Staff briefing (92)
Aug. '90

OUTLINE FOR PRESENTATION ON

HISTORY OF PART 60

I. HLW Regulatory Development circa 1978 -- regulations should match repository design.

A. Reprocessing wastes -- 1,000 year problem.

B. No reliance on waste package for containment.

C. Glass waste form being questioned.

D. Virtually total reliance on site for waste isolation.

II. NRC staff conceptual goal -- three-way redundancy -- repository design should meet regulatory objectives.

A. 1,000 year containment by canisters.

B. 1,000 year containment by repository.

C. 1,000 year containment by site.

III. 1980 ANPR -- Part 60 Technical Criteria

A. Regulatory philosophy -- Multiple barriers with minimum performance standards for major barriers. 10,000 year problem.

B. 1,000 year waste package containment

C. 1,000 year containment in underground facility, assuming release from waste packages.

D. $10^{-5}$/year release rate from engineered system after first 1,000 years.

E. 1,000 year radionuclide travel time through the host rock and surrounding units.

F. No attempt to correlate with EPA standards.

IV. 1981 Proposed Technical Criteria for Part 60.

A. Regulatory philosophy -- continuation of multiple barrier rather than "systems" approach.

B. 1,000 year waste package containment.

C. $10^{-5}$/year release rate from engineered system after 1,000 years.

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D. 1,000 year pre-emplacement groundwater travel time from disturbed zone to accessible environment.

E. No attempt to correlate with EPA standards.

V. 1983 Final Technical Criteria for Part 60.

A. Regulatory philosophy -- Multiple barrier approach, but with explicit provision for "trade-offs" among barriers. 60.113(b)

B. Waste package containment to be "substantially complete" for 300 - 1,000 years.

C. $10^{-5}$/year release rate following containment period.

D. 1,000 year pre-emplacement groundwater travel time from disturbed zone to accessible environment.

E. Case-by-case approval or specification of other subsystem performance objectives.

F. Technical analyses of NUREG-0804 demonstrate that compliance with Part 60 performance objectives increases the likelihood of compliance with EPA standards. Part 60 objectives not shown to be necessary or sufficient to ensure compliance.

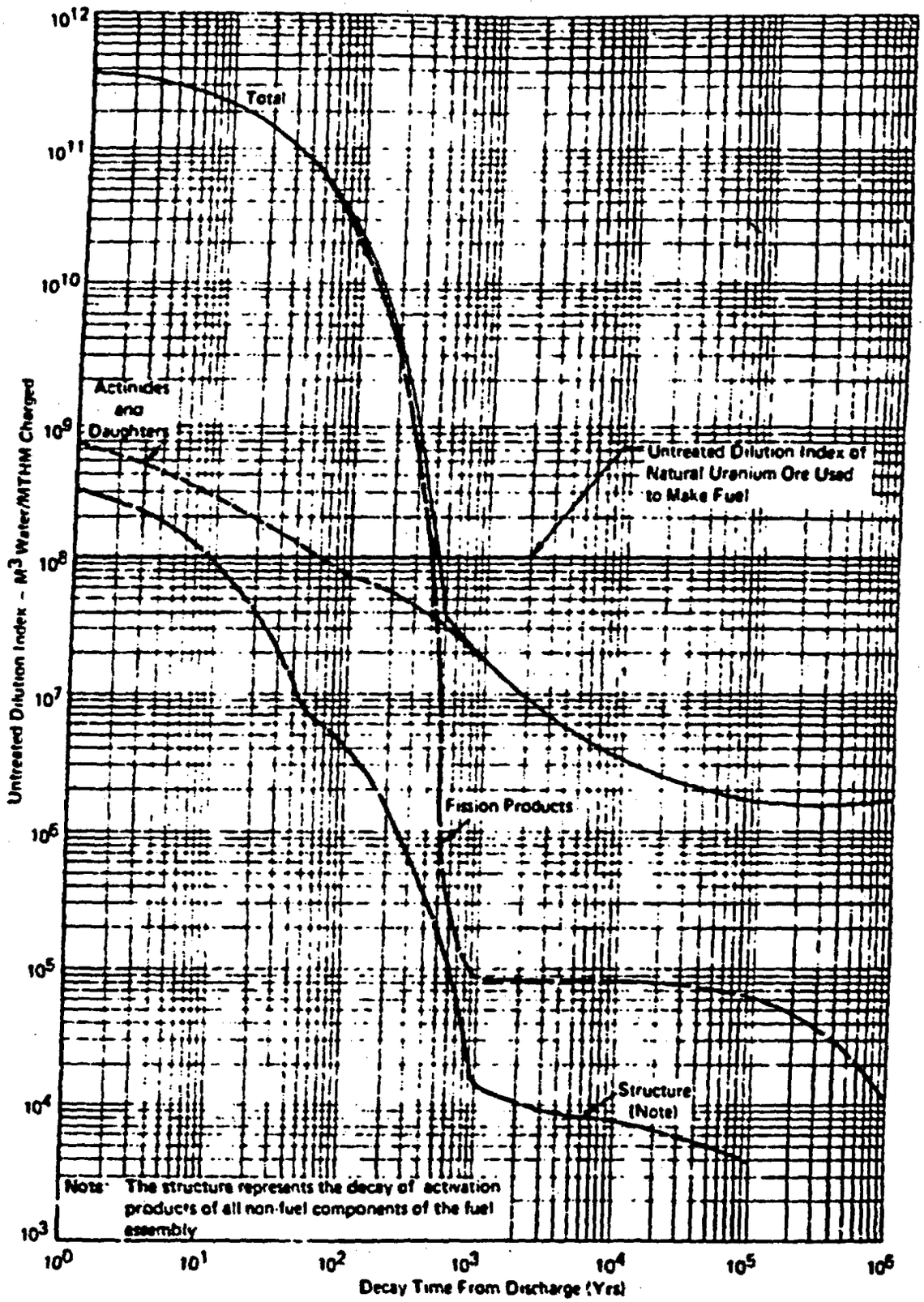


FIGURE A-12 PWR $UO_2$ CYCLE (CASE 2) – REPROCESSED WASTE – UNTREATED DILUTION INDEX – (ALL SOURCES)

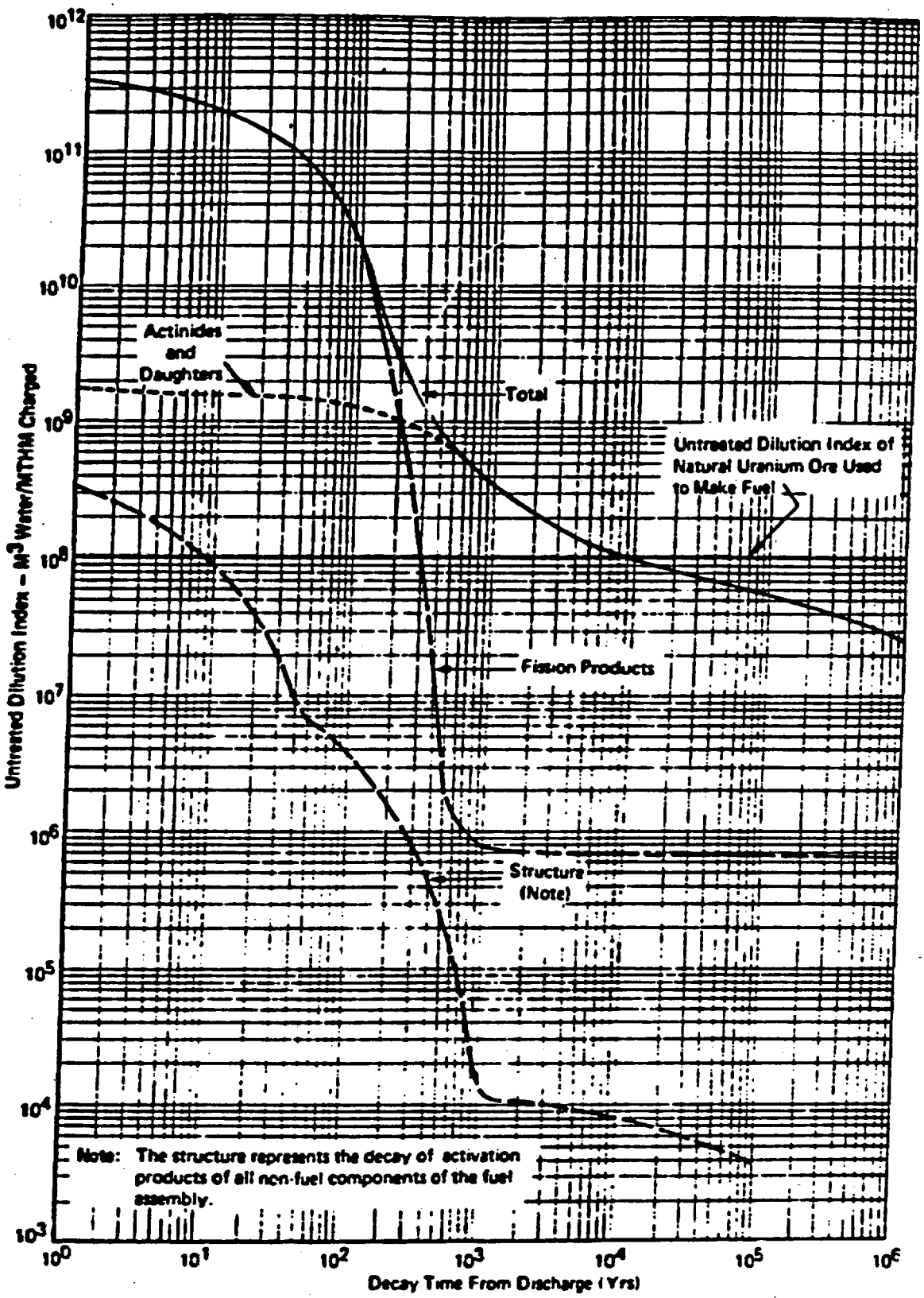


FIGURE A–6 PWR THROWAWAY CYCLE (CASE 1) – UNTREATED DILUTION INDEX (ALL SOURCES)

Table 5. Effectiveness of $10^{-5}$ per year release rate in complying with the EPA standard.

| NUCLIDE | REPOSITORY INVENTORY @ 1000 yr (Ci/100,000 MTHM) | RELEASE RATE IF EQUAL TO INVENTORY TIMES $10^{-5}$* (Ci/yr) | TOTAL RELEASES (YEARS 1000 to 10,000) (Ci) | EPA LIMIT (Ci/100,000 MTHM) | RATIO OF TOTAL RELEASE TO EPA LIMIT |
|---|---|---|---|---|---|
| Am-241 | 9.24E7 | 9.2E2 | 3.0E6 | 1000 | 3,000 |
| Am-243 | 1.57E6 | 1.6E1 | 1.4E5 | 400 | 350 |
| C-14 | 1.35E3 | 1.4E-2 | 1.2E2 | 20,000 | 0.006 |
| Cs-135 | 2.23E4 | 2.2E-1 | 2.0E3 | 200,000 | 0.01 |
| Cs-137 | 1.00 | 1.0E-5 | 3.4E-3 | 50,000 | 0 |
| Np-237 | 1.0E5 | 1.0E0 | 9.0E3 | 2,000 | 4.5 |
| Pu-238 | 9.8E4 | 9.8E-1 | 8.2E2 | 40,000 | 0.02 |
| Pu-239 | 3.2E7 | 3.2E2 | 2.9E6 | 10,000 | 290 |
| Pu-240 | 4.4E7 | 4.4E2 | 4.0E6 | 10,000 | 400 |
| Pu-242 | 1.7E5 | 1.7E0 | 1.5E4 | 10,000 | 1.5 |
| Ra-226 | 2.84E2** | 2.84E-3 | 2.6E1 | 300 | 0.09 |
| Sr-90 | 1.5E-1 | 1.5E-6 | 4.8E-4 | 8,000 | 0 |
| Tc-99 | 1.4E6 | 1.4E1 | 1.3E5 | 200,000*** | 0.65*** |
| Sn-126 | 5.6E4 | 5.6E-1 | 5.0E3 | 8,000 | 0.62 |
| Total | $1.7 \times 10^{8}$ | 1.7E3 | | | |

*Equal to $10^{-5}$ x values in column 1. Note that release rates at or below 1.7 Ci/yr (0.1% of total rate) meet the rule.

**Release calculations based on inventory at 1000 years. In the absence of leaching, the quantity of Ra-226 would increase to 1.22E4 Ci per 100,000 MTHM at 10,000 years.

***The proposed EPA standard published in the Federal Register revised the Tc-99 release limit to 1,000,000 Ci/100,000 MTHM. The corresponding ratio of total release to the EPA limit would be 0.13. This change has no impact on the overall conclusions regarding the effectiveness of a $10^{-5}$ per year release rate in complying with the EPA standard. See Appendix A for further discussion.

TABLE 4. Variables and their ranges. (For normal and lognormal distributions, ranges are for .001 and .999 quantiles.)

| Variable | Distribution | Range in basalt | Range in welded tuff non-zeolitized | Range in bedded salt | units |
|---|---|---|---|---|---|
| Kd for Am in host rock | Lognormal | (2.5E1, 2.0E6) | (6.5E1, 9.5E3) | (5.0E1, 1.0E4) | ml/g |
| Kd for Pu in host rock | Lognormal | (4.5E1, 9.2E3) | (7.0E1, 2.0E3) | (3.0E1, 1.0E4) | ml/g |
| Kd for U in host rock | Lognormal | (4.0E0, 1.3E3) | (1.0E-2, 1.5E1) | (1.0E-2, 2.7E2) | ml/g |
| Kd for Mo in host rock | Lognormal | (1.5E0, 2.8E4) | (4.5E0, 3.1E1) | (2.0E0, 4.0E2) | ml/g |
| Kd for fission products in host rock | Lognormal | (1.7E1, 9.8E3) | (5.0E1, 2.1E5) | (1.0E-2, 3.0E3) | ml/g |
| Kd for Am in aquifer | Lognormal | (1.0E-2, 1.0E5) | (6.5E1, 3.6E2) | (5.0E1, 1.0E4) | ml/g |
| Kd for Pu in aquifer | Lognormal | (1.0E-2, 1.0E4) | (7.0E1, 4.5E2) | (3.0E1, 1.0E4) | ml/g |
| Kd for U in aquifer | Lognormal | (1.0E-2, 1.0E4) | (1.0E-2, 1.1E1) | (1.0E-2, 2.7E2) | ml/g |
| Kd for Mo in aquifer | Lognormal | (1.0E-2, 5.0E1) | (5.0E0, 7.0E0) | (2.0E0, 4.0E2) | ml/g |
| Kd for fission products in aquifer | Lognormal | (1.0E-2, 5.0E2) | (1.2E2, 8.6E3) | (1.0E-2, 3.0E3) | ml/g |
| Solubility limit for Am | | leach-limited | leach-limited | leach-limited | g/g |
| Solubility limit for Pu | Lognormal | (2.5E-12, 2.5E-8) | leach-limited | (6.0E-17, 4.0E-4) | g/g |
| Solubility limit for U | Lognormal | (2.0E-6, 2.0E-4) | leach-limited | (1.6E-6, 3.0E-2) | g/g |
| Solubility limit for Mo | Lognormal | (2.5E-19, 2.5E-13) | leach-limited | (1.3E-25, 5.0E-7) | g/g |
| Solubility limit for Tc | Lognormal | (1.0E-9, 1.0E-7) | leach-limited | (1.5E-9, 9.5E-5) | g/g |
| Solubility limit for fission products | | leach-limited | leach-limited | (6.3E-17, 1.6E-4) | g/g |
| Dispersivity | Uniform | (5.0E1, 5.0E2) | (5.0E1, 5.0E2) | (5.0E1, 5.0E3) | ft |
| Radionuclide release time | Loguniform | (1.0E3, 1.0E7) | (1.0E3, 1.0E7) | (1.0E3, 1.0E7) | yr |
| Conductivity in aquifer (legs A & B) | Lognormal | (1.0E0, 1.0E4) | (1.0E-5, 2.0E0) | (1.5E-1, 6.8E2) | ft/da |
| Porosity in aquifer (legs A & B) | Normal | (1.0E-1, 3.0E-1) | (2.0E-1, 4.8E-1) | (1.0E-1, 2.0E-1) | -- |
| Conductivity in host rock (legs C & D) | | Loguniform (1.0E-7, 1.0E0) | Lognormal (3.1E-5, 9.1E0) | Lognormal (2.3E-10, 3.3E-2) | ft/da |
| Porosity in host rock (legs C & D) | Lognormal | (1.1E-3, 1.0E-1) | (1.2E-5, 1.3E-2) | (6.8E-4, 7.2E-2) | -- |
| Gradient in host rock | Uniform | (5.0E-3, 3.0E-2) | (1.0E-2, 4.0E-2) | (5.0E-2, 3.0E-2) | ft/ft |
| Gradient in aquifer | | Uniform (1.0E-4, 1.0E-2) | Loguniform (1.0E-3, 1.0E-1) | Uniform (2.0E-3, 1.0E-2) | ft/ft |
| Canister life | Loguniform | (1.0E2, 1.0E4) | (1.0E2, 1.0E4) | (1.0E2, 1.0E4) | yr |

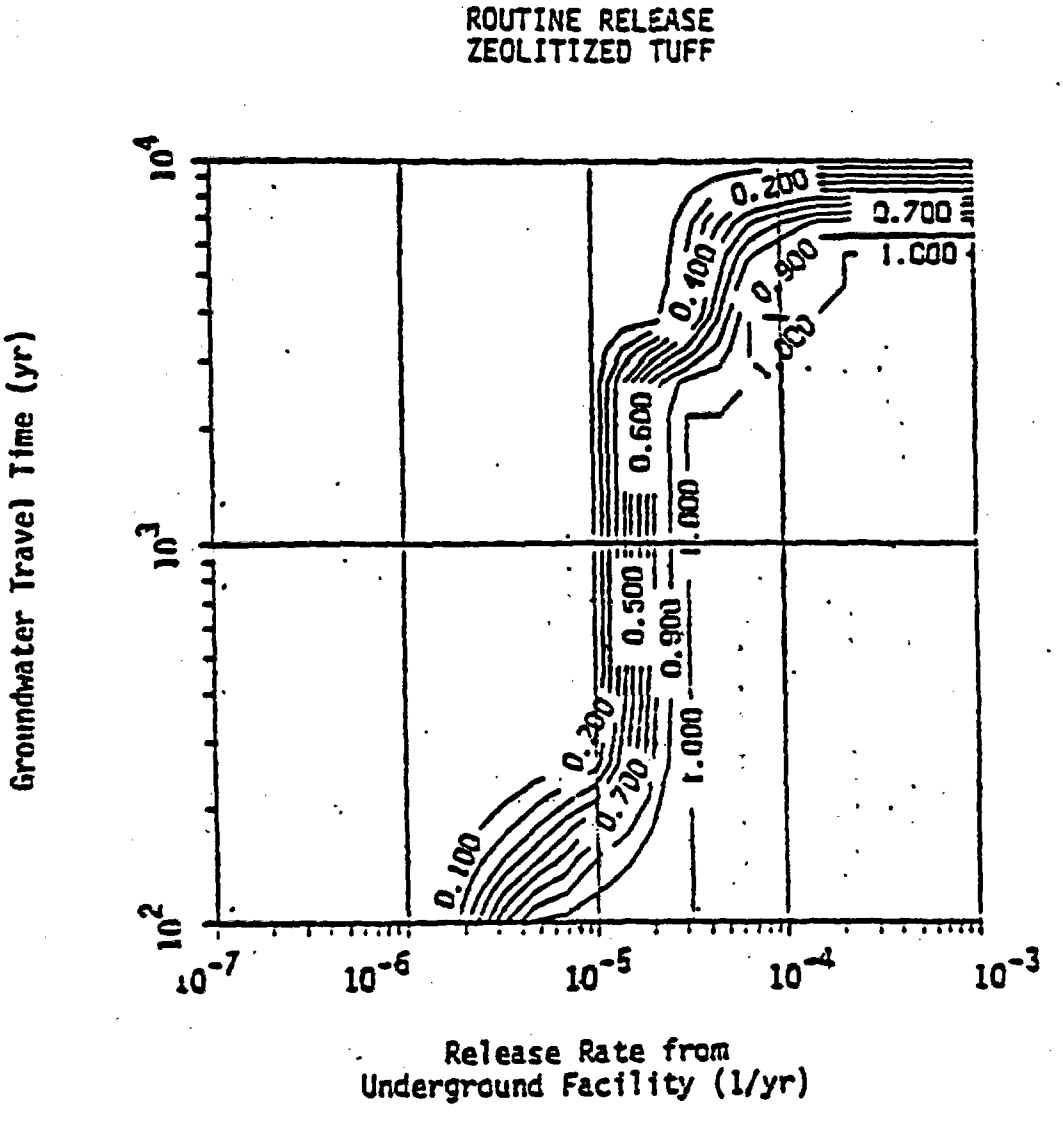


Figure 18. Contours of constant fraction of cases failing to comply with the assumed standard, as a function of limiting release rate and travel time. Medium is zeolitized tuff.

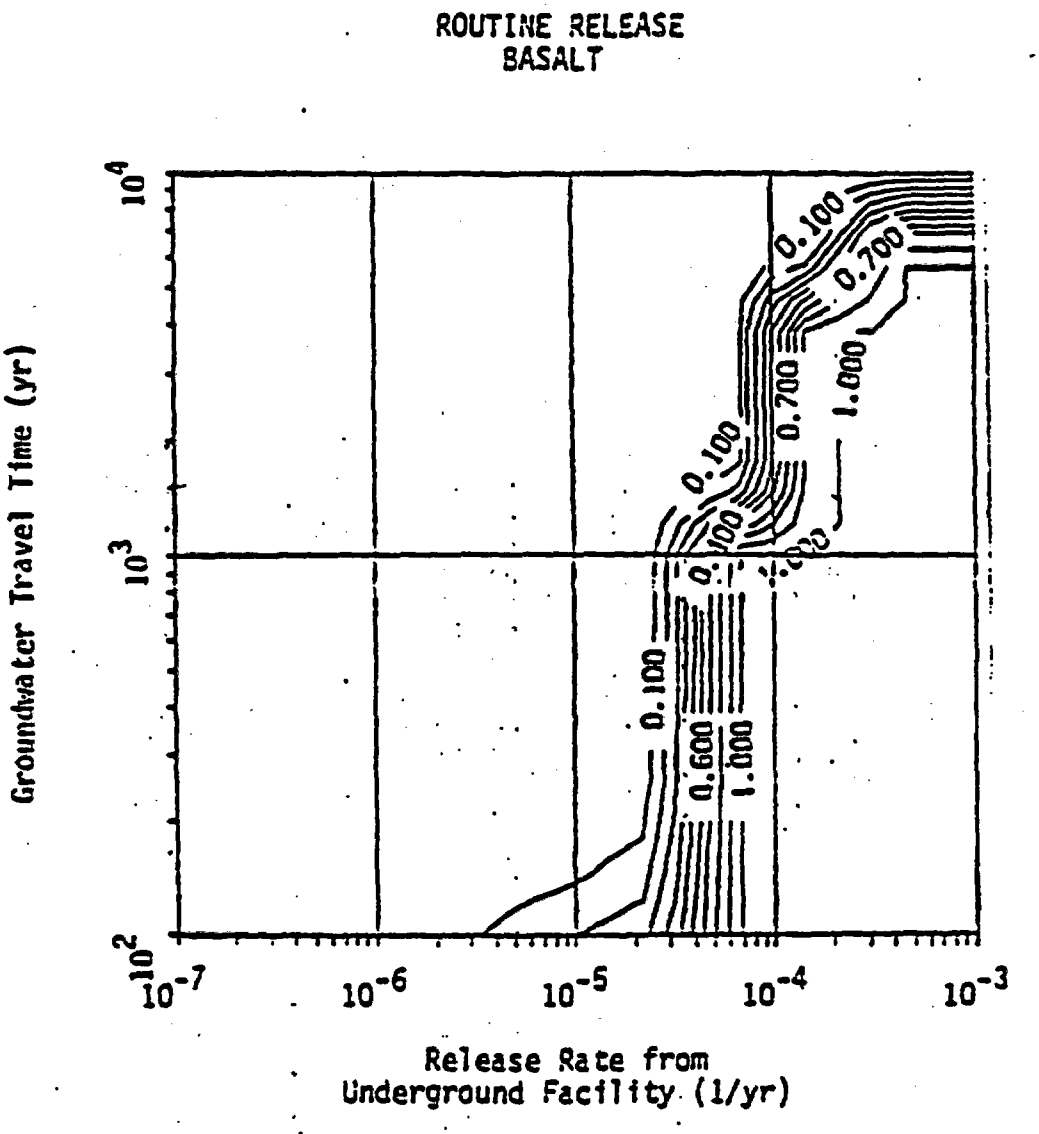


Figure 15. Contours of constant fraction of cases failing to comply with the assumed standard, as a function of limiting release rate and travel time. Medium is basalt.

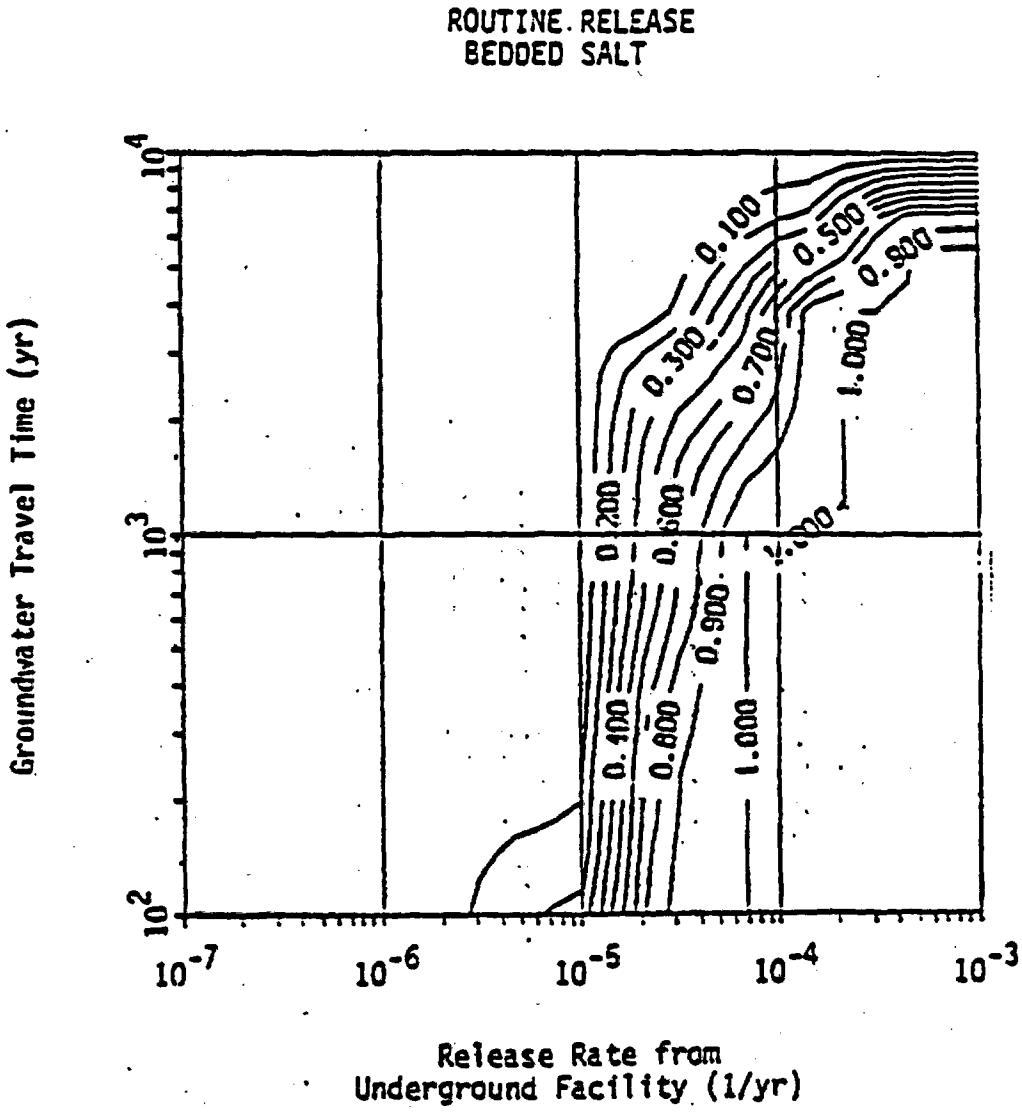


Figure 16. Contours of constant fraction of cases failing to comply with the assumed standard, as a function of limiting release rate and travel time. Medium is bedded salt.

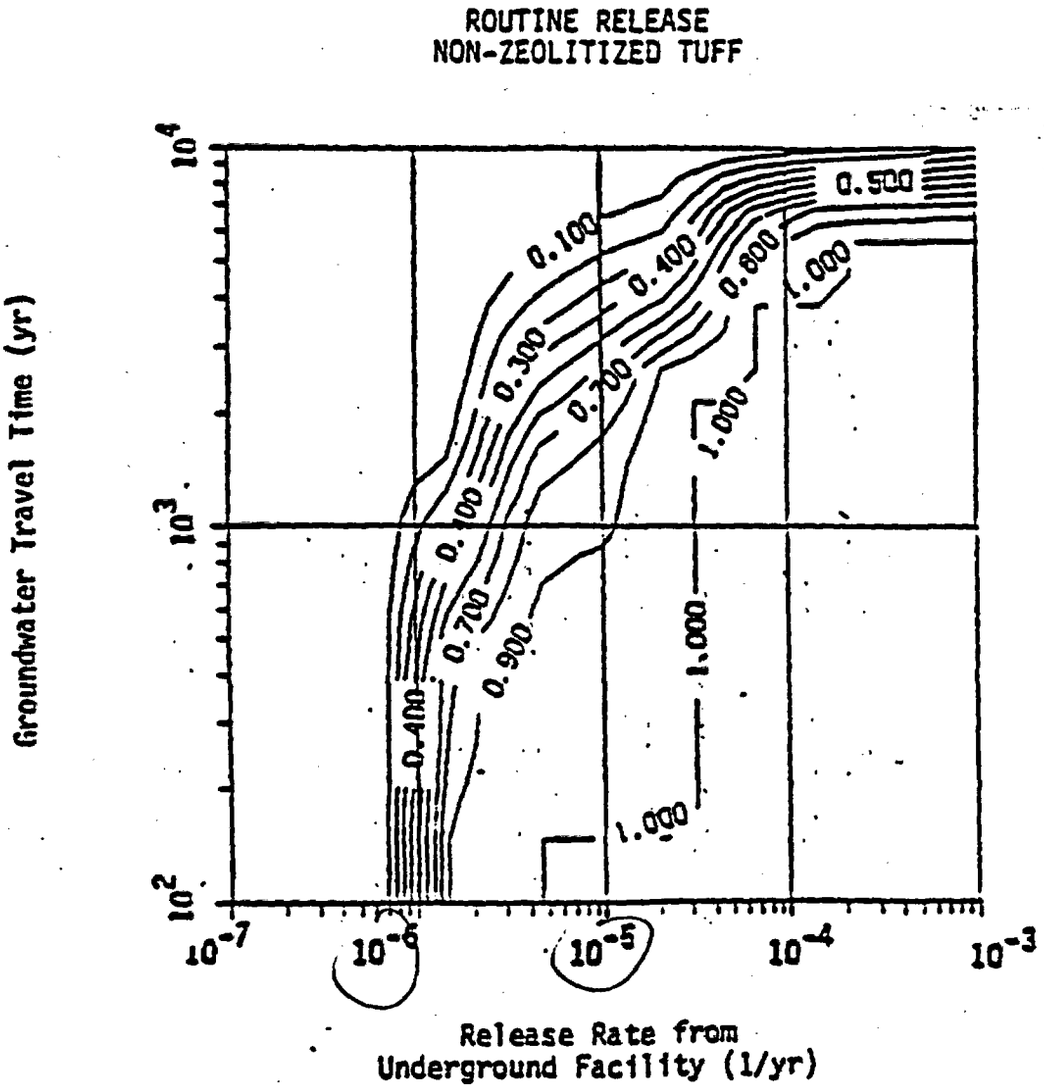


Figure 17. Contours of constant fraction of cases failing to comply with the assumed standard, as a function of limiting release rate and travel time. Medium is non-zeolitized tuff.

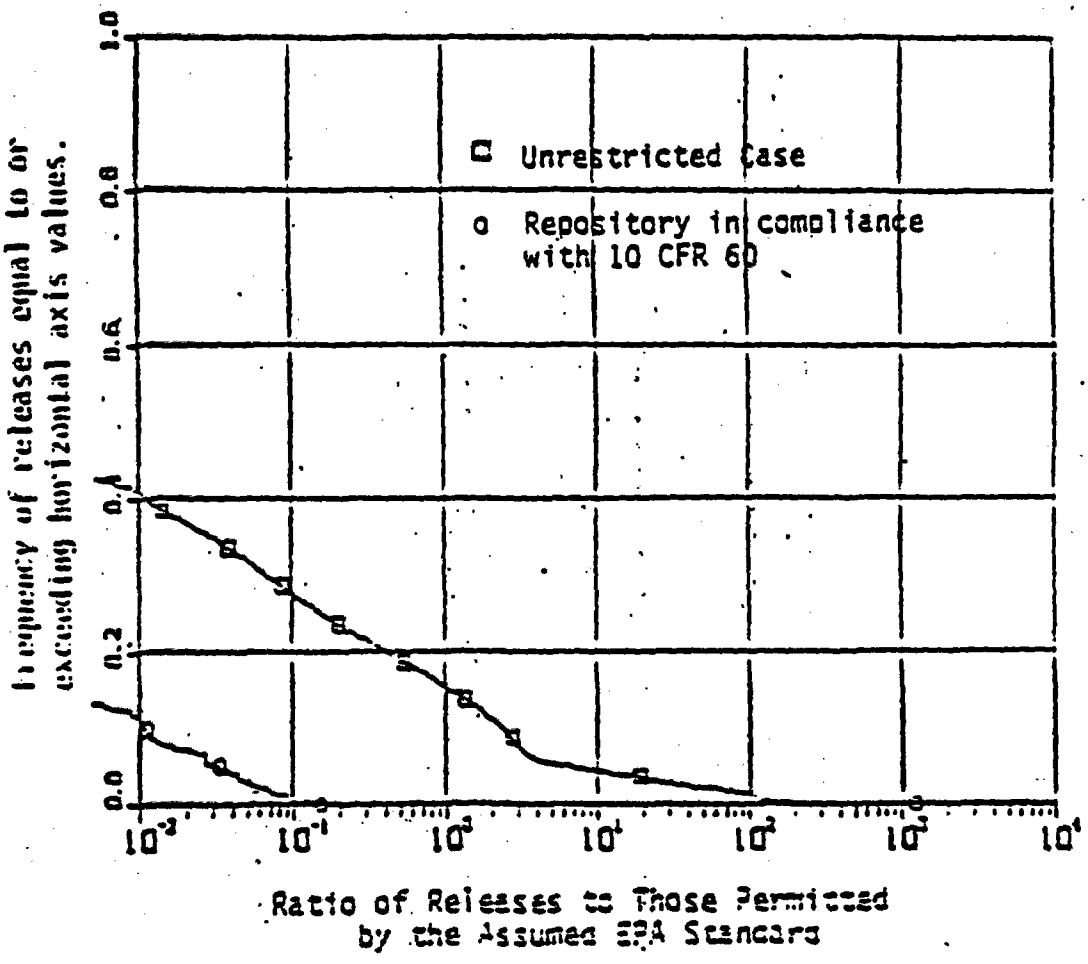


Figure 13. Relationship Between Releases From a Geologic Repository and the Probability of Those Releases for the Routine Release Scenario for Basalt.

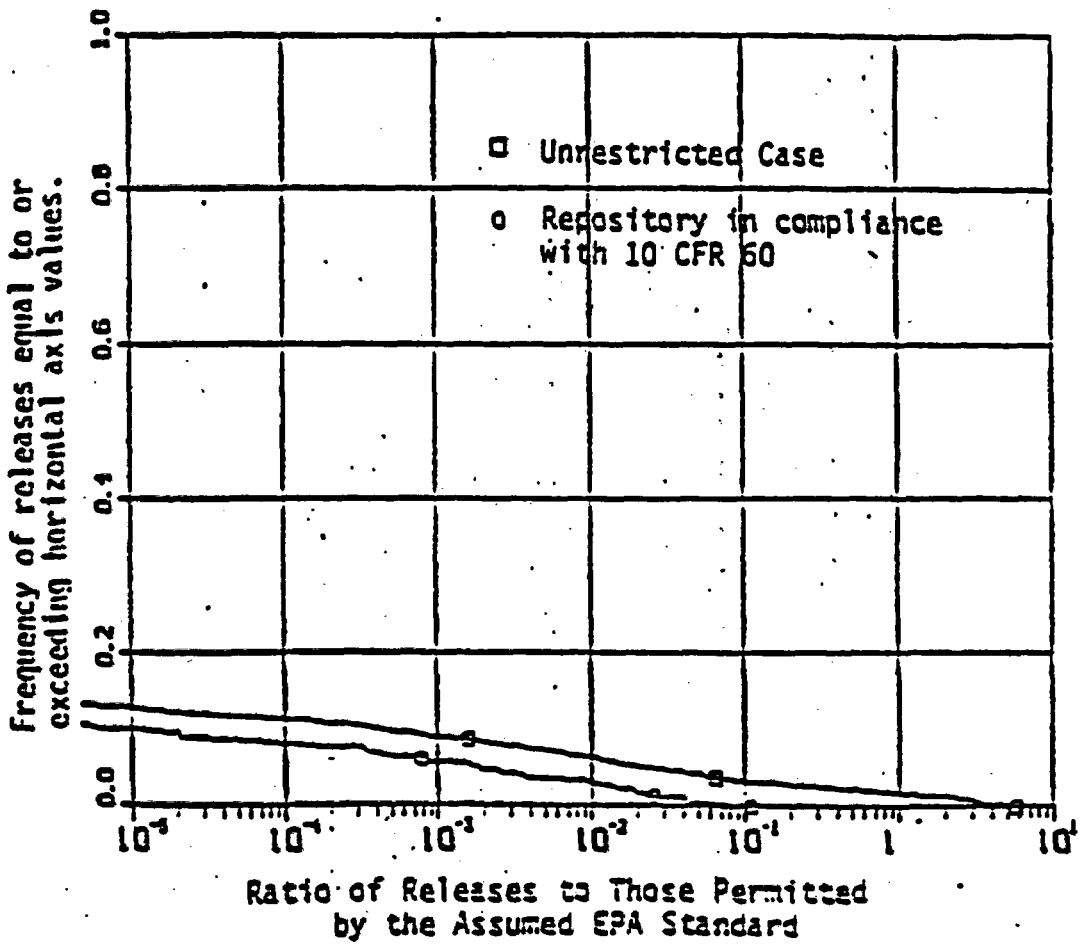


Figure 20. Relationship Between Releases From a Geologic Repository and the Probability of Those Releases for the Routine Release Scenario for Bedded Salt.

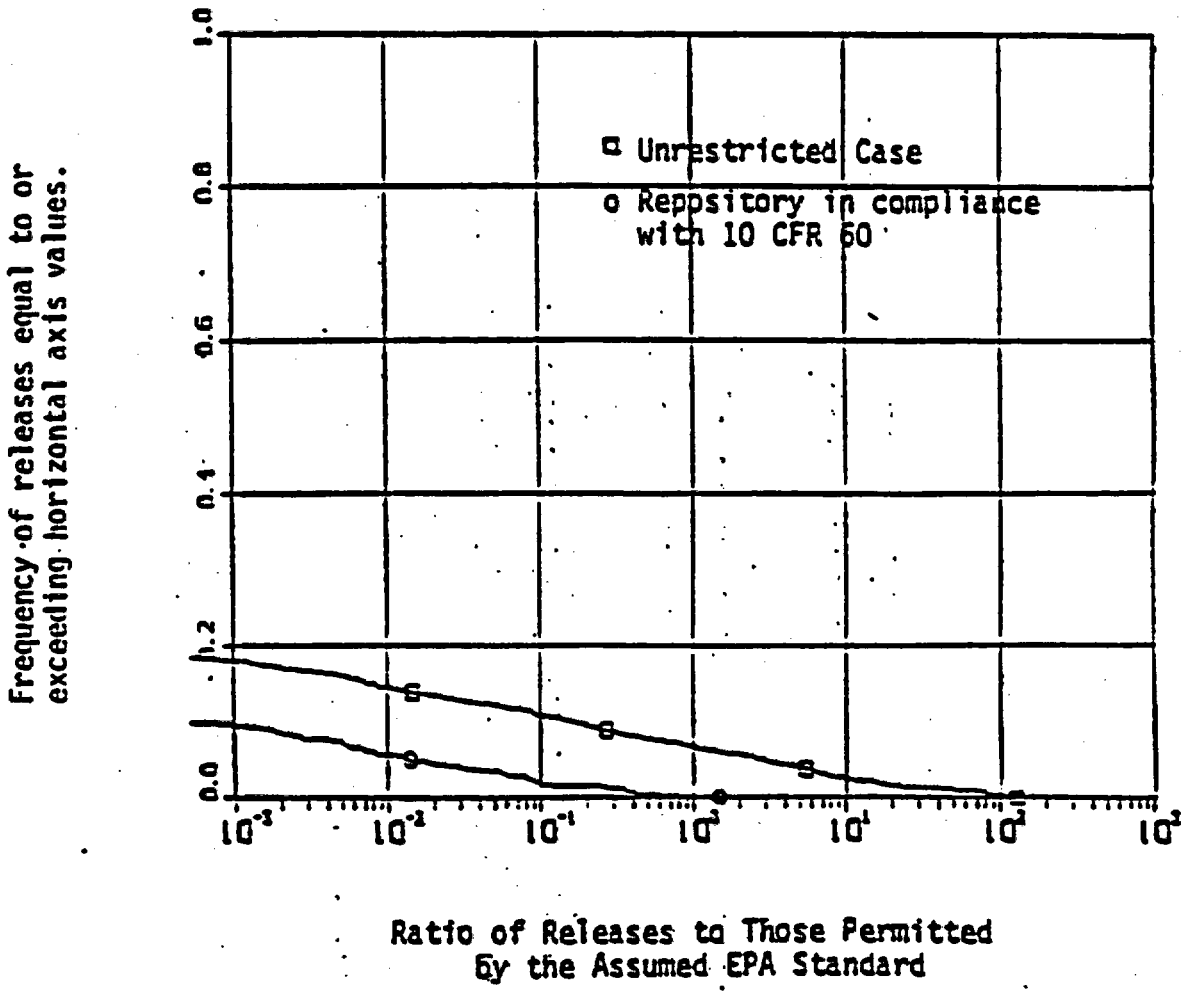


Figure 21. Relationship Between Releases From a Geologic Repository and the Probability of Those Releases for the Routine Release Scenario for Non-Zeolitized Tuff.

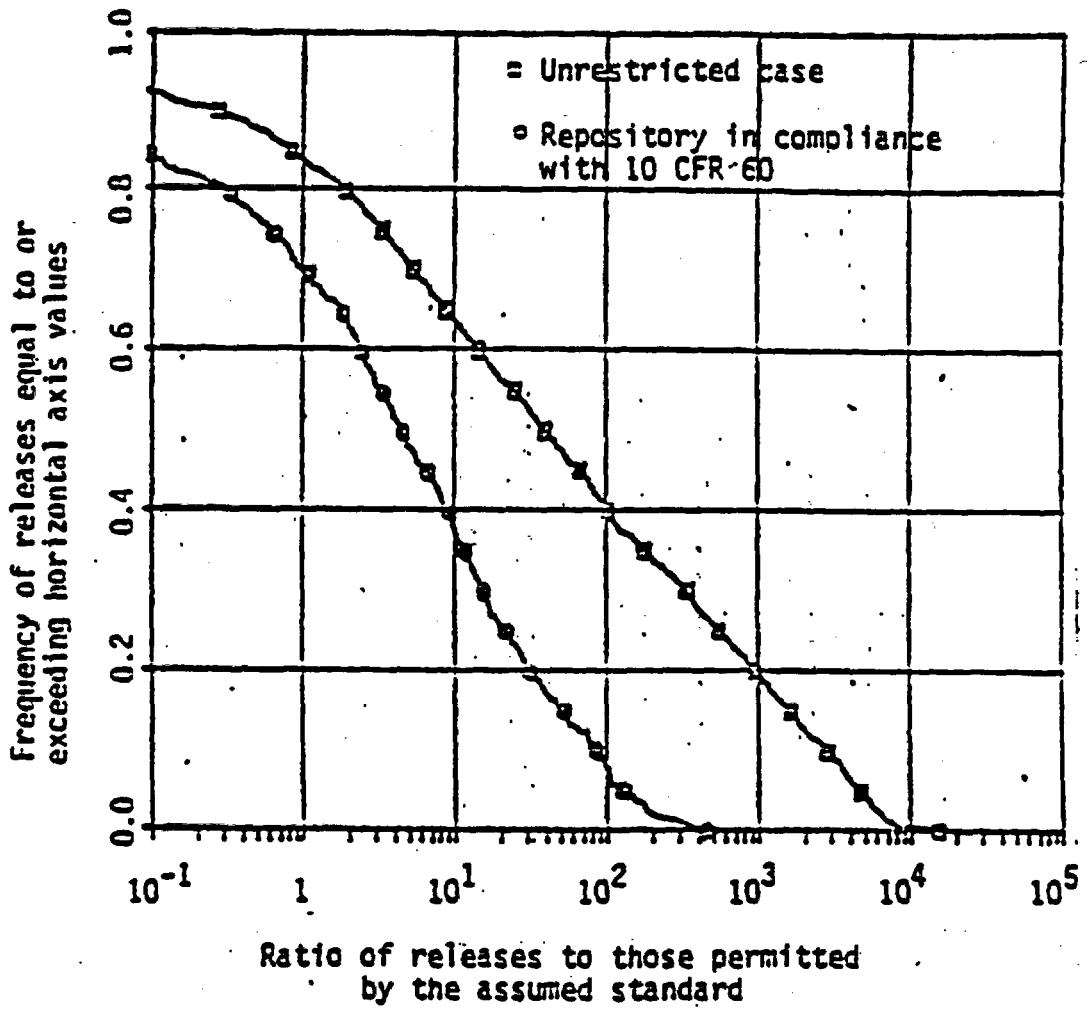


Figure 23. Relationship between releases in the fault scenario and probability of those releases.