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External Memorandum

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From: M. C. Thorne, Ph. D

To: Robert Loux, Executive Director, Nevada Agency for Nuclear Projects

Subject: **Comparing Yucca Mountain's Cost With That of Interim Storage**

This memorandum provides an update on previous studies. Here I estimate the economic benefit of deferring the construction of the Yucca Mountain repository for 100 or 200 years, based on discount rates of 3, 5 or 7 percent, in line with those used by OMB over the past 25 years.

Conclusions

Deferring of construction for either 100 or 200 years makes the present cost of construction small. Costs of storage for 200 years are not much larger than costs of storage for 100 years, because only a small investment is required now to fund the second period of 100 years. Overall, the cost savings for deferring construction by 100 years are $29.2 billion at a discount rate of 3%, $25.8 billion at a discount rate of 5% and $20.7 billion at a discount rate of 7%. The corresponding cost savings for deferring construction for 200 years are $30.7 billion at a discount rate of 3%, $26.0 billion at a discount rate of 5% and $20.7 billion at a discount rate of 7%. The savings decrease with increasing discount rate because the current investment needed to construct the repository in the period 2015 to 2025 decreases with increasing discount rate.

Taking storage to 2025, 2125 or 2225 into account and assuming correspondingly that the facility is available to receive spent fuel in 2026, 2126 or 2226, using a 3% discount rate, the total cost of storage plus construction is $44.09 billion for operation in 2026, $14.85 billion for operation in 2126 and $13.40 billion for operation in 2226. Thus, deferring construction and operation by 100 to 200 years reduces the overall present-day cost of storage plus disposal to about one third of that associated with commencing disposal operations in 2026.

Calculational Methodology

I have assumed that the cost of completing the repository is $58 billion, based on a 2025 opening date. The cost is the current (though obsolete) DOE estimate. Previous experience with major projects shows that cost over-runs are common, so this figure can reasonably be regarded as a lower bound. Using actual cost numbers from DOE's recent utility lawsuit settlements and court-ordered damages penalties, I have assumed conservatively that the operating cost of at-reactor storage is currently $40 million/year per reactor, or $400 million/year nationwide. This figure excludes the initial cost of casks, as this cost is common to both early disposal and indefinite storage options (see below).

The requirement is to calculate the present value of future investments. Consider an investment made at time t in the future. Its present cost, V, is given by $V = I e^{-kt}$, where k is the discount rate. This arises because an investment of V made at the present day is considered to increase in value at a real rate (over inflation) of k, so its purchasing value in current terms increases as Ve^{kt}. Note that we are considering the purchasing power of the investment in current terms, so the relevant rate is less than the rate at which one borrows or lends, as this includes an inflationary component that degrades the purchasing power of a unit of currency.

Consider now an investment made at a uniform rate between times t_1 and t_2 in the future. Take this rate to be Q. Thus, the investment made in an infinitesimal interval t to t + dt, where $t_1 < t < t_2$, is Qdt. The present value of this investment is $Qe^{-kt}dt$. Thus, by integration, the present value of the investment between t_1 and t_2, V, is given by:

$$V = \int Qe^{-kt}dt$$

where the integral is over the period t_1 to t_2.

This is readily shown to be:

$$V = (Q/k)\times[\exp(-kt_1) - \exp(-kt_2)]$$

Now consider Yucca Mountain. Three options are compared:

(a) Construct the repository by 2025, store fuel until 2025 and then dispose of the fuel in the repository from 2026 onward;

(b) Defer repository construction by 100 years;

(c) Defer repository construction by 200 years.

I have used an artificially low estimate of the present cost of the option that involves construction of the Yucca Mountain repository by neglecting any costs of operating the

repository between 2026 and 2325 (*i.e.* during the proposed 300-year "retrievability" period before final closure). The construction cost is taken to be $58 billion spread over a 10-year period running up to initial operation of the repository. This, too, is a low estimate, as any costs incurred earlier than this would have a larger value in present day terms. Thus, the investment rate over this period is taken as $5.8 billion per year.

The costs of storage to 2025 have been ignored, as they are common to all options.

Present values have been computed for three discount rates spanning a realistic range: 3%, 5% and 7%; *i.e.*, k = 0.03, 0.05 or 0.07.

Option (a)

The only cost of relevance is the Yucca repository construction cost, which is taken to be $58 billion spread over a 10-year period, from the beginning of 2016 to the end of 2025, *i.e.*, $5.8 billion per year over a ten-year period. The present cost (in 2006) for various discount rates is given in Table 1.

Discount Rate (%)	Present Cost (billion $)
3	38.3
5	29.1
7	22.2

Table 1: Present Cost of Option (a) Excluding Costs Common to All Options

Option (b)

In this case, the construction cost of $58 billion is spread over a 10-year period from the beginning of 2116 to the end of 2125. In addition, there is the cost of 100 additional years of storage from the beginning of 2026 to the end of 2125. These two cost components and their sum are shown in Table 2.

Discount Rate (%)	Present Cost (billion $)		
	Construction	Storage 2026 to 2125	Total
3	1.90	7.16	9.06
5	0.20	3.07	3.27
7	0.02	1.51	1.53

Table 2: Present Cost of Option (b) Excluding Costs Common to All Options

Option (c)

In this case, the construction cost of $58 billion is spread over a 10-year period from the beginning of 2216 to the end of 2225. In addition, there is the cost of 200 additional

years of storage from the beginning of 2026 to the end of 2225. These two cost components and their sum are shown in Table 3.

Discount Rate (%)	Present Cost (billion $)		
	Construction	Storage from 2026 to 2225	Total
3	0.09	7.52	7.61
5	small	3.09	3.09
7	small	1.51	1.51

Table 3: Present Cost of Option (c) Excluding Costs Common to All Options

Deferring of construction for either 100 or 200 years makes the present cost of construction small. This is the investment that would be required now to fund construction at the required time. Costs of storage for 200 years are not much larger than costs of storage for 100 years, because only a small investment is required now to fund the second period of 100 years. Overall, the cost savings for deferring construction by 100 years are $29.2 billion at a discount rate of 3%, $25.8 billion at a discount rate of 5% and $20.7 billion at a discount rate of 7%. The corresponding cost savings for deferring construction for 200 years are $30.7 billion at a discount rate of 3%, $26.0 billion at a discount rate of 5% and $20.7 billion at a discount rate of 7%. The savings decrease with increasing discount rate because the current investment needed to construct the repository in the period 2015 to 2025 decreases with increasing discount rate.

It may be helpful to look at this comparison in a slightly different way. From my previous analysis, the cost now of storage to 2025 is $5.79 billion (*i.e.*, $304 million per year, which is less than $400 million per year because of earnings on the capital throughout the 19 years). Thus, at a discount rate of 3%, it would require an investment today of only $7.16 billion (Table 2) plus $5.79 billion, i.e. $12.95 billion, to pay for the costs of dry storage at all 100 U.S. reactor sites until 2125. For storage until 2225, the corresponding total would be $7.52 billion plus $5.79 billion, i.e. $13.31 billion. For comparison, at a discount rate of 3%, today's cost of constructing the Yucca Mountain facility by 2026 is $38.3 billion (Table 1). To this has to be added the cost of storage to 2025 of $5.79 billion. The present day costs of constructing the Yucca Mountain facility with delays of 100 years or 200 years are $1.90 billion and $0.09 billion, respectively. Thus, the present day costs of early and deferred construction of the Yucca Mountain facility, taking storage into account and adopting a 3% discount rate, are as listed in Table 4.

Component	**Present Day Cost (billions of dollars)**		
	Construct Facility by 2026	**Construct Facility by 2126**	**Construct Facility by 2226**
Storage to 2025	5.79	5.79	5.79
Storage 2026 to 2125	not applicable	7.16	7.16
Storage 2126 to 2225	not applicable	not applicable	0.36
Construction	38.3	1.90	0.09
Total	**44.09**	**14.85**	**13.40**

Table 4: Breakdown of Costs for Different Options Based on a 3% Discount Rate

Thus, taking storage to 2025, 2125 or 2225 into account and assuming correspondingly that the facility is available to receive spent fuel in 2026, 2126 or 2226, using a 3% discount rate, the total cost of storage plus construction is $44.09 billion for operation in 2026, $14.85 billion for operation in 2126 and $13.40 billion for operation in 2226. Thus, deferring construction and operation by 100 to 200 years reduces the overall present-day cost of storage plus disposal to about one third of that associated with commencing disposal operations in 2026.