Hanford Waste Vitrification Plant Project Waste Form Qualification Program and Approach

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Nuclear Waste Technical Review Board Richland, Washington

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Hanford Waste Vitrification Plant

Waste Form Qualification

- Waste form qualification (WFQ) documentation per U.S. Department of Energy Waste Acceptance Process
- Process overview
- Approach for WFQ compliance
- Technology and WFQ schedule
- WFQ summary

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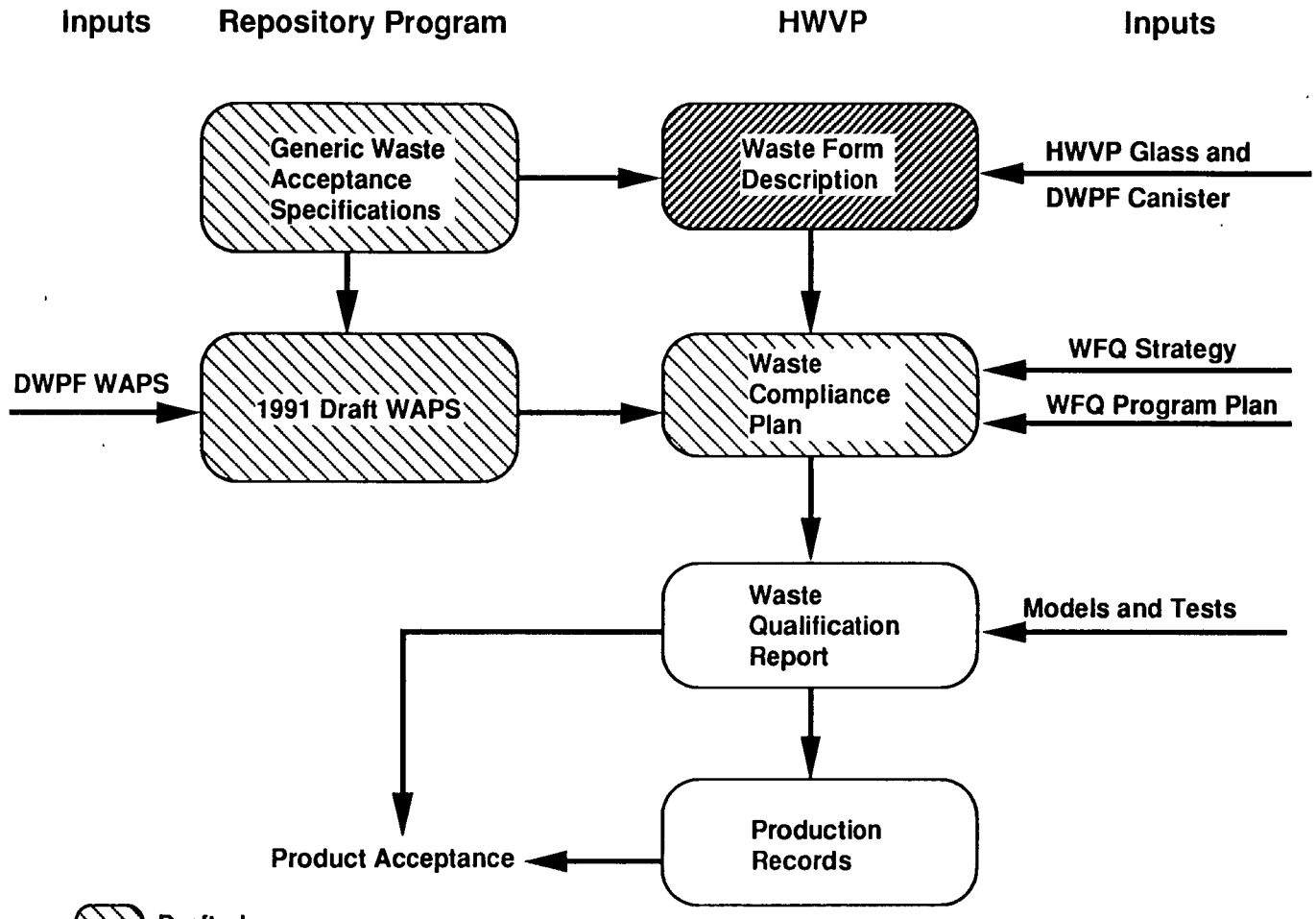
WFQ Document Flowchart



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DWPF = Defense Waste Processing Facility
HWVP = Hanford Waste Vitrification Plant
WAPS = Waste Acceptance Preliminary Specifications
WFQ = Waste form qualification

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Waste Acceptance Preliminary Specifications

Technical requirements

1.0 Waste Form

- Chemical composition
- Radionuclide inventory
- Product consistency
- Phase stability

2.0 Canister

- Material
- Fabrication and closure
- Identification and labeling

3.0 Canistered Waste Form

- Free Liquids
- Gases
- Explosives, pyrophorics, combustibles
- Organic materials
- Fill height
- Surface contamination
- Heat generation
- Maximum dose rate
- Chemical compatibility
- Subcriticality
- Weight, length, diameter, overall dimensions
- Drop test
- Handling features

4.0 Quality Assurance

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Process Overview

- Receive pretreated high-level and transuranic waste slurries
- Incorporate radioactive waste components into a vitrified borosilicate glass
- Seal vitrified waste in stainless steel canisters
- Provide interim storage of filled canisters until shipment for disposal at a federal repository
- Size the plant for 100-kg/h glass production

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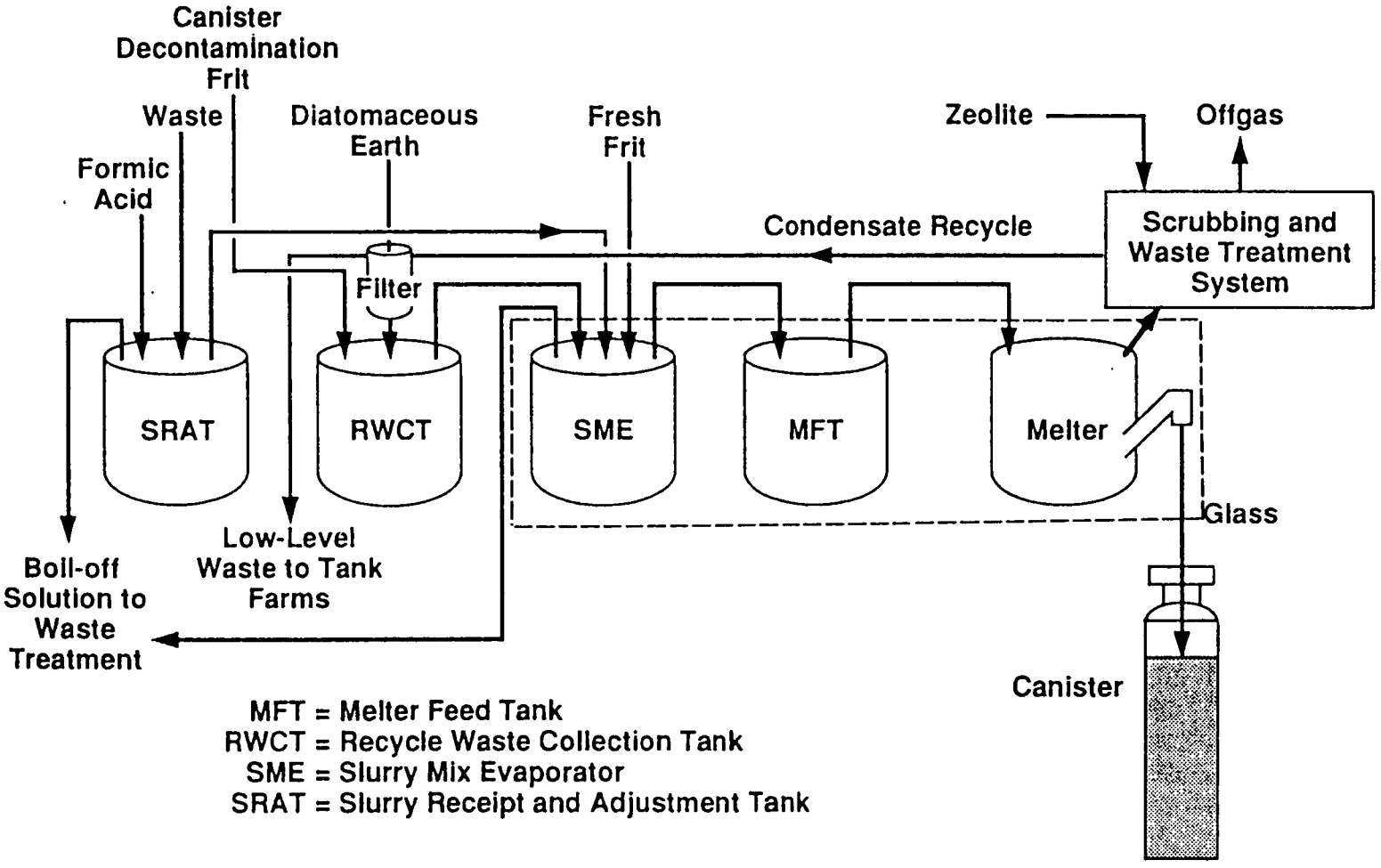
HWVP Glass Production-- Process Flow Schematic Diagram



MFT = Melter Feed Tank
RWCT = Recycle Waste Collection Tank
SME = Slurry Mix Evaporator
SRAT = Slurry Receipt and Adjustment Tank

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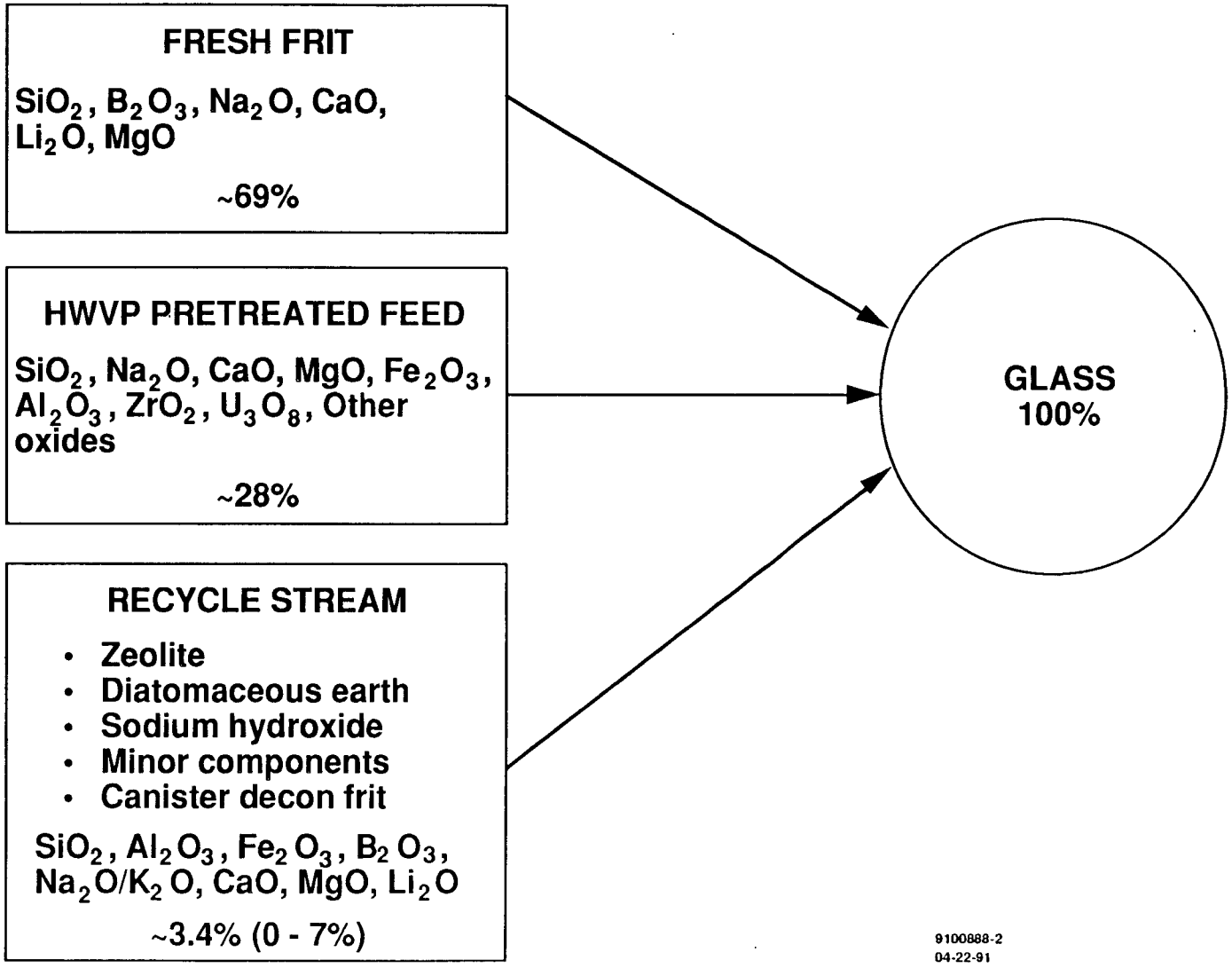
Contribution of Major Process Stream Components to HWVP Glass Composition



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HWVP = Hanford Waste Vitrification Plant 9201130 WEBER/NUCLEAR/WASTE/BOARD-7

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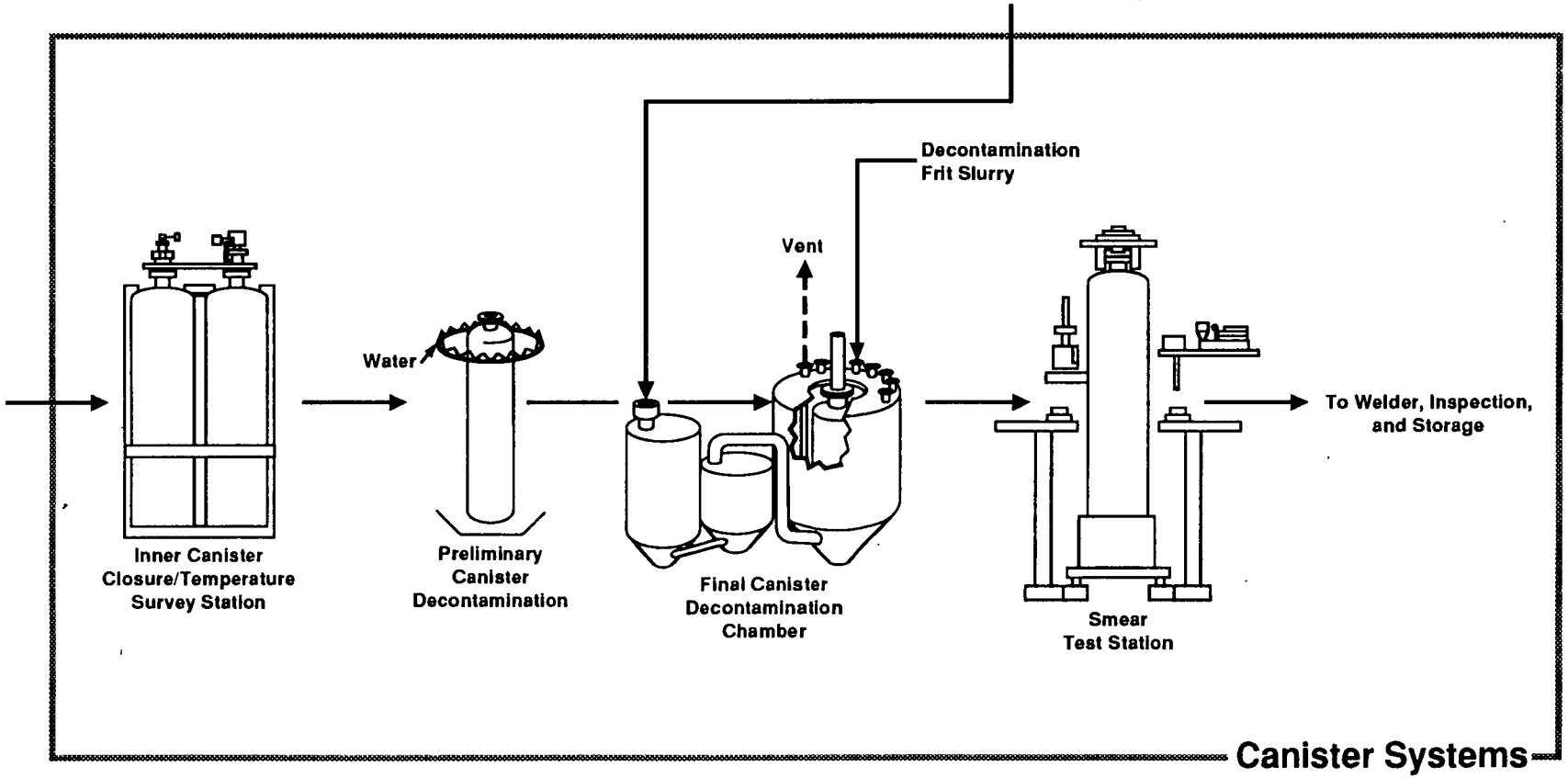
HWVP Filled Canister Processing



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Approach for WFQ Compliance

- Adapt technology and design applications from the West Valley Demonstration Project (WVDP) and especially the Defense Waste Processing Facility (DWPF)

- Control glass properties by controlling glass composition
  - Composition variability study (CVS) property correlations
  - Qualified composition region
  - Feed processibility assessment
  - Process/product composition control models

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Approach for WFQ Compliance (cont)

- Perform confirmation testing
  - Scaled testing
  - DWPF Project experience
  - HWVP testing
  - HWVP hot production

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Application of DWPF and WVDP Technology and Design to Support HWVP WFQ

Direct application to support WFQ compliance

- 2.1 Canister Material
- 2.2 Canister and Fabrication Closure
- 2.3 Canister Identification and Labeling
- 3.6 Removable Radioactive Contamination on External Surfaces
- 3.11 Dimensions
- 3.12 Drop Test
- 3.13 Handling Features

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Application of DWPF and WVDP Technology and Design to Support HWVP WFQ (cont)

Adaptations of methodology to support WFQ compliance

- 1.1 Chemical Composition
- 1.2 Radionuclide Inventory
- 1.3 Product Consistency
- 1.4 Phase Stability
- 3.1 Free Liquid
- 3.2 Gases
- 3.3 Explosives, Pyrophoricity, and Combustibility
- 3.4 Organic Material

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Application of DWPF and WVDP Technology and Design to Support HWVP WFQ (cont)

Adaptations of methodology to support WFQ compliance (cont)

- 3.5 Fill Height
- 3.7 Heat Generation
- 3.8 Maximum Dose Rates
- 3.10 Subcriticality

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Control Glass Properties by Controlling Glass Composition

Product composition control is a significant contributor to compliance strategy of the following Waste Acceptance Preliminary Specifications:

- 1.1 - "Glass Composition and Phases"
- 1.2 - "Radionuclide Inventory"
  - 3.7 Heat Generation
  - 3.8 Maximum Dose Rate
  - 3.10 Subcriticality
- 1.3 - "Product Consistency"
- 1.4 - "Chemical and Phase Stability"

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Control Glass Properties by Controlling Glass Composition (cont)

HWVP CVS

- Correlates glass properties to glass composition using:
  - Ten major oxide components
  - Multi-component constraints

- Determines qualified composition region per property constraints for:
  - Liquidus
  - Viscosity
  - Electrical conductivity
  - Product Consistency Specification (1.3)

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Control Glass Properties by Controlling Glass Composition (cont)

HWVP CVS (cont)

- Determines overall envelope of acceptable glass compositions
- Provides basis for optimizing frit compositions

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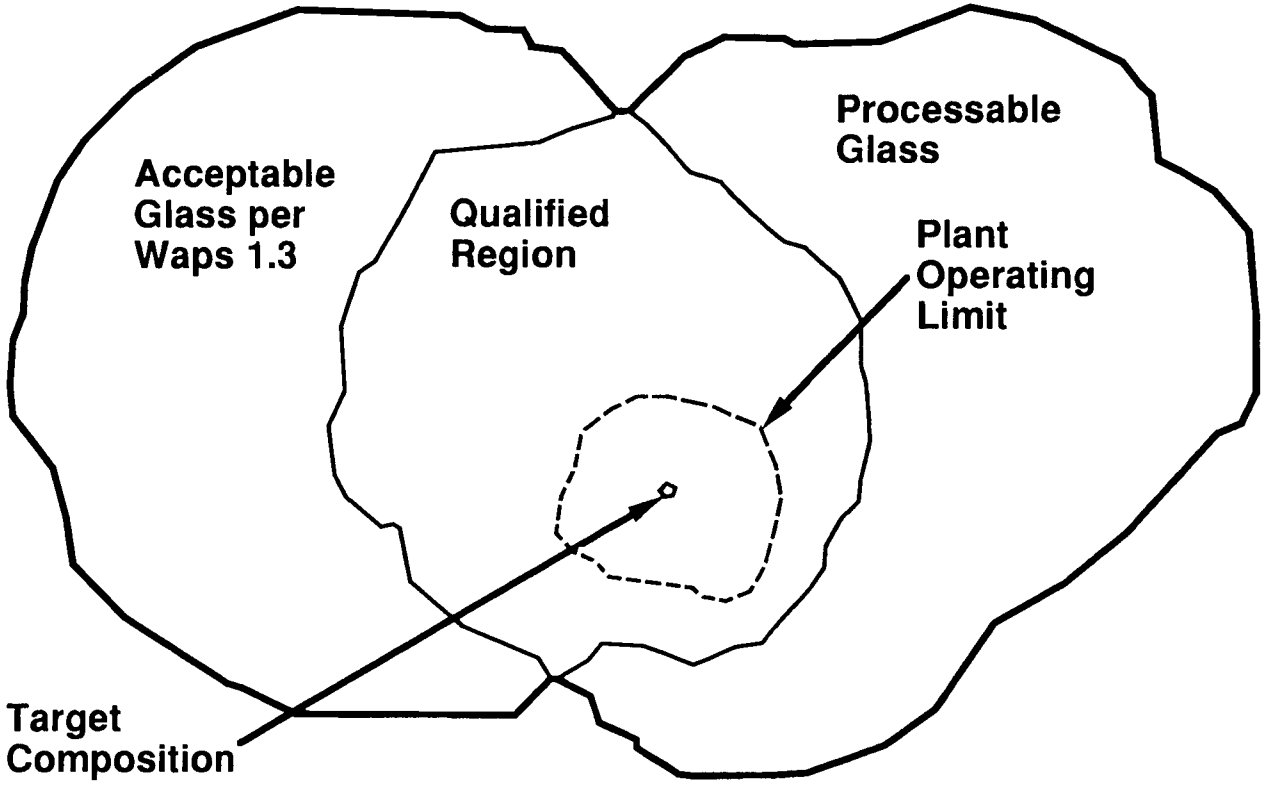
Schematic of Qualified Composition Region



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Feed Processibility Assessment

- Structured to:
  - Systematically assess most current feed characterization data
  - Evaluate relationship of projected feed characteristics to HWVP design basis
  - Project glass formulations and waste loadings based on CVS models
  - Assess specific plant process streams for compatibility with design
  - Integrate vitrification feed constraints with pretreatment capability

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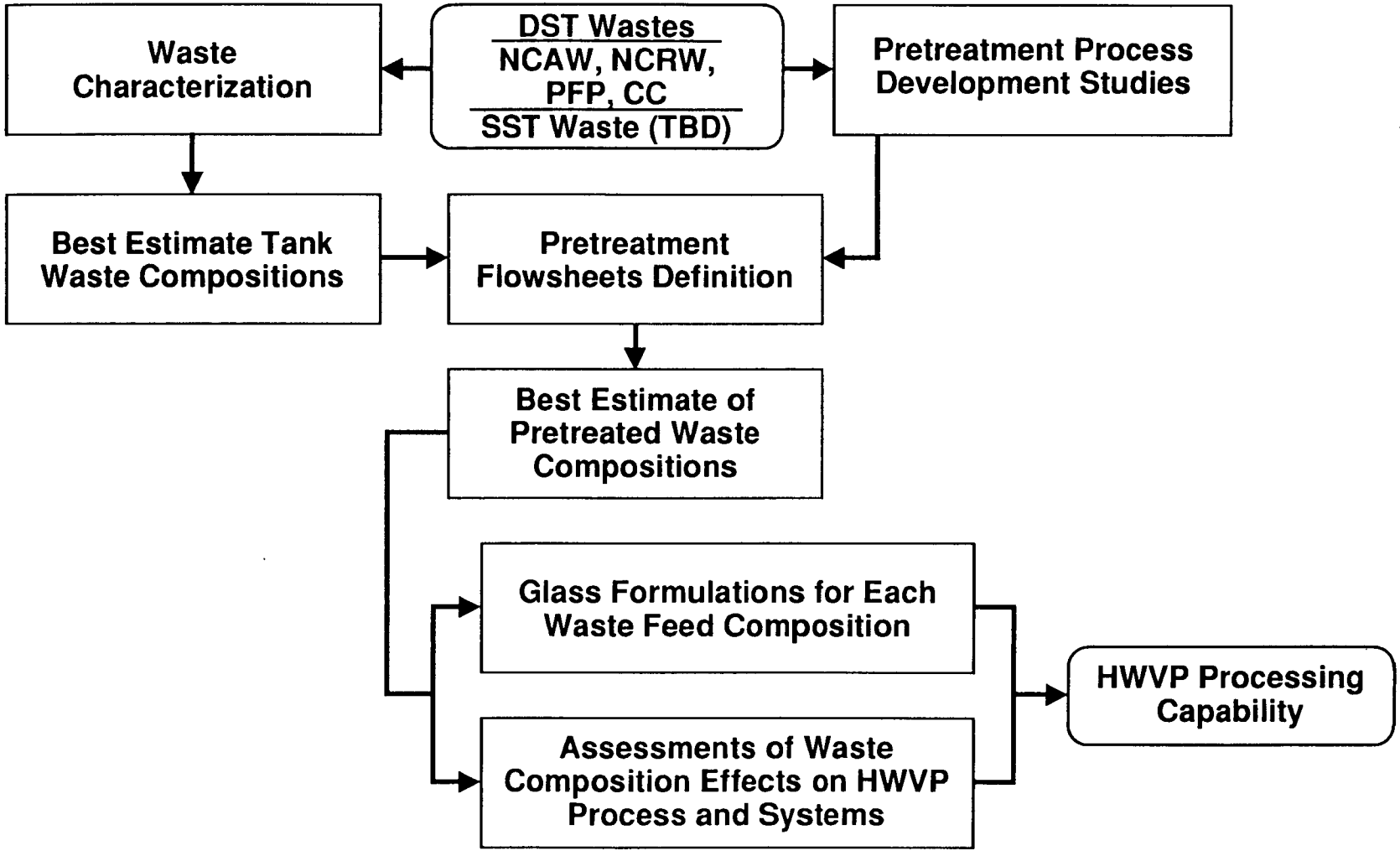
Waste Processibility Assessment



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Feed Processibility Assessment (cont)

- Double-shell tank wastes
  - Initial assessments have been completed for four defined high-level waste types:
    - Neutralized current acid waste
    - Neutralized cladding removal waste
    - Plutonium Finishing Plant waste
    - Complexant concentrate waste
- Single-shell tank wastes
  - Assessment work has recently started for initial candidates

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Projected HWVP Feed and Frit Compositions for Double-Shell Tank Waste Types

Nonvolatile oxides	Wt% of total nonvolatile oxides			
	NCAW	CC	PFP	NCRW
	Waste			
SiO_2	0.4	69.1	4.7	6.6
B_2O_3	--	--	0.3	1.1
Na_2O	21.4	9.9	4.3	0.3
Li_2O	--	--	--	--
CaO	0.8	0.3	0.3	0.4
MgO	0.2	0.2	0.3	0.2
Fe_2O_3	28.2	1.1	3.2	0.6
Al_2O_3	9.0	11.4	75.2	35.2
ZrO_2	15.1	--	0.2	49.6
Others	24.9	8.0	11.5	6.0
	Frit			
SiO_2	73.6	3.9	57.6	57.6
B_2O_3	19.6	77.7	31.5	31.0
Na_2O	--	--	--	--
Li_2O	6.8	18.4	11.0	11.5
CaO	--	--	--	--
MgO	--	--	--	--

CC = Complexant concentrate
NCAW = Neutralized current acid waste
NCRW = Neutralized cladding removal waste
PFP = Plutonium Finishing Plant

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Projected HWVP Glass Compositions and Attributes for Double-Shell Tank Waste Types

Attribute	NCAW	CC[1]	PFP	NCRW
Waste loading (%)[2]	26	64	22	22
E 1150 (S/cm)	0.34	0.34	0.34	0.34
B release (g/m^2)/7 days[3]	4.6	5.0	0.2	1.0
Glass T (6 Pa•s) (°C)	1,100	1,100	1,100	1,100
Nonvolatile oxides, wt%				
SiO_2	50.0	52.2	42.8	43.3
B_2O_3	12.8	17.5	22.0	21.9
Na_2O	8.3	10.4	2.6	1.5
Li_2O	4.4	4.2	7.6	8.0
CaO	0.3	0.2	0.1	0.1
MgO	0.1	0.2	0.1	0.1
Fe_2O_3	8.8	0.9	1.0	0.2
Al_2O_3	3.0	8.2	20.5	9.6
ZrO_2	4.7	--	--	13.4
Others	8.0	6.2	3.4	1.9

[1]Compositions listed are for CC contained in 200 East Area tanks.
[2]Waste loading reduced 5% below maximum to allow flexibility for processing.
[3]Product consistency test results.

CC = Complexant concentrate
NCAW = Neutralized current acid waste
NCRW = Neutralized cladding removal waste
PFP = Plutonium Finishing Plant

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Product Composition Control Modeling

- Glass properties modeling
  - Predictive modeling of glass properties versus glass composition (CVS work)

- Process mass balance modeling
  - Predictive modeling of glass composition based on process stream samples and mass balance model
  - Modeling will rationalize analytical errors and uncertainties of process measurements

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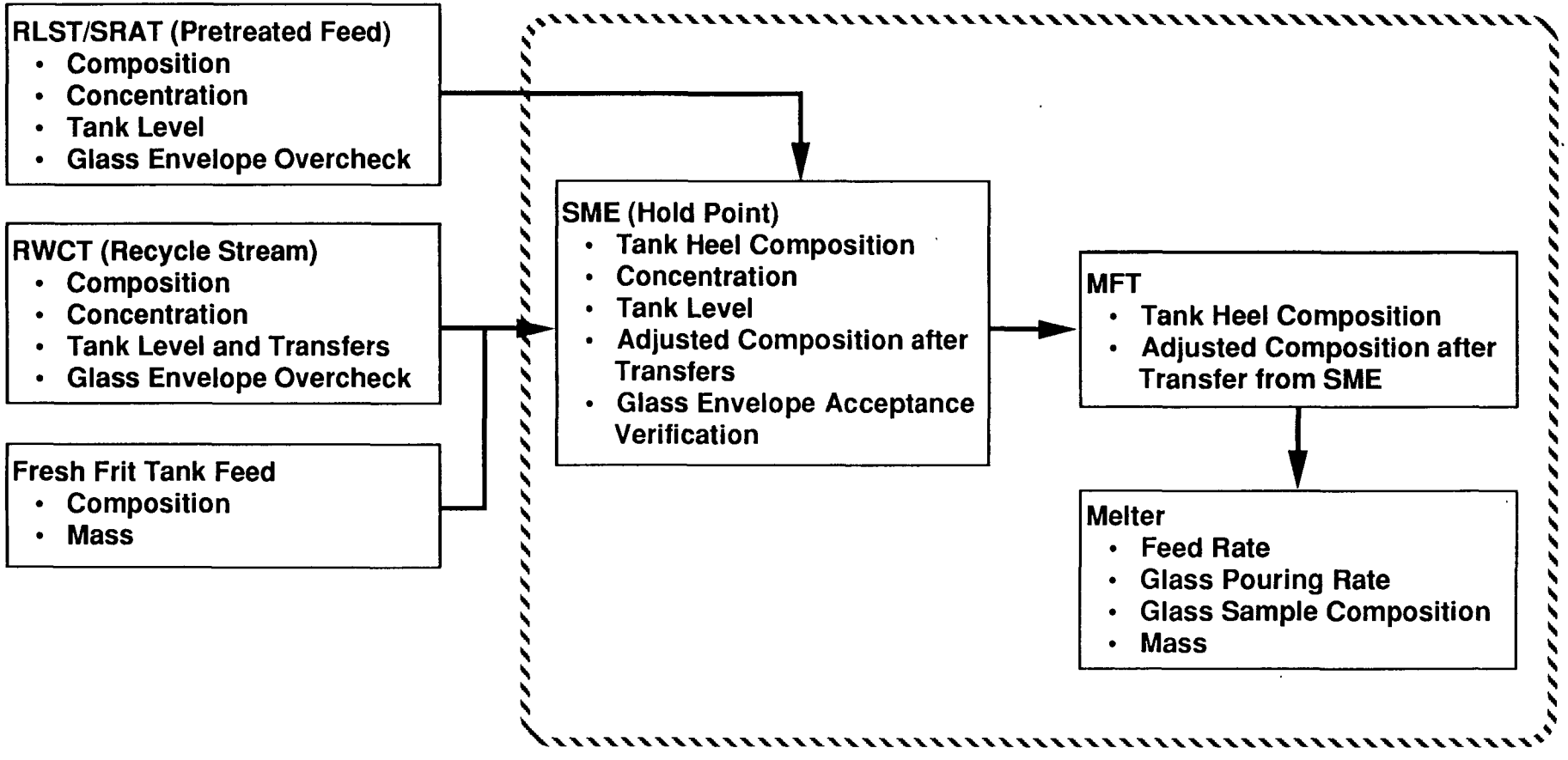
Process Data Sources for Mass Balance Modeling to Support Product Composition Control



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Confirmation Testing

Nonradioactive Feed

Scaled systems	Full-scale system
• Bench (1/50)	• Simulated process tank(s)
• Pilot (1/10)	• HWVP (operations testing and qualification runs)
• Demonstration (~1/2)	• DWPF experience

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Confirmation Testing (cont)

Radioactive Feed

Scaled systems	Full-scale system
• Laboratory crucible work	• HWVP hot production experience (confirmation of compliance with certain acceptance specifications)
• Bench-scale	
• DWPF Project experience	• DWPF hot production

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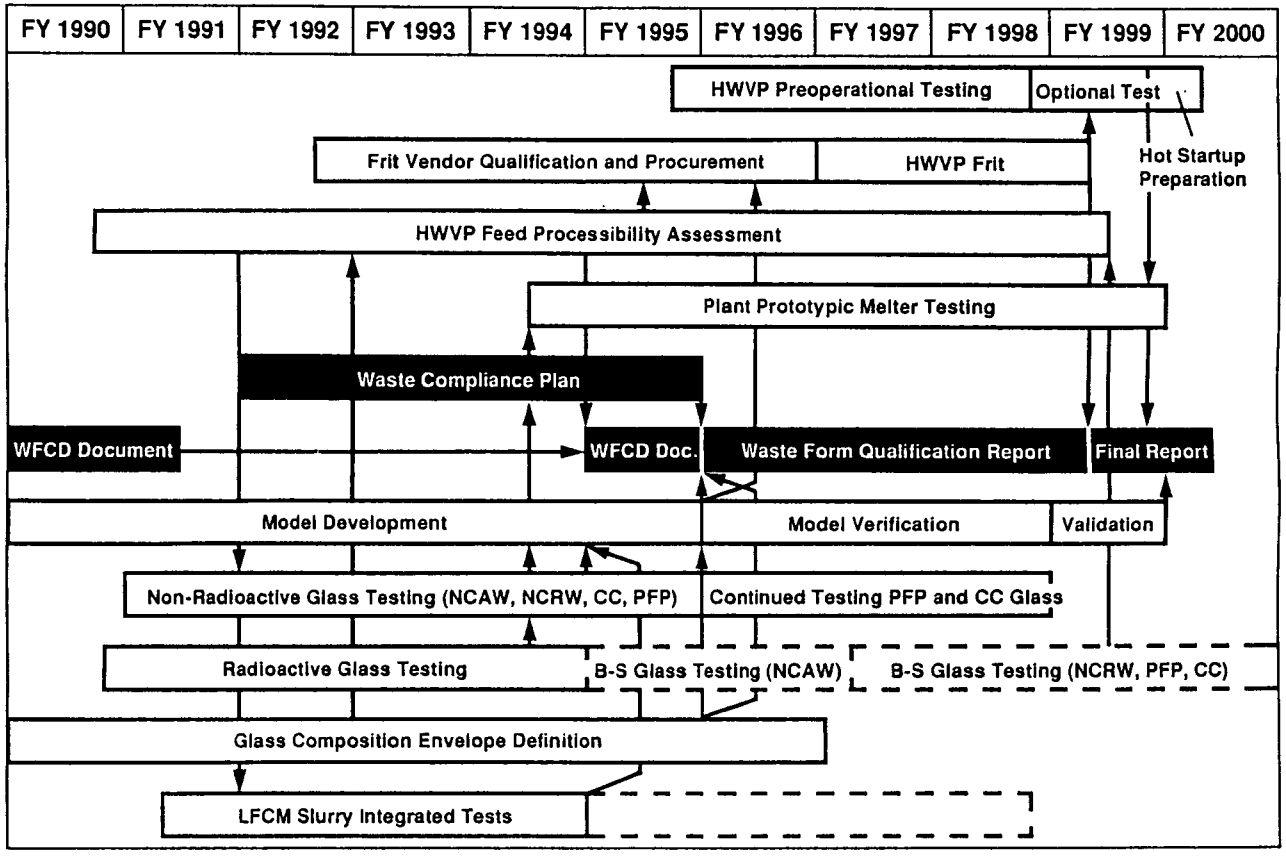
Technology and Waste Form Qualification Overview Schedule



CC = Complexant Concentrate
HWVP = Hanford Waste Vitrification Plant
LFCM = Liquid-Fed Ceramic Melter
NCAW = Neutralized Current Acid Waste
NCRW = Neutralized Cladding Removal Waste
PFP = Plutonium Finishing Plant
WFCD = Waste Form Qualification Description
B-S = Bench-Scale

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WFQ Summary

- HWVP gains technical benefits from DWPF and WVDP
- Hanford Site wastes will require unique process and WFQ approaches
- Control of glass properties will be achieved by:
  - Correlating glass properties to glass composition
  - Establishing a qualified composition (glass) region
  - Glass composition control via mass balance modeling
- Perform scaled and full-sized (HWVP) testing to establish and confirm bases for acceptance specifications compliance