U.S. DEPARTMENT OF ENERGY
OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT

PRESENTATION TO THE NUCLEAR WASTE TECHNICAL REVIEW BOARD

SUBJECT: EXPLORATORY SHAFT FACILITY ALTERNATIVES STUDY - SENSITIVITY ANALYSIS

PRESENTER: DR. LEE MERKHOFER

PRESENTER'S TITLE AND ORGANIZATION: PRINCIPAL
APPLIED DECISION ANALYSIS, INC.

PRESENTER'S TELEPHONE NUMBER: (415) 854-7101

DENVER, COLORADO
MARCH 6-7, 1991

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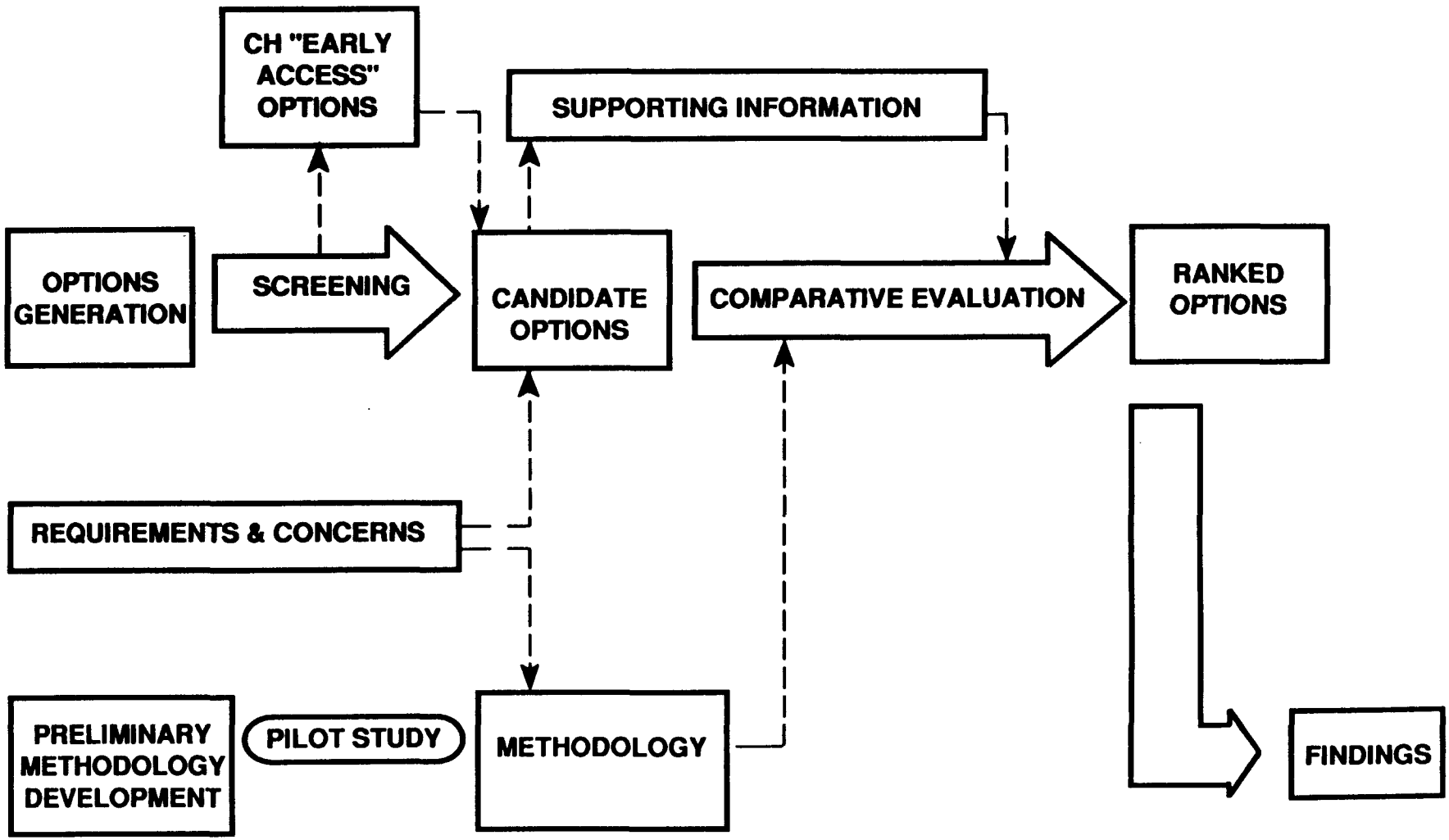
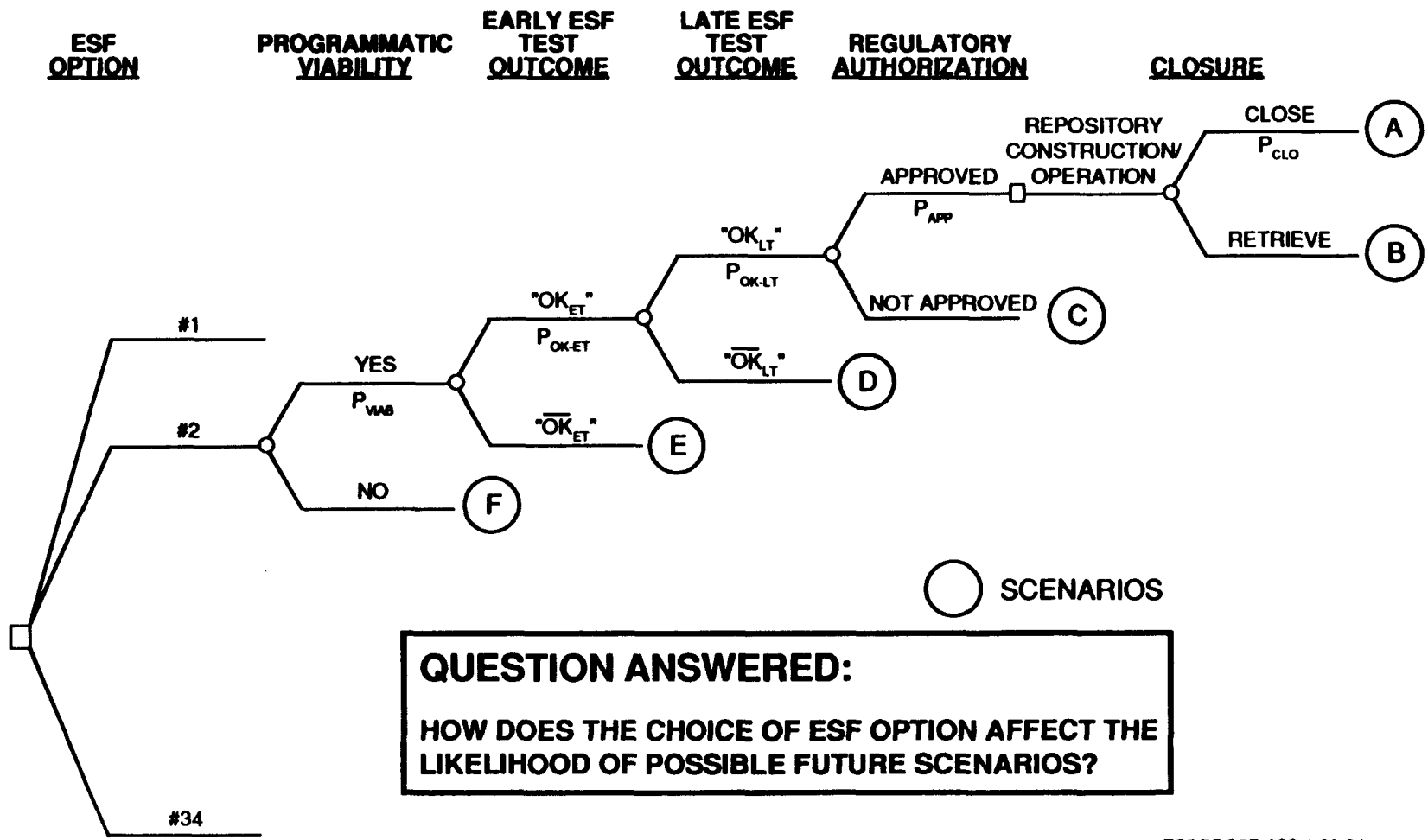
ESF ALTERNATIVES STUDY



ESOVTH5P.125/1-29-91

ESF OPTIONS ARE EVALUATED BY ESTIMATING:

1. THE IMPACT OF THE ESF OPTION ON THE LIKELIHOOD OF IMPORTANT DOWN-STREAM REPOSITORY DECISIONS



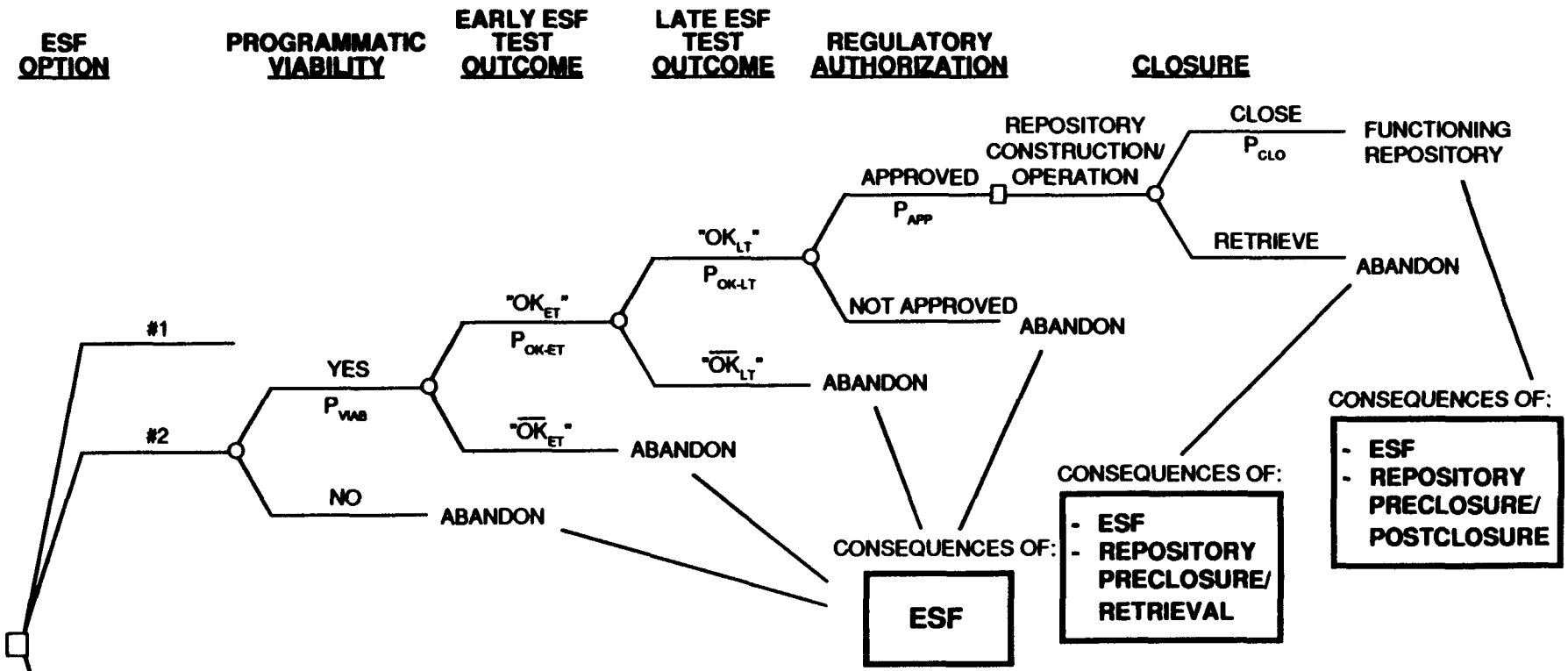
QUESTION ANSWERED:

HOW DOES THE CHOICE OF ESF OPTION AFFECT THE LIKELIHOOD OF POSSIBLE FUTURE SCENARIOS?

ESDPPG5P.A33/1-29-91

ESF OPTIONS ARE EVALUATED BY ESTIMATING:

2. THE END CONSEQUENCES OF EACH OF THE POSSIBLE FUTURE SCENARIOS

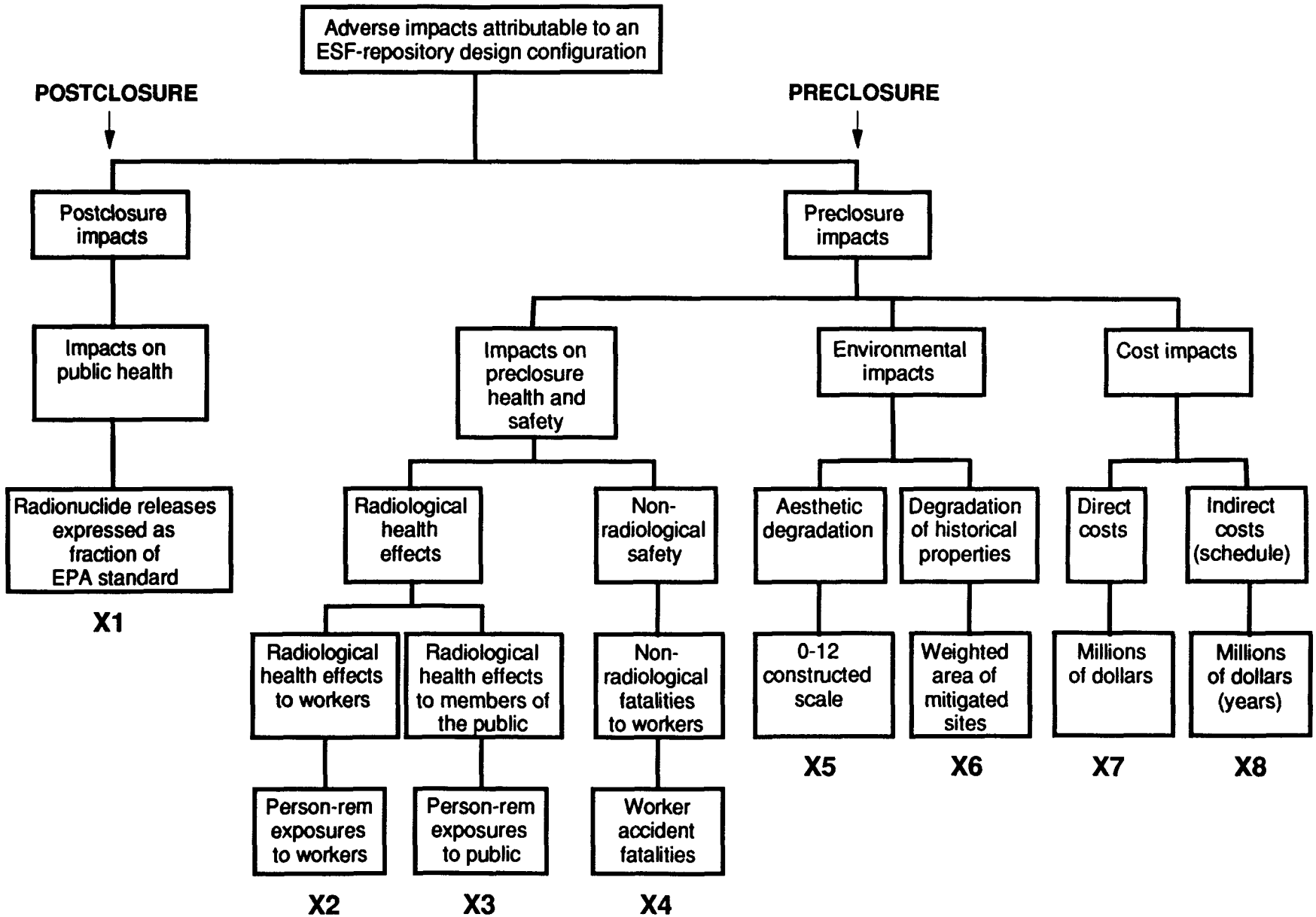


QUESTION ANSWERED:

e.g., SUPPOSE A GIVEN ESF CHOICE LEADS TO A CLOSED REPOSITORY -- WHAT IS THE ESTIMATE OF POSTCLOSURE RELEASES?

ESDPPG5P.A33/1-29-91

MEASURES DEFINED FOR QUANTIFYING END CONSEQUENCES



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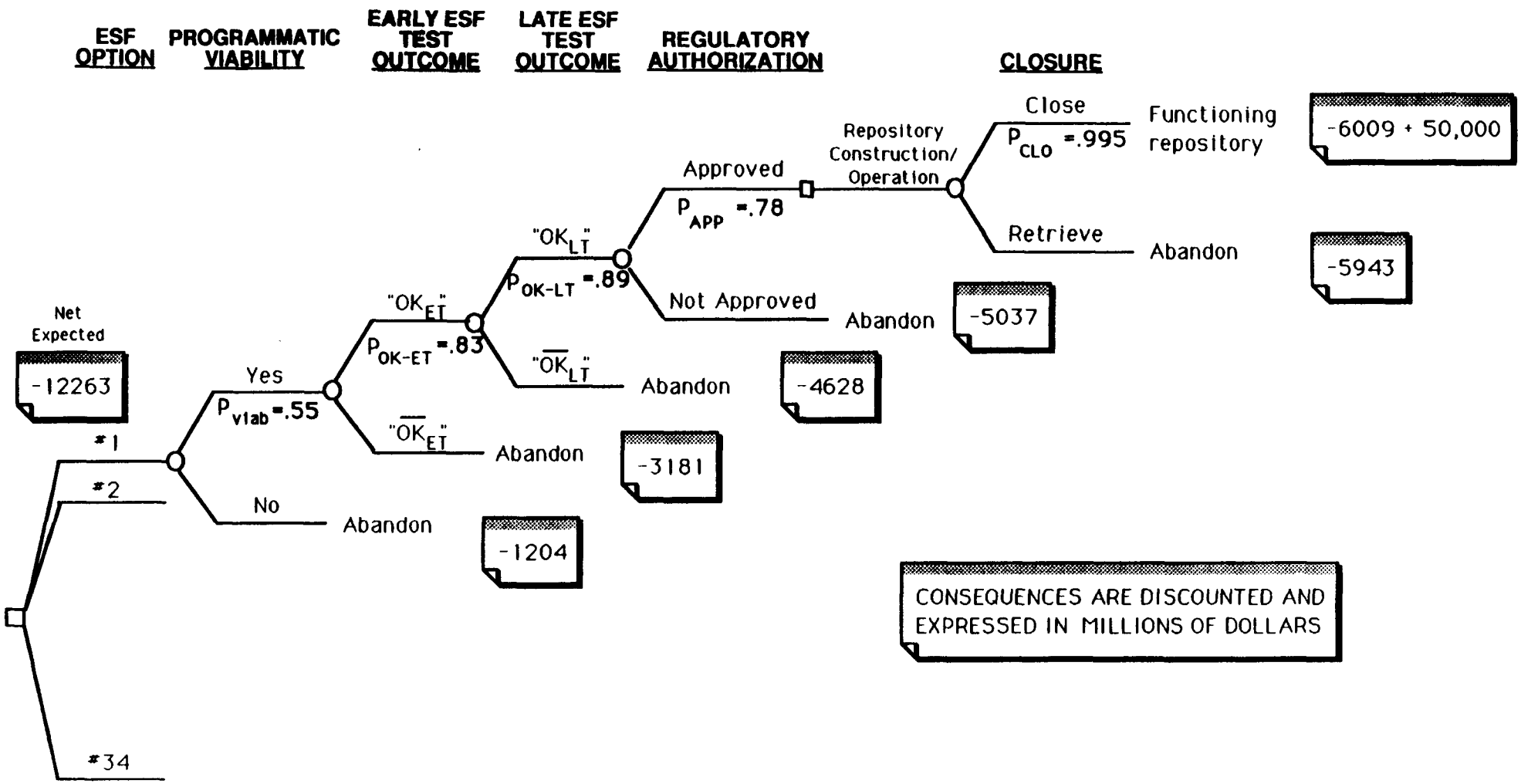
SUMMARY OF CONSEQUENCE ESTIMATES

		<---------- Assumes a Closed Repository (Scenario A) ---------->															
		X1 Releases		X2 Rad Worker		X3 Rad Public		X4 Nonrad Wker		X5 Aesthetic		X6 Hist Prop		X7 Cost		X8 Ind. Cost	
Option		frctn EPA std		person-rem		person-rem		fatalities		cnst scale		sq meters		$ million		$ million	
B.Case	1	0.020	19th	0.05	5th	1.0E-6	5th	13.20	20th	8	1st	29,186	13th	1,101	2nd	5,343	15th
A1	2	0.019	15th	0.05	5th	1.0E-6	5th	13.88	28th	8	1st	29,296	17th	1,209	6th	5,339	12th
A2	3	0.020	19th	0.05	5th	1.0E-6	5th	13.87	26th	8	1st	29,296	17th	1,149	4th	5,343	16th
A4-1	4	0.019	15th	0.05	5th	1.0E-6	5th	13.98	30th	8	1st	29,296	17th	1,281	17th	5,676	31st
A5	5	0.017	5th	0.10	15th	2.0E-6	27th	13.55	22nd	0.5	29th	281	3rd	1,224	9th	5,343	14th
A7	6	0.017	1st	0.05	5th	1.0E-6	5th	13.87	27th	8	1st	29,295	15th	1,250	13th	5,337	10th
B3-2	7	0.020	19th	0.10	15th	1.0E-6	5th	12.60	10th	8	1st	29,296	17th	1,269	16th	5,340	13th
B3-3	8	0.020	19th	0.10	15th	1.0E-6	5th	12.60	13th	8	1st	29,296	17th	1,231	11th	5,305	5th
B3-4	9	0.023	33rd	0.10	15th	1.0E-6	5th	12.60	9th	8	1st	29,296	17th	1,304	20th	5,676	32nd
B3-5	10	0.020	19th	0.10	15th	1.0E-6	5th	12.60	11th	8	1st	29,296	17th	1,227	10th	5,307	6th
B3-6	11	0.020	19th	0.10	15th	1.0E-6	5th	12.61	14th	8	1st	29,296	17th	1,219	7th	5,318	9th
B4	12	0.017	5th	0.20	29th	2.0E-6	27th	12.75	18th	0.5	29th	281	3rd	1,267	15th	5,346	18th
B7	13	0.017	1st	0.20	29th	2.0E-6	27th	12.56	4th	1	23rd	282	9th	1,359	27th	5,357	22nd
B8	14	0.017	5th	0.20	29th	2.0E-6	27th	12.34	2nd	1	23rd	24,130	11th	1,222	8th	5,346	20th
C1	15	0.017	5th	0.01	1st	2.0E-7	1st	14.15	32nd	8	1st	29,436	33rd	1,350	25th	5,301	4th
C4	16	0.017	5th	0.01	1st	2.0E-7	1st	14.67	34th	0.5	29th	281	3rd	1,337	24th	5,255	1st
R11	17	0.020	19th	0.10	15th	1.0E-6	5th	12.69	16th	1	23rd	280	1st	1,145	3rd	5,343	17th
B.Case	18	0.020	19th	0.05	5th	1.0E-6	5th	13.19	19th	8	1st	29,186	13th	1,161	5th	5,294	3rd
A1	19	0.019	15th	0.05	5th	1.0E-6	5th	13.87	25th	8	1st	29,296	17th	1,304	21st	5,707	33rd
A2	20	0.020	19th	0.05	5th	1.0E-6	5th	13.85	24th	8	1st	29,296	17th	1,241	12th	5,369	26th
A4-1	21	0.019	15th	0.05	5th	1.0E-6	5th	13.97	29th	8	1st	29,296	17th	1,377	29th	5,382	29th
A5	22	0.017	5th	0.10	15th	2.0E-6	27th	13.54	21st	0.5	29th	281	3rd	1,321	23rd	5,370	27th
A7	23	0.017	1st	0.05	5th	1.0E-6	5th	13.85	23rd	8	1st	29,295	15th	1,391	31st	5,707	34th
B3-2	24	0.020	19th	0.10	15th	1.0E-6	5th	12.58	6th	8	1st	29,296	17th	1,374	28th	5,376	28th
B3-3	25	0.020	19th	0.10	15th	1.0E-6	5th	12.59	7th	8	1st	29,296	17th	1,285	18th	5,346	19th
B3-4	26	0.023	33rd	0.10	15th	1.0E-6	5th	12.58	5th	8	1st	29,296	17th	1,359	26th	5,363	23rd
B3-5	27	0.020	19th	0.10	15th	1.0E-6	5th	12.59	8th	8	1st	29,296	17th	1,263	14th	5,337	11th
B3-6	28	0.020	19th	0.10	15th	1.0E-6	5th	12.60	12th	8	1st	29,296	17th	1,317	22nd	5,367	24th
B4	29	0.017	5th	0.20	29th	2.0E-6	27th	12.73	17th	0.5	29th	281	3rd	1,394	32nd	5,384	30th
B7	30	0.017	1st	0.20	29th	2.0E-6	27th	12.55	3rd	1	23rd	282	9th	1,388	30th	5,355	21st
B8	31	0.017	5th	0.20	29th	2.0E-6	27th	12.33	1st	1	23rd	24,130	11th	1,291	19th	5,369	25th
C1	32	0.017	5th	0.01	1st	2.0E-7	1st	14.13	31st	8	1st	29,436	33rd	1,435	33rd	5,317	8th
C4	33	0.017	5th	0.01	1st	2.0E-7	1st	14.66	33rd	0.5	29th	281	3rd	1,454	34th	5,271	2nd
R11	34	0.020	19th	0.10	15th	1.0E-6	5th	12.67	15th	1	23rd	280	1st	1,076	1st	5,309	7th

WEIGHTING FACTORS

MEASURE	UNITS	WEIGHT	BASIS
POSTCLOSURE RELEASES	EPA STANDARD	$3.5 B	$5 M/CANCER DEATH X 700 CANCER DEATHS/EPA STD
RADIOLOGICAL WORKER HEALTH	PERSON-REMS	$4,000	NRC GUIDELINES OF EARLY 70s ($1000/person-rem) INFLATED
RADIOLOGICAL PUBLIC HEALTH	PERSON-REMS	$4,000	NRC GUIDELINES OF EARLY 70s ($1000/person-rem) INFLATED
NON-RADIOLOGICAL WORKER SAFETY	FATALITIES	$1.25M	25% ADDED TO WEIGHT FROM RW/0074 TO ACCOUNT FOR INFLATION
AESTHETICS	CONSTRUCTED SCALE	$4M (full scale)	ASSESSED FROM DOE MANAGERS
HISTORICAL PROPERTIES	SQUARE METER	$30	ASSESSED FROM DOE MANAGERS
DIRECT COSTS	DISCOUNTED $	1	10% DISCOUNT RATE
INDIRECT COSTS	DISCOUNTED $	1	10% DISCOUNT RATE

BASE CASE CONSEQUENCES AND PROBABILITIES

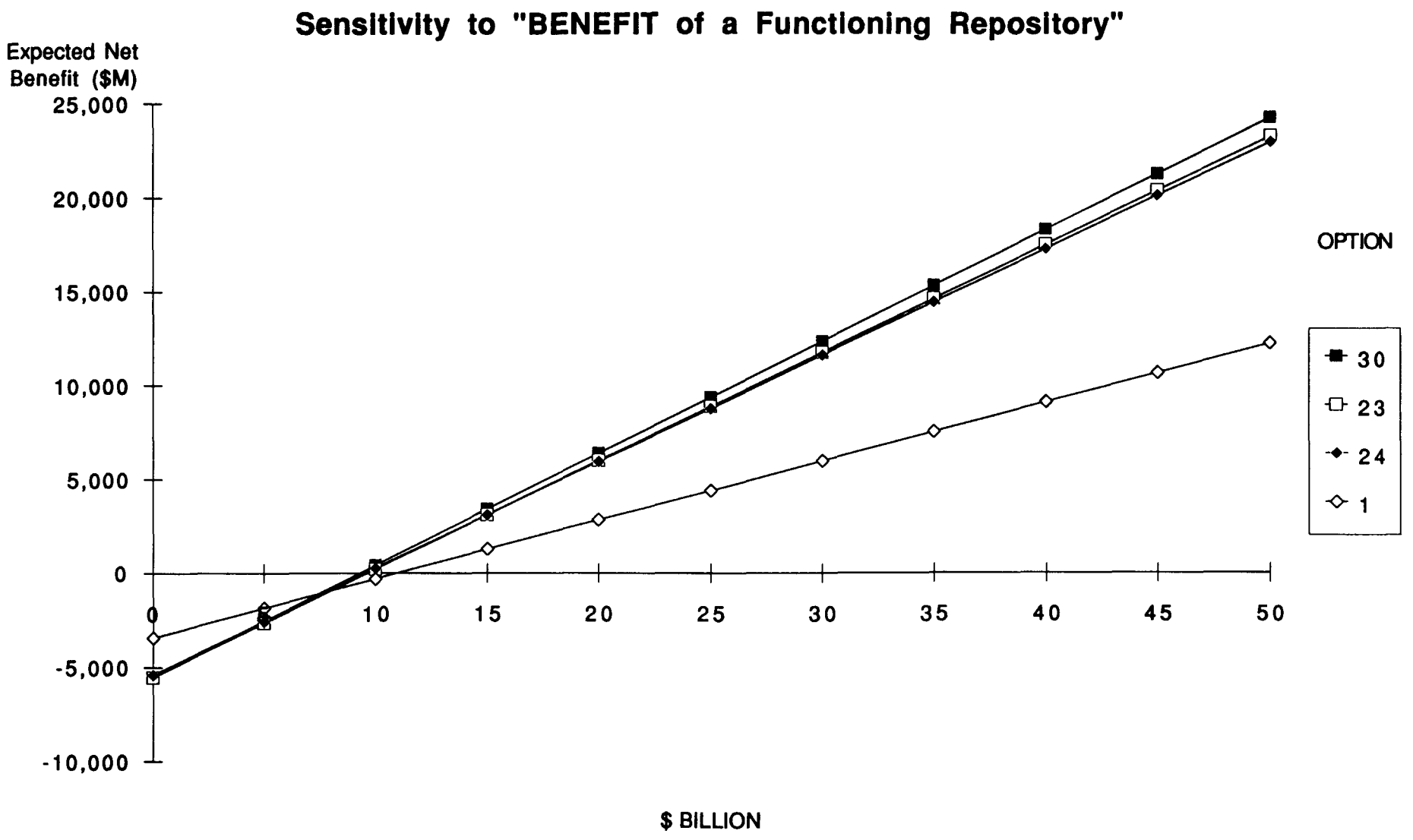


ESF-AS

Rank Order of 34 Alternative Design Options

OVERALL RANKING	OPTION	EXPECTED NET BENEFIT * ($ millions)
1st	30	24,385
2nd	23	23,306
3rd	24	23,006
4th	13	22,579
5th	6	22,218
6th	7	21,990
7th	2	20,829
8th	19	20,404
9th	25	19,920
10th	4	19,684
11th	21	19,579
12th	28	19,211
13th	22	17,760
14th	29	16,921
15th	32	16,759
16th	27	16,340
17th	20	16,322
18th	8	15,984
19th	31	15,862
20th	15	15,454
21st	33	15,306
22nd	5	14,501
23rd	12	13,763
24th	16	13,725
25th	3	13,674
26th	11	13,536
27th	1	12,080
28th	14	11,370
29th	10	11,139
30th	17	10,981
31st	18	10,956
32nd	34	9,852
33rd	26	7,677
34th	9	6,142

* Assumes benefit of a funtioning repository is $50 billion


Sensitivity to "BENEFIT of a Functioning Repository"
Expected Net Benefit ($M)
25,000
20,000
15,000
10,000
5,000
0
-5,000
-10,000
0
10
15
20
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30
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24
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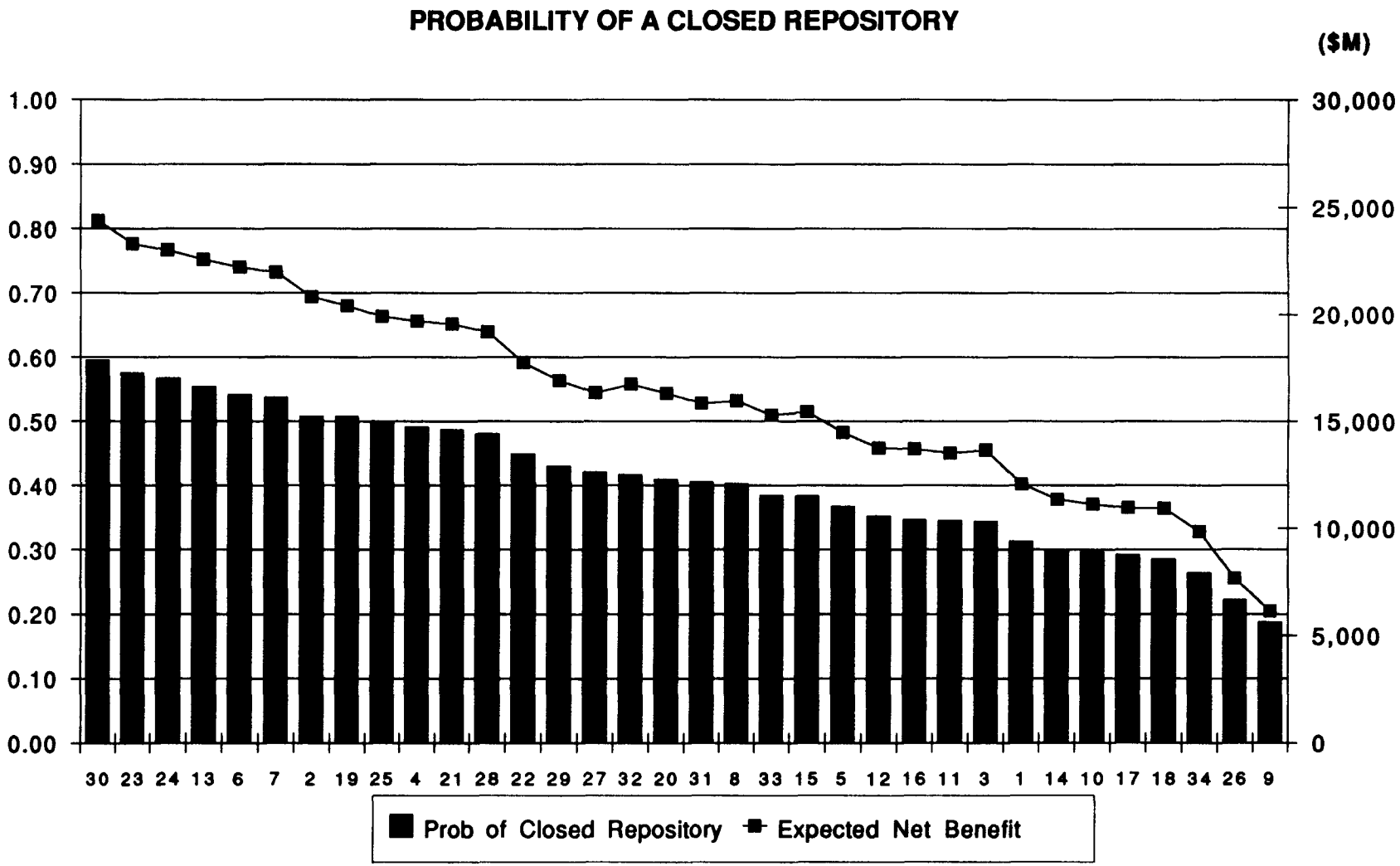
Benefit.cht



C-ProbA 2/26/91

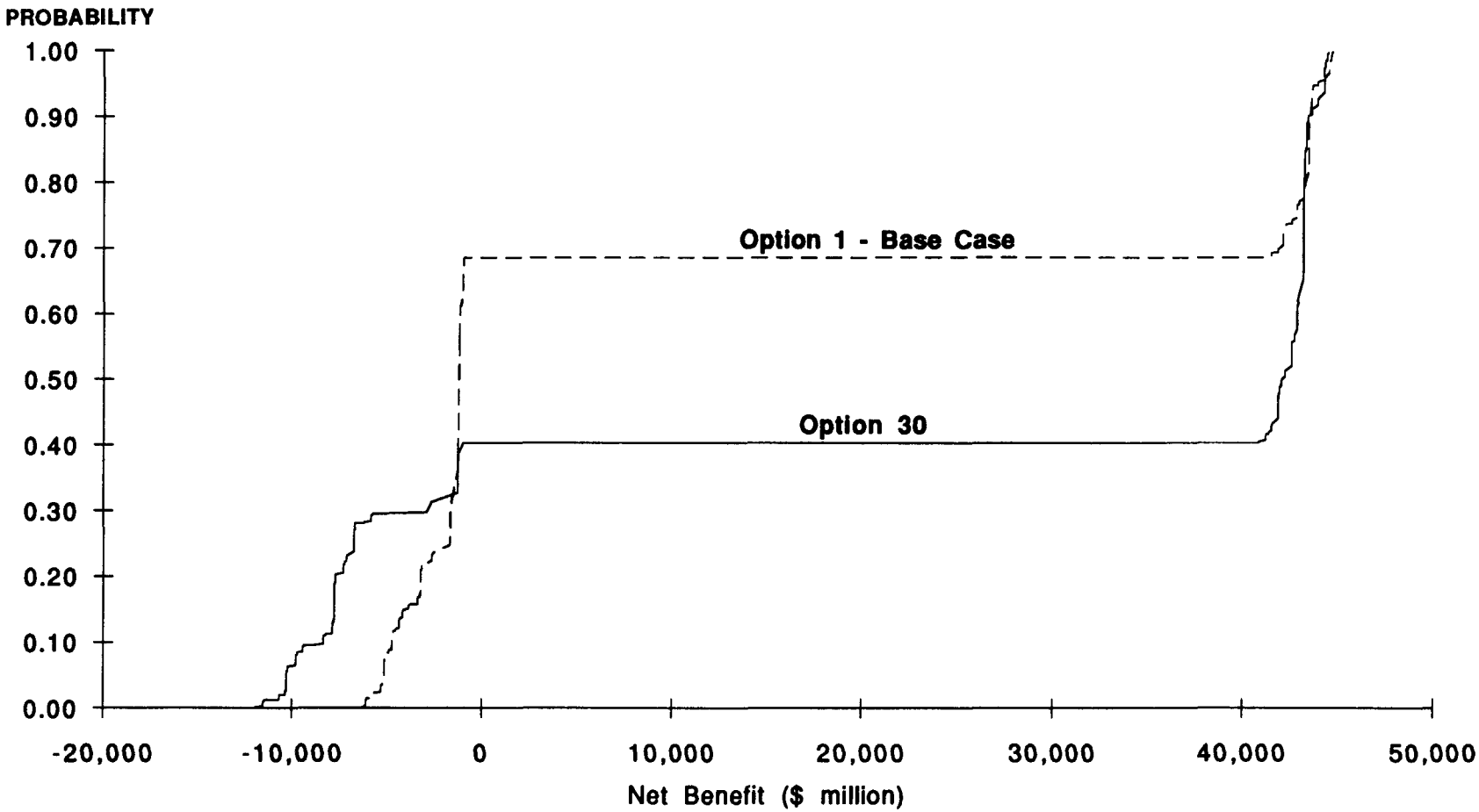
SUMMARY OF DECISION TREE CALCULATIONS

		PROBABILITIES												Expected Net Benefit [$ million] *	
	Option	{Prog. Viab}		{"OK-ET"}		{"OK-LT" / "OK-ET"}		{Approval}		{Closure}		{Scenario A}			
B.Case	1	0.55	26th	0.83	18th	0.89	30th	0.78	24th	0.995	30th	0.31	27th	12,080	27th
A1	2	0.73	15th	0.83	11th	0.91	2nd	0.93	4th	0.998	11th	0.51	7th	20,829	7th
A2	3	0.52	31st	0.83	13th	0.90	5th	0.89	9th	0.998	17th	0.35	26th	13,674	25th
A4-1	4	0.74	13th	0.83	16th	0.92	1st	0.87	12th	0.999	4th	0.49	10th	19,684	10th
A5	5	0.58	21st	0.84	9th	0.90	8th	0.85	15th	0.999	7th	0.37	22nd	14,501	22nd
A7	6	0.78	9th	0.83	15th	0.90	17th	0.93	3rd	0.999	3rd	0.54	5th	22,218	5th
B3-2	7	0.79	7th	0.82	25th	0.90	9th	0.92	5th	0.998	13th	0.54	6th	21,990	6th
B3-3	8	0.64	18th	0.83	24th	0.90	18th	0.85	15th	0.998	15th	0.40	19th	15,984	18th
B3-4	9	0.45	34th	0.74	33rd	0.84	33rd	0.67	33rd	0.991	34th	0.19	34th	6,142	34th
B3-5	10	0.58	22nd	0.78	32nd	0.89	24th	0.74	29th	0.996	28th	0.30	29th	11,139	29th
B3-6	11	0.56	24th	0.82	26th	0.90	6th	0.83	18th	0.997	23rd	0.35	25th	13,536	26th
B4	12	0.58	23rd	0.84	5th	0.90	11th	0.81	21st	0.998	8th	0.35	23rd	13,763	23rd
B7	13	0.81	6th	0.85	1st	0.91	3rd	0.89	9th	0.999	1st	0.55	4th	22,579	4th
B8	14	0.51	33rd	0.84	8th	0.90	7th	0.78	25th	0.998	12th	0.30	28th	11,370	28th
C1	15	0.54	28th	0.83	20th	0.90	10th	0.95	1st	0.999	5th	0.38	21st	15,454	20th
C4	16	0.53	29th	0.81	29th	0.89	23rd	0.90	7th	0.999	2nd	0.35	24th	13,725	24th
R11	17	0.56	25th	0.83	21st	0.90	13th	0.70	31st	0.997	25th	0.29	30th	10,981	30th
B.Case	18	0.52	32nd	0.82	28th	0.88	32nd	0.77	27th	0.995	31st	0.29	31st	10,956	31st
A1	19	0.77	10th	0.83	12th	0.89	26th	0.90	8th	0.997	18th	0.51	8th	20,404	8th
A2	20	0.67	17th	0.83	17th	0.89	27th	0.83	18th	0.997	21st	0.41	17th	16,322	17th
A4-1	21	0.77	12th	0.84	3rd	0.90	12th	0.84	17th	0.998	16th	0.49	11th	19,579	11th
A5	22	0.77	11th	0.84	4th	0.90	20th	0.78	25th	0.997	22nd	0.45	13th	17,760	13th
A7	23	0.87	3rd	0.83	14th	0.89	28th	0.90	6th	0.998	10th	0.58	2nd	23,306	2nd
B3-2	24	0.90	1st	0.82	27th	0.89	25th	0.86	14th	0.997	24th	0.57	3rd	23,006	3rd
B3-3	25	0.84	4th	0.83	23rd	0.90	16th	0.80	22nd	0.997	19th	0.50	9th	19,920	9th
B3-4	26	0.55	27th	0.74	34th	0.83	34th	0.66	34th	0.991	33rd	0.22	33rd	7,677	33rd
B3-5	27	0.83	5th	0.79	31st	0.89	31st	0.73	30th	0.996	29th	0.42	15th	16,340	16th
B3-6	28	0.79	8th	0.83	22nd	0.90	14th	0.82	20th	0.997	26th	0.48	12th	19,211	12th
B4	29	0.73	14th	0.84	7th	0.90	15th	0.79	23rd	0.997	20th	0.43	14th	16,921	14th
B7	30	0.89	2nd	0.85	2nd	0.91	4th	0.87	13th	0.999	6th	0.60	1st	24,385	1st
B8	31	0.70	16th	0.84	6th	0.90	21st	0.77	28th	0.997	27th	0.41	18th	15,862	19th
C1	32	0.62	19th	0.80	30th	0.90	19th	0.94	2nd	0.998	9th	0.42	16th	16,759	15th
C4	33	0.59	20th	0.83	19th	0.90	22nd	0.88	11th	0.998	14th	0.39	20th	15,306	21st
R11	34	0.53	30th	0.83	10th	0.89	29th	0.69	32nd	0.995	32nd	0.26	32nd	9,852	32nd

* Assumes benefit of functioning closed repository is $50 billion.

Prelim.prob4 2/26/91

Distribution on Net Benefit



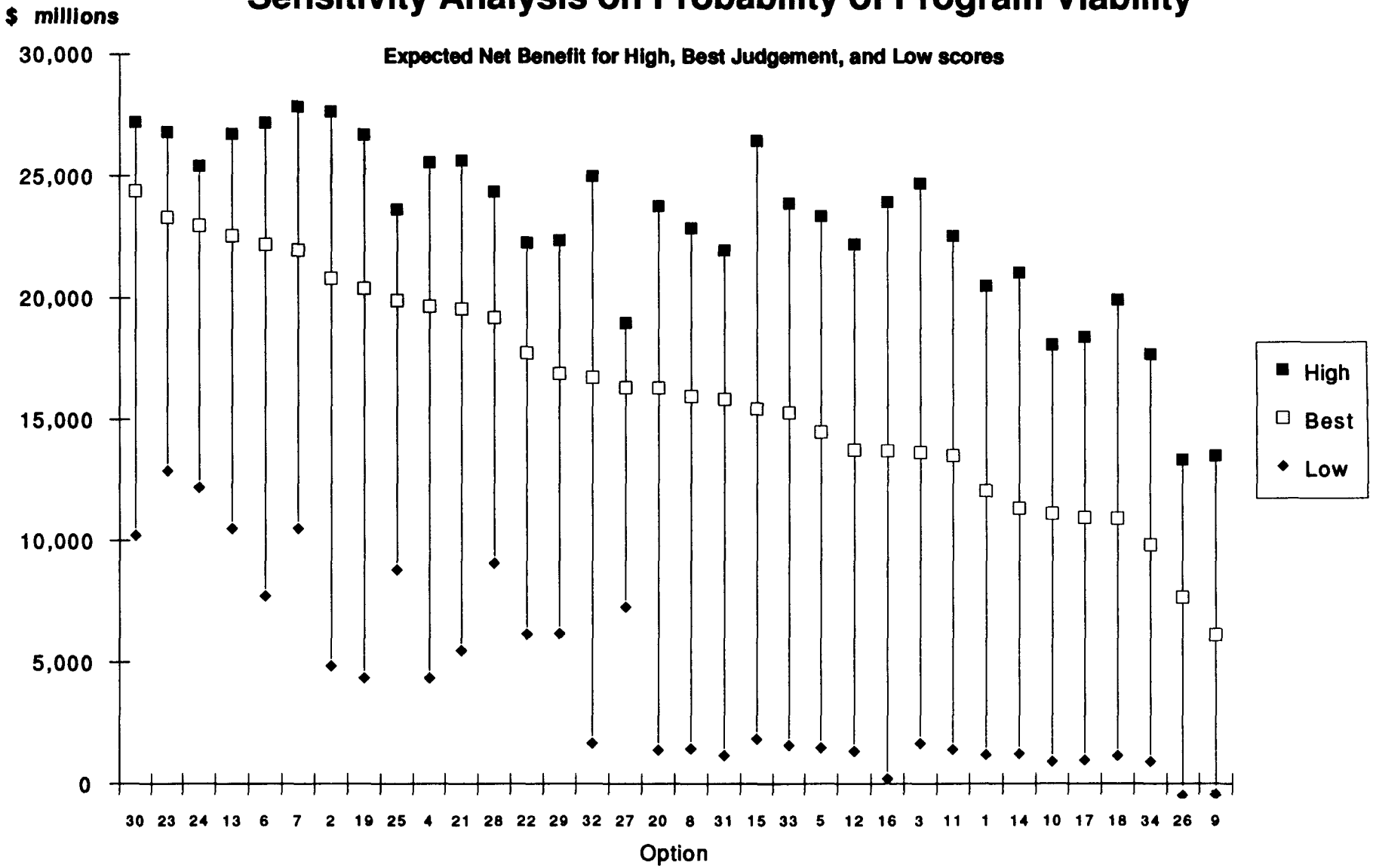
distOPT30.1

SENSITIVITY RESULTS

RANK ORDER OF OPTIONS UNDER VARIOUS MAJORITY/MINORITY REPORTS

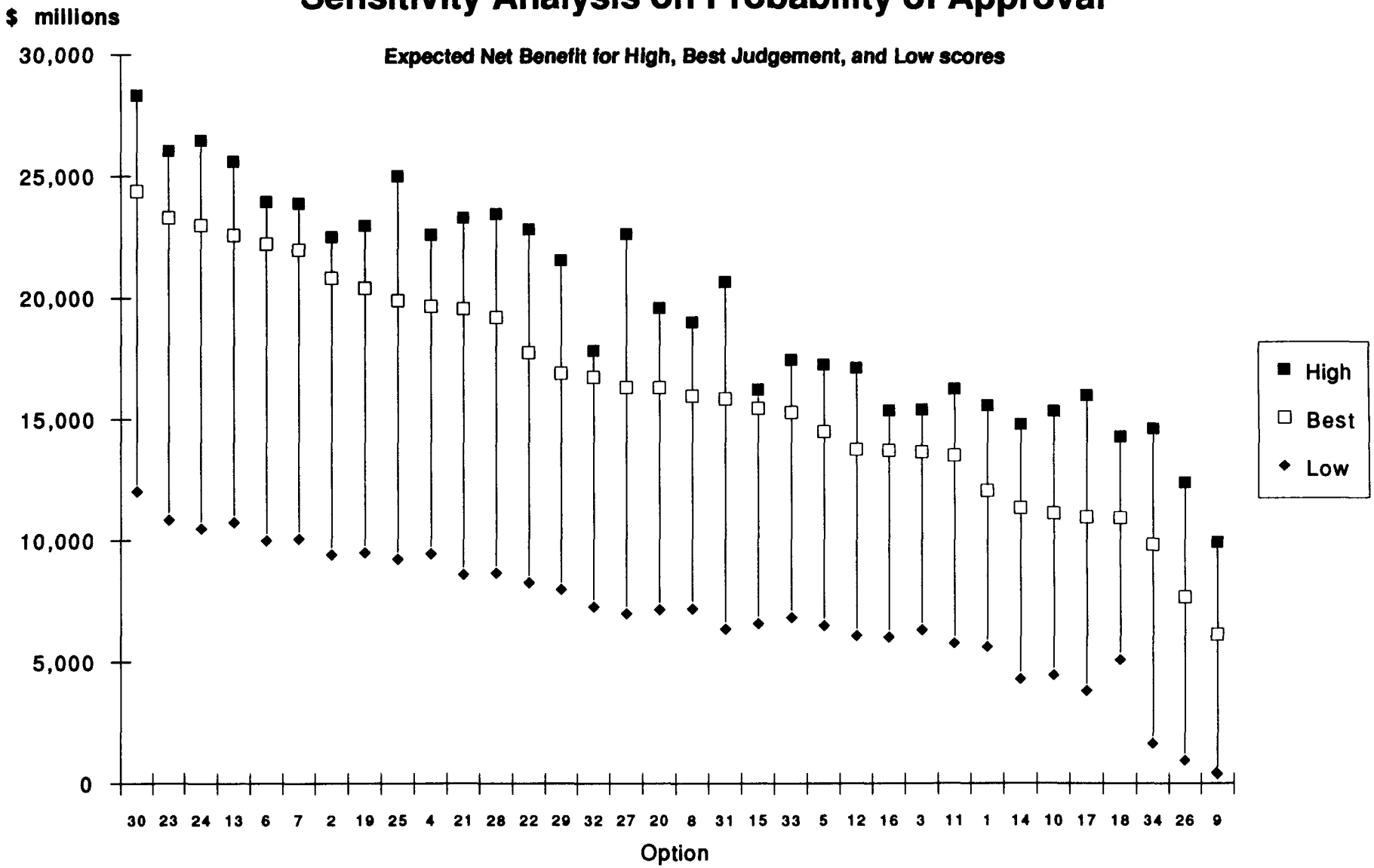
MAJORITY BEST JUDGEMENT RANKING		Minority View for Prog. Viab.		Ranking without Prog. Viab.		Minority EFN View #1 (7 experts)		Minority EFN View #2 (2 experts)		Minority View on Retrieval *(NO CHANGE)*		Ranking without C14 Releases *(NO CHANGE)*		Revised Estimates for Testing Probabilities	
30	1st	13	1st	15	1st	30	1st	23	1st	30	1st	30	1st	30	1st
23	2nd	2	2nd	2	2nd	13	2nd	24	2nd	23	2nd	23	2nd	23	2nd
24	3rd	6	3rd	6	3rd	23	3rd	6	3rd	24	3rd	24	3rd	24	3rd
13	4th	23	4th	13	4th	24	4th	30	4th	13	4th	13	4th	13	4th
6	5th	19	5th	7	5th	7	5th	7	5th	6	5th	6	5th	6	5th
7	6th	4	6th	32	6th	6	6th	2	6th	7	6th	7	6th	7	6th
2	7th	7	7th	3	7th	4	7th	13	7th	2	7th	2	7th	2	7th
19	8th	5	8th	30	8th	19	8th	19	8th	19	8th	19	8th	19	8th
4	9th	21	9th	23	9th	2	9th	25	9th	25	9th	25	9th	4	9th
25	10th	24	10th	19	10th	25	10th	28	10th	4	10th	4	10th	25	10th
21	11th	15	11th	4	11th	21	11th	21	11th	21	11th	21	11th	21	11th
28	12th	12	12th	16	12th	28	12th	32	12th	28	12th	28	12th	28	12th
22	13th	3	13th	33	13th	22	13th	27	13th	22	13th	22	13th	22	13th
29	14th	20	14th	5	14th	29	14th	4	14th	29	14th	29	14th	29	14th
32	15th	29	15th	21	15th	8	15th	20	15th	32	15th	32	15th	32	15th
20	16th	32	16th	24	16th	32	16th	22	16th	27	16th	27	16th	27	16th
27	17th	14	17th	8	17th	20	17th	29	17th	20	17th	20	17th	20	17th
8	18th	22	18th	11	18th	27	18th	8	18th	8	18th	8	18th	8	18th
31	19th	28	19th	20	19th	33	19th	15	19th	31	19th	31	19th	31	19th
15	20th	31	20th	12	20th	5	20th	33	20th	15	20th	15	20th	33	20th
33	21st	30	21st	28	21st	15	21st	31	21st	33	21st	33	21st	15	21st
5	22nd	8	22nd	25	22nd	31	22nd	16	22nd	5	22nd	5	22nd	5	22nd
12	23rd	25	23rd	29	23rd	3	23rd	5	23rd	12	23rd	12	23rd	16	23rd
3	24th	16	24th	14	24th	12	24th	11	24th	16	24th	16	24th	12	24th
16	25th	11	25th	22	25th	16	25th	1	25th	3	25th	3	25th	3	25th
11	26th	33	26th	31	26th	11	26th	12	26th	11	26th	11	26th	11	26th
1	27th	18	27th	1	27th	1	27th	3	27th	1	27th	1	27th	1	27th
14	28th	1	28th	18	28th	18	28th	10	28th	14	28th	14	28th	14	28th
10	29th	17	29th	17	29th	14	29th	18	29th	10	29th	10	29th	10	29th
17	30th	10	30th	10	30th	10	30th	17	30th	17	30th	17	30th	17	30th
18	31st	27	31st	27	31st	17	31st	14	31st	18	31st	18	31st	18	31st
34	32nd	34	32nd	34	32nd	34	32nd	34	32nd	34	32nd	34	32nd	34	32nd
26	33rd	9	33rd	9	33rd	26	33rd	26	33rd	26	33rd	26	33rd	26	33rd
9	34th	26	34th	26	34th	9	34th	9	34th	9	34th	9	34th	9	34th

Sensitivity Analysis on Probability of Program Viability



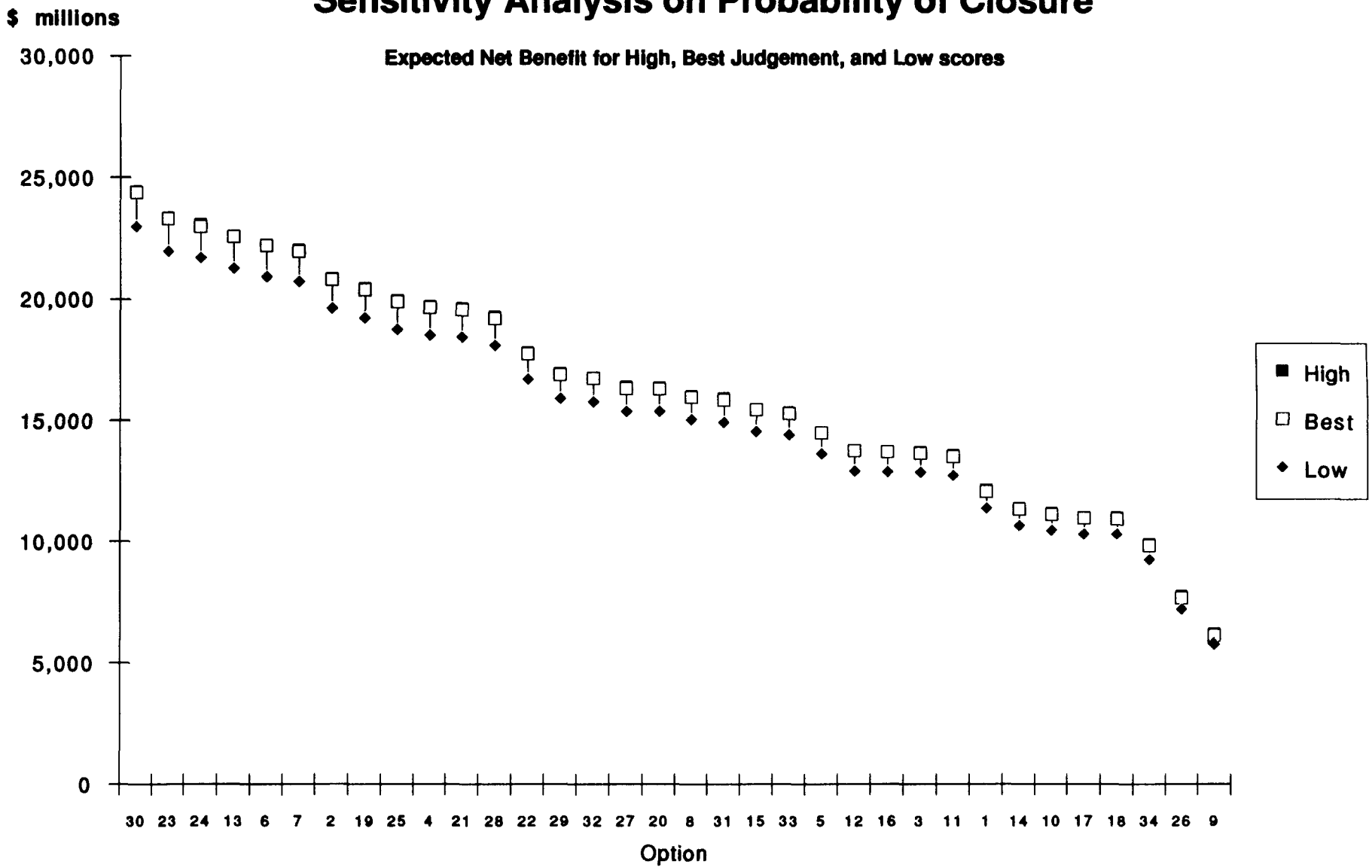
P-PVB.sen 2/26/91

Sensitivity Analysis on Probability of Approval



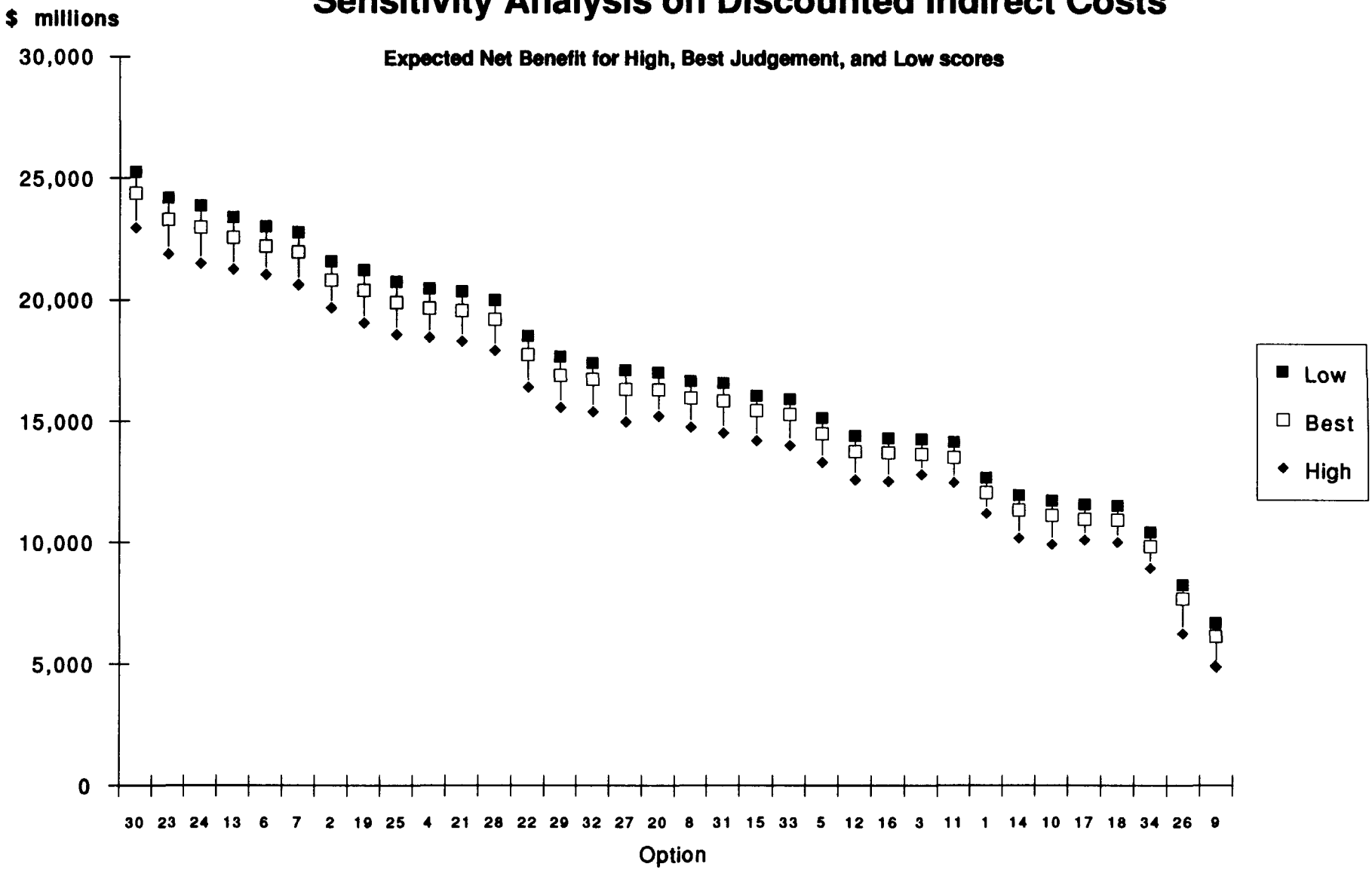
P-APP.sen 2/26/91

Sensitivity Analysis on Probability of Closure



P-CLO.sen 2/26/91

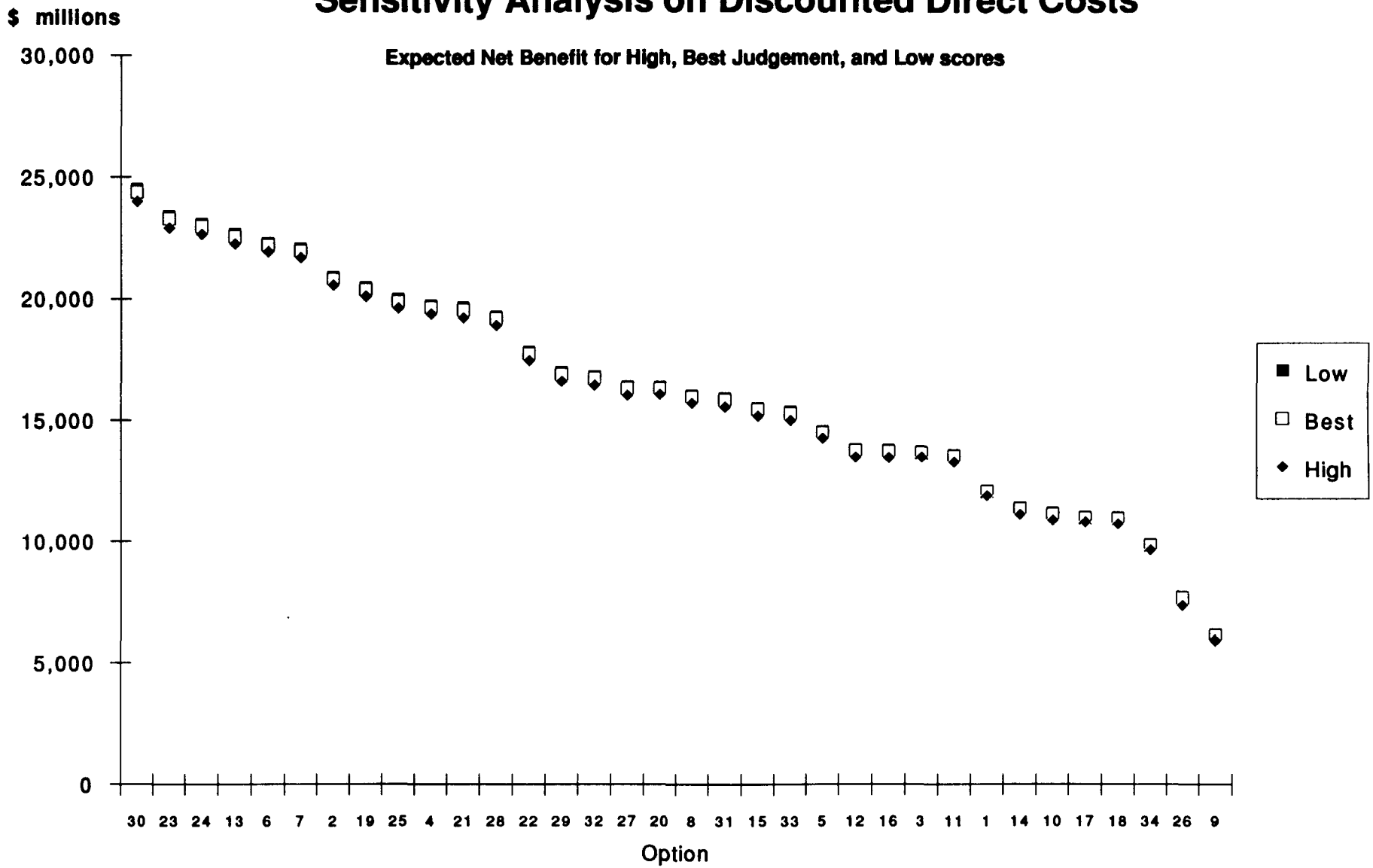
Sensitivity Analysis on Discounted Indirect Costs



INDCOST.sen 2/26/91

Sensitivity Analysis on Discounted Direct Costs

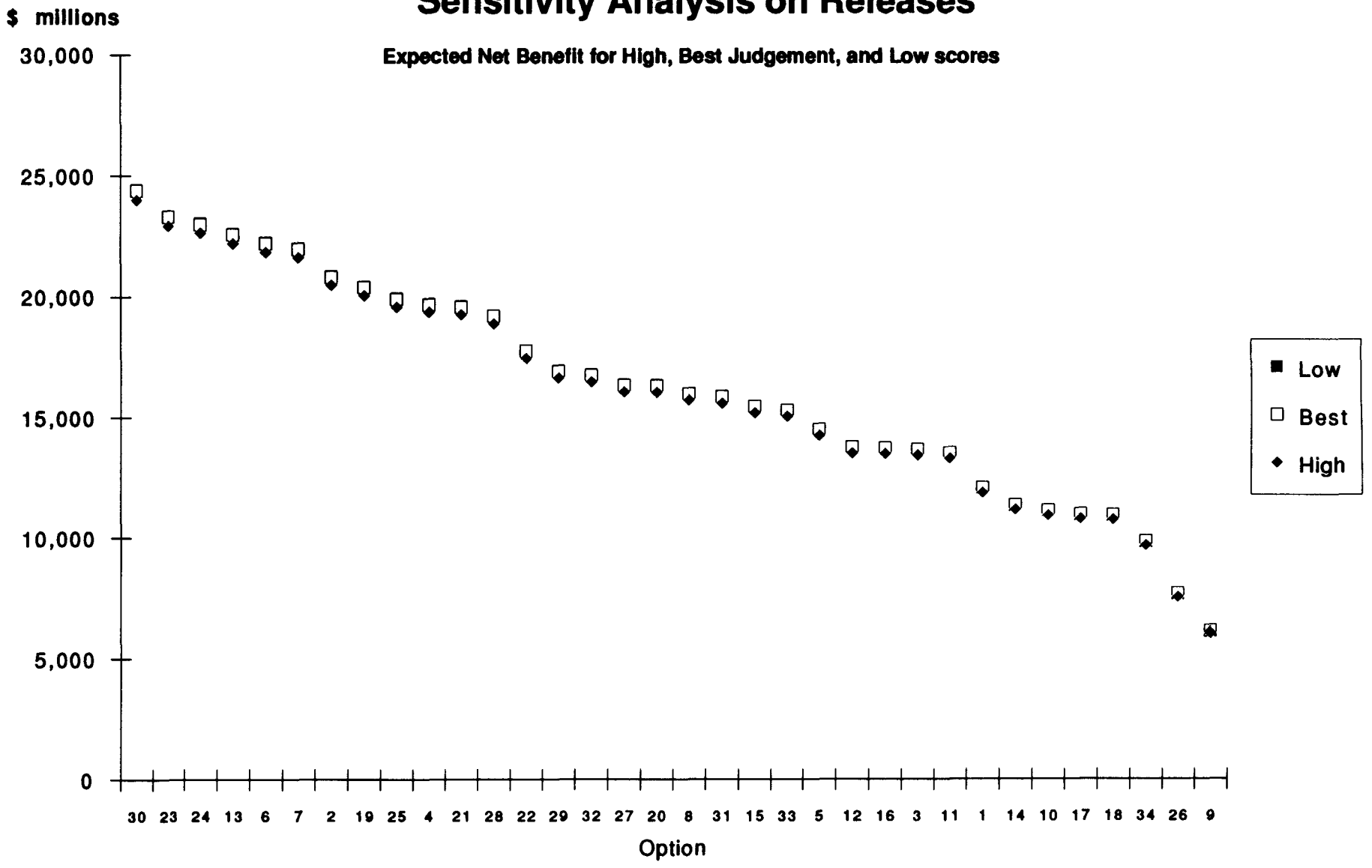
Expected Net Benefit for High, Best Judgement, and Low scores



DCOST.sen 2/26/91

Sensitivity Analysis on Releases

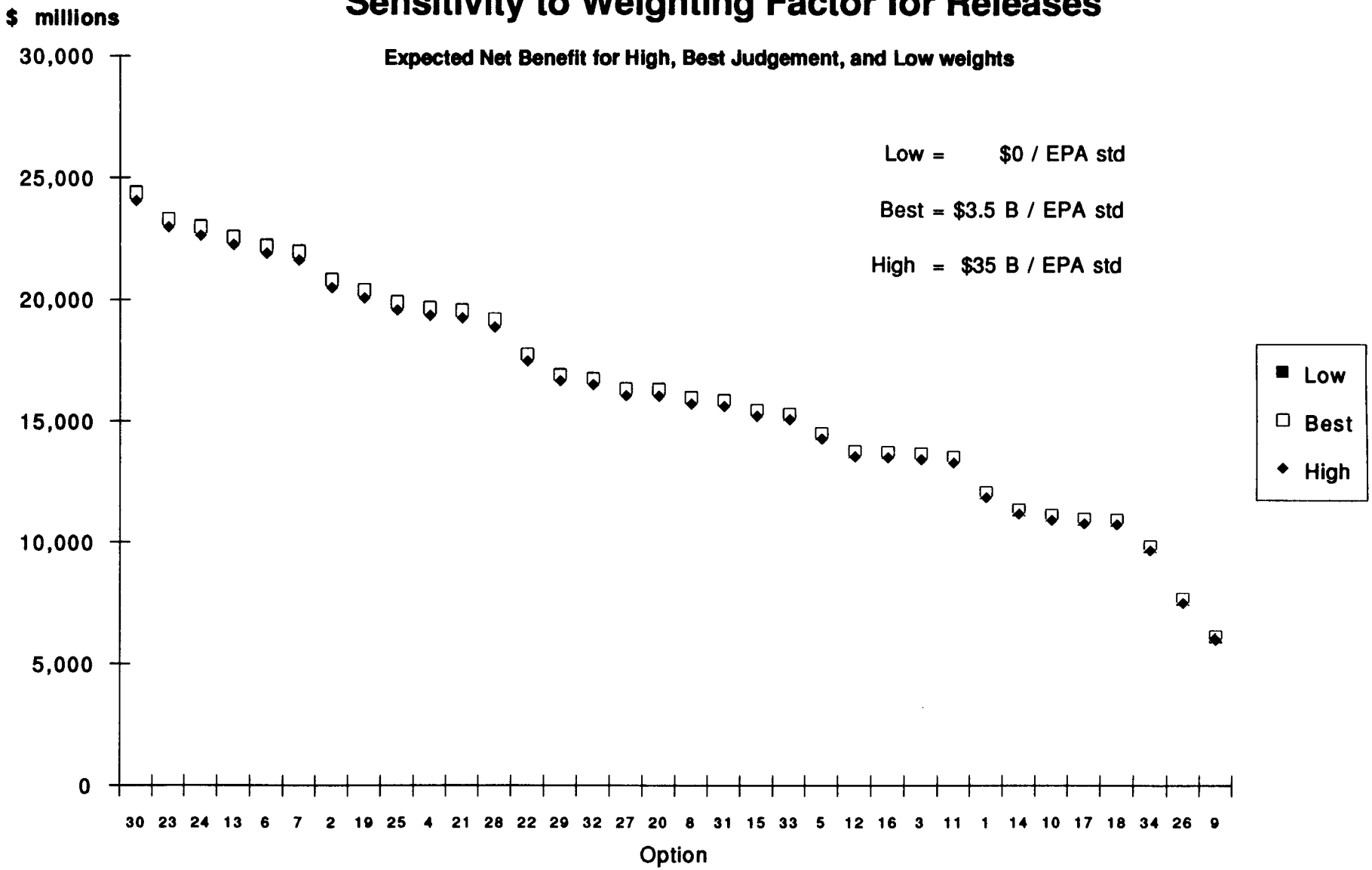
Expected Net Benefit for High, Best Judgement, and Low scores



RELEASES.sen 2/26/91

Sensitivity to Weighting Factor for Releases

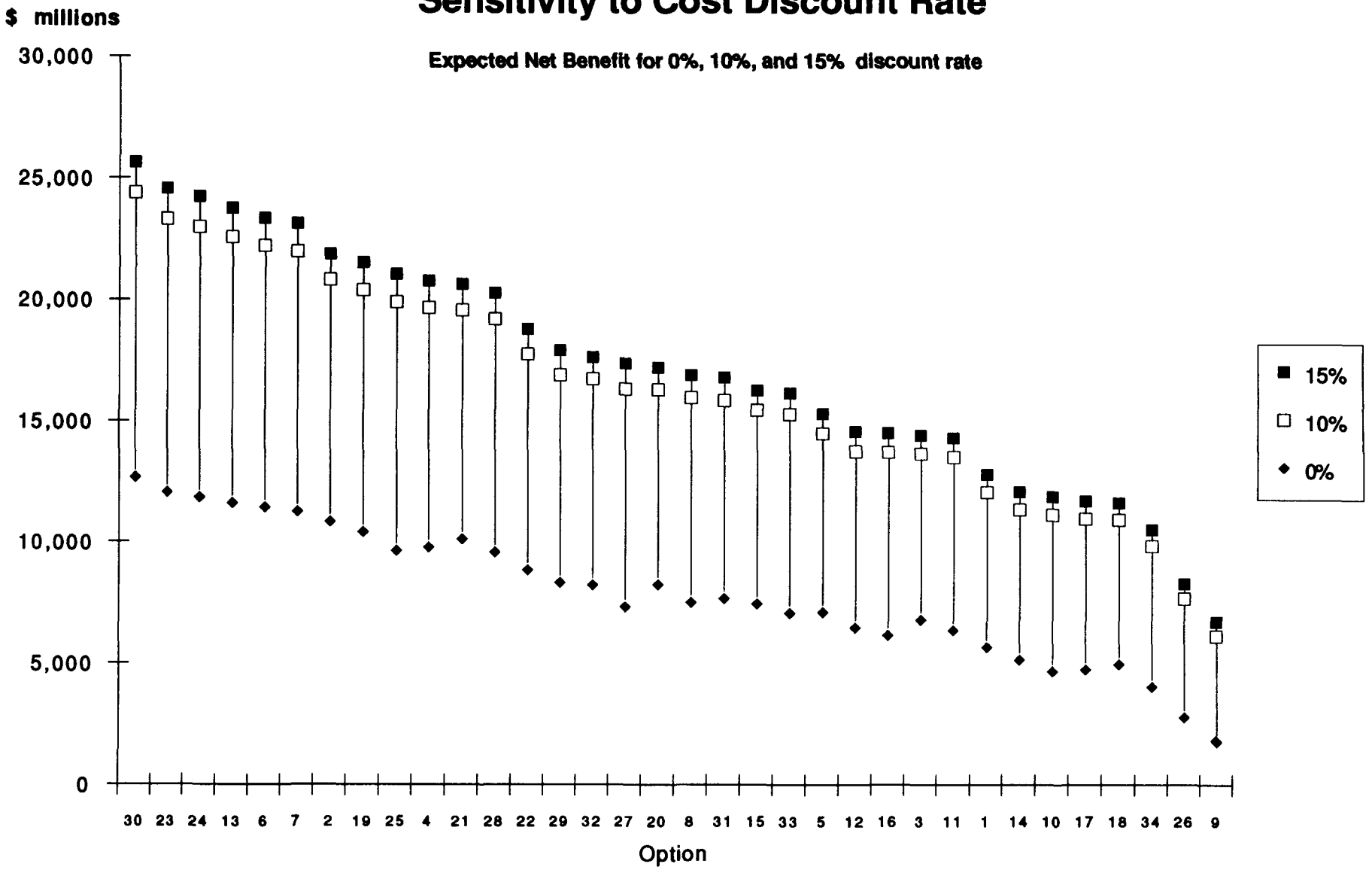
Expected Net Benefit for High, Best Judgement, and Low weights



WEIGHT-rel.sen 2/26/91

Sensitivity to Cost Discount Rate

Expected Net Benefit for 0%, 10%, and 15% discount rate



DiscountRate.sen 2/26/91

KEY MEASURES FROM SENSITIVITY ANALYSIS OF EXPERT PANEL JUDGEMENTS

HIGHLY RANKED ESF OPTIONS ARE LIKELY TO:

1.	ENSURE NEAR-TERM PROGRAMMATIC VIABILITY	0.910
2.	ACHIEVE REGULATORY APPROVAL	0.636
3.	LEAD TO REPOSITORY CLOSURE	0.534
4.	PRODUCE LOW RADIONUCLIDE RELEASES	0.511
5.	LEAD TO A LOW P_{EFP}	0.381
6.	LEAD TO A LOW P_{LFN}	0.319
7.	LEAD TO A LOW P_{EFN}	0.307

CORRELATION COEFFICIENT

EPOPG6P.126/1-29-91

CORRELATION OF JUDGEMENTS BY EXPERT PANEL ON PROGRAMMATIC VIABILITY WITH PRINCIPAL FACTORS IN INFLUENCE DIAGRAM

FACTOR	CORRELATION COEFFICIENT
NWTRB CONCERNS	0.628
NRC CONCERNS	0.485
END OF LATE TESTING	0.404
DURATION OF EARLY TESTING	0.278
PENALTY DELAY BETWEEN ET/LT END/START	0.220
COSTS TO END OF LT	-0.156
SCHEDULE SLIPPAGE DUE TO REDESIGN REQUIREMENTS	0.065
DESIGN DISSIMILARITY	0.027

KEY INSIGHTS FROM COMPARATIVE EVALUATION OF ESF OPTIONS

- ALTHOUGH SIGNIFICANT UNCERTAINTIES EXIST ABOUT THE PROJECTED PERFORMANCE OF ESF OPTIONS, A SINGLE OVERALL RANKING OF THE 34 OPTIONS WAS OBTAINED, CONSISTENT WITH THE MAJORITY OPINIONS OF THE EXPERT PANELS

- THE RANK ORDERING WAS DETERMINED ALMOST ENTIRELY BY THE RELATIVE LIKELIHOOD OF OBTAINING A CLOSED REPOSITORY (SCENARIO A)

- THE RANK ORDERING WAS RELATIVELY INSENSITIVE TO THE HIGH/LOW UNCERTAINTY (1 CHANCE IN 20) ESTIMATES OF END CONSEQUENCES

KEY INSIGHTS FROM COMPARATIVE EVALUATION OF ESF OPTIONS

(CONTINUED)

- PROBABILITY OF PROGRAMMATIC VIABILITY WAS THE SINGLE MOST INFLUENTIAL CONSIDERATION DETERMINING THE RANK ORDERING

- THE PRINCIPAL FACTORS INFLUENCING ESTIMATES OF PROGRAMMATIC VIABILITY WERE:

  - RESOLUTION OF NWTRB AND NRC CONCERNS

  - DURATION OF CHARACTERIZATION TESTING

KEY INSIGHTS FROM COMPARATIVE EVALUATION OF ESF OPTIONS

(CONTINUED)

- THE EIGHT HIGHEST-RANKED ESF OPTIONS ...
  - REPRESENT FOUR PAIRS OF ESF DESIGNS (i.e., ONE FEATURING EARLY ACCESS TO THE TS UNIT AND ONE WITH EARLY ACCESS TO THE CH UNIT
  - WERE JUDGED, ON AVERAGE, TO HAVE: P_{viab} > 82%, $P_{"ok\text{-}et"}$ > 83%, P_{app} = 90%, $P_{"ok\text{-}lt"/"ok\text{-}et"}$ = 90%, AND P_{cio} = 99.8%
  - EXPECTED RELEASES LESS THAN 0.001% OF THE EPA RN LIMIT TO THE ACCESSIBLE ENVIRONMENT BY AQUEOUS TRANSPORT
  - EXPECTED DOSES, DUE TO UNDERGROUND ACCIDENTS, LESS THAN 0.2 PERSON-REM TO WORKERS AND 0.000002 PERSON-REM TO THE PUBLIC
- THROUGHOUT THE FORMAL DELIBERATIONS, THERE WERE NO JUDGEMENTS EXPRESSED THAT ANY ESF OPTION WOULD FAIL TO MEET ANY APPLICABLE REQUIREMENT

U.S. DEPARTMENT OF ENERGY
OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT

PRESENTATION TO THE NUCLEAR WASTE TECHNICAL REVIEW BOARD

SUBJECT: EXPLORATORY SHAFT FACILITY ALTERNATIVES STUDY - DESIGN/TECHNICAL FEATURES

PRESENTER: DR. LAURENCE S. COSTIN

PRESENTER'S TITLE AND ORGANIZATION: DIVISION SUPERVISOR
GEOMECHANICS ANALYSIS AND TESTING DIVISION
SANDIA NATIONAL LABORATORIES

PRESENTER'S TELEPHONE NUMBER: (505) 846-0488

DENVER, COLORADO
MARCH 6-7, 1991

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OVERVIEW

- DOE APPROACH TO ADDRESSING 10 CFR 60.21

  - STATEMENT OF CONSIDERATIONS
    "THE COMMISSION HAS STRESSED THE IMPORTANCE OF EVALUATING ALTERNATIVES TO MAJOR DESIGN FEATURES THAT ARE IMPORTANT TO WASTE ISOLATION, SEE 10 CFR 60.21 (c) (1) (ii) (D), AND IN THE CASE OF THE DESIGN AND LOCATION OF THE EXPLORATORY SHAFTS, THIS CAN ONLY BE DONE PRIOR TO THEIR SINKING"
  - COMMENTS IN SCA
  - COMMENTS ON DAA
  - NRC LETTER TO DOE - CONCERNS REGARDING DOE APPROACH

- RESULTS OF EVALUATION

INTRODUCTORY REMARKS ON APPROACH

- AS AN INTEGRAL PART OF THE ESF ALTERNATIVES STUDY, MAJOR DESIGN FEATURES WERE INCORPORATED IN 17 BASIC CONFIGURATIONS, WHICH WERE COMPARATIVELY EVALUATED

- FEATURES WERE EVALUATED IN THE CONTEXT OF AN ESF/REPOSITORY SYSTEM

  - INDIVIDUAL FEATURES CANNOT BE EVALUATED SEPARATELY BECAUSE THEIR IMPACTS MAY NOT BE INDEPENDENT
  - THE TOTAL EFFECT OF A NUMBER OF FEATURES COMBINED INTO AN OPTION MAY BE QUITE DIFFERENT THAN THE SUM OF INDIVIDUAL IMPACTS

- EVALUATION WAS MULTI-DIMENSIONAL

GENERAL APPROACH

- FIVE MAJOR DESIGN FEATURES WERE IDENTIFIED FOR SPECIFIC INCLUSION IN THE OPTIONS IN VARIOUS ALTERNATIVE WAYS AND COMBINATIONS

- ALL EXISTING ESF AND REPOSITORY CONFIGURATIONS WERE COMBINED WITH A NUMBER OF NEW CONFIGURATIONS TO FORM AN INITIAL POOL OF OPTIONS

- NEW CONFIGURATIONS WERE SPECIFICALLY CREATED TO
  - HAVE VARIOUS COMBINATIONS OF ALTERNATIVE DESIGN FEATURES
  - INCORPORATE A NUMBER OF FEATURES THAT WERE IDENTIFIED BY NRC AND NWTRB CONCERNS

GENERAL APPROACH

(CONTINUED)

- INITIAL SCREENING PROCESS WAS DESIGNED TO ENSURE THAT THE PROPER RANGE OF ALTERNATIVE MAJOR FEATURES WAS INCORPORATED IN THE SET OF OPTIONS TO BE EVALUATED

- DETAILED COMPARATIVE EVALUATION OF OPTIONS WAS PERFORMED CONSIDERING A NUMBER OF DIMENSIONS
  - POSTCLOSURE PERFORMANCE
  - CHARACTERIZATION TESTING
  - REGULATORY APPROVAL
  - PROGRAMMATIC VIABILITY
  - ETC

GENERAL APPROACH

(CONTINUED)

- ADDITIONAL PERFORMANCE EVALUATIONS WERE DONE TO DETERMINE WHICH MAJOR FEATURES WERE POTENTIAL DISCRIMINATORS FOR POSTCLOSURE PERFORMANCE
  - BEST AVAILABLE ANALYSES AND DATA WERE USED
  - RESULTS PROVIDED TO THE POSTCLOSURE PANEL

GENERAL APPROACH

(CONTINUED)

- POST-EVALUATION ANALYSIS WAS PERFORMED TO:
  - DETERMINE WHICH ALTERNATIVE FORMS OF THE MAJOR FEATURES CONTRIBUTED TO AN OPTION'S ABILITY TO PERFORM WELL IN THE OVERALL EVALUATION
  - IDENTIFY ANY NEW FEATURES THAT CONTRIBUTED TO GOOD OVERALL PERFORMANCE

FIVE MAJOR DESIGN FEATURES CONSIDERED

MAJOR DESIGN FEATURE	ALTERNATIVES	
1. MEANS OF ACCESS	SHAFTS ONLY RAMPS ONLY SHAFT/RAMP COMBINATION	
2. LOCATION OF ACCESSES	ALL IN NORTHEAST ALL IN SOUTH COMBINATION OF LOCATIONS	
3. LOCATION OF MAIN TEST LEVEL (MTL) CORE AREA IN TOPOPAH SPRING (TS)	NORTHEAST SOUTH	
4. EXCAVATION METHOD OF OPENINGS	SHAFTS	- DRILL AND BLAST - SHAFT BORING MACHINE - BLIND HOLE DRILL - V-MOLE - RAISE BORE
	RAMPS	- TUNNEL BORING MACHINE (TBM) - ROAD HEADER - DRILL AND BLAST

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FIVE MAJOR DESIGN FEATURES CONSIDERED

(CONTINUED)

MAJOR DESIGN FEATURE	ALTERNATIVES	
4. EXCAVATION METHOD OF OPENINGS (CONT.)	MTL (TS) CORE AREA	- DRILL AND BLAST - MOBILE MINER - TBM*
	EXPLORATORY DRIFTING IN TS & CH	- DRILL AND BLAST - MOBILE MINER - TBM - ROAD HEADER
5. TOTAL NUMBER OF ACCESSES	ESF ACCESSES ARE AN INTEGRATED SUBSET OF THE TOTAL NUMBER OF ACCESSES FOR THE REPOSITORY	

* TBM NOT SPECIFICALLY CONSIDERED FOR MTL EXCAVATION BUT IS EXPECTED TO BE AN ACCEPTABLE ALTERNATIVE FOR PART OF THE EXCAVATION

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POST-EVALUATION ANALYSIS OF FEATURES

- A QUALITATIVE EVALUATION OF FEATURES WAS ACCOMPLISHED BY ASSESSING THE RELATIVE MERIT OF THE INDIVIDUAL FORMS OF THE FEATURE IN CONJUNCTION WITH THE RANK ORDER OF THE OPTIONS
  - MAJOR DESIGN FEATURES
  - FEATURES INCLUDED BY GUIDANCE
  - ADDITIONAL FEATURES IDENTIFIED AS A RESULT OF THE EVALUATION
- SYSTEMATIC ANALYSIS OF FEATURE EFFECTIVENESS
  - KEY MEASURES
  - FACTORS RELATED TO KEY MEASURES
  - DESIGN FEATURES RELATED TO KEY MEASURES
- CORRELATION OF POTENTIALLY FAVORABLE FEATURES WITH THE FEATURES CONTAINED IN THE HIGHLY RANKED OPTIONS

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QUALITATIVE EVALUATION

MAJOR DESIGN FEATURES

- **MEANS OF ACCESS**
  - OPTIONS WITH TWO RAMPS PREFERRED
  - SHAFT PREFERRED FOR SITE CHARACTERIZATION
- **LOCATION OF ACCESSES**
  - FROM A CHARACTERIZATION TESTING PERSPECTIVE, ACCESS LOCATION COMBINATIONS THAT PERMIT BROAD SPATIAL DISTRIBUTION OF EXPOSED ROCK ARE PREFERRED
    - * LARGE SPATIAL COVERAGE OF DATA
    - * REDUCED POTENTIAL FOR INTERFERENCES
    - * LOCATIONALLY REPRESENTATIVE DATA

QUALITATIVE EVALUATION

(CONTINUED)

- LOCATION OF MAIN (CORE) TESTING AREA (MTL)
  - NO PREFERENCE IDENTIFIED
- SOME OPTIONS HAVE THE FLEXIBILITY TO MOVE THE MTL TO EITHER THE NORTH OR SOUTH, THIS MAY BE OF SOME ADVANTAGE IN THE DESIGN PROCESS
- EXCAVATION METHODS
  - MECHANICAL EXCAVATION OF ACCESSES AND DRIFTS WAS PREFERRED
- TOTAL NUMBER OF ESF/REPOSITORY ACCESSES
  - FEWER ACCESSES WERE PREFERRED

FEATURES INCLUDED BY GUIDANCE

THREE FEATURES WERE INCLUDED IN ALL OPTIONS EXCEPT THE BASE CASE (OPTION 1) AS A RESULT OF THE DESIRE TO ADDRESS SPECIFIC CONCERNS OF THE NRC AND NWTRB

- TWO INTERCEPTS (MINIMUM) OF THE GHOST DANCE FAULT
  - ONE TOWARD NORTH END OF BLOCK, ONE TOWARD THE SOUTH
- EAST-WEST DRIFT IN THE TOPOPAH SPRING ROCK UNIT
- LARGER DEDICATED MAIN TEST LEVEL (EXCEPT OPTION 18)

ADDITIONAL FEATURES IDENTIFIED BY STUDY

- NO CONSTRUCTED PATHWAY FOR DIRECT GRAVITY FLOW OF WATER FROM THE REPOSITORY (TS) LEVEL TO THE CALICO HILLS (CH) LEVEL (OPTION 30)
- INCREASE THE DISTANCE FROM THE WASTE EMPLACEMENT LEVEL TO THE WATER TABLE (OPTIONS 15, 16, 32, AND 33)
- AVOID EMPLACEMENT DRIFTS CROSSING THE GHOST DANCE FAULT (OPTIONS 15, 16, 32, AND 33)
- LARGE EXPOSURE OF ROCK, BOTH ON AND OFF THE BLOCK (OPTIONS 30, 13, 4, et al.)
- ATTRIBUTES THAT ALLOW FOR EARLY EXPLORATION OF BOTH THE TS AND CH ROCK UNITS (OPTIONS 4,13, 24, 25, 30, et al.)

ANALYSIS OF SIGNIFICANCE OF FEATURES WITHIN THE COMPARATIVE EVALUATION OF OPTIONS

- KEY MEASURES IDENTIFIED
  - RANKING OF OPTIONS RELATIVE TO EACH MEASURE WAS CORRELATED WITH THE OVERALL RANKING
  - MEASURES WITH HIGH CORRELATIONS ARE JUDGED TO BE MOST INFLUENTIAL IN DETERMINING OVERALL RANKING
- FACTORS THAT SIGNIFICANTLY INFLUENCED THE KEY MEASURES WERE IDENTIFIED FROM THE INFLUENCE DIAGRAMS AND OTHER MATERIAL
- SIGNIFICANT FACTORS WERE RELATED TO SPECIFIC DESIGN FEATURES THAT ADDRESSED THESE FACTORS

IDENTIFICATION OF FAVORABLE FEATURES IN HIGHLY RATED OPTIONS

RANK	TOP-RANKED OPTIONS OPTION	1 NUMBER OF RAMP(S)	2 NUMBER OF SHAFT(S)	3 NUMBER OF ACCESSES	4 MTL LOCATION FLEXIBILITY	5 MECHANICAL MINED ACCESSES	6 NO GRAVITY FLOW PATHWAY FROM TS UNIT TO CHn	7 MAXIMIZE DISTANCE FROM EMPLACEMENT LEVEL TO WATER TABLE	8 AVOID EMPLACEMENT DRIFTS CROSSING GHOST DANCE FAULT	9 MAXIMIZE EXPOSED ROCK-ON AND OFF BLOCK	10 FLEXIBILITY FOR EARLY DRIFTING IN TS OR CH OR BOTH	11a 2 INTERCEPTS OF GHOST DANCE FAULT IN TS	11b E-W DRIFT IN TS	11c LARGER MTL AREA TO AVOID INTERFERENCES
1	30	2	0	4	✓	✓	✓			✓	✓	✓	✓	✓
2	23	2	0	4		✓						✓	✓	✓
3	24	1	1	5		✓					✓	✓	✓	✓
4	13	2	0	4	✓	✓				✓	✓	✓	✓	✓
5	6	2	0	4		✓						✓	✓	✓
6	7	1	1	5		✓						✓	✓	✓
7	2	1	1	5								✓	✓	✓
8	19	1	1	5								✓	✓	✓
9	25	1	1	5		✓					✓	✓	✓	✓
10	4	1	2	5						✓	✓	✓	✓	✓
20	15	1	1	4				✓	✓			✓	✓	✓

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FEATURES INCLUDED IN HIGHLY-RATED OPTIONS

- POTENTIALLY FAVORABLE FEATURES THAT WERE IDENTIFIED WERE CORRELATED WITH THE HIGHLY RATED OPTIONS
- HIGHLY RATED OPTIONS CONTAIN MANY FAVORABLE FEATURES
- NO OPTION HAS ALL FEATURES IDENTIFIED AS POTENTIALLY FAVORABLE

FEATURES INCLUDED IN HIGHLY-RATED OPTIONS

(CONTINUED)

- SOME MODIFICATION OF HIGHLY RATED OPTIONS COULD IMPROVE CERTAIN FEATURES WITHOUT SIGNIFICANT CHANCE OF DEGRADING THE OPTION OVERALL

- IN GENERAL, THE ADDITION OF MAJOR FEATURES WOULD REQUIRE DETAILED ANALYSES TO BALANCE THE FAVORABLE AND ADVERSE EFFECTS OF THE FEATURE AS INCORPORATED IN A SPECIFIC CONFIGURATION

ENHANCING THE ESF DESIGN

- SUBJECT TO DESIGN CONTROL PROCESS
- SELECTED KEY FEATURES WILL BE SUBJECT TO ENGINEERING TRADE-OFF STUDIES DURING DESIGN PHASE
- ENGINEERING DESIGN METHODOLOGIES WILL BE USED TO REFINE OR IMPROVE ALL FEATURES OF THE BASELINED OPTION