Reducing Time and Costs to Site Closeout Through DNAPL Removal

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Introduction and Overview

- Existing Situation at Many Sites
  - Early remedies have focused on stabilizing the groundwater plume
  - Contaminant mass reduction is not occurring quickly enough to advance toward site closure
  - Life-cycle operating, maintenance, and monitoring (OMM costs) could be very large
- Goal
  - Implement a technology or approach to remove or destroy DNAPL from source areas
- Presentation Topics
  - Methodology
  - Sources of information
  - Time savings analysis
  - Cost savings analysis
  - Conclusions

Key Questions for Site Managers

- Is DNAPL removal likely to provide significant benefits at my site?
- What is the expected reduction in time to attain closure criteria once the DNAPL removal technology is implemented?
- How long should the system be operated?
- How much DNAPL mass should be removed?
- What are the cost implications (positive or negative) associated with DNAPL removal?

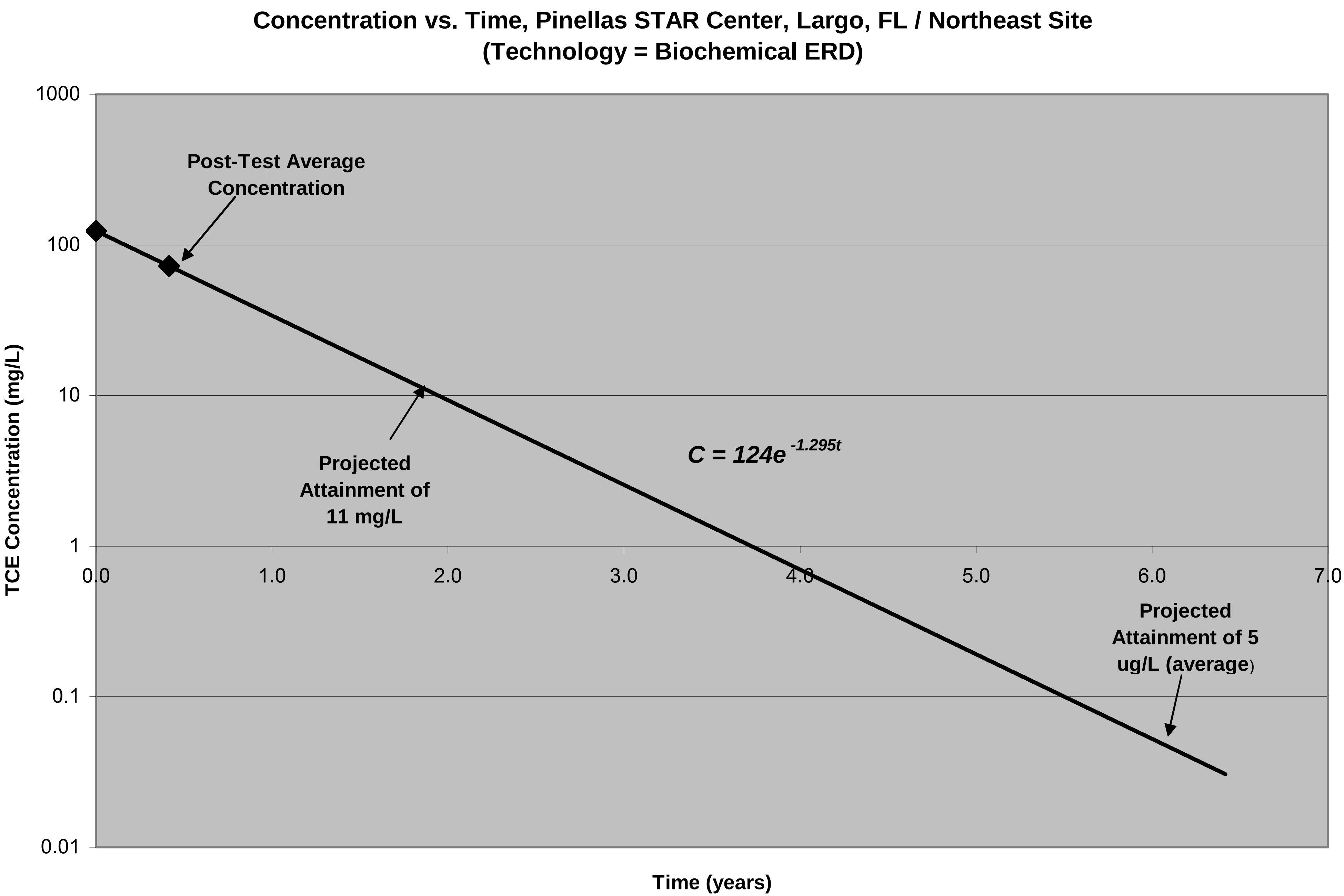
Technologies

- Technologies initially selected for analysis
  – Surfactant flushing
  – Thermal treatment (steam and/or electrical resistance heating)
  – *In situ* chemical oxidation (ISCO)
  – *In situ* biochemical enhanced reductive dechlorination (ERD)

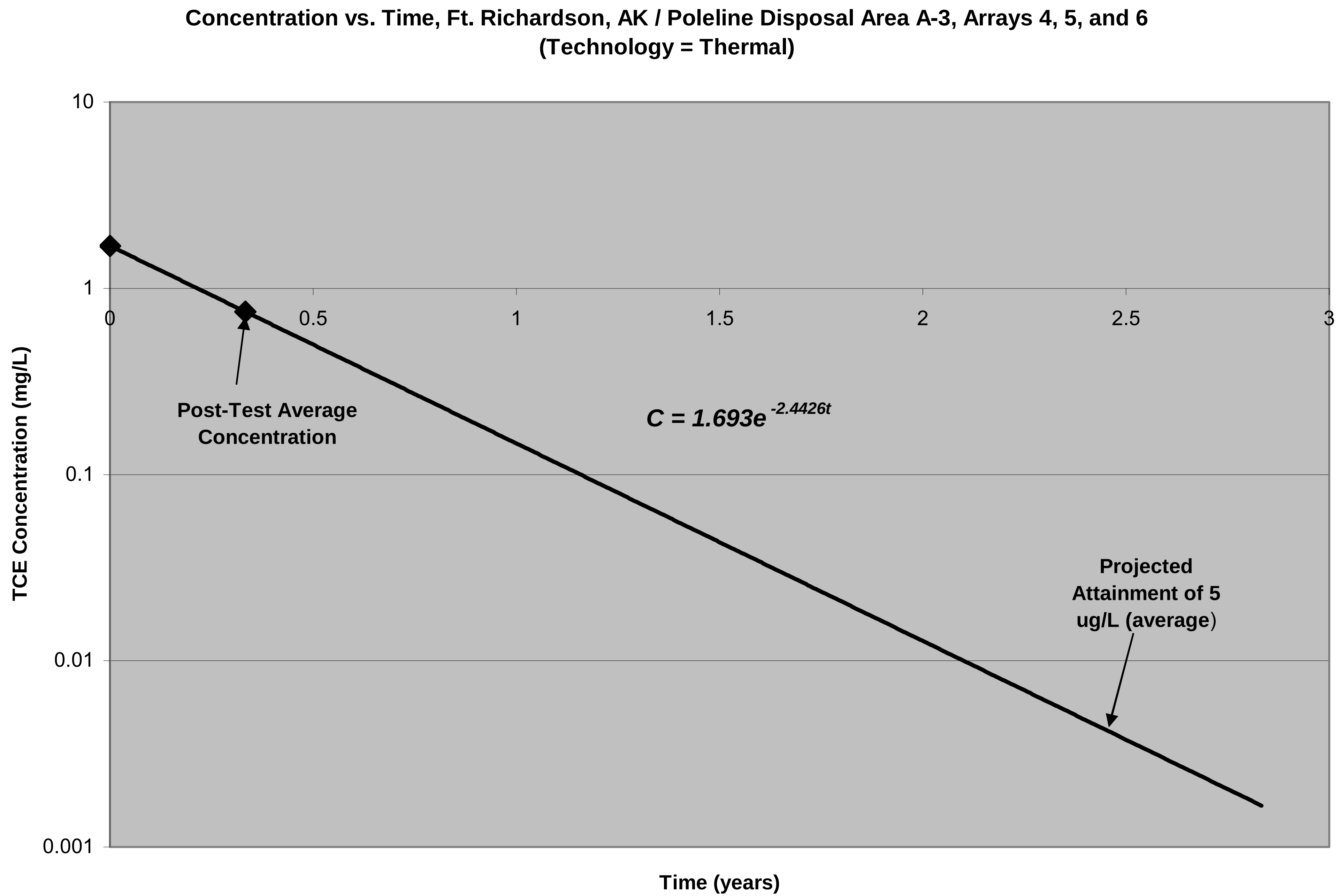
- Rationale
  – These are the technologies most frequently applied at DNAPL source areas to date
  – Expected to have the largest body of available data

Case Histories

- Criteria for use
  - Confirmed DNAPL in the aquifer or significant probability (e.g., concentrations above 1% of solubility)
  - Pilot- or full-scale projects
  - Actual and detailed groundwater sampling data present in the literature
- Primary source
  - Cost and Performance Reports compiled by the Federal Remediation Technologies Roundtable (FRTR) and the U.S. EPA's Technology Innovation Program
- Total of 11 sites, various technologies:
  - Thermal methods (3 sites)
  - ERD (4 sites)
  - ISCO (4 sites)
- Common principal contaminants
  - Trichloroethylene (TCE) and "daughter" compounds



Concentration vs. Time, Pinellas STAR Center, Largo, FL / Northeast Site
(Technology = Biochemical ERD)
1000
100
10
1
0.1
0.01
TCE Concentration (mg/L)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
Time (years)
Post-Test Average Concentration
Projected Attainment of 11 mg/L
C = 124e -1.295t
Projected Attainment of 5 ug/L (average)



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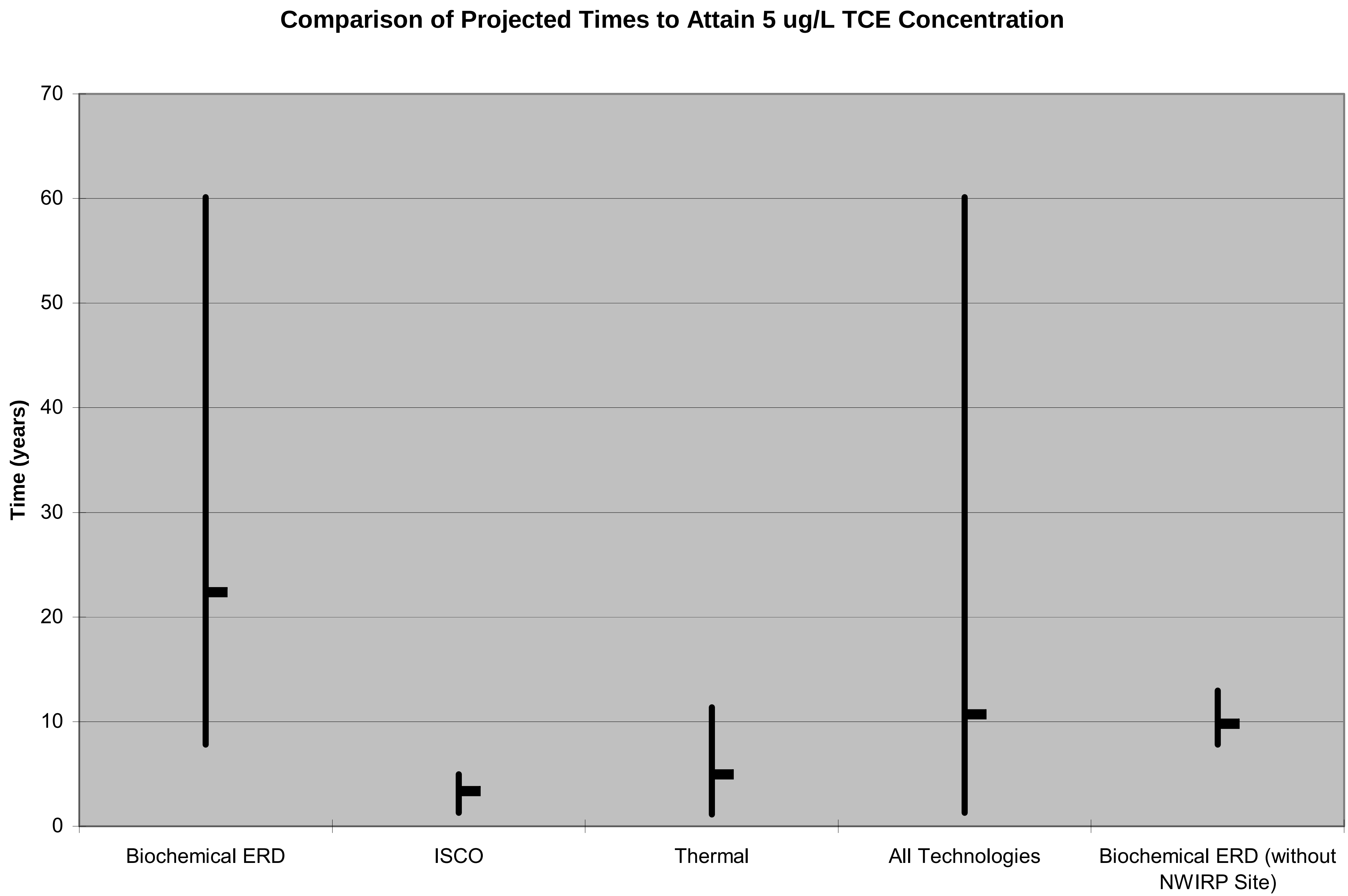

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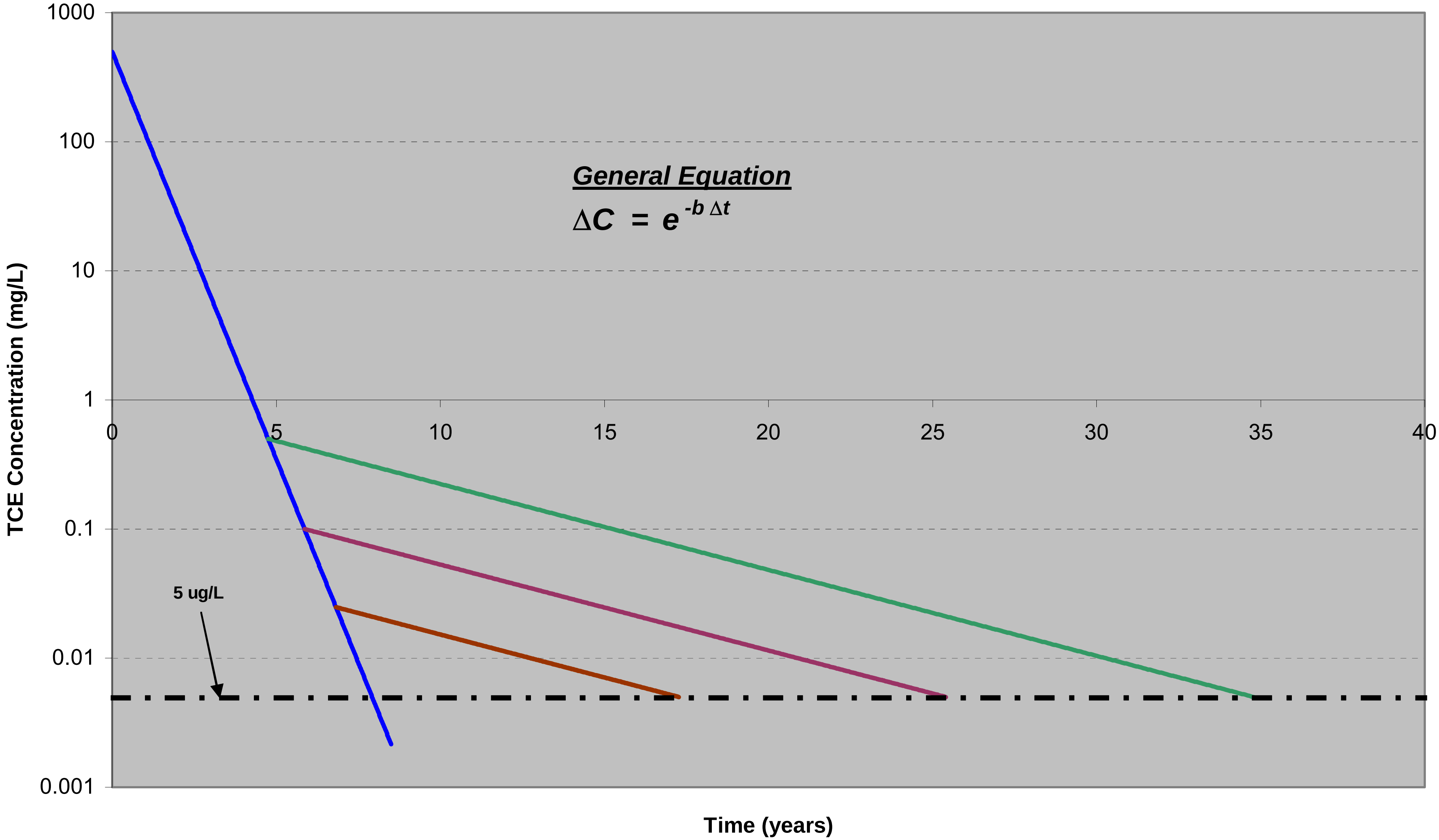
Comparison of Projected Times to Attain 5 ug/L TCE Concentration

Technology	*High*	*Low*	*Average*
Biochemical ERD	60.1	7.8	22.4
ISCO	4.9	1.3	3.4
Thermal	11.4	1.1	5.0
All Technologies	60.1	1.1	10.7
Biochemical ERD (without NWIRP Site)	13.0	7.8	9.8

Additional Considerations

- Operating time is not the only criteria for selecting a technology
- Cost/time tradeoff, active versus passive remedies
- Technical issues
  - Aquifer injection permits
  - Proximity of structures and utilities
  - Existing aquifer conditions (oxidation-reduction potential [ORP], dissolved oxygen, nutrient levels)
  - On-site electrical power, steam, and/or potable water
  - Current and future site uses

Concentration vs. Time, Active DNAPL Remediation Followed by Monitored Natural Attenuation (Hypothetical Site)



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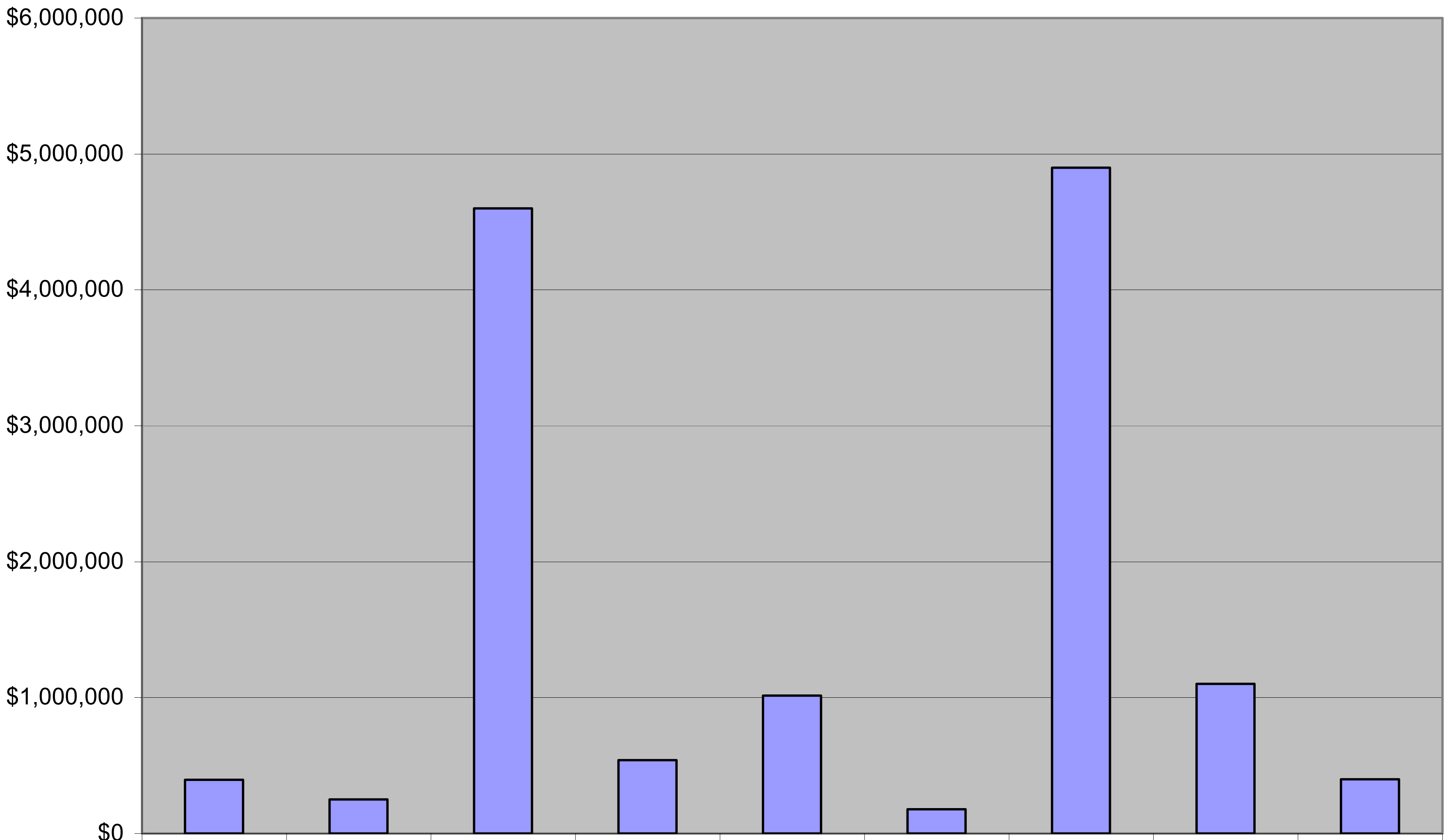
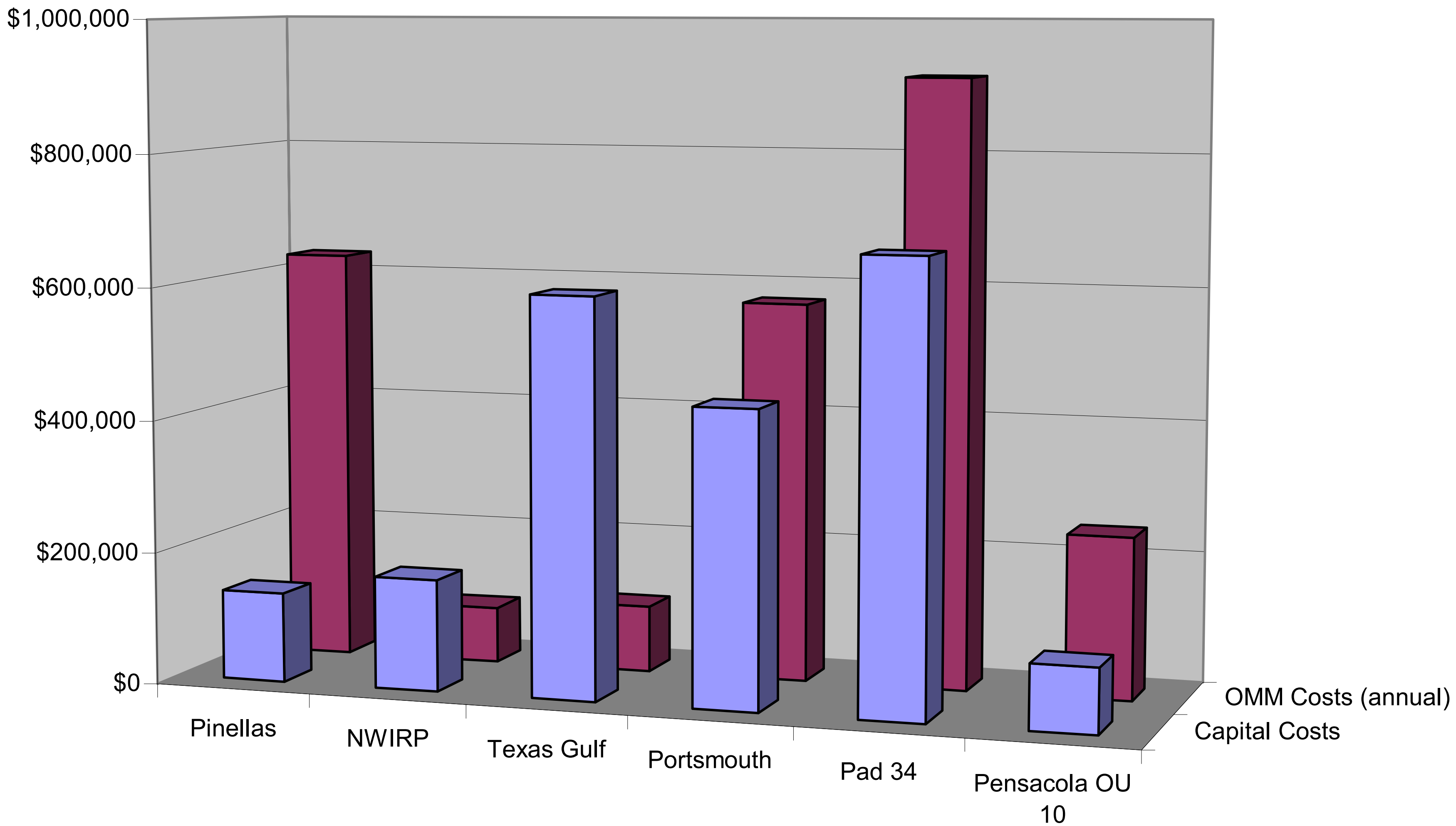
Total Project Costs For Case Histories



	Pinellas	NWIIRP	Texas Gulf	Portsmouth	Pad 34	Pensacola OU 10	A.G. Comm.	Skokie	Emeryville
Total Project Costs	$397,101	$252,557	$4,600,000	$539,520	$1,013,947	$178,338	$4,900,000	$1,100,000	$400,000

Capital and OMM Costs for Case Histories

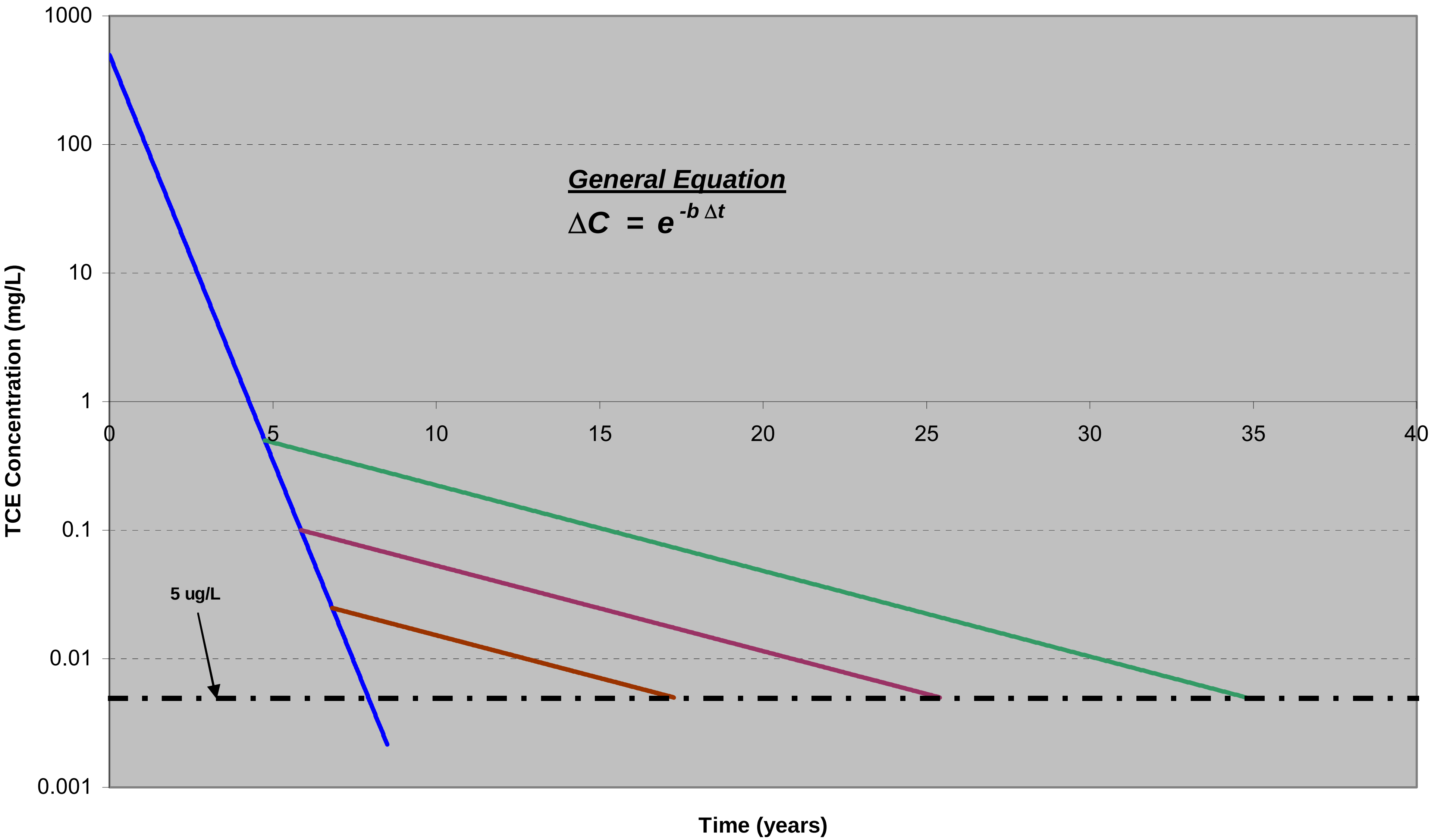


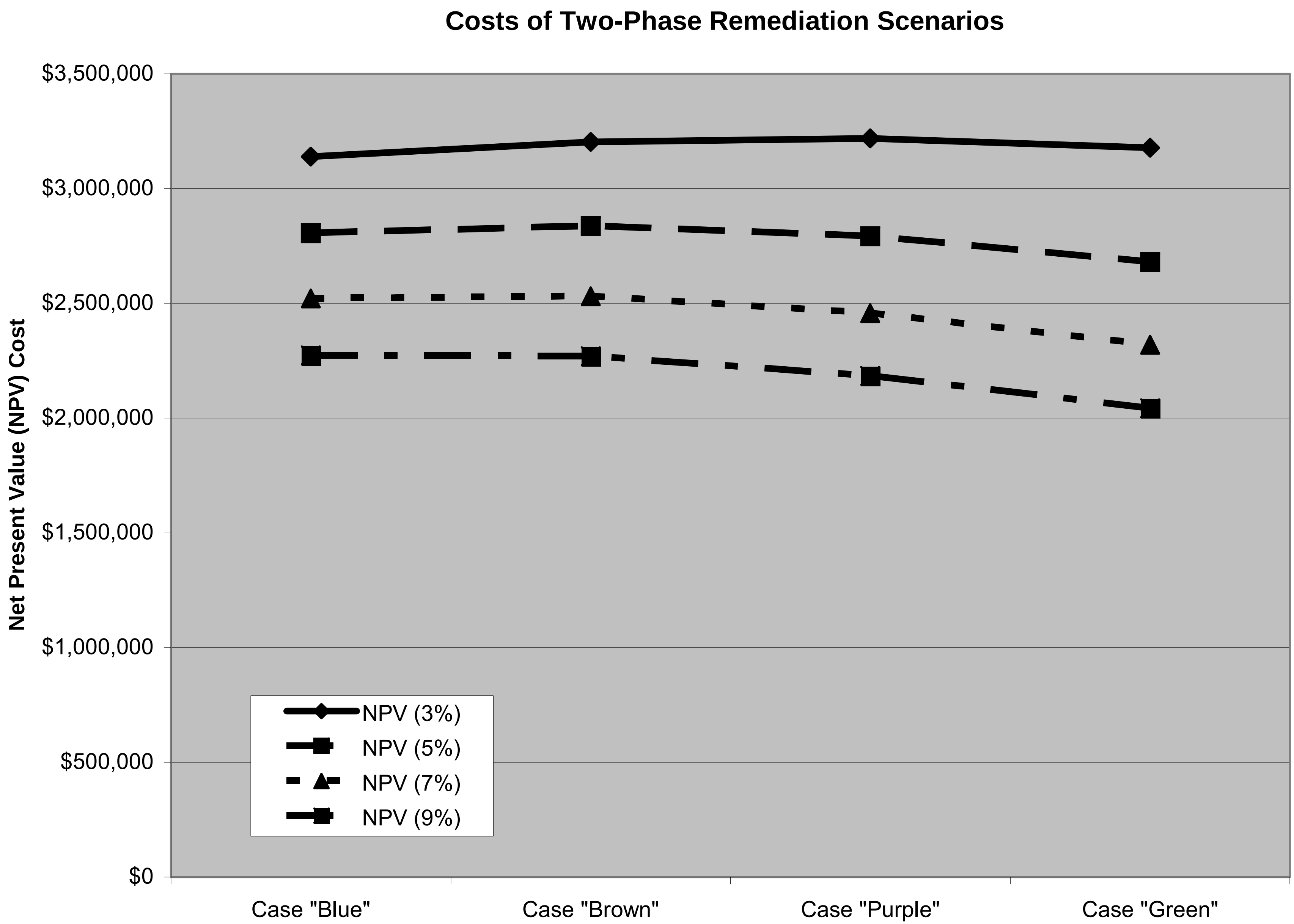
	Pinellas	NWIRP	Texas Gulf	Portsmouth	Pad 34	Pensacola OU 10
Capital Costs	$135,043	$168,340	$600,000	$443,980	$670,776	$97,018
OMM Costs (annual)	$628,939	$84,217	$100,000	$573,240	$915,123	$243,960

Kennedy Space Center Launch Complex 34

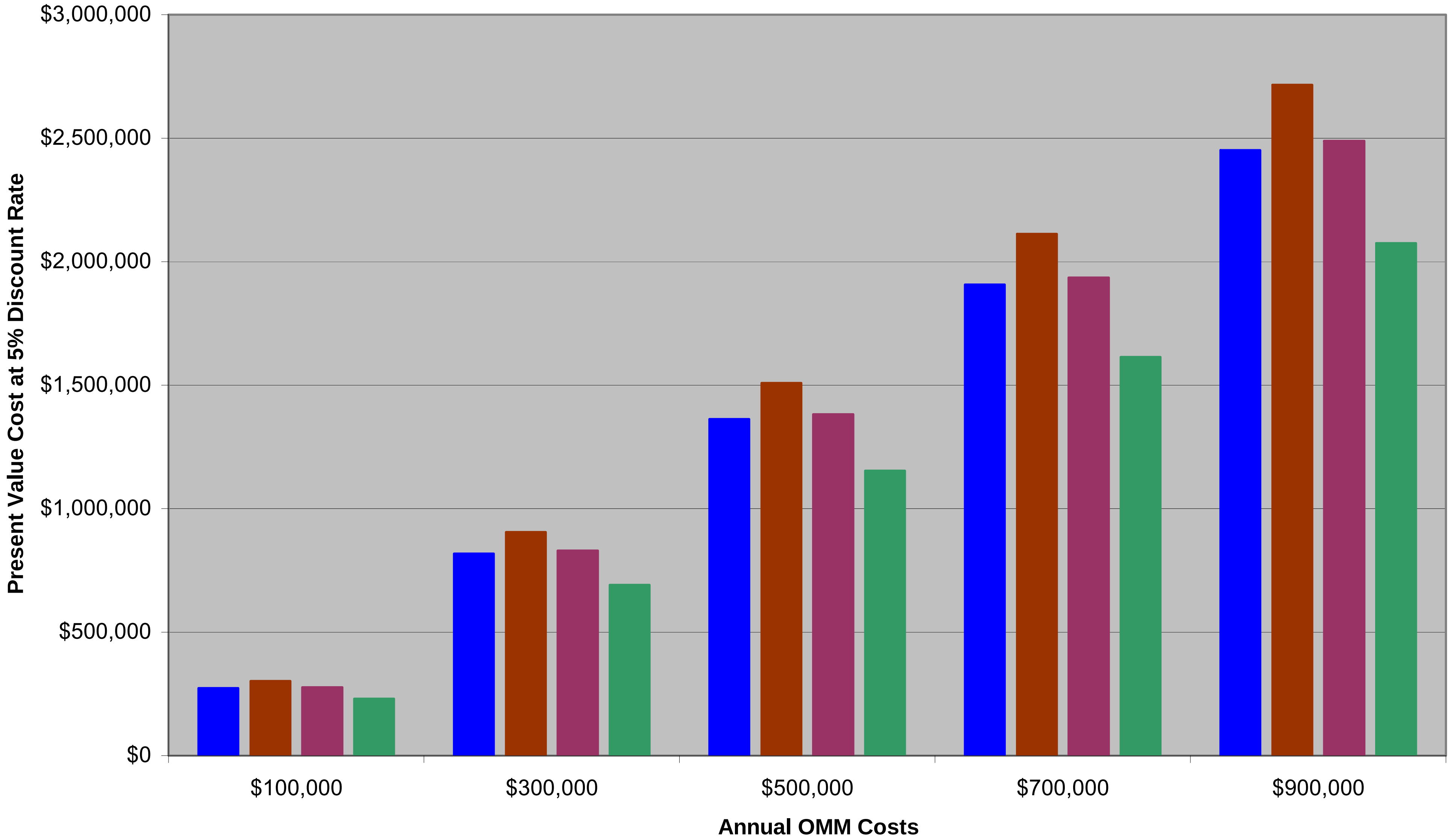
- Estimated life-cycle costs of ISCO versus pump and treat
- Operating time frames assumed:
  - ISCO (< 1 year) – followed by MNA
  - Pump and treat (30 years)
- Net Present Value (NPV) costs
  - ISCO ($850,000)
  - Pump and treat ($1,406,000)
- Projected savings = $556,000 (≈ 40%)

Concentration vs. Time, Active DNAPL Remediation Followed by Monitored Natural Attenuation (Hypothetical Site)




Costs of Two-Phase Remediation Scenarios
Net Present Value (NPV) Cost
$3,500,000
$3,000,000
$2,500,000
$2,000,000
$1,500,000
$1,000,000
$500,000
$0
NPV (3%)
NPV (5%)
NPV (7%)
NPV (9%)
Case "Blue"
Case "Brown"
Case "Purple"
Case "Green"

Present Value Costs from Year 5 Forward at Different Annual OMM Costs (Hypothetical Site)



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Present Value Costs from Year 5 Forward at Different Annual OMM Costs (thousand $)

Annual OMM Cost	*Case "Blue"*	*Case "Brown"*	*Case "Purple"*	*Case "Green"*
$100,000	$272	$302	$277	$231
$300,000	$817	$905	$830	$692
$500,000	$1,362	$1,509	$1,383	$1,153
$700,000	$1,906	$2,112	$1,936	$1,614
$900,000	$2,450	$2,716	$2,489	$2,075

Key Questions for Site Managers – *Insights and Path Toward Resolution*

- *Is DNAPL removal likely to provide significant benefits at my site?*
  - Site-specific decision, but often the answer will be “Yes”
  - Either mandated or viewed favorably by CERCLA, RCRA, and State programs
- *What is the expected reduction in time to attain closure?*
  - This research indicated three to 11 years to closure (compared to 20 to 30 years or more for pump and treat)
  - Highly site-dependent, a detailed analysis incorporating local parameters is strongly recommended
- *How long should the system be operated?*
  - Combination of treatment and MNA extends closure date but may provide cost savings

Key Questions for Site Managers
Insights and Path Toward Resolution

- How much DNAPL mass should be removed?
  - Important question; first have to determine if a correlation (other than an intuitive one) exists
  - Not enough site data to perform a thorough evaluation at this time
- What are the cost implications (positive or negative) associated with DNAPL removal?
  - Short-term costs (e.g., capital investment and first several years of OMM) will likely be higher than pump and treat or other conventional treatment approach
  - Life-cycle costs will likely be lower than pump and treat
  - Costs can be optimized by using a two-phase approach (e.g., active treatment followed by MNA)

Conclusions

- There are quantifiable time and cost reductions associated with DNAPL removal
- An important research need is data to correlate mass of DNAPL removed or destroyed to decreases in groundwater concentrations
- Our ability to predict the performance of these technologies will improve as they are optimized in the field
- The methodology described in this paper is flexible and easily extended to site-specific circumstances