

EVALUATION OF CANDIDATE WASTE STREAMS FOR INCLUSION IN THE EPRI BRC PROGRAM

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ABSTRACT

There are several waste streams produced at nuclear power plants that contain very low radioactivity concentrations and could be classified as Below Regulatory Concern (BRC), thus exempting that waste from low-level waste disposal requirements. The Electric Power Research Institute (EPRI) has embarked on a program to develop generic BRC exemptions for specific waste streams. In order to focus the finite resources of time and money on those waste streams which would provide the maximum benefit to the industry, an evaluation of potential BRC waste streams was performed. This evaluation provides a systematic and documented approach to identify candidate BRC waste streams for inclusion in the EPRI BRC program. This paper outlines the methods used to identify potential BRC waste streams, define appropriate evaluation/selection criteria, and provide an evaluation of each waste stream with respect to these criteria. The final result of this evaluation was a prioritized list of BWR and PWR waste streams, in decreasing order of attractiveness, suitable for inclusion in the EPRI BRC program.

Purpose and Objectives

The purpose of the evaluation was to conduct a systematic and documented evaluation of candidate BRC waste streams. The specific objectives of this evaluation with respect to identifying several waste streams for inclusion in EPRI's BRC program were as follows:

- To perform a quantitative and qualitative evaluation of the benefits and waste stream properties considered important to the overall acceptance by the NRC as a BRC waste.
- To provide documentation of the evaluation process used to identify candidate BRC waste streams.
- To identify a list of candidate waste streams in decreasing order of attractiveness for inclusion in the EPRI BRC program.

This paper outlines the methodology used to define, evaluate, and rank these candidate BRC waste streams. The final report, which contains more specific information regarding the waste stream evaluations relative to each criteria, is currently in publication by EPRI.

Evaluation Methodology

The methodology used to evaluate potential waste streams involved a "Figure of Merit" decision analysis technique, which included the following key elements:

1. Define a list of potential BRC waste streams

2. Identify the selection criteria to evaluate the waste streams
3. Develop a system to weight the criteria relative to overall importance in the EPRI BRC program
4. Evaluate each waste stream relative to the criteria
5. Provide a prioritized list of candidate BRC waste streams for inclusion in the EPRI BRC program

Waste Stream Identification

The first step in evaluating candidate BRC waste streams was to identify a list of potential waste streams containing very low activities that are typically generated by nuclear power reactors. References 1 through 4 were reviewed, and plants were contacted via telephone surveys to identify potential waste streams generated by Boiling Water Reactor plants (BWRs) and/or Pressurized Water Reactor plants (PWRs). In addition, a Technical Advisory Committee for the EPRI BRC program developed an initial list of potential waste streams to be considered for BRC exemption. As a result of these efforts, the final unranked list of candidate BRC waste streams was defined as follows:

Compacted Dry Active Waste (DAW)	Noncompacted DAW
Waste Oils	Evaporator Concentrates
Secondary Side Resins (PWRs only)	Sandblasting Grit

Contaminated Soil	Water Treatment Sludges
Tank and Sump Sludges	Sewage Sludge
Secondary Side Large Components	Condenser Tubes (BWRs only)

Evaluation/Selection Criteria

After the potential candidate BRC waste streams were identified, evaluation/selection criteria were developed to determine which waste streams would result in the maximum benefit to the industry if appropriate exemptions were established. In addition, criteria relating to perceived difficulties in obtaining a BRC exemption were developed to evaluate each waste stream. Both quantitative and qualitative criteria were defined.

The quantitative evaluation criteria relating to the magnitude of the benefits from a generic BRC program were identified as:

Annual Volume of Waste - Identification of typical plant waste volumes for each of the very low activity waste streams considered for BRC exemption. The volumes were identified on an approximate annual basis to assess the potential benefit(s) of a BRC exemption over a plant lifetime. The specific criteria used to evaluate waste volumes were:

- Projected industry BRC volumes
- Average annual BRC volumes for only those units reporting generation of the waste stream
- Current total industry generation of the waste stream
- Volume reduction potential before BRC

Applicability to All Plants - Identification of the number (or percentage) of plants which would potentially benefit from the exemption of the specific waste stream. Based on available data and telephone contacts with utility personnel, it was identified whether or not each candidate waste stream was generated at the plant. The frequency of generation of each waste stream (i. e., weekly, monthly, annually, once every five years, etc.) was also considered in the evaluation.

The remaining criteria deemed important in evaluating waste streams for inclusion in a generic BRC program pertained to the real or perceived difficulties in characterizing each waste stream and in receiving NRC approval for the exemption. For the most part, quantifiable data for these criterion did not exist. Therefore, a qualitative evaluation was performed for each waste stream based on engineering judgement and general knowledge of the waste stream characteristics. The purpose of this evaluation was to identify potential problem areas for each of the candidate waste streams. Each of these criteria will be evaluated at a later

date as part of the detailed EPRI BRC implementation program. These criterion include:

Non-Recyclable Characteristics - The recycle potential of the waste material is a required input into the IMPACTS computer code which calculates doses that could result from the disposal of very low level radioactive waste streams. Because of the NRC's concern for the potential recycle of waste material (and subsequent exposure to an intruder), this criterion was evaluated based on the reusability of the waste products. For example, tools and discarded equipment may have a higher recycle potential than rags, paper, and general trash.

Similarities to Other Non-Radiological Wastes - This criteria relates to the ability to distinguish the BRC waste materials from other non-radiological waste materials typically disposed by the proposed disposal option. Evaluation of this criteria is a qualitative assessment of the public's perception of the waste form with respect to other non-radiological wastes.

Ease of Developing Radiological Characterization - Some waste streams, by their nature, are easier to characterize radiologically and possess less variability than others. This criteria relates to ease of sampling and homogeneity of the waste stream with respect to physical and radiological characteristics.

Variability in Nuclide Concentration and Distribution - This criterion considers the effect on NRC approval of each candidate BRC waste stream from the radionuclide concentration and isotopic distribution, as well as the variability in these factors within the same waste stream. Evaluation based upon this criterion is divided into two parts:

- Variability of Nuclide Distribution
- Variability in Nuclide Concentrations
- Each of these criteria were evaluated with respect to the entire industry as well as variability within a single plant. Significant variability in a specific waste stream's nuclide concentration and/or distribution could result in difficulties obtaining a generic BRC exemption for that waste stream.

Typical Activity Concentrations - Because the relative sources and methods of generation vary significantly among the waste streams, some wastes could typically contain extremely low concentrations of radioactive materials which are far below any limiting concentration for a proposed BRC disposal option. Extremely low activity concentrations would aid in radiological characterization and compliance, and would improve the suitability of the waste stream for a generic BRC application, relative to other wastes. On the other hand, typically high activity concentrations may limit a waste stream's volume reduction potential through a

generic BRC exemption. Therefore, typical activity concentrations were evaluated for each waste stream.

Relative Cost to Characterize the Waste Stream - This criteria relates to the relative cost to characterize each waste stream based upon:

- Waste composition/physical characteristics
- Variability of chemical properties
- Variability of radiochemical properties
- Variability of physical properties

Simplicity of Compliance Program - This criterion involves an evaluation based on the simplicity or ease of implementing a compliance program. The evaluation for each candidate waste stream considers requirements of the compliance program such as sampling, monitoring, and documentation to demonstrate that the BRC limits had been met.

Weighting and Ranking System

Because some of the criteria were considered to be more important than others in evaluating the candidate BRC waste streams, a Figure of Merit system was used to properly account for all of the criteria. Consistent with the objectives of the EPRI program, the quantitative criteria relating to the magnitude of the benefits were weighted more heavily than the qualitative criteria. The weights assigned to each criterion were:

Quantitative (Supporting Data)

Annual Volume of Waste	40 Pts.
Applicability to All Plants	26 Pts.
	66 Pts.

Qualitative (No Supporting Technical Data)

Non-Recyclable Characteristics	7 Pts.
Similarities to Other Non-Radiological Waste	3 Pts.
Ease of Developing Radiological Characterization	6 Pts.
Variability in Nuclide Concentration & Distribution	6 Pts.
Typical Activity Concentration	3 Pts.
Relative Cost to Characterize the Waste Stream	5 Pts.

Simplicity of Compliance Program 4 Pts.

34 Pts.

The evaluation of each potential candidate waste stream with respect to the identified criteria resulted in a "raw score" ranging from 1 to 10 for that waste stream. A score equal to 1 corresponded to "least suitable" for a BRC program, while a score equal to 10 corresponded to "most suitable" for the program. A raw score of zero was assigned in certain cases where it was determined that the characteristics of the waste stream, relative to the criteria being evaluated, made it unsuitable for a BRC program. Table I outlines the relative scoring method based upon the various evaluation/selection criteria.

Stream Evaluations

The next step was to evaluate each of the candidate BRC waste streams relative to the evaluation criteria, and assign relative scores to each waste stream in accordance with the scoring methods summarized in Table I. As shown in the table, several of the evaluation criteria considered several different indicators to thoroughly evaluate each waste stream. The result of the waste stream evaluations are more than 40 pages of documented justification for the final scores awarded to each waste stream. Due to publication restrictions, the quantitative and qualitative support for each of the raw scores awarded could not be included herein. These results are currently in publication by EPRI.

Tables II and III do, however, summarize the quantitative data relating to potential BRC waste volumes and applicability to all plants used in the evaluation. EPRI's extensive data base of radwaste volumes and characteristics (1, 2) from 1978 through 1985 was used as the primary source of information for many of the "typical" waste streams such as compacted dry active waste (DAW), non-compacted DAW, oil, concentrates, secondary side resin, tank/sump sludge, etc. For waste streams in which specific information was limited, an industry-wide telephone survey was conducted to each utility, where radwaste managers were asked to identify generation of the waste stream (yes/no) and approximate annual quantities (7).

Based on the information summarized in Tables II and III, raw scores were assigned to each waste stream based on the quantitative criteria discussed previously. Tables IV and V summarize these resultant raw scores, along with the scores assigned based upon the qualitative evaluation criteria for both the PWR and BWR analyses.

Final Ranking of the Potential Candidate Waste Streams

The resultant raw scores from the waste stream evaluations were input into "evaluation matrices" where raw scores were multiplied by the relative weighting factors for each of

TABLE I

Relative Scoring Method for Evaluation/Selection Criteria

	Max Score 10 Pts	Min Score 1 Pt
Annual Volume of Waste per Plant		
- Potential BRC Volume	High	Low
- Annual Volume Shipped (Industry Generation)	High	Low
- Volume Minimization Potential Before BRC	Low	High
Applicability to All Plants		
- Percent of Plants Generating Waste	High	Low
- Frequency of Future Generation	High	Low
Non-Recyclable Characteristics	None	Many
Similarity to Other Non-Radiological Waste	High	Low
Ease of Developing Radiological Characterization		
- Homogeneity of Waste Stream	High	Low
- Ease of Sampling	Easy	Hard
Variability in Nuclide Concentration & Distribution		
- Variability in Nuclide Distribution	Low	High
- Variability in Nuclide Concentration	Low	High
Typical Activity Concentrations	Low	High
Relative Cost to Characterize the Waste Stream	Low	High
Simplicity of Compliance Program	Easy	Hard

Note: A score of zero was assigned in certain cases where it was determined that the characteristics of the waste stream, relative to the evaluation criteria, made it unsuitable for a BRC program.

TABLE II

Summary of Volumes and Plant Applicability for BWR Waste Streams

WASTE STREAM	COMP DAW	NON COMP DAW	OIL	PWR SEC SIDE RESIN	EVAP CONC	SOIL	GRIT	WATER TREAT SLUDGE	TANK/ SUMP SLUDGE	SEWAGE SLUDGE	SEC SIDE LARGE COMP	BWR COND TUBES
NO. OF UNITS REPORTING WASTE	27	27	26	N/A	9	16	24	2	15	7	13	8
NO. OF UNITS NOT REPORTING WASTE	0	0	1	N/A	18	12	4	24	11	21	9	18
AVERAGE VOLUME (ALL PLANTS)	296	228	25	N/A	63	50	4	1	2	2	7	13
AVERAGE VOLUME (PLANTS W/ WASTE)	296	228	26	N/A	191	95	5	16	3	10	11	40
RANGE OF VOLUMES												
- LOW	79	2	2	N/A	14	0	0	16	0	1	2	31
- HIGH	943	787	78	N/A	387	566	28	16	11	23	48	65
% ASSUMED SUITABLE FOR BRC	40%	40%	90%	N/A	0%	90%	100%	100%	50%	100%	80%	80%
AVERAGE BRC VOLUMES												
ALL UNITS	118	91	23	N/A	0	45	4	1	1	2	6	11
ONLY UNITS WITH WASTE	118	91	24	N/A	0	85	5	16	1	10	9	32
INDUSTRY TOTAL (CUBIC METERS PER YEAR)	4,130	3,185	805	N/A	0	1,575	140	35	35	70	210	385

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TABLE III

Summary of Volumes and Plant Applicability for PWR Waste Streams

WASTE STREAM	COMP DAW	NON COMP DAW	OIL	PWR SEC SIDE RESIN	EVAP CONC	SOIL	GRIT	WATER TREAT SLUDGE	TANK/ SUMP SLUDGE	SEWAGE SLUDGE	SEC SIDE LARGE COMP	BWR COND TUBES
NO. OF UNITS REPORTING WASTE	53	53	35	32	20	29	25	7	25	9	18	N/A
NO. OF UNITS NOT REPORTING WASTE	0	0	21	21	36	27	31	49	29	47	36	N/A
AVERAGE VOLUME (ALL PLANTS)	180	105	8	16	33	13	1	7	1	1	1	N/A
AVERAGE VOLUME (PLANTS W/ WASTE)	180	105	11	27	93	24	3	50	3	7	6	N/A
RANGE OF VOLUMES												
- LOW	30	0	0	1	7	0	0	6	0	2	1	N/A
- HIGH	493	617	52	183	295	212	8	156	16	11	21	N/A
% ASSUMED SUITABLE FOR BRC	40%	40%	90%	80%	5%	90%	100%	100%	50%	100%	100%	N/A
AVERAGE BRC VOLUMES												
ALL UNITS	72	42	7	13	2	11	1	7	1	1	1	N/A
ONLY UNITS WITH WASTE	72	42	10	22	5	22	3	50	1	7	6	N/A
INDUSTRY TOTAL (CUBIC METERS PER YEAR)	5,544	3,234	539	1,001	154	847	77	539	77	77	77	N/A

Volumes are in cubic meters per unit-year except where noted.

The total number of plants surveyed varies due to the use of different references and/or no response by the plant during the survey (Ref. 7) conducted as part of the BRC waste stream evaluation.

TABLE IV

Raw Scores for BWR Waste Streams Relative to Evaluation Criteria

WASTE STREAM	COMP DAW	NON COMP DAW	OIL	PWR SEC SIDE RESIN	EVAP CONC	SOIL	GRIT	WATER TREAT SLUDGE	TANK/ SUMP SLUDGE	SEWAGE SLUDGE	SEC SIDE LARGE COMP	BWR COND TUBES
VOLUME	10	9	5	0	2	7	3	2	1	2	4	5
APPLICABILITY	10	10	8	0	6	5	8	1	5	2	4	2
NON-RECYCLE CHARACTERISTICS	8	0	10	0	7	5	5	5	5	5	0	0
NONRAD WASTE SIMILARITIES	7	6	10	0	3	9	9	9	9	9	5	8
RADIOLOGICAL CHARACTERIZATION	3	1	10	0	9	7	9	8	8	8	1	1
WASTE STREAM VARIABILITY	4	3	8	0	3	6	6	9	2	9	6	6
TYPICAL ACTIVITY CONCENTRATION	4	3	5	0	1	10	7	10	2	10	9	8
COST TO CHARACTERIZE	3	2	9	0	5	8	8	9	5	9	6	6
COMPLIANCE PROGRAM	4	2	8	0	5	7	7	9	6	9	6	6

TABLE V

Raw Scores for PWR Waste Streams Relative to Evaluation Criteria

WASTE STREAM	COMP DAW	NON COMP DAW	OIL	PWR SEC SIDE RESIN	EVAP CONC	SOIL	GRIT	WATER TREAT SLUDGE	TANK/ SUMP/ SLUDGE	SEWAGE SLUDGE	SEC SIDE LARGE COMP	BWR COND TUBES
VOLUME	10	8	5	7	4	5	2	6	1	3	3	0
APPLICABILITY	10	10	6	6	6	6	6	1	4	2	2	0
NON-RECYCLE CHARACTERISTICS	8	0	10	6	7	5	5	5	5	5	0	0
NONRAD WASTE SIMILARITIES	7	6	10	9	3	9	9	9	9	9	5	0
RADIOLOGICAL CHARACTERIZATION	3	1	10	7	9	7	9	8	8	8	1	0
WASTE STREAM VARIABILITY	4	3	8	5	3	6	6	9	2	9	6	0
TYPICAL ACTIVITY CONCENTRATION	4	3	5	6	1	10	7	10	2	10	9	0
COST TO CHARACTERIZE	3	2	9	6	5	8	8	9	5	9	6	0
COMPLIANCE PROGRAM	4	2	8	6	5	7	7	9	6	9	6	0

the evaluation criteria to calculate a total weighted score for each waste stream. In addition, the average score for each of the nine criteria evaluated was calculated. A waste stream with a high total weighted score, but with a low average score, is perceived as having significant benefit to the industry through a generic BRC exemption; however, the potential difficulties in obtaining this exemption are also relatively high.

As a result of the systematic evaluation described in this report, a total weighted score was calculated for each potential BRC waste stream. A high total weighted score, relative to other waste streams, indicates that the waste stream is more suitable for inclusion in the EPRI BRC program. The final list of BWR candidate waste streams, in decreasing order of attractiveness for inclusion in the EPRI BRC program, is shown as Table VI. The corresponding table for PWR candidate waste streams is included as Table VII.

SUMMARY

As a result of the candidate waste stream evaluations, waste streams were ranked in decreasing order of attractiveness for inclusion in EPRI's BRC program. Based upon EPRI's preliminary investigations, it was concluded that the BRC program should address multiple waste streams to provide maximum benefit to the industry.

Also because of schedule concerns and cost effectiveness, the multiple waste streams should be pursued in parallel. EPRI has selected the top four waste streams for both BWR's and PWR's (Tables VI and VII) for a more detailed

analysis and evaluation in the ongoing EPRI effort to provide the technical research required to support an NRC rulemaking petition for exemption of part of these wastes as BRC.

REFERENCES

The references listed herein have been reviewed during the course of this project, or were conducted as part of this evaluation, and have contributed to the preparation and content of this document. Many of the references are applicable to more than one of the subsections in this report and would necessitate their being repeated.

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Facilities by Alternate Means. Columbia, MD. : General Physics Corporation, March 1986, GP-R-211013 Revision 1, Draft.

6. C. Lan. "De Minimis Applications for Alternate Disposal of Very Low Level Radioactive Waste at Duke Power

Company. " In Proceedings of Waste Management '86, vol 3, 1986, pp. 133-138.

7. Industry Telephone Survey (28 BWR & 56 PWR Units) to Identify and Quantify Potential BRC Waste Streams, Analytical Resources Inc., May 1987.

TABLE VI

Final Ranking of BWR Candidate Waste Streams

<u>WASTE STREAM</u>	<u>TOTAL WEIGHTED SCORE</u>	<u>AVERAGE SCORE</u>	<u>RELATIVE RANK</u>
Compacted DAW	822	4.78	1
Waste Oil	708	7.56	2
Contaminated Soil	648	6.33	3
Sandblasting Grit	569	6.56	4
Sewage Sludge	407	6.78	5
Water Treatment Sludge	381	6.67	6
Tank/Sump Sludge	347	4.67	7
Evaporator Concentrates	#		
Noncompactible DAW	***		
Secondary Side Large Components	***		
BWR Condenser Tubes	***		
PWR Secondary Side Resins	N/A		

TABLE VII

Final Ranking of PWR Candidate Waste Streams

<u>WASTE STREAM</u>	<u>TOTAL WEIGHTED SCORE</u>	<u>AVERAGE SCORE</u>	<u>RELATIVE RANK</u>
Compacted DAW	822	4.78	1
Waste Oil	656	7.33	2
PWR Secondary Side Resins	649	5.67	3
Contaminated Soil	594	6.44	4
Water Treatment Sludge	541	6.67	5
Evaporator Concentrates	494	4.33	6
Sandblasting Grit	477	6.33	7
Sewage Sludge	447	6.78	8
Tank/Sump Sludge	321	4.56	9
Noncompactible DAW	***		
Secondary Side Large Components	***		
BWR Condenser Tubes	N/A		

The radiological characteristics of BWR evaporator concentrates are not expected to be suitable for BRC

*** These waste streams most likely would not meet the criteria for non-recyclable characteristics

N/A This waste stream is Not Applicable to PWRs/BWRs