Fuel or raw material drying

- Grinding, pulverization
- Particulate collectors
- Coal washing
- Pretreatment steps
- Vents

- Reactors/Convertors/Combustors
  - Raw material feed mechanism
  - Chemical/physical transformations
  - Leakage and venting
  - Flue gas from combustion/power steam generation from fuel or fuel residues
  - Product utilization

- Process Stream Separation/Cleaning/Treatment
  - Raw gas cleanup
  - Gas purification systems
  - Catalyst/sorbent regeneration
  - Claus sulfur plant tail gas treatment
  - Flue gas desulfurization units
  - Vents and flares
  - Particulate collectors
  - Tar oil/water separators
  - Waste water treatment
  - Leaks
  - Cleaning agents and additives

- Products and By-Products
  - Product upgrading and recovery
  - Sulfur and other by-product recovery
  - Handling and storage losses
  - Utilization

- Final Disposal
  - Flyash, ash, and slag
  - Spent catalyst and sorbent disposal
  - Hazardous solid wastes
  - Ponds
  - Landfills
  - Piles
  - Thermal cooling (air, water, heat, cooling water, blowdown, drift)

- Auxiliary Facilities
  - Oxygen plant
  - Hydrogen plant

- Accidental/Transient Release

ENVIRONMENTAL DATA ACQUISITION

A phased approach:

Level 1 - *Comprehensive Screening* ("Criteria pollutants" included)

Level 2 - Directed *Detailed Analysis* Based on Level 1

Level 3 - *Process Monitoring on Selected Priority Pollutants* Based on Levels 1 and 2

ENVIRONMENTAL DATA ACQUISITION

Level 1 Sampling and Analysis

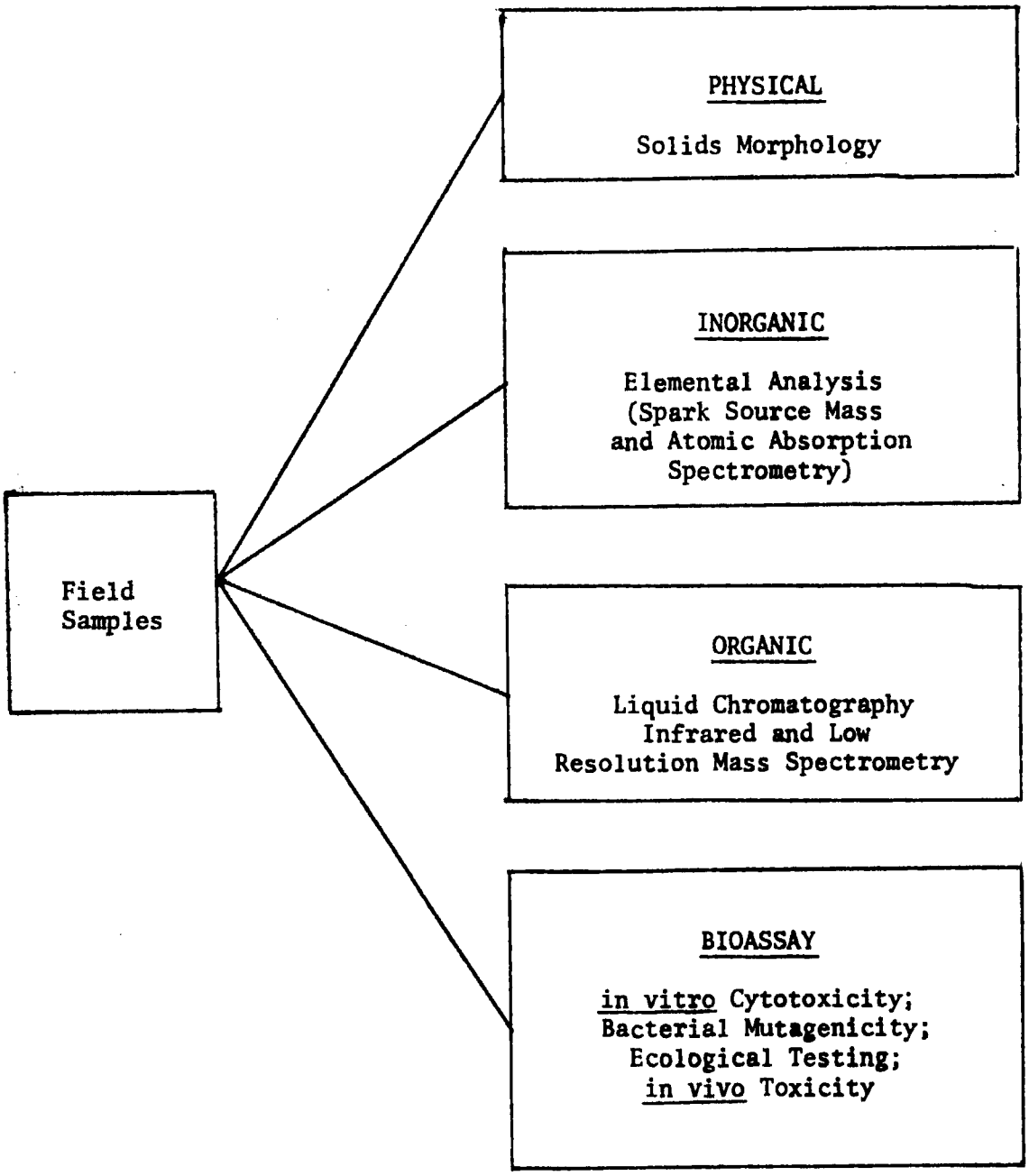
Effluent Samples:	Gases Liquids Solids
Evaluated for Discharge to Media:	Air Water Land
Analyses:	Physical Chemical Biological
Key Environmental Parameters:	Health Ecological

ENVIRONMENTAL DATA ACQUISITION

Level 1 Sampling*

Stream	Sample size	Location	Sampling procedure
Gas	30 m^3	Ducts, stacks	SASS train
Liquid	10 l	Lines or tanks	Tap or valve sampling
		Open free-flowing streams	Dipper method
Solids	1 kg	Storage piles	Coring
		Conveyors	Full stream cut

* Environmental Assessment Sampling and Analysis: Phased Approach and Techniques for Level 1, EPA-600/2-77-115 (NTIS No. PB 268563/AS), June 1977.



LEVEL 1 ANALYSIS*

*Environmental Assessment Sampling and Analysis: Phased Approach and Techniques for Level 1, EPA-600/2-77-115 (NTIS No. PB 268563/AS), June 1977.

ENVIRONMENTAL DATA ACQUISITION
DRAFT BIOASSAY PROTOCOLS*

LEVEL 1 - MINIMAL TEST MATRIX

Sample Type	Health Effects Tests			Ecology Effects Tests	
Water and Liquids	Microbial Mutagenesis	Rodent Acute Toxicity	Algal Bioassay	Static Bioassays	Soil Microcosm
Solids (Aqueous Extract, Feed, Product, Waste)	Microbial Mutagenesis	Rodent Acute Toxicity	Algal Bioassay	Static Bioassays	Soil Microcosm
Gases (Grab Sample)					Plant Stress Ethylene
Particulates	Microbial Mutagenesis	(Rodent Acute Toxicity)**	Cyto-toxicity		Soil Microcosm
Sorbent (Extract)	Microbial Mutagenesis		Cyto-toxicity		

*IERL-RTP Procedures Manual: Level 1 Environmental Assessment, Biological Tests for Pilot Studies, EPA-600/7-77-043 (NTIS No. PB 268484/AS) April 1977.

**Recommended test not specified because of limited sample availability of secondary priority.

LEVEL 1 - BIOASSAY TESTS ORGANISMS

Health Effects Tests

- Microbial Mutagenesis
  - Salmonella typhimurium

- Cytotoxicity
  - Rabbit Alveolar Macrophages (RAM)
  - Human Lung Embryo Fibroblasts (WI-38)

- Rodent Acute Toxicity
  - Rats

Ecological Effects Tests

Fresh Water

- Algae Bioassay
  - Selenastrum capricornutum
  - Microcystis aeruginosa
  - Amacystis cyanea
  - Anabaena fos-Aquae
  - Diatom-Cyclotella
  - Diatom-Nitzschia

- Static Bioassay
  - Fathead minnow
  - Daphnia pulex

Marine

- Marine Algae Bioassay
  - Skeletonema costatum

- Static Bioassay
  - Juvenile sheepshead minnows (cyprinodon variegatus)
  - Adult grass shrimp (Palaemonetes pugio or P. vulgaris)

Terrestrial

- Plant Stress Ethylene Test
  - Soybean

- Soil-Litter Microcosm
  - Soil organisms

ENVIRONMENTAL ASSESSMENT MEASUREMENT AND EVALUATION SUMMARY

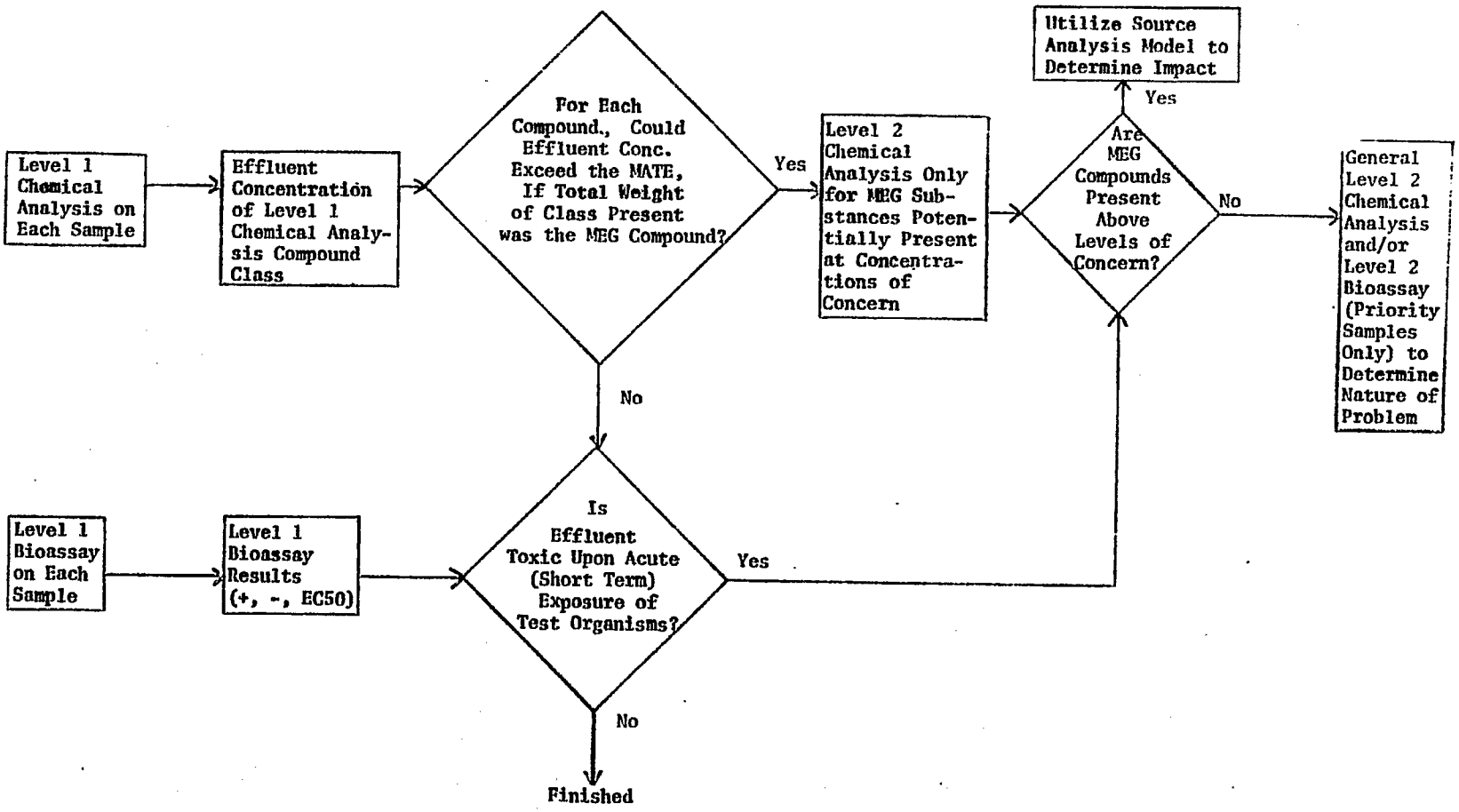
Environmental Assessment Measurement Levels	Sampling	Analysis					Environmental Alternatives Analysis			
		Chemical		Bioassay			Assessment Alternatives (Multimedia Environ. Goal Sets Used)	Source Analysis Models Used	Media Evaluated	Effect Level Evaluated
	Accuracy	Accuracy/ Specificity	Conc. Level Measured	Accuracy/ Specificity	Effect Level Measured	Media Measured				
Level 1 (Comprehensive Screening)	Low	Low	Effluent	Low	Acute Exposure	Effluent	MATE*	SAM/IA	Effluent	Acute Exposure
Level 2 (Directed Detailed Analysis Based on Level 1)	Higher	Higher	Effluent	Higher	Acute Exposure	Effluent	MATE* (EPC** ES***)	SAM/IA SAM/I SAM/II	Effluent (Est. Ambient)	Acute Exposure Chronic Exposure
Level 3 (Process Measurements on Selected Priority Pollutants Based on Levels 1 and 2)	Highest	Highest	Effluent	Highest	Chronic Exposure	Effluent	(EPC** ES***)	SAM/II	(Est. Ambient)	Chronic Exposure

* MATE (Minimum Acute Toxicity Effluent)
** EPC (Estimated Permissible Concentrations)
*** ES (Existing Standards)

ANALYTICAL CHEMICAL TECHNIQUES APPLICABLE
IN LEVEL 2 FOLLOWING LEVEL 1 SURVEY OF STREAM CONTENTS*

Category A	Category B
Wet Chemical Methods	Separation Techniques
(e.g., SO_4, NO_3, F, total phenolics)	High-Performance Liquid Chromatography
	Gas Chromatography
Elemental Analysis	Ion Exchange
Spark-Source Mass Spectrometry	Solvent Extraction
Atomic Absorption Spectrometry	Structure Elucidation
Arc and Spark Emission Spectrometry	Nuclear Magnetic Resonance
Neutron Activation Analyses	High-Resolution Mass Spectrometry
X-Ray Fluorescence	Photoelectron/Inner Shell Electron Spectrometry (Surface Inorganics)
Organic Materials	Infrared Spectrometry
Infrared Spectrometry	Quantitative Measurement
G.C. - Mass Selective Detector	
G.C. - Selective Detector	
(e.g., Flame Ionization, Flame Emission, Electron Capture)	If not achieved in Separation or Structure Elucidation, utilize Category A.
Chemi-Ionization Mass Spectrometry	

*This is not an all inclusive or an exclusive list. Choice of the most cost/information effective methods will vary from sample to sample. Environmental Assessment Sampling and Analysis: Phased Approach and Techniques for Level 1, EPA-600/2-77-115 (NTIS No. PB 268563/AS), June 1977.



DECISION LOGIC FOR PHASED LEVEL 1-LEVEL 2 ANALYSIS

CURRENT ENVIRONMENTAL BACKGROUND

- REPORTS
  - Potentially Hazardous Emissions from the Extraction and Processing of Coal and Oil (Battelle) (EPA-650/2-75-038, NTIS No. PB 241803, May 1975)
  - Summary of Key Federal Regulations and Criteria for Multimedia Environmental Control (RTI) (Draft, June 1977)
  - Estimation of Permissible Concentrations of Pollutants for Continuous Exposure (RTI) (EPA-600/2-76-155, NTIS No. PB 253959/AS, June 1976)
  - Preliminary Format for Compilation of Ambient Trace Substances Data (RTI) (August 1976)

- ACTIVITIES
  - Compilation of Existing Physical, Chemical, and Toxicological Data for Specific Pollutants
  - Gathering of Information on Transport/Transformation Models
  - Compilation of Ambient Trace Substances Data

FEDERAL REGULATIONS APPLYING QUANTITATIVE LIMITATIONS TO SPECIFIC, POTENTIAL ENVIRONMENTAL POLLUTANTS

- National Primary and Secondary Ambient Air Quality Standards
- Occupational Safety and Health Administration Standards for Air Contaminants
- National Emission Standards for Hazardous Air Pollutants
- New Stationary Source Performance Standards
- Emissions Standards for Control of Air Pollution from New Motor Vehicles and New Motor Vehicle Engines
- National Interim Primary Drinking Water Regulations

Supplement: 1962 Public Health Service Regulations on Drinking Water

- EPA Effluent Standards
- EPA Toxic Pollutant Effluent Standards (Proposed)
- EPA Pesticide Limits
- Standards for Protection Against Radiation
- Criteria for the Evaluation of Permit Applications for Ocean Dumping of Materials

ENVIRONMENTAL OBJECTIVES DEVELOPMENT

(Multimedia Environmental Goals)

General Classes

- Organic and Inorganic Totals
- Organic Compounds
- Inorganic Compounds
- Physical Agents
- Complex Effluent Assays
- Heat
- Noise
- Microorganisms
- Radionuclides
- Nonpollutant Factor (e.g., water use, land use)

SELECTION FACTORS FOR CHOICE OF CHEMICAL SUBSTANCES AND PHYSICAL AGENTS TO BE INCLUDED IN MEG CHART

PRIMARY SELECTION FACTORS

- Known or Suspected as an Emission from Coal or Oil Processing
- All Classes of Compounds/Substances Represented

SECONDARY SELECTION FACTORS

- Found as Pollutant in the Environment
- Highest Toxicity

PRIORITIZING FACTORS

- Standards or Criteria Proposed or Set (Ambient, Emission, or Occupational)
- TLV or LD_{50} Known

- On EPA Ordered NIOSH Carcinogen List
- On EPA Consent Decree List

Approximate makeup of organic and inorganic categories and classes of substances on the list thus far:

	Categories	Classes	Substances
Organics Portion	26	45	350
Inorganics Portion	59	--	300
	85	45	650

MULTIMEDIA POTENTIAL POLLUTANT LIST

ORGANIC-COMPOUND CATEGORIES AND CLASSES

Category	Class
1 - Aliphatic Hydrocarbons	Alkanes and Cyclic Alkanes
	Alkenes, Cyclic Alkenes, and Dienes
	Alkynes
2 - Alkyl Halides	Saturated Alkyl Halides
	Unsaturated Alkyl Halides
3 - Ethers	Ethers
4 - Halogenated Ethers	Halogenated Ethers
5 - Alcohols	Primary Alcohols
	Secondary Alcohols
	Tertiary Alcohols
6 - Glycols, Epoxides	Glycols
	Epoxides
7 - Aldehydes, Ketones	Aldehydes, Ketones
8 - Carboxylic Acids & Derivatives	Carboxylic Acids with Additional Function Groups
	Amides
	Esters
9 - Nitriles	Nitriles
10 - Amines	Primary Amines
	Secondary Amines
	Tertiary Amines
11 - Azo Compounds, Hydrazine, & Deriv.	Azo Compounds, Hydrazine, & Deriv.
12 - Nitrosamines	Nitrosamines
13 - Mercaptans, Sulfides & Disulfides	Mercaptans
	Sulfides, Disulfides
14 - Sulfonic Acidas, Sulfoxides	Sulfonic Acids
	Sulfoxides
15 - Benzene, Substituted Benzene Hydrocarbons	Benzene, Substituted Benzene Hydrocarbons
16 - Halogenated Aromatic Hydrocarbons	Halogenated Aromatic Hydrocarbons
17 - Aromatic Nitro Compounds	Aromatic Nitro Compounds
18 - Phenols	Monohydrics
	Dihydrics, Polyhydrics
	Hydroxy Compounds with Fused Rings
19 - Halophenols	Halophenols
20 - Nitrophenols	Nitrophenols
21 - Fused Aromatic Hydrocarbons & Derivatives	Fused Aromatic Hydrocarbons & Derivatives
22 - Fused Non-Alternant Polycyclic Hydrocarbons	Fused Non-Alternant Polycyclic Hydrocarbons
23 - Heterocyclic Nitrogen Compounds	Pyridine & Substituted Pyridines
	Fused 6-membered Ring Heterocycles
	Pyrrole & Fused Ring Derivatives of Pyrrole
	Nitrogen Heterocycles Containing Additional Hetero Atoms
24 - Heterocyclic Oxygen Compounds	Heterocyclic Oxygen Compounds
25 - Heterocyclic Sulfur Compounds	Heterocyclic Sulfur Compounds
26 - Organometallics	Alkyl or Aryl Organometallics
	Sandwich Type Organometallics
	Metal Porphyrins & Other Chelates

MULTIMEDIA POTENTIAL POLLUTANT LIST

INORGANIC CATEGORIES

(Element category includes zero valence species, ions of the element, and certain specific compounds)

Group		Category
IA	-	27 - Lithium
		28 - Sodium
		29 - Potassium
		30 - Rubidium
		31 - Cesium
IIA	-	32 - Beryllium
		33 - Magnesium
		34 - Calcium
		35 - Strontium
		36 - Barium
IIIA	-	37 - Boron
		38 - Aluminum
		39 - Gallium
		40 - Indium
		41 - Thallium
IVA	-	42 - Carbon
		43 - Silicon
		44 - Germanium
		45 - Tin
		46 - Lead
VA	-	47 - Nitrogen
		48 - Phosphorus
		49 - Arsenic
		50 - Antimony
		51 - Bismuth
VIA	-	52 - Oxygen
		53 - Sulfur
		54 - Selenium
		55 - Tellurium
VIIA	-	56 - Fluorine
		57 - Chlorine
		58 - Bromine
		59 - Iodine
IIIB	-	60 - Scandium
		61 - Yttrium
IVB	-	62 - Titanium
		63 - Zirconium
		64 - Hafnium
VB	-	65 - Vanadium
		66 - Niobium
		67 - Tantalum
VIB	-	68 - Chromium
		69 - Molybdenum
		70 - Tungsten
VIIB	-	71 - Magnese
VIII	-	72 - Iron
		73 - Ruthenium
		74 - Cobalt
		75 - Rhodium
		76 - Nickel
		77 - Platinum
IB	-	78 - Copper
		79 - Silver
		80 - Gold
IIB	-	81 - Zinc
		82 - Cadmium
		83 - Mercury
		84 - Lathanides
		85 - Actinides

MULTIMEDIA ENVIRONMENTAL GOALS

Emission Level Goals

	Based on Best Technology		Based on Ambient Factors				
	Existing Standards	Developing Technology	Minimum Acute Toxicity Effluent		Ambient Level Goal		Elimination of Discharge
	NSPS, BPT, BAT	Engineering Estimates (R&D Goals)	Based on Health Effects	Based on Ecological Effects	Based on Health Effects	Based on Ecological Effects	Natural Background
AIR WATER LAND							

Ambient Level Goals

	Current or Proposed Ambient Standards or Criteria		Toxicity Based on Estimated Permissible Concentration		Zero Threshold Pollutants Estimated on Permissible Concentrations
	Based on Health Effects	Based on Ecological Effects	Based on Health Effects	Based on Ecological Effects	Based on Health Effects
AIR WATER LAND					

CATEGORY: 15

WLN: R

BENZENE: C_6H_6 (benzol, phenylhydride, phene).
A clear, colorless liquid.

STRUCTURE:

PROPERTIES:

Molecular wt: 78.11; mp: 5.5; bp: 80.1;
d: 0.87863_4^{20}; vap. press: 100 mm at 26.1° C; vap. d: 2.77;
solubility in water: 1,780 mg/ℓ at 25° (ref. 52); soluble in tissue lipids.

NATURAL OCCURRENCE, CHARACTERISTICS, ASSOCIATED COMPOUNDS:

Benzene occurs in straight-run petroleum distillates and in coal-tar distillates. Rural background for benzene is reported as 0.1 ppbc (ref. 1). This is equivalent to 0.017 ppb or 0.054 $\mu g/m^3$. The odor recognition level is 10.5 to 210 mg/m^3 (ref. 3). Benzene participates to a very limited degree in photooxidation reactions (ref. 3). Benzene has been identified in at least one drinking water supply in the United States in concentrations as high as 10 µg/ℓ (ref. 13). There is a strong indication that plants may perform a major role in the degradation and synthesis of benzene in the environment (ref. 52).

TOXIC PROPERTIES, HEALTH EFFECTS:

Benzene is an acute and chronic poison. It is absorbed through the skin, but most often poisoning occurs through inhalation. The rate of absorption of benzene through the skin has been reported to be 0.4 $mg/cm^2/hr$ (ref. 53). It is estimated that 50 percent to 70 percent of benzene inhaled may be absorbed through the lungs (ref. 53). In acute poisoning, benzene acts as a narcotic. Chronic poisoning is characterized by damage to the blood-forming tissues and changes in body organs, including the lymph nodes (ref. 54). Inhalation of 210 ppm has resulted in blood disorders for exposed workers (refs. 4,2,9). Benzene can induce chromosomal aberrations in humans (ref. 54).

Benzene is listed in the NIOSH Suspected Carcinogens List. The EPA/NIOSH ordering number is 7222. Inhalation of 2,100 mg/m^3 for 4 years has resulted in cancer in an exposed worker, and large doses of benzene painted repeatedly on the skin of mice have resulted in some incidence of skin carcinomas. TD_{Lo}'s associated with these tests are extremely high and are probably not indicative of the true carcinogenic potential of benzene. An epidemiological study conducted by NIOSH indicates that the incidence of leukemia in workers exposed to benzene is at least five times the expected incidence (ref. 54).

Benzene is toxic to aquatic life: 96 hours. TLm's are reported ranging from 10-100 ppm (ref. 2).

REGULATORY ACTIONS, STANDARDS, CRITERIA, RECOGNITION, CANDIDATE STATUS FOR SPECIFIC REGULATION:

TLV: 30 mg/m^3 (10 ppm). ACGIH classified benzene as an Occupational Substance Suspected of Oncogenic Potential for workers. (Evidence linking benzene to leukemia was limited at the time the TLV was established.)
Benzene appears on EPA Consent Decree List with an assigned priority of 1.
Benzene is the subject of a NIOSH Criteria Document (ref. 55).
The Labor Department has issued emergency temporary standards limiting worker exposure to benzene to 1 ppm as an 8-hour time-weighted average concentration, with a ceiling level of 5 ppm for any 15-minute period during the 8-hour day (ref. 54). The emergency standard is based on conclusive evidence that exposure to benzene presents a leukemia hazard (ref. 54). The standard also prohibits repeated or prolonged skin exposure to liquid benzene.

MINIMUM ACUTE TOXICITY CONCENTRATIONS:

Air, Health: 3.0×10^3 $\mu g/m^3$
Water, Health: $15 \times 3.0 \times 10^3 = 4.5 \times 10^4$ µg/ℓ
Land, Health: $0.002 \times 4.5 \times 10^4 = 90$ µg/g

Air, Ecology:
Water, Ecology: $100 \times 10 = 1.0 \times 10^3$ µg/ℓ
Land, Ecology: $0.002 \times 1.0 \times 10^3 = 2$ µg/g

ESTIMATED PERMISSIBLE CONCENTRATIONS:

$EPC_{AH1} = 10^3 \times 30/420 = 71.4$ $\mu g/m^3$
$EPC_{AH1a} = 10/420 = 0.024$ ppm
$EPC_{WH1} = 15 \times 71.4 = 1{,}071$ µg/ℓ
$EPC_{WH2} = 13.8 \times 30 = 414$ µg/ℓ
$EPC_{LH} = 0.002 \times 414 = 0.83$ µg/g
$EPC_{AC1} = 10^3 \times 3/420 = 7.1$ $\mu g/m^3$
$EPC_{WC} = 15 \times 7.1 = 107$ µg/ℓ
$EPC_{LC} = 0.002 \times 107 = 0.21$ µg/g

$EPC_{WE1} = 50 \times 10 = 500$ µg/ℓ
$EPC_{LE} = 0.002 \times 500 = 1$ µg/g

MULTIMEDIA ENVIRONMENTAL GOALS

X
15
BENZENE

EMISSION LEVEL GOALS

	I. Based on Best Technology		II. Based on Ambient Factors				
	A. Existing Standards	B. Developing Technology	A. Minimum Acute Toxicity Effluent		B. Ambient Level Goal*		C. Elimination of Discharge
	NSPS, BPT, BAT	Engineering Estimates (R&D Goals)	Based on Health Effects	Based on Ecological Effects	Based on Health Effects	Based on Ecological Effects	Natural Background*
Air, $\mu g/m^3$ (ppm Vol)			3.0E3		7.1		0.054
Water, µg/l (ppm Wt)			4.5E4	1.0E3	107	500	10†
Land, µg/g (ppm Wt)			9.0E1	2.0E0	0.21	1	

*To be multiplied by dilution factor

AMBIENT LEVEL GOALS

	I. Current or Proposed Ambient Standards or Criteria		II. Toxicity Based Estimated Permissible Concentration		III. Zero Threshold Pollutants Estimated Permissible Concentration
	A. Based on Health Effects	B. Based on Ecological Effects	A. Based on Health Effects	B. Based on Ecological Effects	Based on Health Effects
Air, $\mu g/m^3$ (ppm Vol)			71.4 (0.024)		7.1
Water, µg/l (ppm Wt)			414	500	107
Land, µg/g (ppm Wt)			0.83	1	0.21

†Maximum concentration identified in drinking water.

CONTROL TECHNOLOGY ASSESSMENT

- Control System and Disposal Option Information and Design Principles
- Control Process Pollution and Impacts—E. A. Contractors Plus Special Facilities
- Accidental Release, Malfunction, Transient Operation Studies
- Field Testing in Related Applications
- Define Best Control Technology Recommendations

CONTROL TECHNOLOGY ASSESSMENT

Multimedia Environmental Control Engineering Manual (Control Approach Categories):

- Gas Treatment
- Liquids Treatment
- Solids Treatment
- Final Disposal
- Process Modification
- Combustion Modification
- Fuel Cleaning
- Fugitive Emissions Control
- Accelerated Release Technology

CONTROL APPROACHES

- **Gas Treatment**
  - Mechanical Collection
  - Electrostatic Precipitators
  - Filters (fabric, granular, etc.)
  - Liquid Scrubbers/Contactors (aqueous, inorganic, organic)
  - Condensers
  - Solid Sorbents (mol sieves, activated carbon)
  - Incineration (direct and catalytic)
- **Liquids Treatment**
  - Settling, Sedimentation
  - Precipitation, Flocculation, Sedimentation
  - Centrifugation and Filtration
  - Evaporation and Concentration
  - Distillation, Flashing
  - Liquid-Liquid Extraction
  - Gas-Liquid Stripping
  - Neutralization
  - Biological Oxidation
  - Wet Thermal Oxidation
  - Activated Carbon Absorption
  - Ion Exchange System
  - Cooling Tower (wet and dry)
  - Chemical Reaction and Separation
- **Solids Treatment**
  - Fixation
  - Recovery/Utilization
  - Processing/Combustion
  - Chemical Reaction and Separation
  - Oxidation/Digestion
  - Physical Separation (specific gravity, magnetic, etc.)
- **Final Disposal**
  - Pond Lining
  - Deep Well Reinjection
  - Burial and Landfill
  - Sealed-Contained Storage
  - Dilution
  - Dispersion
- **Process Modifications**
  - Feedstock Change
  - Stream Recycle
- **Combustion Modification**
  - Flue Gas Recycle
  - Water Injection
  - Staged Combustion
  - Low Excess Air Firing
  - Optimum Burner/Furnace Design
  - Alternate Fuels/Processes
- **Fuel Cleaning**
  - Physical Separation (specific gravity, surface properties, magnetic)
  - Chemical Refining
  - Carbonization/Pyrolysis
  - Liquefaction/Hydrotreating (HDS, HDN, Demetallization)
  - Gasification/Separation
- **Fugitive Emissions Control**
  - Surface Coatings/Covers
  - Vegetation
  - Leak Prevention
- **Accidental Release Technology**
  - Containment Storage
  - Flares
  - Spill Cleanup Techniques

CLASSIFICATION	GENERIC DEVICE OR PROCESS
Fuel Cleaning	Physical Separation - Dense Media Separator of Coal

SPECIFIC DEVICE OR PROCESS	NUMBER
Belknap Calcium Chloride Washer[A]	7.1.1.3

POLLUTANTS CONTROLLED	AIR			WATER		LAND	
	GASES	PARTICULATES		DISSOLVED	SUSPENDED	LEACHABLE	FUGITIVE DUST
ORGANIC							
x INORGANIC	X SO_2						
THERMAL							
NOISE							

PROCESS DESCRIPTION[B]

Figure 1 shows a schematic diagram of the Belknap calcium chloride washer. Presized and prewetted raw coal enters at the surface of the washer solution and is separated according to the various specific gravities.[C] Refuse settles to the bottom and is removed by a screw conveyor running parallel to the refuse conveyor.[D] Solution within the washer is circulated by two opposing impellers.

The Belknap washer uses calcium chloride solutions ranging in specific gravity from 1.14 to 1.25. These solutions are circulated through the washer in an upward direction to produce an effective specific gravity of 1.40 to 1.60. Both flow and density are carefully controlled to provide the desired separation.

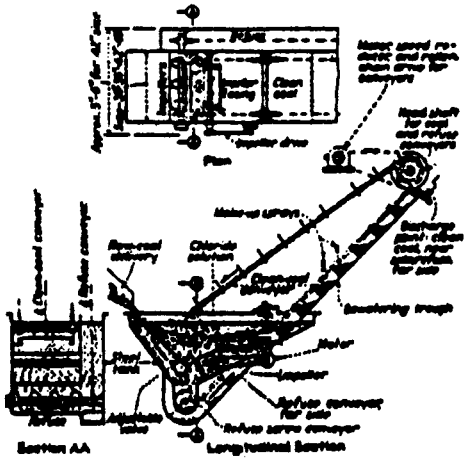


Figure 1. THE BELKNAP CALCIUM CHLORIDE WASHER (1)

A second method which could be used to control the specific gravity within the washer is to wash the coal product with a calcium chloride solution to remove any suspended solids (slimes). This dense solution is then recycled to the washer to maintain the right specific gravity. In this case, the calcium chloride is used more as a stabilizing agent than the dense media itself. If the suspended solids from the washed coal product can be recycled back to the washer, the amount of calcium chloride required for density control can be reduced. In this way, the solids which naturally occur in the coal can be used to maintain the heavy density medium. Considerations of this type could improve the economics of this systems over other dense medium systems which utilize material from an outside source for density control, e. g. Magnetite Processes.

The washed coal product leaving the system has a considerable amount of entrained calcium chloride solution. This entrainment can reduce potential problems in coal dusting and freezing. The loss of calcium chloride, however, may limit the economic application of the process to coarser sizes of coal.

APPLICATION RANGE

The effective specific gravity within the washer can be adjusted from 1.40 to 1.60 by varying the solution density or recirculation rate. Consequently, the range of physical separation is limited to a specific gravity within this range.

OPERATING RANGES	METRIC (SI)	ENGLISH
TEMPERATURE	20 °C	68 °F
PRESSURE	101.3 kPa	14.7 psi
VOLUMETRIC RATE	-- m^3/s	-- ft^3/min
MASS RATE	-- kg/s	-- lb/hr
ENERGY RATE	-- J/s	-- BTU/hr

Feed sizes can range from 8-in. (20.3 cm) to 3/8 in. (.95 cm), however, the feed to a single unit should not fluctuate very much. The size range that can be washed in a standard washer can be varied up to a 4:1 ratio, but should be limited to 3:1 or 2:1 if possible.

CAPITAL COSTS

OPERATING COST

OPERATING EFFICIENCIES

The recovery efficiency for coal coarser than 1/4-inch is 95 to 99% of the laboratory float sink tests. Trace elements association and removal characteristics for the physical separation of coal in general are shown in Table 1. The level of fluorine, which is present as part of the mineral apatite, would also be reduced. The chlorine and bromine contaminants (as well as the sodium and potassium associated with them) which are commonly present as the mineral halite would be removed along with other matter removed during coal beneficiation, (3).

Table 1. TRACE ELEMENT ASSOCIATION AND REMOVAL CHARACTERISTICS

Association	Trace Elements	Expected Removal
Organic	Ge, Be, B and U	None
More organic	P, Ga, Ti, V, and Sb	Small Amount
More mineral	Co, Ni, Cr, Se and Cu	Partial
Mineral	Hg, Zn, Cr, Cd, As, Pb, Mo, and Mn	Significant

NOTES

A) For other dense media separators, see all devices under 7.1.1 and 7.1.2.

B) Based on information from the Process Machinery Division of the Arthur G. McKee & Co., (reference 1)

C) This device can also be used in a secondary circuit to separate sink product from a primary separator into middlings and refuse.

D) Units can be designed with the separating compartment divided into two parallel sections. Each section would be equipped with individual medium circulation systems thus making it possible to wash a much wider range in one machine.

ENVIRONMENTAL PROBLEMS

Coal preparation reduces stack gas emissions but may also create pollution problems in the following areas.

1) land pollution created by refuse disposal.

2) water pollution from the leaching of oxidized refuse material.

3) air pollution from the spontaneous combustion of refuse piles.

MANUFACTURER / SUPPLIER

ASV Engineering Ltd.
GEOMIN
Minerals Processing Co., Div. of Trojan Steel Co.
Process Machinery Division, Arthur G. McKee & Company

REFERENCES

1) Mitchell, David R., and Leonard, Joseph W., ed. Coal Preparation, AIME, New York, Second Edition, (1950); Third Edition, (1968).

2) Lowry, H. H., ed., Chemistry of Coal Utilization, John Wiley and Sons, New York, First Edition, (1945); Second Edition (1963).

3) Mezey, E. J., Singh, S., and Hissong, D. W., "Fuel Contaminants: Volume I, Chemistry " EPA 600/2-76-177a, (1976).

CONTROL TECHNOLOGY ASSESSMENT

Multimedia Environmental Control Engineering Manual (Stepwise guidance for defining specific control options for specific situations):

- Medium Phase (gas, liquid, solid)
- Medium Description (combustible gases, black water, coal cleaning waste, etc.)
- Medium Physical Properties (temperature, pressure)
- Pollutant Species Present
- Pollutant Concentration
- General Technology (physical, chemical treatment; prevention of pollutant formation; final disposal)
- Generic Device (ESP, dry inertial collector, etc.)
- Specific Device (commercial devices and specifications)

STANDARDS OF PRACTICE MANUALS

- Subject
  - A uniquely different basic energy process (at the commercial demonstration stage) in a particular industry
- Example
  - Low-Btu Gasification - Wellman Galusha
- Aim
  - Provide an integrated, multimedia, industry-oriented, single-package review of the environmental requirements, guidelines and best control/disposal options. Accounts for variations needed for different regional site alternatives.

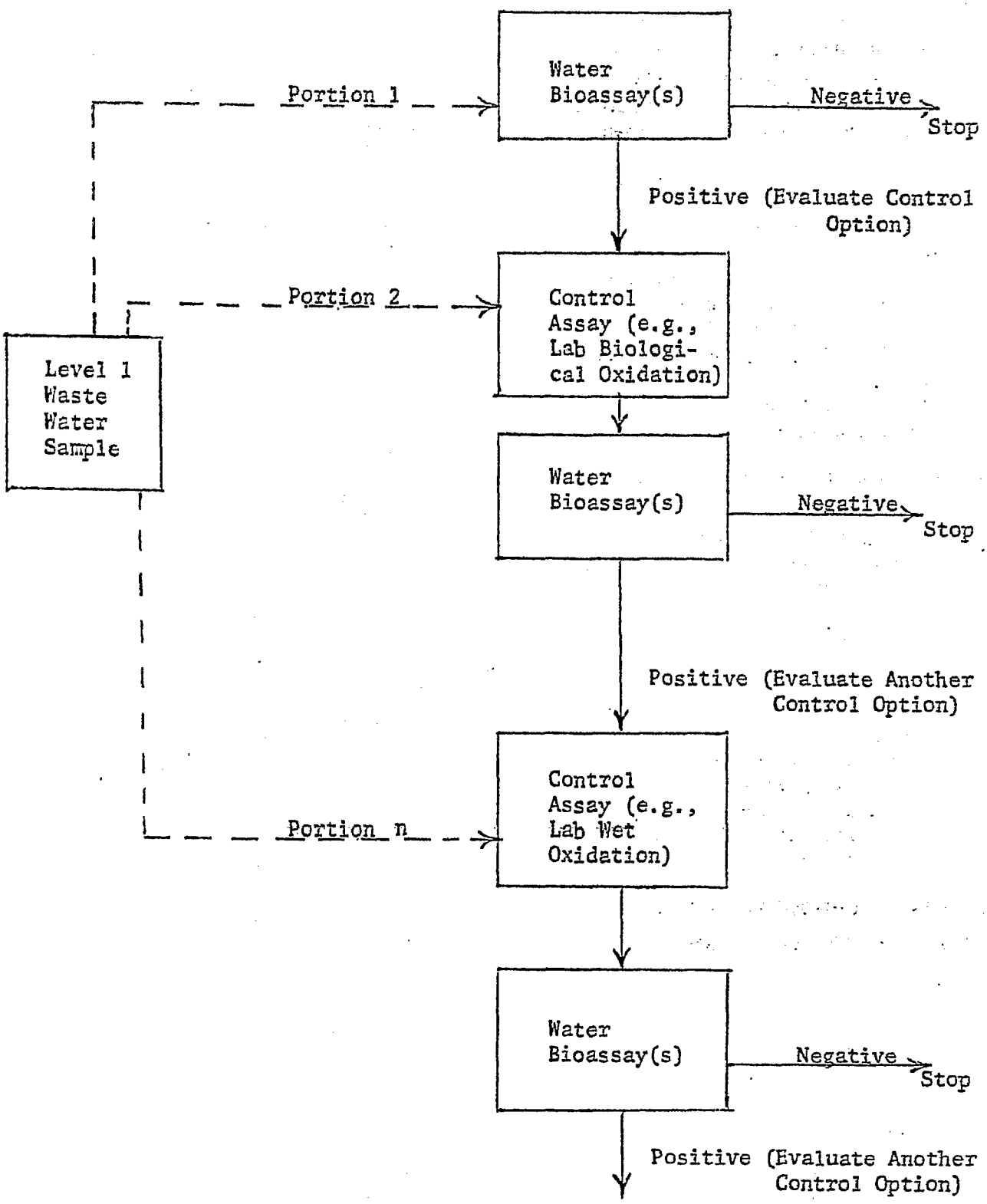
CONTROL TECHNOLOGY ASSESSMENT

Standards of Practice Manual Outline

- Summary
- Outline of Basic Process
  - Process Modules
  - Control/Disposal Modules
  - Control/Disposal Costs
  - Variations Resulting from Regional Siting Factors
- Existing Environmental Requirements
  - Existing Standards
    - Air
    - Water
    - Land
  - Other Environmental Requirements
  - Environmental Guidelines
  - Regional Considerations
- Environmental Emissions and Factors Achievable
  - Criteria
  - MEG (Pollutant)
  - MEG (Nonpollutant)
- Best Control/Disposal Practice
  - Gas Treatment
  - Liquids Treatment
  - Solids Treatment
  - Final Disposal
  - Combustion Modification
  - Fuel Cleaning
  - Fugitive Emissions Control
  - Accidental Release Technology
  - Regional Variations
- Detailed Definition of Basic Process
  - Process Module No. 1
    - Source Unit Operations (Unit Operations Pollutant Sources)
      - Control Options/Emissions/Costs
        - Commercially Operated
        - Commercially Operated on a Different Process/Industry
        - Pilot Data Available
  - Process Module No. 2, 3 ...
  - Process Module No. n

CONTROL TECHNOLOGY ASSESSMENT

Control Assay Example



ASSESSMENT ALTERNATIVES USING MEG'S

ASSESSMENT ALTERNATIVES		Air	Water	Land
		MEG Types		
BT	° Existing standards	1A	1W	1L
BT	° Developing technology			
BT	- 1983	2A	2W	2L
BT	- 1988	3A	3W	3L
BT	- 1993	4A	4W	4L
EPC / ES	° Current vs Proposed Ambient Stds or Criteria			
EPC / ES	- Based on Health Effects	5A	5W	5L
EPC / ES	- Based on Ecological Effects	6A	6W	6L
EPC	° Toxicity Based Estimated Permissible Concentration			
EPC	- Based on Health Effects	7A	7W	7L
EPC	- Based on Ecological Effects	8A	8W	8L
EPC	° Zero Threshold Pollutants Est. Perm. Conc.			
EPC	- Based on Health Effects	9A	9W	9L
NB	° Elimination of Discharge - Based on Natural Background	10A	10W	10L
SD	° Significant Deterioration - Based on Regional Average Backgrounds	11A	11W	11L
MATE	° Minimum Acute Toxicity Effluent			
MATE	- Based on Health Effects	12A	12W	12L
MATE	- Based on Ecological Effects	13A	13W	13L

ENVIRONMENTAL ALTERNATIVES ANALYSES

Source Analysis Models (SAM's)

- SAM/IA - For Rapid Screening
- SAM/I - For Screening
- SAM/II - General Approach to Evaluating any U.S. Regional Site Alternative

Source (a, b, c . . .)
(gas, liquid, solid)

Control Options
(α, β, γ . . .)

Air Effluent Streams → ($k_\alpha, k_\beta, k_\gamma$ . . .)

Water Effluent Streams → ($k_\alpha, k_\beta, k_\gamma$ . . .)

Land Effluent Streams → ($k_\alpha, k_\beta, k_\gamma$ . . .)

SCHEMATIC IDENTIFICATION OF SOURCES/CONTROL-OPTIONS/EFFLUENTS

ENVIRONMENTAL ALTERNATIVES ANALYSES

Assessment Alternatives

- Best Technology (BT)
- Minimum Acute Toxicity Effluent (MATE)
- Existing Ambient Standards (ES)
- Estimated Permissible Concentration (EPC)
- Natural Background/Elimination of Discharge (NB)
- Significant Deterioration (SD)

ENVIRONMENTAL ALTERNATIVES ANALYSIS

Source Analysis Model SAM/IA
(For Rapid Screening)

- Effluent Concentration Basis
- Assessment Alternative: (MATE)
- No Transport/Transformation Analysis
- Degree of Hazard Calculation
- Toxic Unit Discharge Rate Calculation

ENVIRONMENTAL ALTERNATIVES ANALYSIS

Source Analysis Model
Basic Calculations

- For a specific MEG pollutant:

$$\text{H = degree of hazard (severity)} = \frac{C_{\text{pollutant}}}{C_{\text{MEG}}}$$

- For a complex effluent:

$$\text{Toxic Unit Discharge Rate} = \text{(mass or volumetric discharge rate)} \times \sum H$$

Category	Compound	Air µg/m^3 (ppm)		Water µg/ℓ		Land µg/ℓ
		Health	Ecology	Health	Ecology	
14B	Dimethyl sulfoxide	8.14E2		1.22E3	N	2.44E0
15	Benzene	3.00E3 (1)		4.50E4	1.00E3	2.00E0
	Toluene	3.75E5 (100)		5.63E6	1.00E3	2.00E0
	Ethylbenzene	4.35E5 (100)		6.53E6	1.00E3	2.00E0
	Styrene	4.20E5 (100)		6.30E6	1.00E3	2.00E0
	Propylbenzene	2.17E5		3.25E6	1.00E3	2.00E0
	Isopropylbenzene	6.30E4		9.45E5	1.00E3	2.00E0
	Butylbenzene	2.25E5		3.38E6	N	6.76E3
	Biphenyl	1.00E3		1.5E4	N	3.00E1
	4,4'-Diphenylbiphenyl	N		N	N	N
	Xylenes	4.35E5 (100)		6.53E6	1.00E3	2.00E0
	Dialkylbenzenes	2.25E5		3.38E6	1.00E3	2.00E0
	Tetrahydronaphthalenes	1.29E5		1.94E6	1.00E3	2.00E0
	Dihydronaphthalenes	1.27E5		1.91E6	N	3.82E3
	Terphenyls	9.00E3 (1)			N	2.70E2
	Trimethylbenzenes	----------Example Page----------				
	Tetramethylbenzenes	(DRAFT--5/10/77)				
16A	Chlorobenzene	MINIMUM ACUTE TOXICITY EFFLUENT (MATE) VALUES FOR ORGANIC AND INORGANIC COMPOUNDS FROM FOSSIL ENERGY PROCESSES				
	Bromo and Dibromobenzenes	A Subset of Multimedia Environmental Goals for Environmental Assessment Use in Rapid Screening of Effluents				
	Bromochlorobenzenes					

SAM/IA SUMMARY SHEET

Form IA01

1. SOURCE AND APPLICABLE CONTROL OPTIONS

2. PROCESS THROUGHPUT OR CAPACITY

3. USE THIS SPACE TO SKETCH A BLOCK DIAGRAM OF THE SOURCE AND CONTROL ITEMS SHOWING ALL EFFLUENT STREAMS. INDICATE EACH STREAM WITH A CIRCLED NUMBER USING 101-199 FOR GASEOUS STREAMS, 201-299 FOR LIQUID STREAMS AND 301-399 FOR SOLID WASTE STREAMS.

4. LIST AND DESCRIBE GASEOUS EFFLUENT STREAMS USING RELEVANT NUMBERS FROM STEP 3.

101 _____

102 _____

103 _____

5. LIST AND DESCRIBE LIQUID EFFLUENT STREAMS USING RELEVANT NUMBERS FROM STEP 3.

201 _____

202 _____

203 _____

6. LIST AND DESCRIBE SOLID EFFLUENT STREAMS USING RELEVANT NUMBERS FROM STEP 3.

301 _____

302 _____

303 _____

7. FOR EACH EFFLUENT STREAM COMPLETE FORM IA02.

8. LIST SUMS FROM LINE 7, FORMS 1A02, IN TABLE BELOW

TOXIC DISCHARGE UNITS BY EFFLUENT STREAM								
GASEOUS (#/SEC)			LIQUID (#/SEC)			SOLID (g/SEC)		
STREAM CODE	TOXIC DISCHARGE UNITS		STREAM CODE	TOXIC DISCHARGE UNITS		STREAM CODE	TOXIC DISCHARGE UNITS	
	HEALTH BASED	ECOL. BASED		HEALTH BASED	ECOL. BASED		HEALTH BASED	ECOL BASED
A	B	C	D	E	F	G	H	I

9. SUM SEPARATELY GASEOUS, LIQUID AND SOLID TOXIC DISCHARGE UNITS FROM TABLE IN LINE 8 (I.E., SUM COLUMNS):

	TOTAL TOXIC DISCHARGE UNITS	
	HEALTH BASED	ECOLOGICAL BASED
GASEOUS	(Σ Col. B) 9a _____	(Σ Col. C) 9a' _____
LIQUID	(Σ Col. E) 9b _____	(Σ Col. F) 9b' _____
SOLID	(Σ Col. H) 9c _____	(Σ Col. I) 9c' _____

10. NUMBER OF EFFLUENT STREAMS

GASEOUS	10a _____
LIQUID	10b _____
SOLID	10c _____

11. AVERAGE TOXIC DISCHARGE UNIT RATES

	HEALTH BASED	ECOLOGICAL BASED
GASEOUS	(9a/10a) 11a _____	(9a'/10a) 11a' _____
LIQUID	(9b/10b) 11b _____	(9b'/10b) 11b' _____
SOLID	(9c/10c) 11c _____	(9c'/10c) 11c' _____

12. LIST POLLUTANT SPECIES KNOWN OR SUSPECTED TO BE EMITTED FOR WHICH NO RATES ARE AVAILABLE.

1. SOURCE/CONTROL OPTION

2. EFFLUENT STREAM

CODE # _____ NAME _____

3. EFFLUENT STREAM FLOW RATE

Q = _____

(air = m³/sec — liquid = l/sec — solid = g/sec)

4. COMPLETE THE FOLLOWING TABLE FOR THE EFFLUENT STREAM OF LINE 2 (USE BACK OF FORM FOR SCRATCH WORK)

A	B	C	D	E	F	G	H	I	J	K	L
POLLUTANT SPECIES	EMISSION FACTOR	POLLUTANT FLOW RATE (B X CAPACITY)	POLLUTANT CONCENTRATION (C/LINE 3)	HEALTH MATE CONCENTRATION	ECOLOGICAL MATE CONCENTRATION	DEGREE OF HEALTH HAZARD (D/E)	DEGREE OF ECOLOGICAL HAZARD (D/F)	CHECK (√) IF HEALTH MATE EXCEEDED	CHECK (√) IF ECOLOGICAL MATE EXCEEDED	TOXIC UNIT FLOW RATE (HEALTH BASED) (G X LINE 3)	TOXIC UNIT FLOW RATE (ECOLOGICAL BASED) (H X LINE 3)
UNITS						———	———	———	———		

5. EFFLUENT STREAM TOXIC UNIT CONTENT

HEALTH MATE BASED (Σ COL. G) 5a _____

ECOLOGICAL MATE BASED (Σ COL. H) 5b _____

6. NUMBER OF POLLUTANTS COMPARED TO MATES

N = _____

7. TOXIC UNIT DISCHARGE RATE

HEALTH BASED (LINE 3 X LINE 5a ÷ N) 7a _____

ECOLOGICAL BASED (LINE 3 X LINE 5b ÷ N) 7b _____

ENVIRONMENTAL ALTERNATIVES ANALYSIS

Outlines for the More Detailed Proposed Source Analysis Models

- *Source Analysis Model (SAM/I) - (For Screening)*
  - Effluent Concentration Basis
  - Assessment Alternatives: Bt, Es, EPC, NB, and SD
  - Effluent Transport/Transformation Analysis (ETTA) - (very approximate)
  - Remaining Steps, Starting with Degree-of-Hazard Calculation or other Ratios, are Similar to SAM/IA

- *Source Analysis Model (SAM/II) -(General Approach to Evaluating any U.S. Regional Site Alternative)*
  - Ambient Concentration Basis
  - Assessment Alternatives: BT, ES, EPC, NB, and SD
  - Recommended Transport/Transformation Models
  - Remaining Steps, Starting with Degree-of-Hazard or Other Calculations, Are Similar to SAM/IA
  - Application of Other Factors or Decision Criteria

PRELIMINARY EXAMPLES OF CONTROL/ CONTROL DEVELOPMENT NEEDS FOR SYNTHETIC FUELS (EXCLUDING PHYSICAL COAL CLEANING PRETREATMENT)

- Gas Treatment
  - Particulate control from coal conveying, load and discharge hoppers, gas purges on transport, coal thermal pretreatment, and coal burning for power
  - Particulate control in converter via baffles, velocity gradients
  - Particulate control in raw gas via water scrubbing cyclones
  - Tar and oil removal from raw gas via liquid scrubbing
  - Tar and oil removal from raw gas via cooling
  - Gaseous contaminants (H_2S, COS, NH_3, trace metals) removal from raw gas via liquid scrubbing
  - Sulfur compound removal from pre-final product gas via guard chamber (physical or chemical)
  - Contaminant removal from vents via scrubbing or combustion
  - Product "polishing" via activated carbon
  - Use or disposal of volatiles from pretreatment

- Liquid Treatment
  - Treatment of run off from storage and process areas via holding ponds
  - Boiler and cooling tower blowdown water treatment
  - Heat exchange for liquid temperature control
  - Treatment of water from tar/oil liquid separators
  - Treatment of water from scrubbers
  - Stripping of constituents from liquids
  - Filtration of liquid products/by-products
  - Contaminant removal from products and by-products
  - By-product separation from water (e.g., phenolsolvan)
  - Effluent pH control
  - Effluent biological treatment
  - Effluent carbon "polishing"

- Solids Treatment
  - Sulfur from Claus or Stretford
  - Char recovery and beneficiation
  - Sludge treatment for valuable constituents
  - Treatment of sludge from biox for fixation or neutralization
  - Sludge fixation from holding ponds
  - Used filter precoat and filtered material recovery and treatment for heating value or constituent recovery
  - Catalyst recovery of deposited materials and/or disposal
- Final Disposal
  - Containment of solid waste disposal area leachate contaminants

- Control of airborne contaminants from solid waste area (e.g., odors)
- Land reuse guidelines
- Site maintenance/surveillance

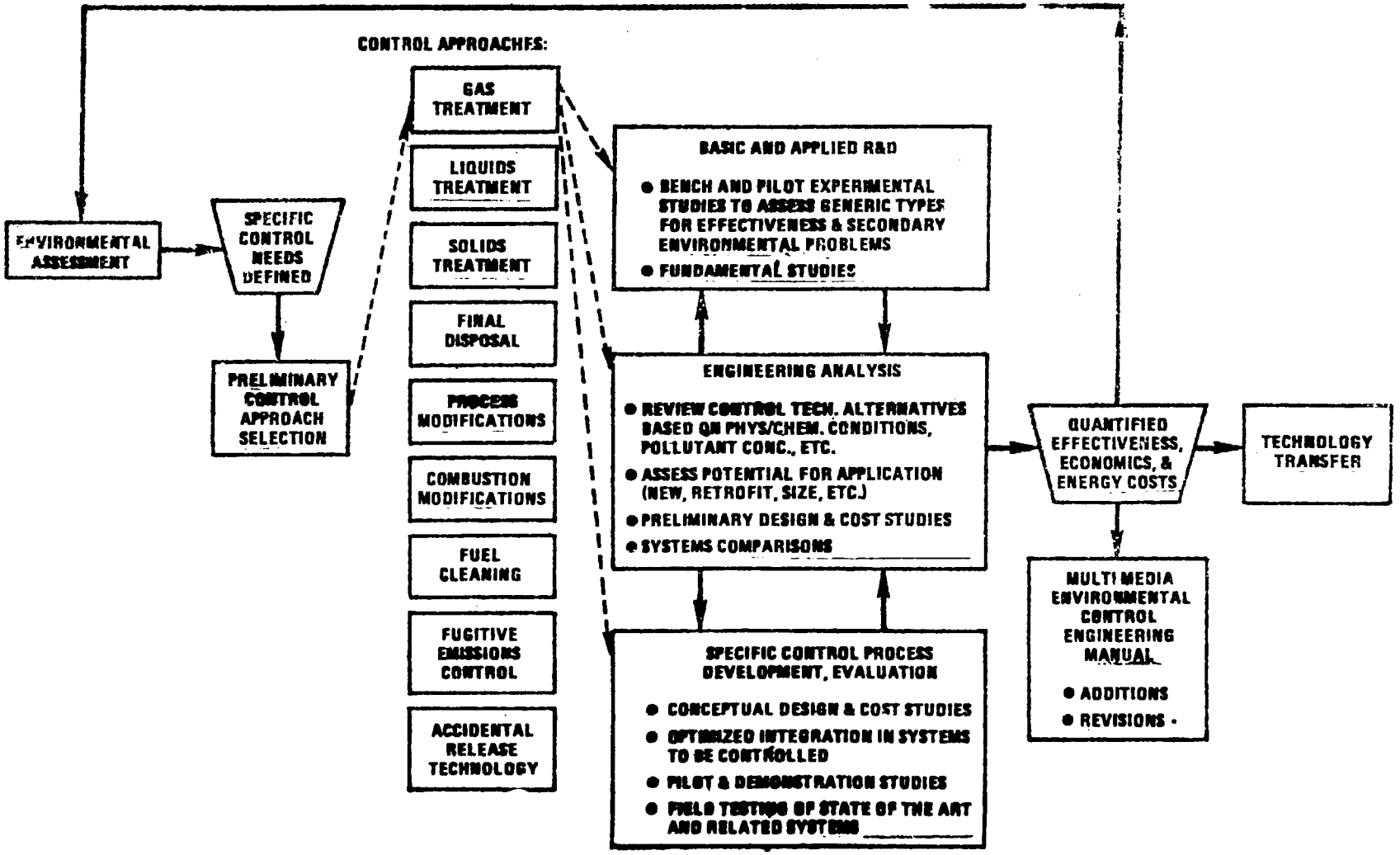
- Process Modifications
  - Selective pretreatment of coal for control of input to the converter via physical, chemical, or pretreatment condition changes
  - Converter operating condition changes for pollutant chemical or physical form change
  - Utilization of alternate technologies for conversion or treatment
  - Improved COS removal technique
  - Improve mechanism for coal feed to converter for reduction of pollutant release
  - Closed circuit liquid cooling
  - Minimization of coal drying and use of water in converter for hydrogen

- Combustion Modifications
  - NO_x, SO_x, and other pollutant control for char combustion
  - NO_x control for high nitrogen liquid fuel products
  - Control for low-Btu, COS containing waste gases
  - Flare improvement for upset conditions

- Fuel Cleaning
  - Selective removal of pollutant constituents or pollutant forming catalysts in pretreatment
  - Beneficiation of char for combustion
  - HDS/HDN for liquid fuels

- Fugitive Emissions Control
  - Coal piles, product and by-product storage for solids via protective coverings or coatings
  - Liquid storage or holding areas via chemical or physical means
  - Improved maintenance and/or equipment for seals, transfer points

- Accidental Release Technology
  - Contingency containment of liquids
  - Burst discs leading to control mechanisms or expansion chambers
  - Emergency cleanup procedures
  - Evaluation of special cold climate effects on failure probabilities (e.g., freezing of drains)



RELATIONSHIP OF CONTROL TECHNOLOGY DEVELOPMENT TO ENVIRONMENTAL ASSESSMENT DIAGRAM

APPENDIX A

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