Financial Framework that Maximizes Benefit of Water-Infrastructure Investment

PURDUE





Background

How the Mississippi water crisis happened

- Since July 29, 2022 ~ Ongoing Issues
- 150,000 Jackson city's residents
- Main water treatment facility was damaged after a high level of flooding
- A result of years-long issues.

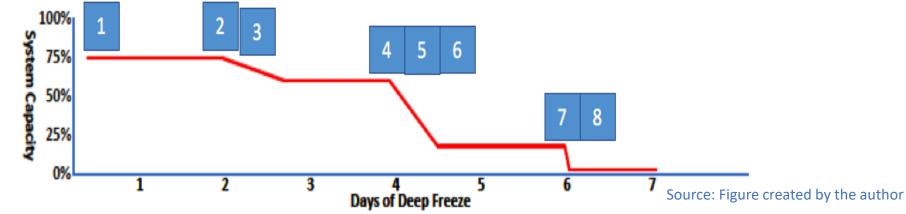






Nearly 50 days of an ongoing boil water advisory has become common Lt is unknown when it will be resolved. Replacing the water treatment facility& solving this crisis could cost billions of dollars. More than a trillion dollars must be invested in water infrastructure by 2030

Background: TX Water Crisis & Deep Freeze



City Water Utilities

- **1** Systems offline
- 2 City Water pumps froze
- **3** Attempt to provide opening all water valves
- 8 Residential pipes burst

Wholesale Provider

- 4 Extended power outages
- **5** Refuel emergency generator fuel supplies, but Iced roads
- 6 Remaining Generator fuel wasted
- 7 Much water production offline

Operational failure of a water utility value stream in some of the US southern states during a deep-freeze event of a winter storm in February 2021 by Time Period







Photo: ABC News

UNDERGROUND CONSTRUCTION TECHNOLOGY



Ongoing Water Crisis Cities

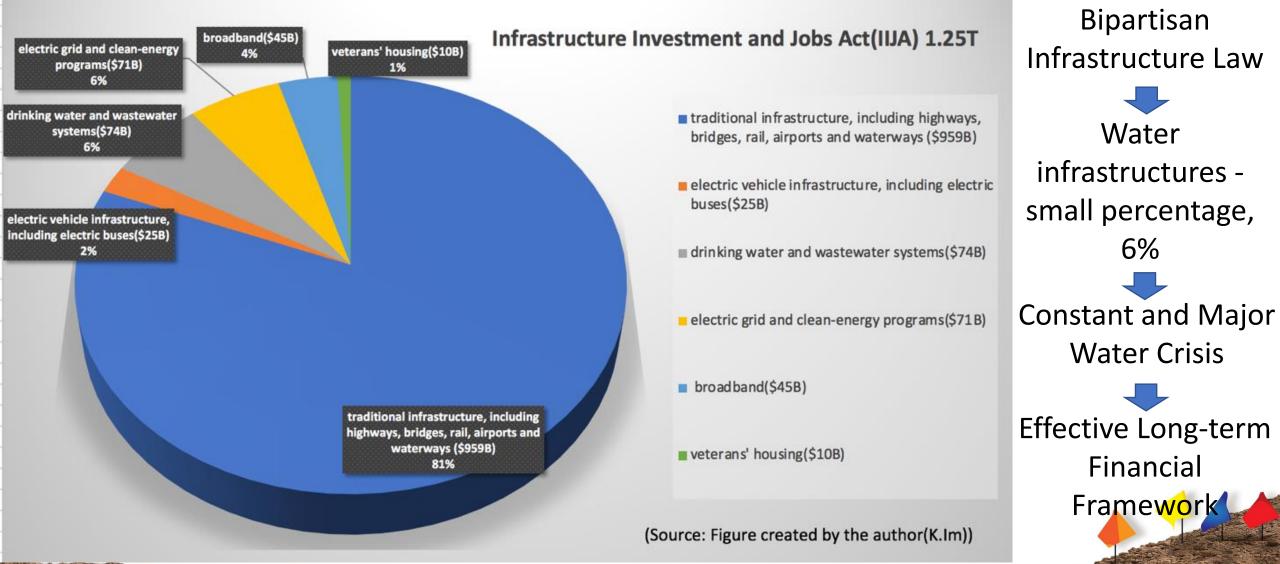


*NM -The fire-related debris and ash due to wildfire contaminated the reservoir. *HI - Jet fuel leaked by

the Navy water system. *TX - water crisis from an ongoing drought and record-breaking heat. *MS - failing water treatment system from heavy rainfall and flooding *MD - the bacteria was detected in the drinking water *MI - lead pollution in the water system

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Infrastructure Investment & Jobs Act



Detailed proportion for each infrastructure based on Infrastructure Investment and Jobs Act (IIJA) 1.25T

UNDERGROUND LITUTIES EVENT & FORMARY 7 0 2023 - Orloado El

Problem Statement & Needs

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- Therefore, there is a need to conduct a cost-benefit assessment related to the capital investment costs that will help government make the efficiency of limited budgets and resources for constructing, improving, and rehabilitating water infrastructures using historical financial and economic data.
- Minimizing risks of ineffectual and wasteful water sector investment through rehabilitating and improving water infrastructures in a rational manner will lead to improving grades of the infrastructure report card and the resiliency of interrelated infrastructures and sectors.

Objectives

Establish a long-term financial framework based on cost-benefit analysis and priorities

Objective

Long-term financial framework including the deep uncertainties for decisionmakers to understand the benefit from investing assets for an optimal level versus the cost of doing nothing allowing the asset to run to failure will be developed using the costbenefit analysis



Establish a long-term financial framework based on cost-benefit assessment and priorities:

Long-term financial framework including the deep uncertainties for decision-makers to understand the benefit from investing in assets for an optimal level versus the cost of doing nothing allowing the asset to run to failure will be developed using the benefit-cost assessment.



Major Purposes of this phase: are to conduct a benefit-cost assessment in terms of private, financial, economic, efficiency using nominal and real terms for maximizing the benefit from investing water sector and for reducing the vulnerability of water infrastructures.



Expected Outcomes

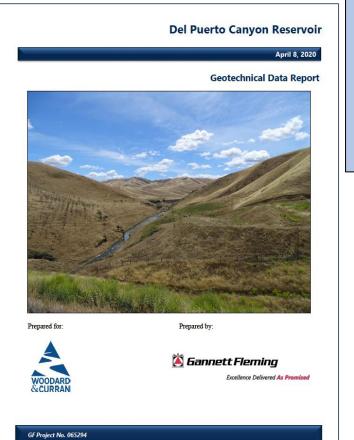
Long-term Financial Framework on water infrastructure

• The long-term financial framework including the deep uncertainties for decision-makers to understand the benefit from investing assets for an optimal level versus the cost of doing nothing allowing the asset to run to failure will be developed using the cost-benefit assessment.

Benefit-Cost Assessment for a strategy of maximizing the efficiency

- In order to measure the benefit and cost of a strategy of maximizing the efficiency of limited budgets and resources, the study will conduct a benefit-cost assessment due to the investment costs for rehabilitating and improving water infrastructures using historical economic and financial data.
- To minimize the increasing challenges associated with the aging water infrastructure and to maximize the efficiency of water infrastructures, this research conducts a benefit-cost assessment related to the investment costs and develops a long-term financial framework for water infrastructure.

Scope of Research



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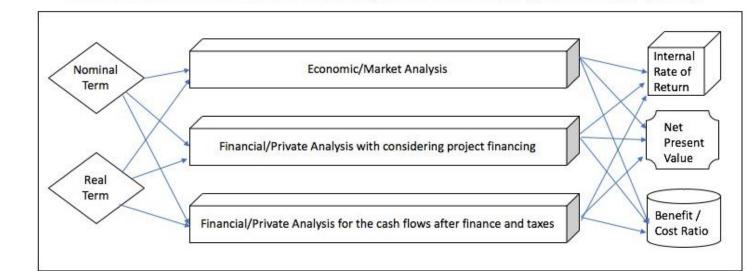
This research focuses on evaluating a proposed project (DPCR project) using a cost-benefit assessment to maximize the benefit of investing in water infrastructure for economic and financial feasibility and developing a long-term financial framework as a feasibility study.

Del Puerto Canyon Reservoir (DPCR)

This water infrastructure project proposes to construct a reservoir on Del Puerto Creek in the Del Puerto Canyon which is in the eastern foothills of the Coast Range Mountains.

The purpose of the DPCR is to develop additional South of Delta water storage, utilizing the water after it is moved through the Delta, to maximize the management and efficient use of existing water supplies.

Several scenarios associated with cost-benefit analysis in the decision-making process & IRR, NPV, and B/C

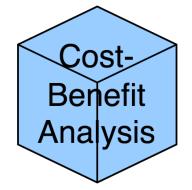


(I) It determines whether the project is efficient from a market perspective.

(II) Since it can be a large-scale infrastructure project that would be financed, built, and operated by the government, a build-operate-transfer contract point of view can be taken into consideration.

(III) It examines the proposed project from the financial perspective by netting the interests, taxes, and debt flows.

Method Used



: A systematic process of evaluating the desirability of a decision by weighing its potential benefits and costs

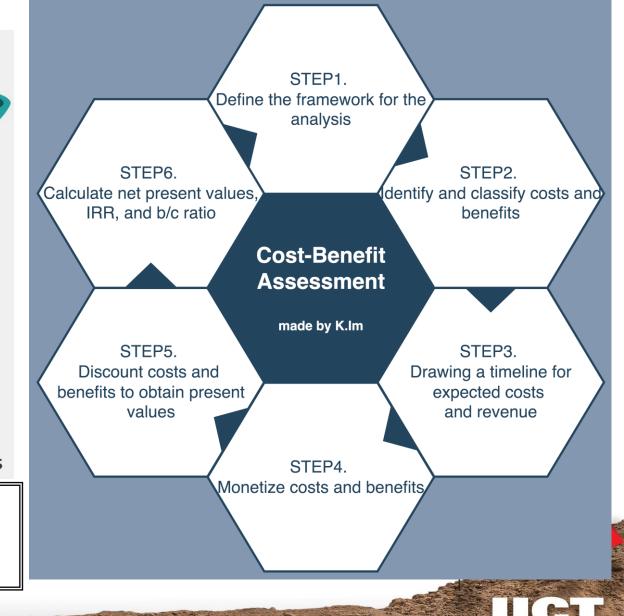
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Benefits - Costs = Net Benefits

: It evaluates the cost versus the benefit of a project to determine project feasibility as well as provide a decisionmaking metric when weighing up multiple options

A Process for Performing a Cost-benefit Assessment



Key Parameters

To conduct a benefit-cost assessment in terms of private, financial, economic, efficiency using nominal and real terms, if the key parameters are summarized in a table, those are as follows

Parameters		
development period	5	years
benefit period	20	years
Benefit_growing annual rate	2.0%	beginning in Y7
Income tax rate	9.3%	California state income tax
Real SPC discount rate	11%	
Initial annual benefit	\$250,000,000	beginning at the end of year
Initial operation and maintenance cost	\$80,000,000	from year 6 to end year
Nominal interest rate_ Debt (proposed project)	8%	
Loan financing	85%	(15% equity)
Loan repayment period	15	years
Inflation rate	3%	
Nominal SPC discount rate	14.33%	<=*(1+r)=(1+r)(1+i)
* Real interest rate_ Debt (* $r = (1+r)/(1+i)-1$): 4.85%		

* Interest during the development period is capitalized

r = (1 + r) (1 + i) - 1

* Under US tax law, depreciation and loan interest, but not loan principal payment, are tax deductible.

Assumptions of Stochastic Analysis-1

- The assumptions of stochastic analysis used in this research have additional main project parameters as follows.
- Stochastic analysis is used to model uncertainty in crucial project parameters in these analyses and to evaluate various risky projects.

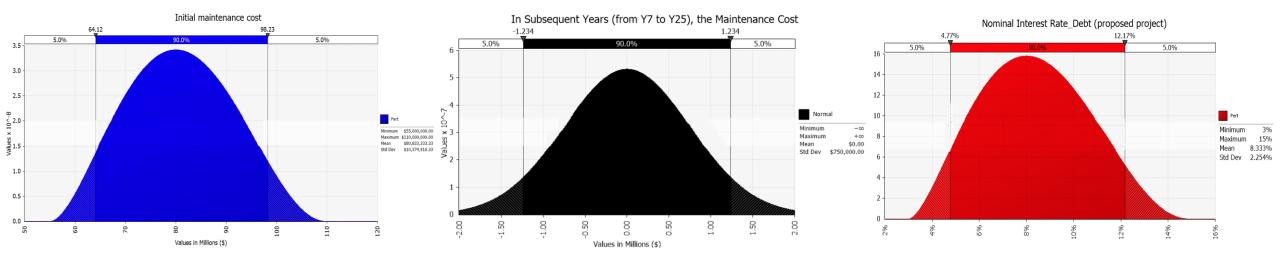
The initial annual benefit level is normally distributed with a mean of \$250,000,000 and a standard deviation of \$36,000,000.

The benefits increase each year has an unknown distribution and hence is assumed triangular with a minimum of -2%, a most likely value of 2%, and a maximum of 5%.



Assumptions of Stochastic Analysis-2

The initial year's operation and maintenance cost has a Pert distribution with a minimum of \$55,000,000, a mode of \$80,000,000, and a maximum of \$110,000,000. In subsequent years (from Y7 to Y25), the operation and maintenance cost is equal to the previous year's cost plus a normally distributed random component with a mean \$0 and a standard deviation of \$750,000. The nominal loan interest rate is not known with certainty, but one it has identified at the beginning of the project, it is fixed for the life of the project. It is assumed a Pert distribution with a minimum of 3%, a mode of 8%, and a maximum of 15%.



<The Initial Year's operation and maintenance Cost - Pert Distribution> <In Subsequent Years (from Y7 to Y25), the Operation and Maintenance Cost>

<The Nominal Loan Interest Rate>

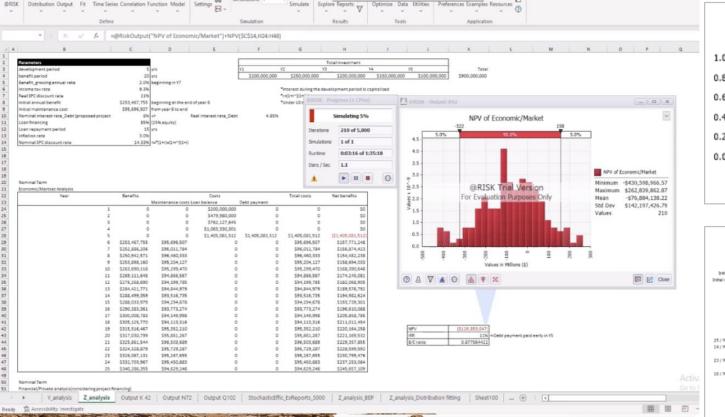
□ Under United States tax law, depreciation and loan interest, but not loan principal payment, are tax-deductible, and the interest during the development period is capitalized.

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I) Economic/market analysis

I) Economic/market analysis - assessing the benefits and costs of the project at market prices without any consideration of financing or taxes except that the interest during construction will be included in the capital charge to be applied in year 5. It is calculated the NPV and IRR. 🖉 fx 🖬





Summary Statistics		
Statistic	Value	
Minimum	-\$ 564,840,771.10	
Maximum	\$405,279,059.27	
Mean	-\$ 73,487,969.39	
Std. Deviation	\$ 136,552,312.03	
Variance	1.865E+016	
Skewness	0.0157	
Kurtosis	2.9642	
Median	-\$ 74,887,569.80	
Mode	-\$ 54,623,445.90	
Left X	-\$299,767,884.55	
Left P	5%	
Right X	\$ 146,837,267.70	
Right P	95%	

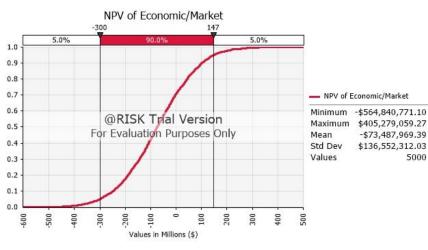


Percentiles		
Percentile	Value	
1%.	-\$ 387,846,404.43	
2.5%	-\$ 344,133,047.03	
5%	-\$ 299,767,884.55	
10%	-\$ 246,914,698.94	
20%	-\$ 188,705,190.75	
25%	-\$ 166,517,658.44	
50%	-\$ 74,887,569.80	
75%	\$ 19,929,648.96	
80%	\$ 43,282,797.50	
90%	\$ 100,815,413.56	
95%	\$ 146,837,267.70	
97.5%	\$ 194,775,559.08	
99%	\$ 254,084,893.89	

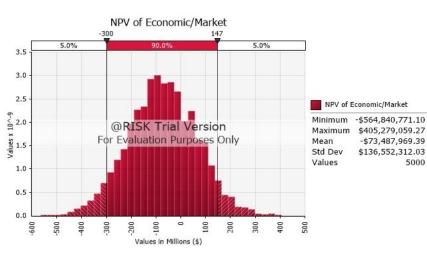
Initial email benefit Initial maintenance cost 7 / Benefits = 8 / Benefits = 9 / Benefits = 15 / Benefits =	4305,001,004,005 4315,001,002,00 4315,000,003 4315,000,003 4315,000,004 4315,000,000 4315,000,	To sut Walt
10 / Benefits = 11 / Benefits = 15 / Benefits = 12 / Benefits =	@RISK Trial Version For Evaluation Purposes Only	Input High
25 / Maintananos colto 24 / Maintananos colto 25 / Bunafito 23 / Maintananos colto	486,007/03644 472,258,00845 -685,001/08155 495,757,534,29 -686,005/04105 484,001,008 53 -686,005/0110 484,001,008 53 -686,005/04105 484,003,008 53	Input Low
15 / Bunafita - 16 / Maintenance costa -	Baseline = -\$73,487,969.39	-
05	300 250 250 250 250 250 250 250 250 250 2	000

Change in Output					
Rank	Name	Lower	Upper		
1	Initial annual benefit	-\$ 302,412,623	\$ 152,938,717		
2	Initial maintenance co	-\$ 135,938,030	-\$ 19,930,958		
3	77Benefits	-\$ 98,765,441	-\$56,793,409		
4	87Benefits	-\$ 97,215,310	-\$ 55,913,909		
5	97Benefits	-\$88,229,369	-\$53,083,736		
6	13 / Benefits	-\$87,428,314	-\$ 54,350,038		
7	10 / Benefits	-\$87,904,834	-\$ 56,811,709		
8	11/Benefits	-\$89,363,476	-\$ 59,129,291		
9	18 / Benefits	-\$87,044,756	-\$ 58,271,258		
10	12 / Benefits	-\$ 90,707,283	-\$62,096,467		
11	257 Maintenance cost	-\$ 89,097,610	-\$ 62,255,850		
12	14 / Maintenance cost	-\$ 85,810,662	-\$59,757,324		
13	15 / Benefits	-\$86,555,655	-\$ 60,925,891		
A CONTRACTOR OF					

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Cumulative Distribution Function of Net Present Value of Economic/Market Analysis



Histogram of Net Present Value of Economic/Market

Analysis

Year		Benefits		Costs		Total costs	Net benefits
		M	laintenance costs Loa	an balance	Debt payment		
	1	0	0	\$200,000,000	0	0	\$0
	2	0	0	\$479,980,000	0	0	\$
	3	0	0	\$762,127,645	0	0	\$
	4	0	0	\$1,063,330,301	0	0	\$
	5	0	0	\$1,405,081,512	\$1,405,081,512	\$1,405,081,512	(\$1,405,081,51
	6	\$250,000,000	\$80,000,000	0	0	\$80,000,000	\$170,000,00
	7	\$254,166,667	\$80,000,000	0	0	\$80,000,000	\$174,166,66
	8	\$258,402,778	\$80,000,000	0	0	\$80,000,000	\$178,402,77
	9	\$262,709,491	\$80,000,000	0	0	\$80,000,000	\$182,709,49
	10	\$267,087,982	\$80,000,000	0	0	\$80,000,000	\$187,087,98
	11	\$271,539,449	\$80,000,000	0	0	\$80,000,000	\$191,539,44
	12	\$276,065,106	\$80,000,000	0	0	\$80,000,000	\$196,065,10
	13	\$280,666,191	\$80,000,000	0	0	\$80,000,000	\$200,666,19
	14	\$285,343,961	\$80,000,000	0	0	\$80,000,000	\$205,343,96
	15	\$290,099,694	\$80,000,000	0	0	\$80,000,000	\$210,099,69
	16	\$294,934,689	\$80,000,000	0	0	\$80,000,000	\$214,934,68
	17	\$299,850,267	\$80,000,000	0	0	\$80,000,000	\$219,850,26
	18	\$304,847,771	\$80,000,000	0	0	\$80,000,000	\$224,847,77
	19	\$309,928,567	\$80,000,000	0	0	\$80,000,000	\$229,928,56
	20	\$315,094,044	\$80,000,000	0	0	\$80,000,000	\$235,094,04
	21	\$320,345,611	\$80,000,000	0	0	\$80,000,000	\$240,345,61
	22	\$325,684,704	\$80,000,000	0	0	\$80,000,000	\$245,684,70
	23	\$331,112,783	\$80,000,000	0	0	\$80,000,000	\$251,112,78
	24	\$336,631,329	\$80,000,000	0	0	\$80,000,000	\$256,631,32
	25	\$342,241,851	\$80,000,000	0	0	\$80,000,000	\$262,241,85

NPV	(\$71,413,805)]
IRR	13%	<-Debt payment paid early in Y5
B/C ratio	0.927531419	

Real Term Economie

5000

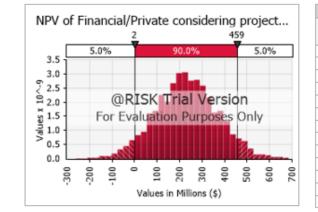
ic/Martket Analysis							
Year		Benefits		Costs		Total costs	Net benefits
		M	laintenance costs	Loan balance	Debt payment		
	1	0	0	\$194,174,757	0	0	\$0
	2	0	0	\$452,427,184	0	0	\$0
	3	0	0	\$697,454,757	0	0	\$0
	4	0	0	\$944,755,200	0	0	\$0
	5	0	0	\$1,212,035,655	\$1,212,035,655	\$1,212,035,655	(\$1,212,035,655)
	6	\$209,371,064	\$66,998,741	0	0	\$66,998,741	\$142,372,324
	7	\$206,660,759	\$65,047,321	0	0	\$65,047,321	\$141,613,438
	8	\$203,985,539	\$63,152,739	0	0	\$63,152,739	\$140,832,800
	9	\$201,344,949	\$61,313,339	0	0	\$61,313,339	\$140,031,611
	10	\$198,738,542	\$59,527,513	0	0	\$59,527,513	\$139,211,029
	11	\$196,165,875	\$57,793,702	0	0	\$57,793,702	\$138,372,173
	12	\$193,626,511	\$56,110,390	0	0	\$56,110,390	\$137,516,121
	13	\$191,120,019	\$54,476,107	0	0	\$54,476,107	\$136,643,912
	14	\$188,645,973	\$52,889,424	0	0	\$52,889,424	\$135,756,549
	15	\$186,203,954	\$51,348,956	0	0	\$51,348,956	\$134,854,999
	16	\$183,793,547	\$49,853,355	0	0	\$49,853,355	\$133,940,192
	17	\$181,414,343	\$48,401,316	0	0	\$48,401,316	\$133,013,027
	18	\$179,065,937	\$46,991,569	0	0	\$46,991,569	\$132,074,368
	19	\$176,747,931	\$45,622,882	0	0	\$45,622,882	\$131,125,049
	20	\$174,459,932	\$44,294,060	0	0	\$44,294,060	\$130,165,872
	21	\$172,201,551	\$43,003,942	0	0	\$43,003,942	\$129,197,609
	22	\$169,972,405	\$41,751,400	0	0	\$41,751,400	\$128,221,005
	23	\$167,772,115	\$40,535,340	0	0	\$40,535,340	\$127,236,775
	24	\$165,600,308	\$39,354,699	0	0	\$39,354,699	\$126,245,609
	25	\$163,456,614	\$38,208,446	0	0	\$38,208,446	\$125,248,169

NPV	(\$71,413,805)	
IRR	9%	<-Debt payment paid early in Y5
B/C ratio	0.927531419	

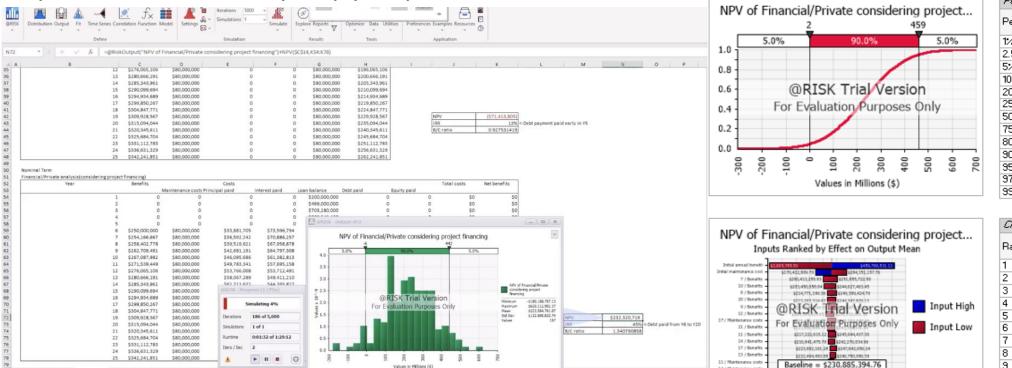
II) Financial/private analysis -(considering project financing)

II) Financial/private analysis - (considering project financing) assessing the benefits and costs to the Special Purpose Corporation (SPC). It is assumed the SPC makes a loan for 85% of the total investment with the 15% equity paid at the end of year 5, repayable at an 8% interest rate. It is assumed that the loan balance at the end of year five, which includes capitalized interest, less equity paid is serviced through equal installments over a fifteen-year repayment period.

0 4 7 4 0 4 * %



Summary Statistics		
Value		
-\$ 261,576,136.81		
\$ 685,137,636.85		
\$ 230,885,394.76		
\$ 136,902,152.19		
1.874E+016		
0.0222		
2.9546		
\$ 229,968,058.35		
\$ 211,700,806.66		
\$ 1,717,919.30		
5%		
\$ 458,560,856.47		
95%		



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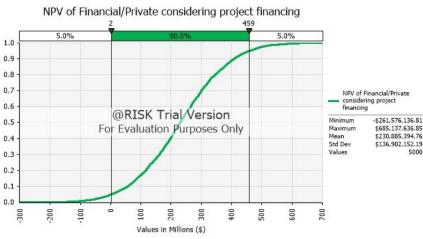
Percentiles			
Percentile	Value		
1%.	-\$83,852,458.08		
2.5%	-\$ 41,623,876.88		
5%	\$ 1,717,919.30		
10%	\$ 56,790,408.11		
20%	\$ 116,217,521.79		
25%	\$ 139,433,252.32		
50%	\$ 229,968,058.35		
75%	\$ 321,267,062.54		
30%	\$ 345,079,402.61		
30%	\$ 408,293,435.27		
35%	\$ 458,560,856.47		
97.5%	\$ 497,764,227.68		
39%	\$ 554,537,296.78		

Change in Dutput					
Rank	Name	Lower	Upper		
1	Initial annual benefit	\$1,665,786	\$459,769,531		
2	Initial maintenance co	\$ 170,422,810	\$284,351,158		
3	7/Benefits	\$200,413,256	\$ 251,855,723		
4	10 / Benefits	\$203,450,058	\$244,627,463		
5	87Benefits	\$ 214,771,199	\$249,399,425		
6	207Benefits	\$ 213,203,314	\$244,347,829		
7	97Benefits	\$217,346,334	\$248,471,368		
8	12 / Benefits	\$209,524,926	\$239,533,002		
9	17 / Maintenance cost	\$215,466,427	\$245,203,048		
10	21/Benefits	\$213,988,865	\$243,388,192		
11	11/Benefits	\$ 217,222,615	\$245,044,437		
12	14 / Benefits	\$216,841,476	\$242,276,035		
13	17 / Benefits	\$ 223,082,161	\$247,642,656		

UNDERGROUND CONSTRUCTION TECHNOLOGY

Values in Millions (\$

Output K 42 Output N72 Output O10



Nominal Term

Real Term

5000

Financial/Private analysis(considering project financing)

Year

Benefits

i con		Dementes		00505						10101 00515	net benefits
			Maintenance costs	Principal paid	Interest paid	b	oan balance	Debt paid	Equity paid		
	1	0	0	0		0	\$200,000,000	0	0	\$0	\$0
	2	0	0	0		0	\$466,000,000	0	0	\$0	\$0
	3	0	0	0		0	\$703,280,000	0	0	\$0	\$0
	4	0	0	0		0	\$909,542,400	0	0	\$0	\$0
	5	0	0	0		0	\$919,959,923	0	\$162,345,869	\$162,345,869	(\$162,345,869)
	6	\$250,000,000	\$80,000,000	\$33,881,705	\$73,596,794	ŧ.	\$886,078,218	\$107,478,499	0	\$187,478,499	\$62,521,501
	7	\$254,166,667	\$80,000,000	\$36,592,242	\$70,886,257	7	\$849,485,976	\$107,478,499	0	\$187,478,499	\$66,688,167
	8	\$258,402,778	\$80,000,000	\$39,519,621	\$67,958,878	3	\$809,966,355	\$107,478,499	0	\$187,478,499	\$70,924,279
	9	\$262,709,491	\$80,000,000	\$42,681,191	\$64,797,308	3	\$767,285,164	\$107,478,499	0	\$187,478,499	\$75,230,992
	10	\$267,087,982	\$80,000,000	\$46,095,686	\$61,382,813	3	\$721,189,478	\$107,478,499	0	\$187,478,499	\$79,609,483
	11	\$271,539,449	\$80,000,000	\$49,783,341	\$57,695,158	3	\$671,406,137	\$107,478,499	0	\$187,478,499	\$84,060,949
	12	\$276,065,106	\$80,000,000	\$53,766,008	\$53,712,491	L	\$617,640,129	\$107,478,499	0	\$187,478,499	\$88,586,607
	13	\$280,666,191	\$80,000,000	\$58,067,289	\$49,411,210)	\$559,572,840	\$107,478,499	0	\$187,478,499	\$93,187,692
	14	\$285,343,961	\$80,000,000	\$62,712,672	\$44,765,827	7	\$496,860,168	\$107,478,499	0	\$187,478,499	\$97,865,462
	15	\$290,099,694	\$80,000,000	\$67,729,686	\$39,748,813	8	\$429,130,482	\$107,478,499	0	\$187,478,499	\$102,621,195
	16	\$294,934,689	\$80,000,000	\$73,148,061	\$34,330,439)	\$355,982,422	\$107,478,499	0	\$187,478,499	\$107,456,189
	17	\$299,850,267	\$80,000,000	\$78,999,905	\$28,478,594		\$276,982,516	\$107,478,499	0	\$187,478,499	\$112,371,768
	18	\$304,847,771	\$80,000,000	\$85,319,898	\$22,158,601	L	\$191,662,619	\$107,478,499	0	\$187,478,499	\$117,369,272
	19	\$309,928,567	\$80,000,000	\$92,145,490	\$15,333,009)	\$99,517,129	\$107,478,499	0	\$187,478,499	\$122,450,068
	20	\$315,094,044	\$80,000,000	\$99,517,129	\$7,961,370)	\$0	\$107,478,499	0	\$187,478,499	\$127,615,544
	21	\$320,345,611	\$80,000,000	0		0	\$0	\$0	0	\$80,000,000	\$240,345,611
	22	\$325,684,704	\$80,000,000	0		0	\$0	\$0	0	\$80,000,000	\$245,684,704
	23	\$331,112,783	\$80,000,000	0		0	\$0	\$0	0	\$80,000,000	\$251,112,783
	24	\$336,631,329	\$80,000,000	0		0	\$0	\$0	0	\$80,000,000	\$256,631,329
	25	\$342,241,851	\$80,000,000	0		0	\$0	\$0	0	\$80,000,000	\$262,241,851

Costs

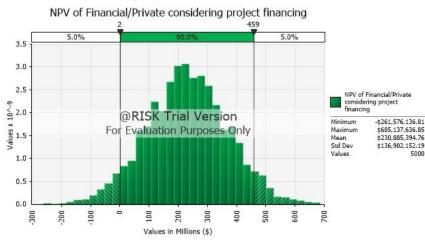
Total costs

Net benefits

NPV	\$232,320,719	
IRR	45%	<-Debt paid from Y6 to Y20
B/C ratio	1.340790858	

Cumulative Distribution Function of Net Present Value of Financial/Private Analysis considering

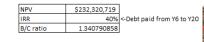
project financing



Histogram Net Present Value of Financial/Private

Analysis considering project financing

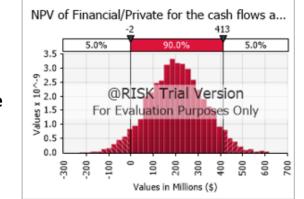
Year		Benefits		Costs					Total costs	Net benefits
			Maintenance costs P	rincipal paid	Interest paid	Loan balance	Debt paid	Equity paid		
	1	0	0	0	C	\$194,174,75	7 0	0	\$0	\$0
	2	0	0	0	C	\$439,249,69	4 O	0	\$0	\$0
	3	0	0	0	C	\$643,600,82	5 0	0	\$0	\$0
	4	0	0	0	C	\$808,116,64	2 0	0	\$0	\$0
	5	0	0	0	C	\$793,565,51	L 0	\$140,040,973	\$140,040,973	(\$140,040,973
	6	\$209,371,064	\$66,998,741	\$28,375,395	\$61,636,156	\$742,076,55	\$90,011,551	0	\$157,010,292	\$52,360,773
	7	\$206,660,759	\$65,047,321	\$29,752,841	\$57,637,014	\$690,709,83	\$87,389,855	0	\$152,437,176	\$54,223,583
	8	\$203,985,539	\$63,152,739	\$31,197,154	\$53,647,366	\$639,394,92	\$84,844,520	0	\$147,997,258	\$55,988,280
	9	\$201,344,949	\$61,313,339	\$32,711,579	\$49,661,741	\$588,060,18	\$82,373,320	0	\$143,686,659	\$57,658,291
	10	\$198,738,542	\$59,527,513	\$34,299,519	\$45,674,578	\$536,632,70	\$79,974,097	0	\$139,501,610	\$59,236,932
	11	\$196,165,875	\$57,793,702	\$35,964,545	\$41,680,210	\$485,038,07	\$77,644,755	0	\$135,438,457	\$60,727,418
	12	\$193,626,511	\$56,110,390	\$37,710,396	\$37,672,860	\$433,200,36	\$75,383,257	0	\$131,493,647	\$62,132,864
	13	\$191,120,019	\$54,476,107	\$39,540,998	\$33,646,630	\$381,041,87	\$73,187,628	0	\$127,663,735	\$63,456,284
	14	\$188,645,973	\$52,889,424	\$41,460,464	\$29,595,485	\$328,483,10	\$71,055,950	0	\$123,945,374	\$64,700,599
	15	\$186,203,954	\$51,348,956	\$43,473,108	\$25,513,251	\$275,442,52	\$68,986,359	0	\$120,335,315	\$65,868,640
	16	\$183,793,547	\$49,853,355	\$45,583,453	\$21,393,594	\$221,836,47	\$66,977,047	0	\$116,830,403	\$66,963,145
	17	\$181,414,343	\$48,401,316	\$47,796,242	\$17,230,018	\$167,578,97	\$65,026,260	0	\$113,427,575	\$67,986,767
	18	\$179,065,937	\$46,991,569	\$50,116,448	\$13,015,843	\$112,581,58	\$63,132,291	0	\$110,123,859	\$68,942,077
	19	\$176,747,931	\$45,622,882	\$52,549,285	\$8,744,201	\$56,753,22	\$61,293,486	0	\$106,916,368	\$69,831,563
	20	\$174,459,932	\$44,294,060	\$55,100,221	\$4,408,018	\$	\$59,508,239	0	\$103,802,299	\$70,657,633
	21	\$172,201,551	\$43,003,942	0	C) Ş(D \$0	0	\$43,003,942	\$129,197,609
	22	\$169,972,405	\$41,751,400	0	C) Ş(D \$0	0	\$41,751,400	\$128,221,005
	23	\$167,772,115	\$40,535,340	0	C) ŞI	D \$0	0	\$40,535,340	\$127,236,775
	24	\$165,600,308	\$39,354,699	0	C) ŞI	D \$0	0	\$39,354,699	\$126,245,609
	25	\$163,456,614	\$38,208,446	0	C	SI SI) \$0	0	\$38,208,446	\$125,248,169



III) Financial/private analysis - (for the cash flows after finance and taxes)

18

III) Financial/private analysis - (for the cash flows after finance and taxes) calculating the NPV and IRR for the cash flows after finance and taxes. The total capital investment can be depreciated under US tax law over a period of 15 years, starting in year 6 using the straight-line method. Salvage value is zero. Under US tax law, depreciation and loan interest (but not loan principal payment) are tax-deductible. It is assumed the interest capitalized in capital investment is not tax-deductible.



Value
-\$227,713,043.57
\$ 619,020,096.16
\$ 204,601,604.87
\$ 124,547,952.30
1.551E+016
0.0269
2.9369
\$ 203,255,170.13
\$ 192,576,815.75
-\$2,238,791.87
5%
\$ 412,810,084.29
95%

Value

-\$ 79,339,178.55

-\$41,855,013,80

-\$2,238,791.87

\$47,639,065.52

\$ 99,204,540.89

\$118,693,475.90

\$203,255,170,13

\$288,223,332.20

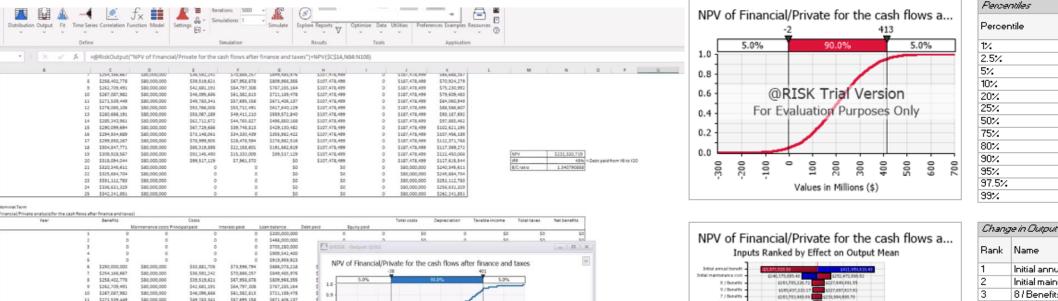
\$309,657,508.13

\$366,609,166,00

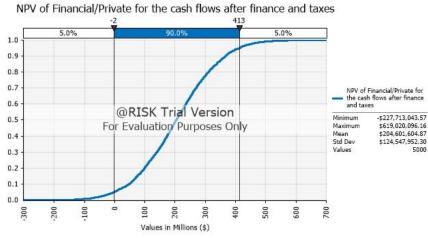
\$412,810,084,29

\$448,109,495.83

\$494.081.819.25

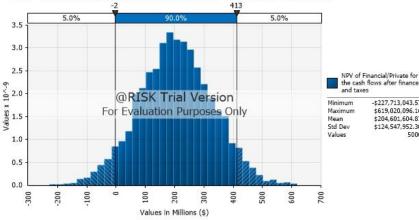


UNDERGROUND CONSTRUCTION TECHNOLOGY



Cumulative Distribution Function of Net Present Value of Financial/Private Analysis for the cash flows after finance and taxes

NPV of Financial/Private for the cash flows after finance and taxes



tion Purposes Only	Minimum -§227,713,043.57 Maximum \$619,020,096.16 Mean \$204,601,604.67 Std Dev \$124,547,952.30 Values 5000	

Histogram Net Present Value of Financial/Private Analysis for the cash flows after finance and taxes

21 \$320,345,611 \$80,000,000 0 0 \$0 \$0 \$0 \$80,000,000 0 \$240,345,611 \$22,352,142 \$217,993,469 22 \$325,684,704 \$80,000,000 0 0 \$0 \$0 \$0 \$80,000,000 0 \$245,684,704 \$22,484,678 \$22,238,027 23 \$331,112,783 \$80,000,000 0 \$0 \$0 \$0 \$0 \$0 \$80,000,000 \$256,681,329 \$23,854,89 \$227,759,294 24 \$336,51,329 \$80,000,000 0 \$0 \$0 \$0 \$80,000,000 0 \$256,681,329 \$23,866,714 \$23,2764,616	nancial/Private analysis(for the cas	h flows a	fter finance and t	axes)										
1 0 0 0 \$200,000,000 0 \$0 </td <td>Year</td> <td></td> <td>Benefits</td> <td></td> <td>Costs</td> <td></td> <td></td> <td></td> <td></td> <td>Total costs</td> <td>Depreciation</td> <td>Taxable income</td> <td>Total taxes</td> <td>Net benefits</td>	Year		Benefits		Costs					Total costs	Depreciation	Taxable income	Total taxes	Net benefits
2 0 0 0 0 54600000 0 0 559,319,047 551,547,849 551,566,21 53,02,445 559,319,047 551,567,576,57 57,356,79 5849,485,976 5107,478,499 511,647,849 561,566,214 548,475,66 54,502,23 550,27,78 57,356,146 50 52,27,77 57,356,146 50 52,27,77 57,356,146 5107,478,499 51,562,214 548,475,65 55,202,78 57,356,146 50 52,27,77 57,356,146 50 52,27,77 57,356,146 50 52,27,77 57,356,146 50 50,27,78 57,356,146 50 50,27,71 57,356,146 50 51				Maintenance costs Pr	incipal paid	Interest paid	Loan balance	Debt paid	Equity paid					
3 0 0 0 0 5703,280,000 0 0 50 50 50 50 50 4 0 0 0 5909,542,400 0 5162,345,869 5166,345,869 5107,478,499		1	0	0	0		0 \$200,000,000) 0	0	\$0	0	\$0	\$0	\$0
4 0 0 0 999542,400 0 0 51 51 <		2	0	0	0		0 \$466,000,000) 0	0	\$0	0	\$0	\$0	\$0
5000\$919,959,2230\$162,345,869\$162,345,8690\$0\$0\$0\$0\$162,345,8696\$250,000,000\$80,000,000\$33,881,705\$77,956,794\$886,078,218\$107,478,4990\$187,478,499\$61,968,214\$34,434,992\$33,202,454\$55,93,19,0477\$254,165,667\$80,000,000\$39,519,621\$67,558,878\$809,966,355\$107,478,4990\$187,478,499\$61,968,214\$44,152,566\$4,508,239\$66,416,0409\$226,708,7941\$80,000,000\$42,681,191\$67,558,878\$107,478,4990\$187,478,499\$61,968,214\$54,956,555\$5,707,285,16410\$267,087,982\$80,000,000\$42,681,191\$567,125,158\$107,478,4990\$187,478,499\$61,968,214\$51,876,756,75\$5,707,285,175,775,47411\$277,505,166\$80,000,000\$53,766,008\$53,712,491\$107,478,4990\$187,478,499\$61,968,214\$51,876,75\$5,83,756,775,47412\$276,055,106\$80,000,000\$53,766,008\$53,712,491\$107,478,4990\$187,478,499\$61,968,214\$80,384,401\$7,478,74913\$238,066,191\$80,000,000\$56,71,272\$44,765,827\$496,816,88\$107,478,4990\$187,478,499\$61,968,214\$108,384,401\$34,480,43314\$225,343,961\$80,000,000\$67,729,866\$39,748,813\$429,130,482\$107,478,4990\$187,478,499\$61,968,214\$189,696,9915 <td></td> <td>3</td> <td>0</td> <td>0</td> <td>0</td> <td></td> <td>0 \$703,280,000</td> <td>) 0</td> <td>0</td> <td>\$0</td> <td>0</td> <td>\$0</td> <td>\$0</td> <td>\$0</td>		3	0	0	0		0 \$703,280,000) 0	0	\$0	0	\$0	\$0	\$0
6 \$250,000,000 \$80,000,000 \$33,881,705 \$73,596,794 \$886,078,218 \$107,478,499 0 \$187,478,499 \$61,968,214 \$34,434,992 \$32,02,454 \$59,319,047 7 \$254,166,677 \$80,000,000 \$39,592,242 \$57,088,6277 \$849,485,976 \$107,478,499 0 \$187,478,499 \$61,968,214 \$44,475,686 \$45,082,298 \$66,46,040 9 \$262,709,491 \$80,000,000 \$42,681,191 \$64,797,308 \$767,285,164 \$107,478,499 0 \$187,478,499 \$61,968,214 \$55,943,968 \$52,02,789 \$70,028,020 10 \$267,087,982 \$80,000,000 \$44,075,868 \$55,313,861,946 \$107,478,499 0 \$187,478,499 \$61,968,214 \$51,87,478,495 \$51,968,214 \$52,92,737 \$73,861,946 11 \$277,159,494 \$80,000,000 \$53,766,008 \$55,712,491 \$61,764,129 \$107,478,499 \$187,478,499 \$61,968,214 \$80,884,401 \$7,475,479 \$81,110,858 13 \$280,666,191 \$80,000,000 \$53,762,008 \$53,712,491 \$61,774,8499 \$187,478,499 \$61,968,214 \$80,886,0920 \$89,254,1607		4	0	0	0		0 \$909,542,400) 0	0	\$0	0	\$0	\$0	\$0
7 \$254,166,667 \$80,000,000 \$36,592,242 \$70,886,257 \$849,485,976 \$107,478,499 0 \$187,478,499 \$61,968,214 \$41,312,195 \$3,842,034 \$56,84,133 8 \$258,402,778 \$80,000,000 \$39,519,621 \$56,7958,878 \$809,966,355 \$107,478,499 0 \$187,478,499 \$61,968,214 \$48,475,686 \$45,002,202 10 \$267,087,882 \$80,000,000 \$46,095,666 \$51,32,413 \$77,285,164 \$107,478,499 0 \$187,478,499 \$61,968,214 \$55,943,968 \$5,202,789 \$70,028,002 11 \$271,539,449 \$80,000,000 \$46,095,666 \$61,382,413 \$77,6141 \$107,478,499 0 \$187,478,499 \$61,968,214 \$51,676,755 \$5,927,537 \$73,736,474 12 \$276,065,106 \$80,000,000 \$53,766,008 \$53,712,491 \$61,761,272 \$107,478,499 0 \$187,478,499 \$61,968,214 \$80,384,401 \$74,75,749 \$81,480,203 13 \$280,666,191 \$80,000,000 \$53,766,028 \$49,41,10 \$555,272,840 \$107,478,499 \$187,478,499 \$61,968,214 \$108,380,666 \$10,775,789		5	0	0	0		0 \$919,959,923	. 0	\$162,345,869	\$162,345,869	0	\$0	\$0	(\$162,345,869)
8 \$258,402,778 \$80,000,000 \$39,519,621 \$67,958,878 \$809,966,355 \$107,478,499 0 \$187,478,499 \$61,968,214 \$54,975,685 \$54,202,798 \$702,282,164 9 \$262,709,491 \$80,000,000 \$42,681,191 \$564,797,308 \$767,285,164 \$107,478,499 0 \$187,478,499 \$61,968,214 \$55,943,868 \$52,02,789 \$70,282,02 10 \$267,087,982 \$80,000,000 \$44,978,341 \$57,695,158 \$671,406,137 \$107,478,499 0 \$187,478,499 \$61,968,214 \$71,876,076 \$6,684,475 \$77,376,474 12 \$276,055,106 \$80,000,000 \$53,766,008 \$53,712,471 \$517,478,499 0 \$187,478,499 \$61,968,214 \$71,876,077 \$8,6684,475 \$77,376,474 13 \$280,666,191 \$80,000,000 \$58,072,289 \$40,411,210 \$559,572,840 \$107,478,499 0 \$187,478,499 \$61,968,214 \$80,884,601 \$84,844,023 14 \$285,343,611 \$80,000,000 \$67,729,686 \$34,304,439 \$355,82,422 \$107,478,499 \$187,478,499 \$61,968,214 \$108,826,666 \$10,079,588 \$89,74		6	\$250,000,000	\$80,000,000	\$33,881,705	\$73,596,79	\$886,078,218	\$107,478,499	0	\$187,478,499	\$61,968,214	\$34,434,992	\$3,202,454	\$59,319,047
9 \$262,709,491 \$80,000,000 \$42,681,191 \$64,797,308 \$767,285,164 \$107,478,499 0 \$187,478,499 \$61,968,214 \$55,943,968 \$52,02,789 \$70,028,020 10 \$267,087,982 \$80,000,000 \$46,095,686 \$51,382,813 \$721,189,478 \$107,478,499 0 \$187,478,499 \$61,968,214 \$55,943,968 \$52,27,589 \$73,081,946 11 \$227,105,91,405 \$80,000,000 \$53,766,008 \$53,712,491 \$617,640,129 \$107,478,499 0 \$187,478,499 \$61,968,214 \$80,384,401 \$7,475,479 \$81,110,858 12 \$276,065,106 \$80,000,000 \$53,766,008 \$53,712,491 \$617,640,129 \$107,478,499 0 \$187,478,499 \$61,968,214 \$80,384,401 \$7,475,479 \$81,110,858 13 \$280,666,191 \$80,000,000 \$56,772,866 \$39,748,813 \$429,130,482 \$107,478,499 \$187,478,499 \$61,968,214 \$80,860,920 \$92,541,607 15 \$290,099,694 \$80,000,000 \$77,31,848,453 \$343,304,39 \$355,982,422 \$107,478,499 \$187,478,499 \$61,968,214 \$118,636,033 \$103,3151		7	\$254,166,667	\$80,000,000	\$36,592,242	\$70,886,25	\$849,485,976	\$107,478,499	0	\$187,478,499	\$61,968,214	\$41,312,195	\$3,842,034	\$62,846,133
10 \$267,087,982 \$80,000,000 \$46,095,686 \$61,382,813 \$721,189,478 \$107,478,499 0 \$187,478,499 \$61,968,214 \$563,736,955 \$5,927,537 \$73,681,946 11 \$271,539,449 \$80,000,000 \$49,783,341 \$57,695,158 \$57,1406,137 \$107,478,499 0 \$187,478,499 \$61,968,214 \$187,478,491 \$61,968,214 \$80,034,401 \$7,475,49 \$73,757,474 12 \$226,666,191 \$80,000,000 \$58,07,288 \$49,41,10 \$559,572,840 \$107,478,499 0 \$187,478,499 \$61,968,214 \$80,384,401 \$7,475,49 \$81,80,484 14 \$285,343,961 \$80,000,000 \$58,271,2672 \$44,658,227 \$496,860,168 \$107,478,499 0 \$187,478,499 \$61,968,214 \$108,824,666 \$10,079,588 \$92,67,67 \$8,80,000,000 \$52,712,672 \$44,658,227 \$496,860,168 \$107,478,499 0 \$187,478,499 \$61,968,214 \$108,824,666 \$10,079,588 \$92,547,67 \$8,80,003,000 \$92,527,67 \$8,80,004,308 \$53,558,242 \$107,478,499 \$187,478,499 \$61,968,214 \$108,62,64 \$108,64,430,38 \$108,644,308 <		8	\$258,402,778	\$80,000,000	\$39,519,621	\$67,958,87	\$809,966,355	\$107,478,499	0	\$187,478,499	\$61,968,214	\$48,475,686	\$4,508,239	\$66,416,040
11\$271,539,449\$80,000,000\$49,783,341\$57,695,158\$671,406,137\$107,478,4990\$187,478,499\$61,968,214\$71,876,076\$6,684,475\$77,376,47412\$276,065,106\$80,000,000\$58,060,008\$58,072,89\$49,112,10\$559,572,840\$107,478,4990\$187,478,499\$61,968,214\$80,384,401\$7,475,749\$81,110,88413\$280,666,191\$80,000,000\$58,072,89\$49,112,10\$559,572,840\$107,478,4990\$187,478,499\$61,968,214\$80,384,602\$89,286,677\$88,303,669\$84,840,2314\$285,343,961\$80,000,000\$62,712,968\$34,765,827\$49,668,168\$107,478,4990\$187,478,499\$61,968,214\$108,882,666\$10,079,588\$92,544,67315\$290,099,694\$80,000,000\$67,729,686\$34,300,439\$355,982,422\$107,478,4990\$187,478,499\$61,968,214\$108,882,666\$11,033,124\$10,203,522\$103,37,24616\$294,934,689\$80,000,000\$78,148,061\$34,330,439\$355,982,422\$107,478,4990\$187,478,499\$61,968,214\$116,862,666\$11,033,72417\$299,850,267\$80,000,000\$78,148,601\$191,662,619\$107,478,4990\$187,478,499\$61,968,214\$112,03,522\$10,337,24618\$304,847,771\$80,000,000\$22,158,601\$191,662,619\$107,478,499\$187,478,499\$61,968,214\$12,627,308\$10,42,82,22319\$309,928,567\$80,000,000 <td< td=""><td></td><td>9</td><td>\$262,709,491</td><td>\$80,000,000</td><td>\$42,681,191</td><td>\$64,797,30</td><td>\$767,285,164</td><td>\$107,478,499</td><td>0</td><td>\$187,478,499</td><td>\$61,968,214</td><td>\$55,943,968</td><td>\$5,202,789</td><td>\$70,028,202</td></td<>		9	\$262,709,491	\$80,000,000	\$42,681,191	\$64,797,30	\$767,285,164	\$107,478,499	0	\$187,478,499	\$61,968,214	\$55,943,968	\$5,202,789	\$70,028,202
12 \$276,065,106 \$80,000,000 \$53,766,008 \$53,712,491 \$617,640,129 \$107,478,499 0 \$187,478,499 \$61,968,214 \$80,384,401 \$7,475,749 \$81,110,858 13 \$280,666,191 \$80,000,000 \$58,067,289 \$44,712,10 \$559,572,840 \$107,478,499 0 \$187,478,499 \$61,968,214 \$80,886,093 \$89,266,76 \$83,03,669 \$84,884,023 14 \$285,343,961 \$80,000,000 \$562,712,62 \$44,752,72 \$44,756,801,188 \$107,478,499 0 \$187,478,499 \$61,968,214 \$89,266,76 \$83,03,669 \$84,884,023 15 \$290,099,694 \$80,000,000 \$77,31,48,661 \$39,748,813 \$429,130,482 \$107,478,499 0 \$187,478,499 \$61,968,214 \$118,636,035 \$11,03,151 \$96,242,038 16 \$294,934,689 \$80,000,000 \$78,149,905 \$187,478,499 \$61,968,214 \$118,636,035 \$11,03,151 \$96,243,501 \$107,478,499 \$187,478,499 \$61,968,214 \$110,31,51 \$96,243,501 \$103,3124 \$103,3124 \$104,220,235 \$114,784,99 \$61,968,214 \$114,94,343 \$104,220,235 \$114,243,24		10	\$267,087,982	\$80,000,000	\$46,095,686	\$61,382,81	\$721,189,478	\$107,478,499	0	\$187,478,499	\$61,968,214	\$63,736,955	\$5,927,537	\$73,681,946
13 \$280,666,191 \$80,000,000 \$58,057,289 \$49,411,210 \$559,572,840 \$107,478,499 0 \$187,478,499 \$61,968,214 \$89,286,767 \$8,303,669 \$84,884,023 14 \$285,343,661 \$80,000,000 \$62,712,672 \$44,765,827 \$496,860,168 \$107,478,499 0 \$187,478,499 \$61,968,214 \$\$98,089,200 \$9,170,723 \$88,694,739 15 \$290,099,694 \$80,000,000 \$67,729,686 \$39,748,813 \$429,130,482 \$107,478,499 0 \$187,478,499 \$61,968,214 \$108,382,666 \$10,079,388 \$94,6423,038 16 \$294,934,689 \$80,000,000 \$73,148,616 \$343,330,439 \$355,582,422 \$107,478,499 0 \$187,478,499 \$61,968,214 \$103,33151 \$96,423,038 17 \$299,850,267 \$80,000,000 \$78,999,905 \$28,478,594 \$276,982,516 \$107,478,499 0 \$187,478,499 \$61,968,214 \$140,720,956 \$12,034,522 \$100,337,246 18 \$304,487,771 \$80,000,000 \$92,145,490 \$191,562,619 \$107,478,499 \$187,478,499 \$61,968,214 \$140,720,956 \$14,943,433 <t< td=""><td></td><td>11</td><td>\$271,539,449</td><td>\$80,000,000</td><td>\$49,783,341</td><td>\$57,695,15</td><td>\$671,406,137</td><td>\$107,478,499</td><td>0</td><td>\$187,478,499</td><td>\$61,968,214</td><td>\$71,876,076</td><td>\$6,684,475</td><td>\$77,376,474</td></t<>		11	\$271,539,449	\$80,000,000	\$49,783,341	\$57,695,15	\$671,406,137	\$107,478,499	0	\$187,478,499	\$61,968,214	\$71,876,076	\$6,684,475	\$77,376,474
14\$285,343,961\$80,000,000\$62,712,672\$44,765,827\$496,860,168\$107,478,4990\$187,478,499\$61,968,214\$98,609,920\$9,170,723\$88,694,73915\$230,099,694\$80,000,000\$67,729,686\$33,748,813\$429,130,482\$107,478,4990\$187,478,499\$61,968,214\$108,382,606\$10,079,588\$92,541,60716\$239,493,689\$80,000,000\$73,148,061\$34,330,439\$355,982,422\$107,478,4990\$187,478,499\$61,968,214\$118,636,066\$11,033,724617\$239,850,267\$80,000,000\$78,199,905\$28,478,594\$27,5982,516\$107,478,4990\$187,478,499\$61,968,214\$110,345,945\$11,034,522\$103,372,4618\$304,847,771\$80,000,000\$85,319,898\$22,158,601\$191,652,619\$107,478,4990\$187,478,499\$61,968,214\$140,720,956\$13,087,049\$104,282,22319\$309,928,567\$80,000,000\$92,145,490\$51,51,330,009\$99,517,129\$107,478,4990\$187,478,499\$61,968,214\$140,720,956\$13,087,049\$104,282,22320\$315,094,044\$80,000,000\$99,517,129\$107,478,4990\$187,478,499\$61,968,214\$156,5164,459\$15,564,255,55021\$320,345,611\$80,000,00000\$0\$0\$0\$107,478,499\$80,000,000\$240,345,611\$22,952,142\$21,793,46822\$325,684,704\$80,000,00000\$0\$0\$0<		12	\$276,065,106	\$80,000,000	\$53,766,008	\$53,712,49	\$617,640,129	\$107,478,499	0	\$187,478,499	\$61,968,214	\$80,384,401	\$7,475,749	\$81,110,858
15 \$290,099,694 \$80,000,000 \$67,729,686 \$39,748,813 \$429,130,482 \$107,478,499 0 \$187,478,499 \$61,968,214 \$108,382,666 \$10,079,588 \$92,541,607 16 \$294,934,689 \$80,000,000 \$73,148,061 \$355,982,422 \$107,478,499 0 \$187,478,499 \$61,968,214 \$118,636,036 \$110,31,15 \$96,6423,038 17 \$299,99,50,267 \$80,000,000 \$78,149,900 \$187,478,499 \$1187,478,499 \$61,968,214 \$112,403,459 \$112,423,459 \$112,403,459 \$112,403,459 \$112,403,459 \$112,403,459 \$112,403,459 \$114,2263,450 \$114,26		13	\$280,666,191	\$80,000,000	\$58,067,289	\$49,411,21	\$559,572,840	\$107,478,499	0	\$187,478,499	\$61,968,214	\$89,286,767	\$8,303,669	\$84,884,023
16 \$294,934,689 \$80,000,000 \$73,148,061 \$34,330,439 \$355,982,422 \$107,478,499 0 \$187,478,499 \$61,968,214 \$118,636,036 \$11,033,151 \$96,423,038 17 \$299,850,267 \$80,000,000 \$78,999,905 \$28,478,594 \$276,982,516 \$107,478,499 0 \$187,478,499 \$61,968,214 \$129,403,459 \$12,034,522 \$100,337,246 18 \$304,847,771 \$80,000,000 \$78,999,905 \$22,158,601 \$191,662,619 \$107,478,499 \$187,478,499 \$61,968,214 \$12,04,325 \$13,087,049 \$13,087,049 \$13,087,049 \$13,087,049 \$13,087,049 \$13,087,049 \$13,087,049 \$13,087,049 \$13,087,049 \$13,087,049 \$13,087,049 \$13,087,049 \$13,087,049 \$13,087,049 \$13,087,049 \$13,087,049 \$13,087,049 \$13,087,049 \$118,478,499 \$61,968,214 \$165,164,459 \$13,087,049 \$13,087,049 \$13,087,049 \$13,087,049 \$13,087,049 \$13,087,049 \$13,087,049 \$112,252,627,344 \$14,194,345 \$102,52,52 \$112,252,52,52 \$112,252,52,52,52,54,54,54		14	\$285,343,961	\$80,000,000	\$62,712,672	\$44,765,82	\$496,860,168	\$107,478,499	0	\$187,478,499	\$61,968,214	\$98,609,920	\$9,170,723	\$88,694,739
17 \$299,850,267 \$80,000,000 \$78,999,905 \$28,478,594 \$276,982,516 \$107,478,499 0 \$187,478,499 \$61,968,214 \$129,403,459 \$12,034,522 \$100,337,246 18 \$304,847,771 \$80,000,000 \$85,319,898 \$22,158,601 \$191,662,619 \$107,478,499 0 \$187,478,499 \$61,968,214 \$140,720,956 \$13,087,049 \$104,282,223 19 \$309,928,567 \$80,000,000 \$92,145,490 \$151,333,009 \$99,517,129 \$107,478,499 0 \$187,478,499 \$61,968,214 \$142,203,455 \$104,282,223 20 \$315,094,004 \$80,000,000 \$99,517,129 \$107,478,499 0 \$187,478,495 \$61,968,214 \$152,627,344 \$14,914,343 \$108,255,255 21 \$320,345,611 \$80,000,000 0 0 \$0 \$0 \$80,000,000 \$240,345,611 \$22,352,142 \$217,933,469 22 \$325,684,704 \$80,000,000 0 \$0 \$0 \$0 \$80,000,000 \$245,684,704 \$22,486,678 \$22,2,352,142 \$217,933		15	\$290,099,694	\$80,000,000	\$67,729,686	\$39,748,81	\$429,130,482	\$107,478,499	0	\$187,478,499	\$61,968,214	\$108,382,666	\$10,079,588	\$92,541,607
18 \$304,847,771 \$80,000,000 \$85,319,898 \$22,158,601 \$191,62,619 \$107,478,499 0 \$187,478,499 \$61,968,214 \$140,720,956 \$13,087,049 \$104,282,223 19 \$309,928,567 \$80,000,000 \$92,145,490 \$153,333,009 \$99,517,129 \$107,478,499 0 \$187,478,499 \$61,968,214 \$152,627,344 \$14,194,343 \$108,255,725 20 \$315,094,044 \$80,000,000 \$99,517,129 \$7961,370 \$0 \$107,478,499 \$61,968,214 \$152,627,344 \$14,194,343 \$108,255,725 21 \$320,345,611 \$80,000,000 0 \$0 \$0 \$0 \$80,000,000 0 \$240,345,611 \$22,352,142 \$217,793,3469 22 \$325,684,704 \$80,000,000 0 \$0 \$0 \$0 \$80,000,000 \$240,345,611 \$22,352,142 \$217,793,9469 22 \$325,684,704 \$80,000,000 0 \$0 \$0 \$80,000,000 \$245,584,704 \$22,846,778 \$22,836,677 23 \$331,112,783 \$		16	\$294,934,689	\$80,000,000	\$73,148,061	\$34,330,43	\$355,982,422	\$107,478,499	0	\$187,478,499	\$61,968,214	\$118,636,036	\$11,033,151	\$96,423,038
19 \$309,928,567 \$80,000,000 \$92,145,490 \$15,333,009 \$99,517,129 \$107,478,499 0 \$187,478,499 \$61,968,214 \$152,627,344 \$14,194,343 \$108,255,725 20 \$315,094,044 \$80,000,000 \$99,517,129 \$7,961,370 \$0 \$107,478,499 0 \$187,478,499 \$61,968,214 \$152,627,344 \$14,194,343 \$108,255,725 21 \$320,345,611 \$80,000,000 0 0 \$0 \$0 \$80,000,000 0 \$240,345,611 \$22,352,142 \$217,993,469 22 \$325,684,704 \$80,000,000 0 0 \$0 \$0 \$0 \$80,000,000 \$242,345,617 \$22,283,677 23 \$331,112,783 \$80,000,000 0 \$0 \$0 \$0 \$80,000,000 \$254,684,704 \$22,283,677,759,294 24 \$336,631,329 \$80,000,000 0 \$0 \$0 \$0 \$80,000,000 \$256,631,329 \$23,866,714 \$232,764,616		17	\$299,850,267	\$80,000,000	\$78,999,905	\$28,478,59	\$276,982,516	\$107,478,499	0	\$187,478,499	\$61,968,214	\$129,403,459	\$12,034,522	\$100,337,246
20 \$315,094,044 \$80,000,000 \$99,517,129 \$7,961,370 \$0 \$107,478,499 0 \$187,478,499 \$61,968,214 \$165,164,459 \$15,360,295 \$112,255,250 21 \$320,345,611 \$80,000,000 0 0 \$0 \$0 \$0 \$80,000,000 0 \$240,345,611 \$22,352,142 \$217,993,469 22 \$325,684,704 \$80,000,000 0 0 \$0 \$0 \$0 \$80,000,000 0 \$244,646,714 \$22,835,487 \$227,759,294 23 \$331,112,783 \$80,000,000 0 \$0 \$0 \$0 \$80,000,000 0 \$227,759,294 24 \$336,631,329 \$80,000,000 0 \$0 \$0 \$0 \$80,000,000 0 \$232,756,4616		18	\$304,847,771	\$80,000,000	\$85,319,898	\$22,158,60	\$191,662,619	\$107,478,499	0	\$187,478,499	\$61,968,214	\$140,720,956	\$13,087,049	\$104,282,223
21 \$320,345,611 \$80,000,000 0 0 \$0 \$0 \$0 \$0 \$80,000,000 0 \$22,352,684,704 \$20,045,661 \$22,352,142 \$217,993,469 22 \$325,684,704 \$80,000,000 0 0 \$0 \$0 \$0 \$80,000,000 0 \$245,684,704 \$22,848,678 \$222,238,027 23 \$331,112,783 \$80,000,000 0 \$0 \$0 \$0 \$0 \$80,000,000 0 \$245,684,704 \$22,848,678 \$222,238,60,775,924 24 \$336,631,329 \$80,000,000 0 \$0 \$0 \$0 \$80,000,000 0 \$256,681,302 \$23,866,714 \$232,764,616		19	\$309,928,567	\$80,000,000	\$92,145,490	\$15,333,00	\$99,517,129	\$107,478,499	0	\$187,478,499	\$61,968,214	\$152,627,344	\$14,194,343	\$108,255,725
22 \$325,684,704 \$80,000,000 0 \$0 \$0 \$0 \$80,000,000 0 \$22,848,678 \$222,836,027 23 \$331,112,783 \$80,000,000 0 \$0 \$0 \$0 \$80,000,000 0 \$22,7,759,294 24 \$336,631,329 \$80,000,000 0 \$0 \$0 \$0 \$80,000,000 0 \$23,764,616		20	\$315,094,044	\$80,000,000	\$99,517,129	\$7,961,37) \$C	\$107,478,499	0	\$187,478,499	\$61,968,214	\$165,164,459	\$15,360,295	\$112,255,250
23 \$331,112,783 \$80,000,000 0 0 \$0 \$0 0 \$80,000,000 0 \$251,112,783 \$23,353,489 \$227,759,294 24 \$336,631,329 \$80,000,000 0 0 \$0 \$0 \$0 0 \$80,000,000 0 \$256,631,329 \$23,866,714 \$232,764,616		21	\$320,345,611	\$80,000,000	0		0 \$C	\$0	0	\$80,000,000	0	\$240,345,611	\$22,352,142	\$217,993,469
24 \$336,631,329 \$80,000,000 0 0 \$0 \$0 0 \$80,000,000 0 \$256,631,329 \$23,866,714 \$232,764,616		22	\$325,684,704	\$80,000,000	0		0 \$C	\$0	0	\$80,000,000	0	\$245,684,704	\$22,848,678	\$222,836,027
		23	\$331,112,783	\$80,000,000	0		0 \$C	\$0	0	\$80,000,000	0	\$251,112,783	\$23,353,489	\$227,759,294
25 \$342,241,851 \$80,000,000 0 0 \$0 \$0 0 \$80,000,000 0 \$262,241,851 \$24,388,492 \$237,853,359		24	\$336,631,329	\$80,000,000	0		0 \$C	\$0	0	\$80,000,000	0	\$256,631,329	\$23,866,714	\$232,764,616
		25	\$342,241,851	\$80,000,000	0		0 \$C	\$0	0	\$80,000,000	0	\$262,241,851	\$24,388,492	\$237,853,359

Real Term Financial/P

Nominal Term

I/Private analysis(for a state of the sta	or the cash	flows after finar	nce and taxes)										
Year		Benefits		Costs					Total costs	Depreciation	Taxable income	Total taxes	Net benefits
			Maintenance costs F	rincipal paid	Interest paid	Loan balance	Debt paid	Equity paid					
	1	0	0	0		\$194,174,757	0	0	\$0	0	0	0	\$0
	2	0	0	0		\$439,249,694	0	0	\$0	0	0	0	\$0
	3	0	0	0		\$643,600,826	0	0	\$0	0	0	0	\$0
	4	0	0	0		\$808,116,642	0	0	\$0	0	0	0	\$0
	5	0	0	0		\$793,565,511	0	\$140,040,973	\$140,040,973	0	0	0	(\$140,040,973)
	6	\$209,371,064	\$66,998,741	\$28,375,395	\$61,636,15	5 \$742,076,558	\$90,011,551	0	\$157,010,292	\$51,897,404	\$28,838,764	\$2,682,005	\$49,678,768
	7	\$206,660,759	\$65,047,321	\$29,752,841	\$57,637,01	\$690,709,836	\$87,389,855	0	\$152,437,176	\$50,385,829	\$33,590,595	\$3,123,925	\$51,099,658
	8	\$203,985,539	\$63,152,739	\$31,197,154	\$53,647,36	5 \$639,394,920	\$84,844,520	0	\$147,997,258	\$48,918,280	\$38,267,154	\$3,558,845	\$52,429,435
	9	\$201,344,949	\$61,313,339	\$32,711,579	\$49,661,74	\$588,060,188	\$82,373,320	0	\$143,686,659	\$47,493,476	\$42,876,393	\$3,987,505	\$53,670,786
	10	\$198,738,542	\$59,527,513	\$34,299,519	\$45,674,57	\$536,632,702	\$79,974,097	0	\$139,501,610	\$46,110,171	\$47,426,280	\$4,410,644	\$54,826,288
	11	\$196,165,875	\$57,793,702	\$35,964,545	\$41,680,21	\$485,038,079	\$77,644,755	0	\$135,438,457	\$44,767,156	\$51,924,807	\$4,829,007	\$55,898,411
	12	\$193,626,511	\$56,110,390	\$37,710,396	\$37,672,86	\$433,200,360	\$75,383,257	0	\$131,493,647	\$43,463,258	\$56,380,002	\$5,243,340	\$56,889,524
	13	\$191,120,019	\$54,476,107	\$39,540,998	\$33,646,63	\$381,041,875	\$73,187,628	0	\$127,663,735	\$42,197,338	\$60,799,944	\$5,654,395	\$57,801,889
	14	\$188,645,973	\$52,889,424	\$41,460,464	\$29,595,48	5 \$328,483,104	\$71,055,950	0	\$123,945,374	\$40,968,290	\$65,192,774	\$6,062,928	\$58,637,671
	15	\$186,203,954	\$51,348,956	\$43,473,108	\$25,513,25	1 \$275,442,527	\$68,986,359	0	\$120,335,315	\$39,775,038	\$69,566,709	\$6,469,704	\$59,398,936
	16	\$183,793,547	\$49,853,355	\$45,583,453	\$21,393,59	\$221,836,476	\$66,977,047	0	\$116,830,403	\$38,616,542	\$73,930,055	\$6,875,495	\$60,087,650
	17	\$181,414,343	\$48,401,316	\$47,796,242	\$17,230,01	\$\$167,578,978	\$65,026,260	0	\$113,427,575	\$37,491,789	\$78,291,221	\$7,281,084	\$60,705,684
	18	\$179,065,937	\$46,991,569	\$50,116,448	\$13,015,84	\$112,581,589	\$63,132,291	0	\$110,123,859	\$36,399,795	\$82,658,731	\$7,687,262	\$61,254,816
	19	\$176,747,931	\$45,622,882	\$52,549,285	\$8,744,20	\$56,753,228	\$61,293,486	0	\$106,916,368	\$35,339,607	\$87,041,242	\$8,094,835	\$61,736,727
	20	\$174,459,932	\$44,294,060	\$55,100,221	\$4,408,01	B \$0	\$59,508,239	0	\$103,802,299	\$34,310,298	\$91,447,557	\$8,504,623	\$62,153,010
	21	\$172,201,551	\$43,003,942	0		D \$0	\$0	0	\$43,003,942	0	\$129,197,609	\$12,015,378	\$117,182,231
	22	\$169,972,405	\$41,751,400	0		D \$0	\$0	0	\$41,751,400	0	\$128,221,005	\$11,924,553	\$116,296,451
	23	\$167,772,115	\$40,535,340	0		D \$0	\$0	0	\$40,535,340	0	\$127,236,775	\$11,833,020	\$115,403,755
	24	\$165,600,308	\$39,354,699	0		D \$0	\$0	0	\$39,354,699	0	\$126,245,609	\$11,740,842	\$114,504,767
	25	\$163,456,614	\$38,208,446	0		D \$0	\$0	0	\$38,208,446	0	\$125,248,169	\$11,648,080	\$113,600,089



\$206,173,183

42% 1.340790858

NPV

IRR

B/C ratio

UNDERGROUND CONSTRUCTION TECHNOLOGY



Conclusion

A vital planning tool for establishing economic and financial feasibility & A feasibility study for developing a long-term financial framework Long-term Financial Framework on water infrastructure, including the deep uncertainties for decision-makers **Research Plan** Benefit-Cost Assessment for a strategy of maximizing the efficiency for rehabilitating and improving water infrastructures analyzes several methodologies according to different points of view and conducts the benefit-**Major Objective** cost analysis in terms of private, financial, economic, and efficiency using nominal and real terms. The cost-benefit assessment of several scenarios for reducing the water crisis and ٠ rehabilitating and improving water infrastructures - develop a long-term financial framework and improve redevelopment decisions for maximizing the benefit of investing in water Contribuiton infrastructures. It can lead to minimize the associated risks of the water sector and the damages from the water crisis, improving the resiliency of the water sector infrastructures, and decreasing the vulnerability of the water service.



Financial Framework that Maximizes Benefit of Water-Infrastructure Investment



PURDUE ENGINEERING



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