How to Determine which Cleanup Action Alternative is Permanent to the Maximum Extent Practicable (PMEP)

Mahbub Alam, PhD, PE
Senior Principal Engineer
Toxics Cleanup Program

DEPARTMENT OF ECOLOGY
State of Washington

May 12, 2026

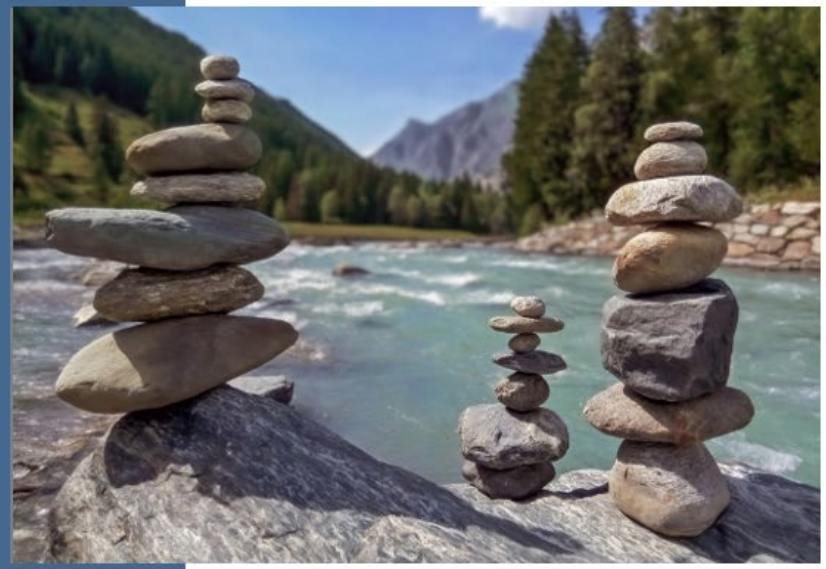
Erfaulet Bridge on PublicDomainPictures.net at:https://www.publicdomainpictures.net/en/view-image.php?image=584764&picture=stone-balancing

Objectives

- What PMEP means under MTCA
- The 4 step PMEP evaluation process
- PMEP evaluation methods: narrative vs. semi-quantitative
- How to use Ecology's PMEP Excel Tool
- How to document PMEP evaluations for Ecology review
- Common issues and how to avoid them

Agenda

- Why PMEP is required
- Key concepts
- The PMEP evaluation process
- PMEP methods
- Evaluation of costs and benefits
- Best professional judgment (BPJ) & uncertainty
- Example PMEP evaluation
- PMEP Tool + demo
- Ecology expectations
- Q&A



Guidance for Making Cleanups Permanent to the Maximum Extent Practicable (PMEP)

Toxics Cleanup Program

Washington State Department of Ecology
Olympia, Washington

December 2025, Publication 25-09-059

DEPARTMENT OF ECOLOGY
State of Washington

Permanent to the Maximum Extent Practicable (PMEP) Tool User's Manual

Toxics Cleanup Program

Washington State Department of Ecology
Olympia, Washington

December 2025, Publication 25-09-060

DEPARTMENT OF ECOLOGY
State of Washington

Audience Survey: Poll Question 1 & 2

- What is your affiliation?
- What is your expertise?

Why PMEP matters?

Purpose of PMEP Under MTCA

- MTCA requires cleanups to:
  - Be protective
  - Use permanent solutions **to the maximum extent practicable**
- PMEP evaluation determines which **protective, compliant** option meets the requirement.
- Ensures transparent and consistent remedy selection.

What PMEP is not

- Not “pick the cheapest remedy”
- Not “compare protective and non-protective alternatives together”
- Not “let the spreadsheet decide”
- Not “ignore public or Tribal concerns until after remedy selection”

PMEP comes after alternatives are developed and screened

Develop	Develop cleanup action alternatives
Screen out	Screen out alternatives that clearly fail threshold requirements
Perform	Perform detailed evaluation of remaining alternatives
Conduct	Then conduct PMEP among the remaining alternatives

What does PMEP evaluation balance?

- Balances preference for permanent solutions with the practicability of those solutions
- PMEP alternative is not necessarily the cheapest or even the most cost-effective option overall

Can PMEP be updated after the FS? Yes

A new or revised PMEP evaluation may be needed when new information becomes available, such as:

- additional FS information
- Tribal consultation
- public input
- changed site understanding

Document in a revised FS or CAP

Photo by Daniel Téllez Cabrera on Unsplash

FS – Feasibility Study; CAP – Cleanup Action Plan

When PMEP Evaluation Is Required?

- Required for **all sites**, including sediment sites.
- Not required only when:
  - A **permanent** cleanup action is selected
  - A **model remedy** is selected
- Applies to independent, and Ecology-conducted or supervised cleanups.

Key PMEP Concepts

Permanent vs Non-Permanent Cleanups

Permanent cleanup actions:

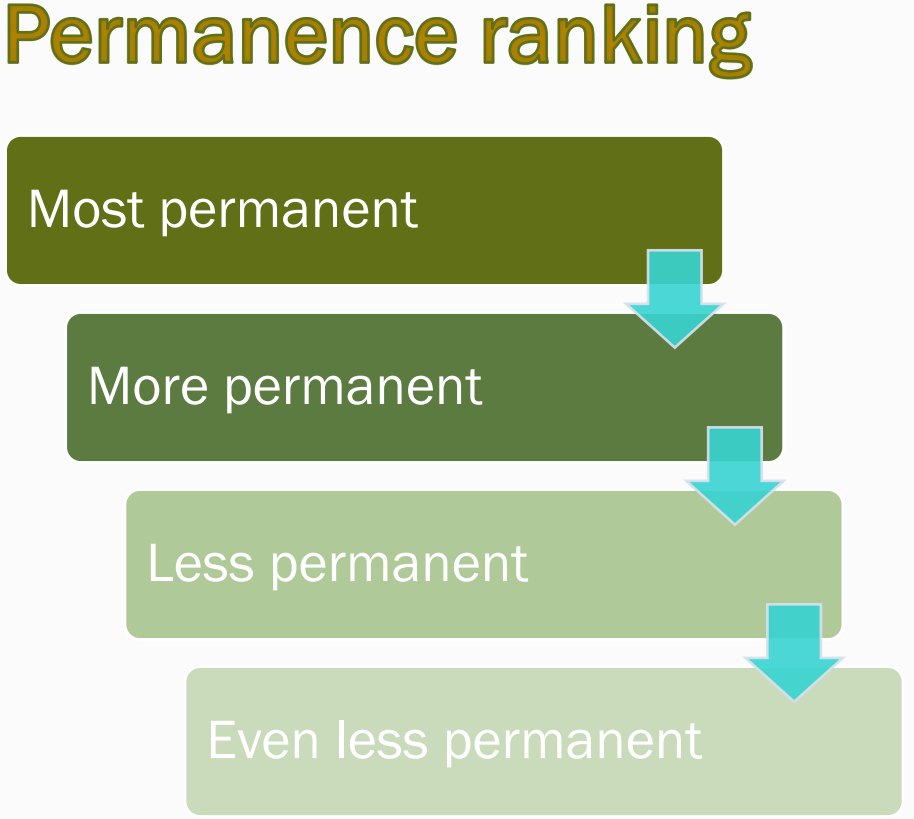
- Meet cleanup standards without long-term controls
- Permanently reduces **toxicity, mobility, or mass**

Non-permanent:

- Can be protective
- Leave contamination above standards
- Rely on engineered or institutional controls

Assessing Degrees of Permanence

- Non-permanent options are assessed by their degree of permanence
- Assess alternatives by:
  - Amount of contamination eliminated
  - Degree of treatment vs. containment
  - Irreversibility of treatment
  - Residuals generated
- Helps create a permanence ranking (Step 2 of PMEP evaluation).

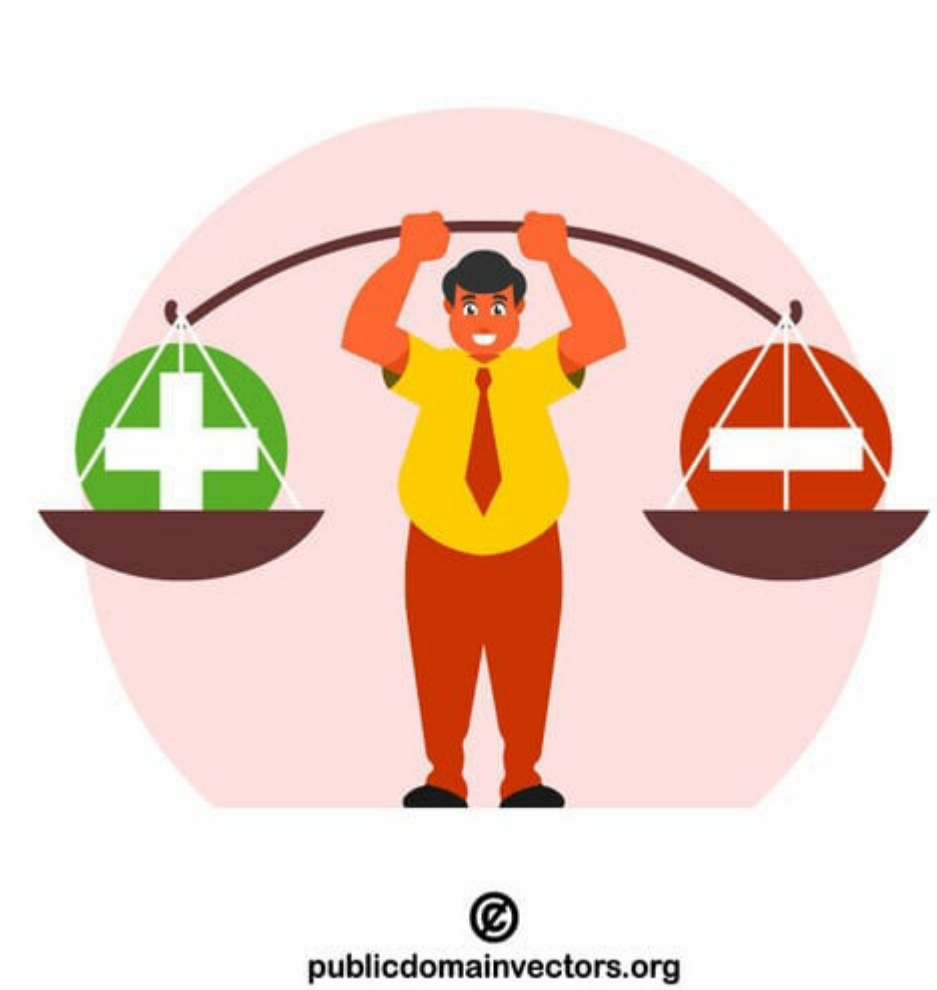


Practicability

- Defined in comparison to **another option**
- A more permanent option is "practicable" when:
  - Its **incremental cost** is **not disproportionate** to its **incremental benefit**
  - Differences in cost and benefit are compared through DCA

DCA is how practicability is determined

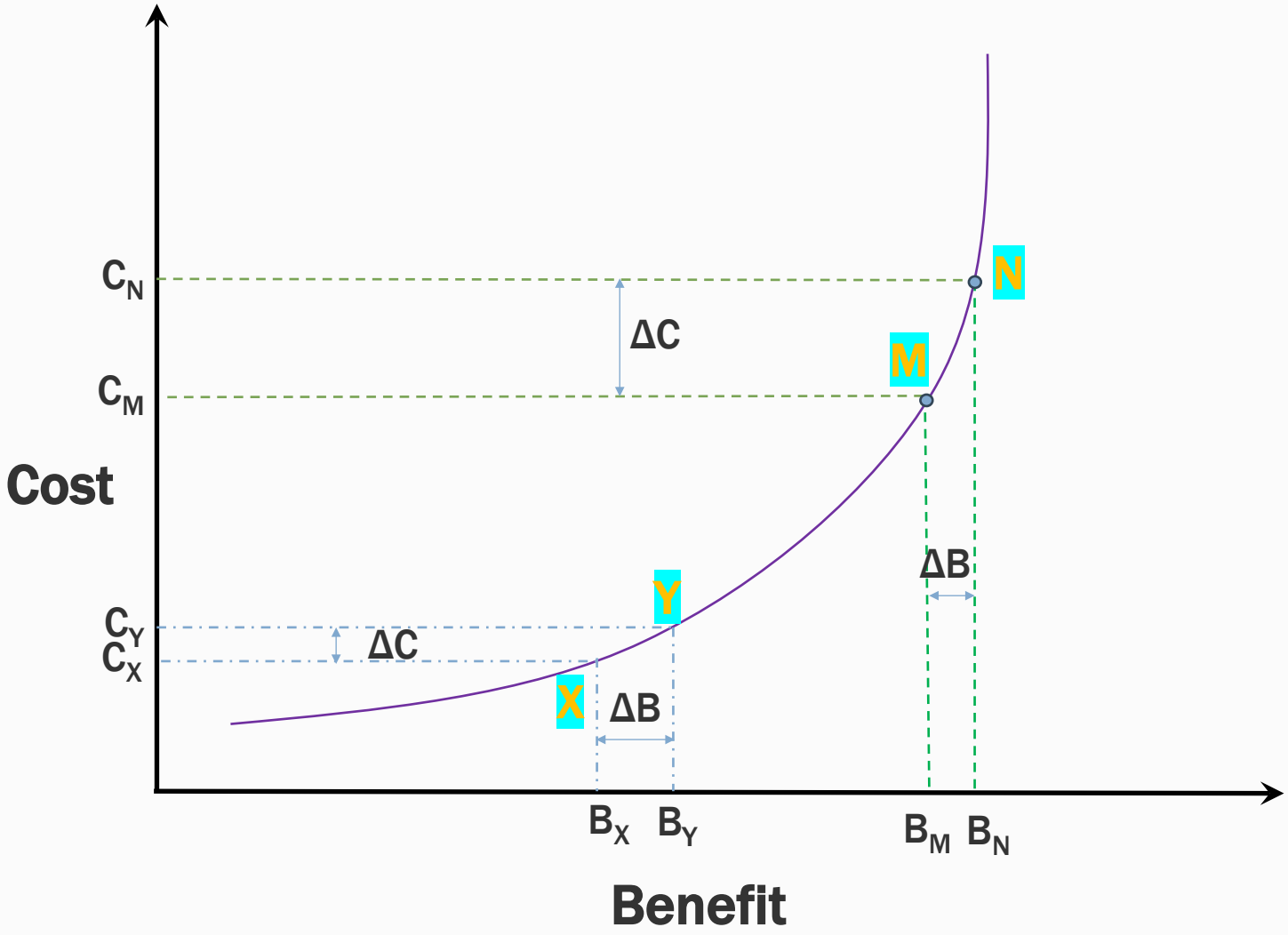
- DCA compares the relative costs and benefits of pairs of alternatives
- If incremental cost is disproportionate to incremental benefit, the more permanent alternative is not practicable
- The analysis proceeds iteratively until PMEP is identified



See WAC 173-340-360(5)(c)(iv)

Graphical Illustration of DCA

- ALT M & N
  - ALT N baseline
  - Incremental cost of ALT N is disproportionate to its incremental benefit
  - ALT N is not practical
- ALT X & Y
  - ALT Y baseline
  - Y is practicable to X



ALT- Alternative; DCA – Disproportionate Cost Analysis

Summary of PMEP Evaluation

PMEP evaluation is a procedure for determining which cleanup action alternative uses permanent solutions to maximum extent practicable

The PMEP cleanup action alternative…

Is

- the most permanent alternative which is more cost-effective than the next most permanent alternative.

is not necessarily

- the least-cost alternative, or
- the most cost-effective alternative.

Knowledge Check: Poll Question 3

When is a PMEP evaluation required under MTCA?

A. Only for Ecology-supervised cleanups

B. For all cleanups unless a permanent remedy or model remedy is selected

C. Only when requested by the public

D. Only for upland sites

Answer: Poll Question 3

When is a PMEP evaluation required under MTCA?

~~A. Only for Ecology-supervised cleanups~~

B. For all cleanups unless a permanent remedy or model remedy is selected

~~C. Only when requested by the public~~

~~D. Only for upland sites~~

Knowledge Check: Poll Question 4

Which statement best describes the purpose of PMEP?

A. Select the least expensive cleanup action

B. Select the most feasible cleanup option

C. Determine which protective, compliant alternative is the most permanent that is practicable

D. Select the alternative that is the most permanent

Answer: Poll Question 4

Which statement best describes the purpose of PMEP?

~~A. Select the least expensive cleanup action~~

~~B. Select the most feasible cleanup option~~

C. Determine which protective, compliant alternative is the most permanent that is practicable

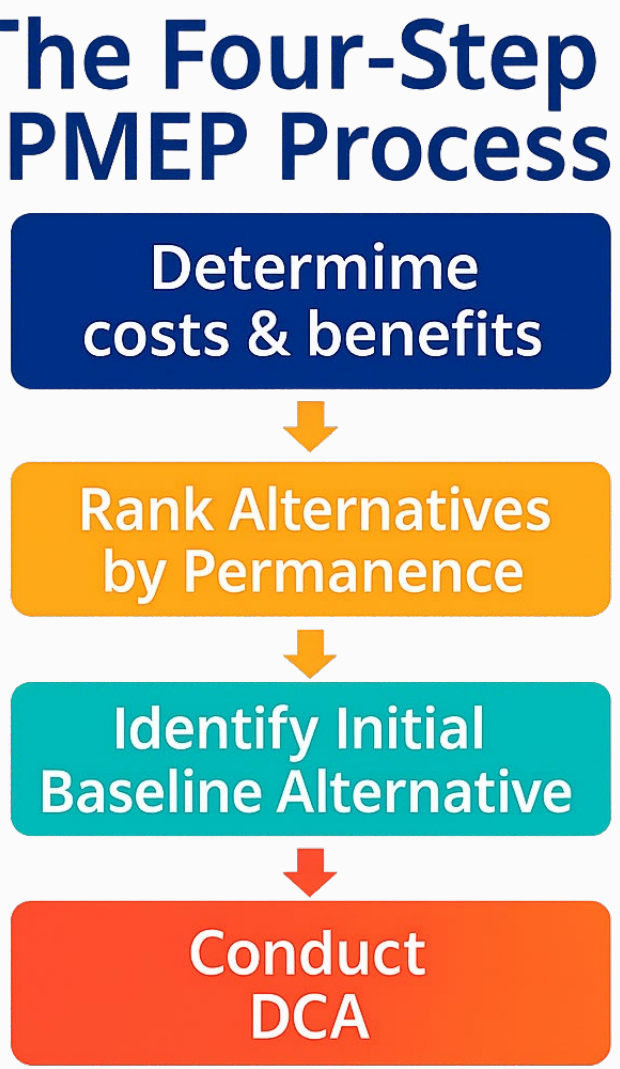
~~D. Select the alternative that is the most permanent~~

Overview of the PMEP Evaluation

PMEP Process Overview

Four steps required by WAC 173-340-360(5):

1. Determine costs & benefits
2. Rank alternatives by permanence
3. Identify initial baseline alternative
4. Conduct disproportionate cost analysis (DCA) iteratively



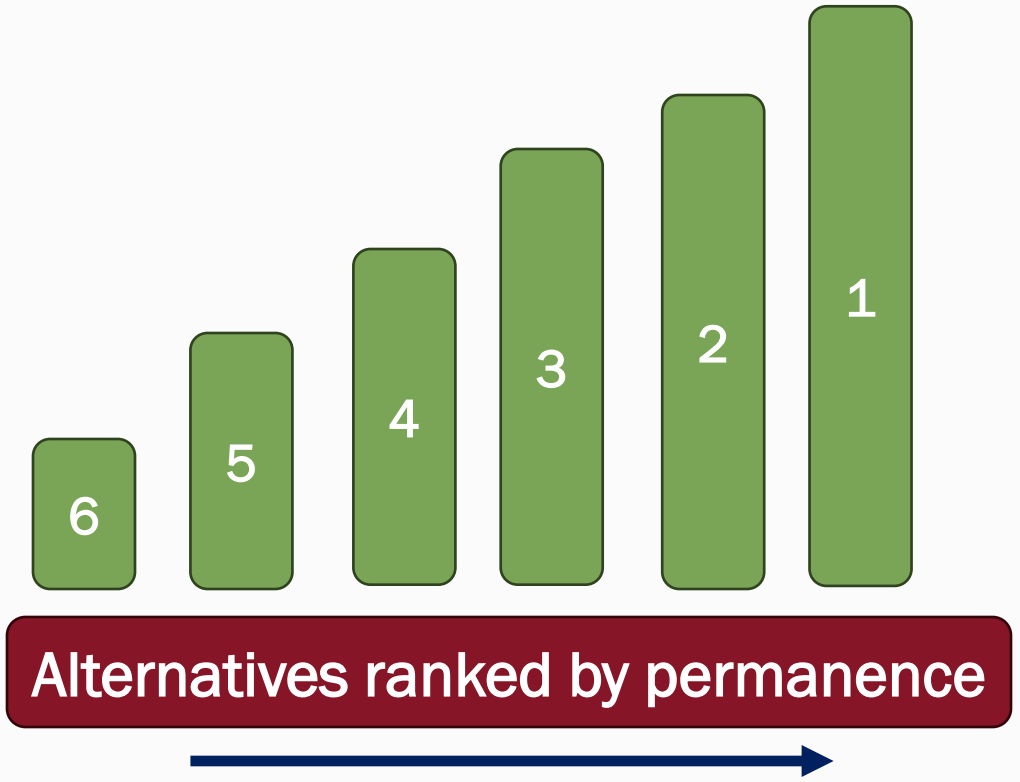
Step 1: Determine Costs & Benefits

For each alternative:

- Evaluate total **costs** (construction + present worth O&M)
- Evaluate five **benefit criteria**:
  - Protectiveness
  - Permanence
  - Long-term effectiveness
  - Implementation risk management
  - Implementability
- Weights may be equal or adjusted with justification

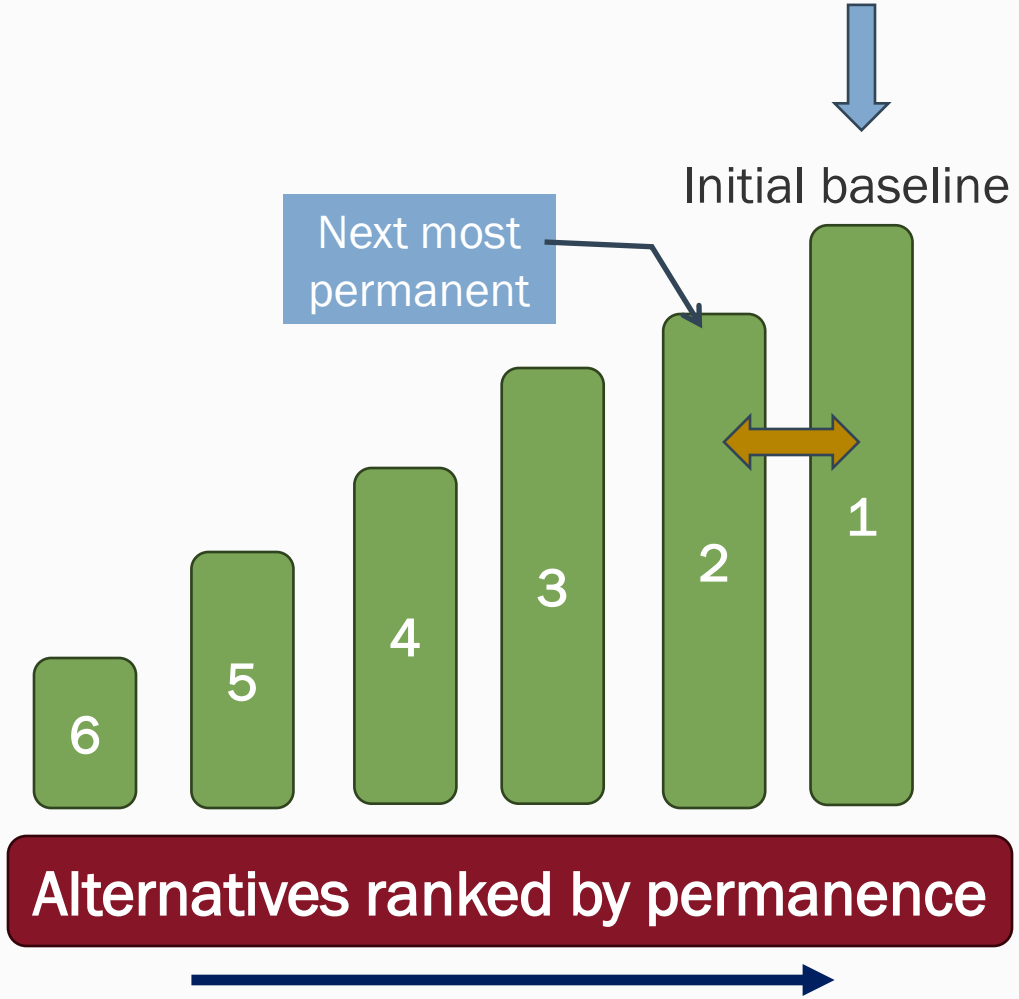
Step 2: Rank Alternatives by Permanence

- A permanent alternative ranks highest, if there is one
- Non-permanent alternatives ranked according to degree of permanence
- No tie in permanence ranks
  - Resolve ties by comparing cost-effectiveness. Eliminate less cost-effective equivalents



Step 3: Identify Initial Baseline Alternative

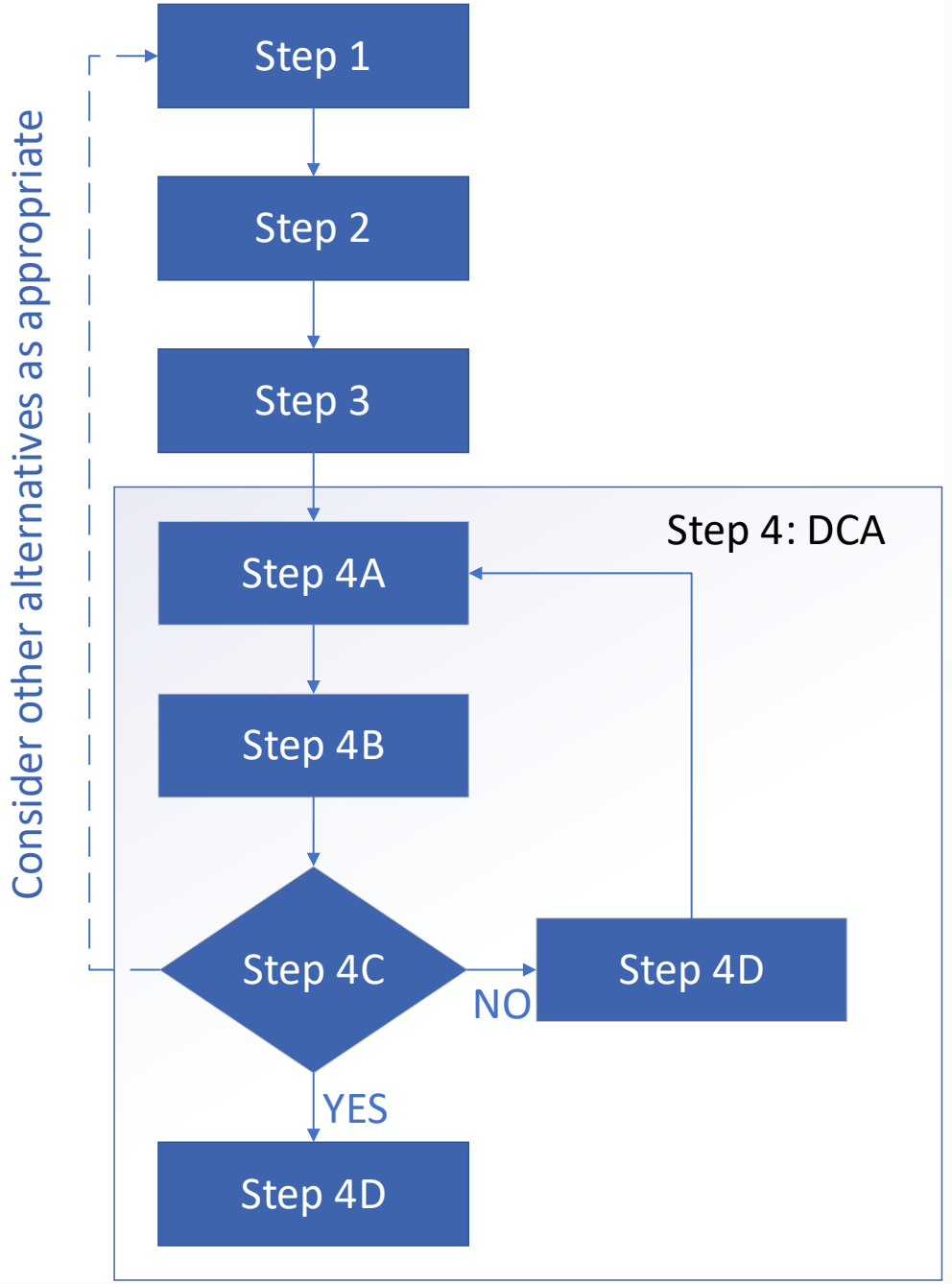
- Initial Baseline = the **most permanent** alternative
- Initial Baseline is used for the **first** DCA pairwise comparison
- If the initial baseline is eliminated, the next most permanent alternative becomes the new baseline for subsequent iteration



Step 4: Conduct DCA

How pairwise DCA works

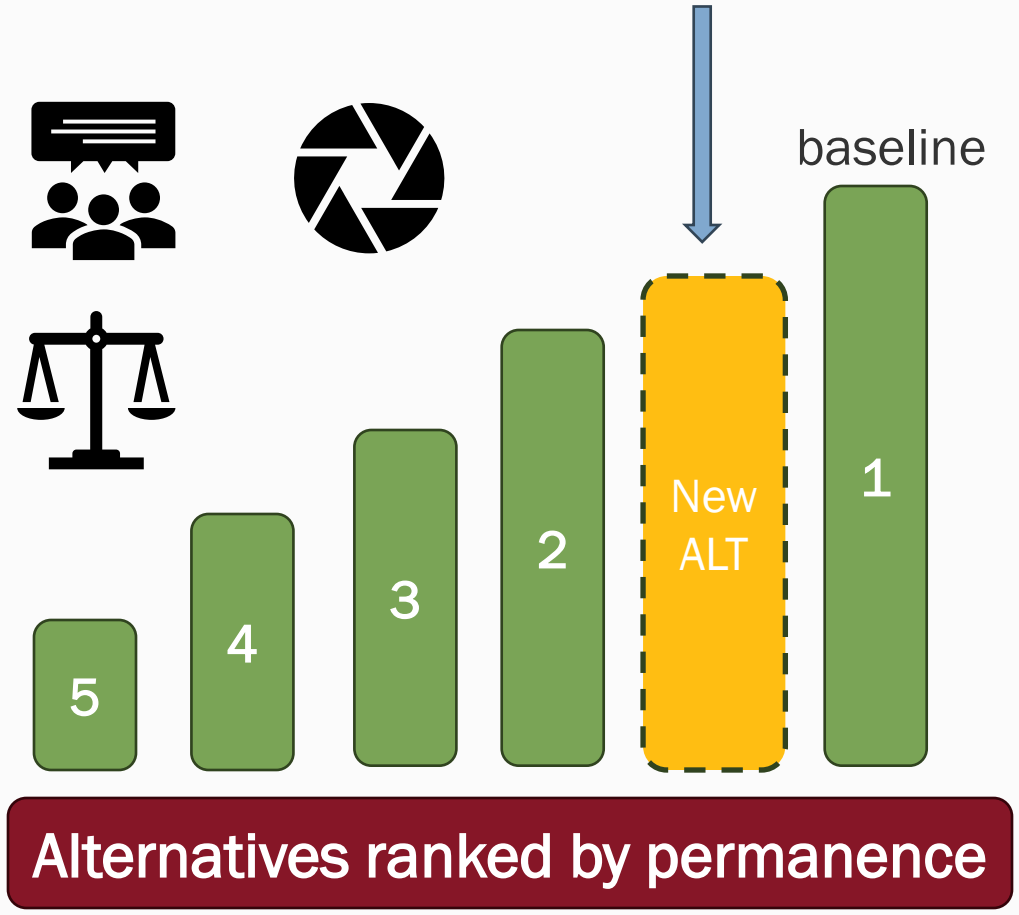
- Step 4A: Identify the baseline and the next most permanent alternatives
- Step 4B: Compare the two alternatives
- **Step 4C: Decision Box:** Determine if baseline is practicable
- **If yes**, step 4D: Baseline is PMEP. **Evaluation ends**.
- **If no**, step 4D: Baseline is eliminated. Continue DCA with next most permanent alternative as the new baseline.



When to Consider New Alternatives

Re-evaluate if:

- Evidence suggests an option between two compared alternatives could be practicable
- New technology combination emerges
- Public/tribal feedback identifies important considerations for a new/revised alternative



Knowledge Check: Poll Question 5

What is the starting point (initial baseline) for the PMEP DCA process?

A. The lowest-cost alternative
B. The alternative with the highest total benefit score
C. The most permanent alternative in the ranked list
D. The alternative preferred by stakeholders

Answer: Poll Question 5

What is the starting point (initial baseline) for the PMEP DCA process?

~~A. The lowest-cost alternative~~

~~B. The alternative with the highest total benefit score~~

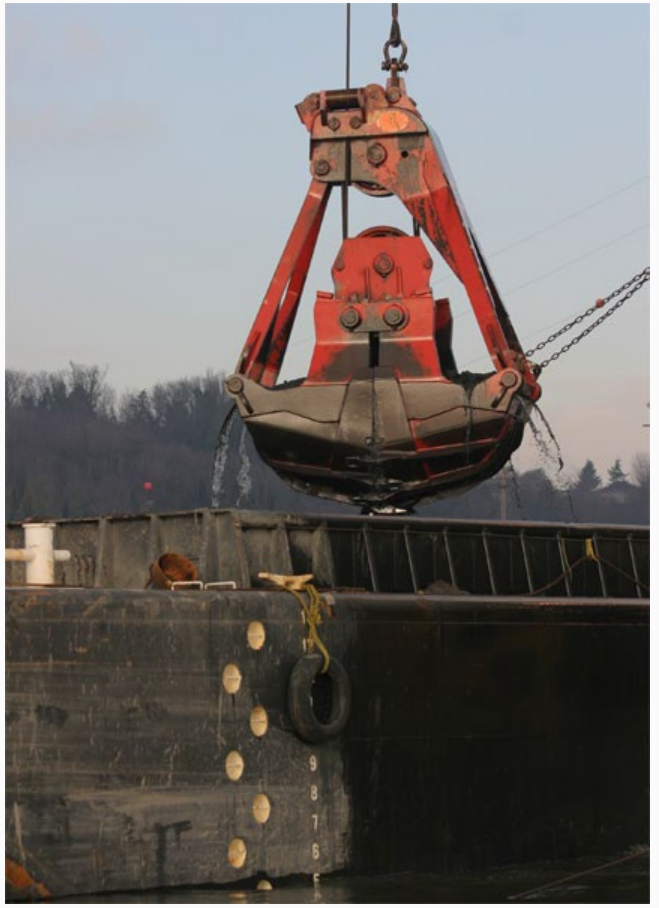
C. The most permanent alternative in the ranked list

~~D. The alternative preferred by stakeholders~~

PMEP Evaluation Methods

How do I Compare Costs and Benefits?

- Cost is quantitative
- Benefit is qualitative
- Questions:
  - How do I compare the benefits?
  - Should I combine all five benefits into one?
  - How do I compare the costs and benefits of one alternative with another?



Two ways to perform PMEP evaluation

Narrative Method

→ compare based on:

- Quantitative costs
- Qualitative benefit rankings

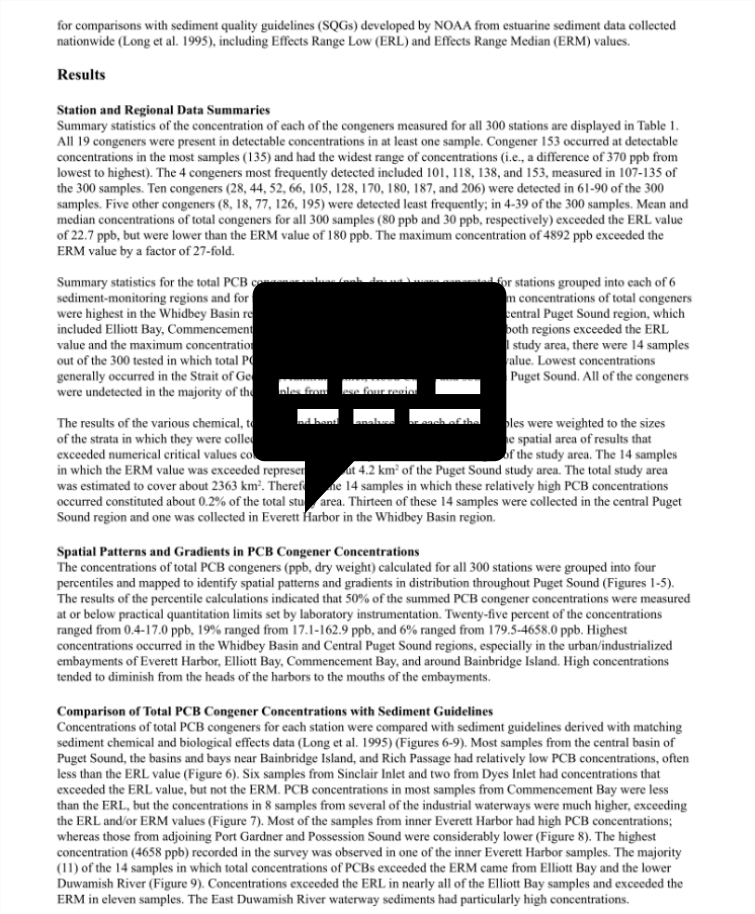
Semi-quantitative Method

→ compare based on:

- Quantitative costs
- Qualitative benefit scores
  - Allows a combined score

Narrative Method Overview

- Rank each benefit for each alternative
- No combining benefit ranks
- Compare cost increases vs. benefit advantages qualitatively
- Requires strong BPJ and clear narrative justification



for comparisons with sediment quality guidelines (SQGs) developed by NOAA from estuarine sediment data collected nationwide (Long et al. 1995), including Effects Range Low (ERL) and Effects Range Median (ERM) values.

Results

Station and Regional Data Summaries

Summary statistics of the concentration of each of the congeners measured for all 300 stations are displayed in Table 1. All 19 congeners were present in detectable concentrations in at least one sample. Congener 153 occurred at detectable concentrations in the most samples (135) and had the widest range of concentrations (i.e., a difference of 370 ppb from lowest to highest). The 4 congeners most frequently detected included 101, 118, 138, and 153, measured in 107-135 of the 300 samples. Ten congeners (28, 44, 52, 66, 105, 128, 170, 180, 187, and 206) were detected in 61-90 of the 300 samples. Five other congeners (8, 18, 77, 126, 195) were detected least frequently; in 4-39 of the 300 samples. Mean and median concentrations of total congeners for all 300 samples (80 ppb and 30 ppb, respectively) exceeded the ERL value of 22.7 ppb, but were lower than the ERM value of 180 ppb. The maximum concentration of 4892 ppb exceeded the ERM value by a factor of 27-fold.

Summary statistics for the total PCB [redacted] for stations grouped into each of 6 sediment-monitoring regions and for [redacted] concentrations of total congeners were highest in the Whidbey Basin re[redacted] central Puget Sound region, which included Elliott Bay, Commencement[redacted] both regions exceeded the ERL value and the maximum concentratio[redacted] study area, there were 14 samples out of the 300 tested in which total PC[redacted] alue. Lowest concentrations generally occurred in the Strait of Ge[redacted] Puget Sound. All of the congeners were undetected in the majority of th[redacted]

The results of the various chemical, t[redacted] les were weighted to the sizes of the strata in which they were colle[redacted] e spatial area of results that exceeded numerical critical values co[redacted] of the study area. The 14 samples in which the ERM value was exceeded represe[redacted] t 4.2 km² of the Puget Sound study area. The total study area was estimated to cover about 2363 km². Theref[redacted] e 14 samples in which these relatively high PCB concentrations occurred constituted about 0.2% of the total st[redacted] area. Thirteen of these 14 samples were collected in the central Puget Sound region and one was collected in Everett Harbor in the Whidbey Basin region.

Spatial Patterns and Gradients in PCB Congener Concentrations

The concentrations of total PCB congeners (ppb, dry weight) calculated for all 300 stations were grouped into four percentiles and mapped to identify spatial patterns and gradients in distribution throughout Puget Sound (Figures 1-5). The results of the percentile calculations indicated that 50% of the summed PCB congener concentrations were measured at or below practical quantitation limits set by laboratory instrumentation. Twenty-five percent of the concentrations ranged from 0.4-17.0 ppb, 19% ranged from 17.1-162.9 ppb, and 6% ranged from 179.5-4658.0 ppb. Highest concentrations occurred in the Whidbey Basin and Central Puget Sound regions, especially in the urban/industrialized embayments of Everett Harbor, Elliott Bay, Commencement Bay, and around Bainbridge Island. High concentrations tended to diminish from the heads of the harbors to the mouths of the embayments.

Comparison of Total PCB Congener Concentrations with Sediment Guidelines

Concentrations of total PCB congeners for each station were compared with sediment guidelines derived with matching sediment chemical and biological effects data (Long et al. 1995) (Figures 6-9). Most samples from the central basin of Puget Sound, the basins and bays near Bainbridge Island, and Rich Passage had relatively low PCB concentrations, often less than the ERL value (Figure 6). Six samples from Sinclair Inlet and two from Dyes Inlet had concentrations that exceeded the ERL value, but not the ERM. PCB concentrations in most samples from Commencement Bay were less than the ERL, but the concentrations in 8 samples from several of the industrial waterways were much higher, exceeding the ERL and/or ERM values (Figure 7). Most of the samples from inner Everett Harbor had high PCB concentrations; whereas those from adjoining Port Gardner and Possession Sound were considerably lower (Figure 8). The highest concentration (4658 ppb) recorded in the survey was observed in one of the inner Everett Harbor samples. The majority (11) of the 14 samples in which total concentrations of PCBs exceeded the ERM came from Elliott Bay and the lower Duwamish River (Figure 9). Concentrations exceeded the ERL in nearly all of the Elliott Bay samples and exceeded the ERM in eleven samples. The East Duwamish River waterway sediments had particularly high concentrations.

BPJ – Best professional judgment

Narrative method: best fit for simpler PMEP evaluations

Use when:

- Site is relatively simple
- Alternatives are relatively simple
- Differences among alternatives are easier to explain qualitatively

Semi-Quantitative Method Overview

Key features:

- Uses numerical benefit **scores**
- Allows **weighting** of criteria
- Computes **total benefit score**
- Compares cost-effectiveness ratios ($/B)
- PMEP Tool automates calculations

$/B

$ = total cost in millions; B = total weighted benefit

Semi-quantitative method: useful when comparisons are harder

Use when:

- Site is complex
- Alternatives with many components
- Benefits differ across several criteria
- Small differences between alternatives

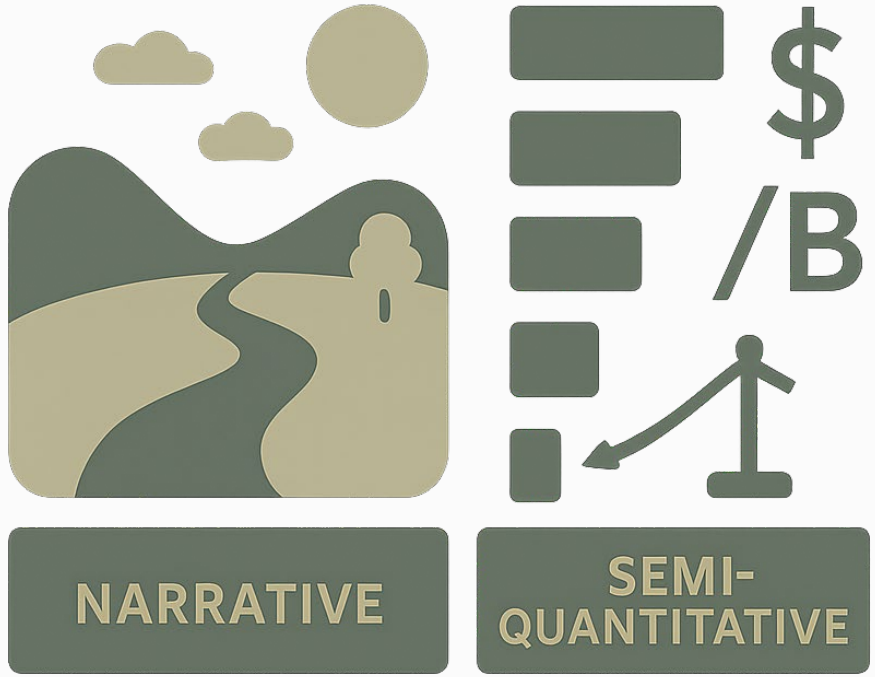
Summary of PMEP Methods

Narrative:

- Qualitative
- Best for simple sites
- Broad differences easy to see

Semi-Quantitative:

- Uses scoring + weighting
- Best for complex sites
- Allows calculation of cost-effectiveness ($/B) for easier comparison in DCA



Evaluating Total Costs

Include:

- Design, permitting
- Construction & management
- Monitoring, O&M
- Replacement, disposal
- Oversight & periodic reviews

Discount long-term costs using U.S. Treasury real rates

Evaluate benefits across five criteria

What evaluators should think about when scoring or ranking benefits

Protectiveness: reduction of risks & timeframe

Permanence: degree of treatment & irreversibility

Long-term effectiveness: degree of certainty & reliability over decades

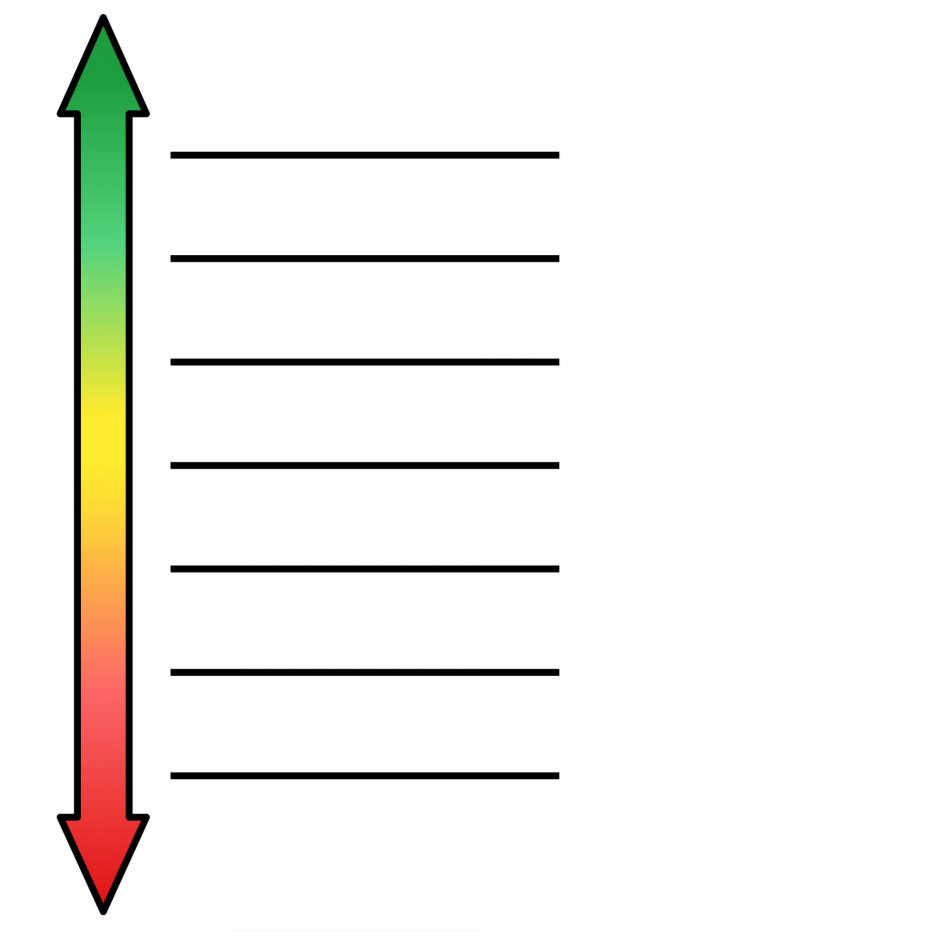
Implementation risk management: ability to control short-term risks

Implementability: technical and administrative feasibility

Benefit Scoring in Semi-Quantitative Method

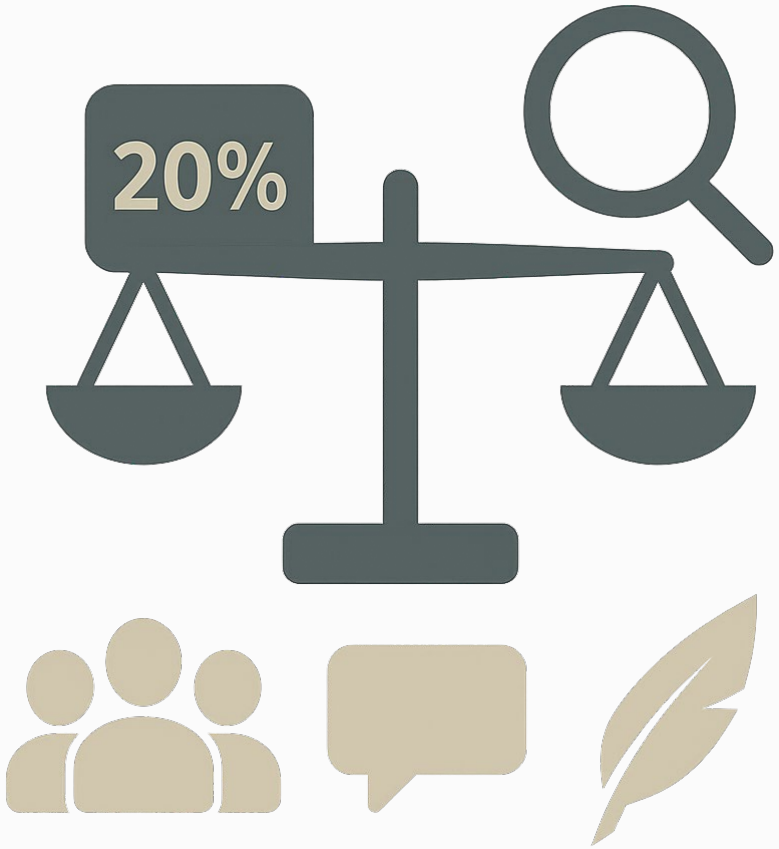
Scoring principles

- Linear scale (e.g., 1–10)
- Assign scores using factors
- Use BPJ
- Use full scale to differentiate options
- Ensure consistent scoring across alternatives



Weighting is allowed, but it needs justification

- Default weighting = **20%** each criterion
- Site-specific weighting may be necessary to consider:
  - Favor/disfavor one or more criteria
  - Public concerns
  - Tribal rights and interests
- If criteria are weighted unequally, explain why
- BPJ is needed



Public & Tribal Considerations

For Ecology-led or supervised cleanups, public and Tribal input can affect PMEP

- Public participation
- Meaningful engagement with Tribes
- Document in the FS report or CAP
- Conduct new PMEP evaluation, if conditions change after FS

Independent cleanups

- Not needed. Ecology can require on a site-specific basis

Public meeting for Swift Creek Project. Photo credit: Mary O'Heron, Ecology

Consider impacts of an alternative to likely vulnerable populations and overburdened communities (VP/OBCs)

- Document in FS, CAP or independent remedial action report
- Identify any likely VP/OBCs
- Describe the impacts
- Explain ranking, scoring, weighting
  - **Protectiveness**
  - **Long-term effectiveness**
  - **Implementation risk management**

Knowledge Check: Poll Question 6

Which of the following is not one of the five PMEP benefit criteria?

A. Protectiveness
B. Permanence
C. Cost-effectiveness
D. Long-term effectiveness
E. Implementation risk management

Answer: Poll Question 6

Which of the following is not one of the five PMEP benefit criteria?

~~A. Protectiveness~~

~~B. Permanence~~

C. Cost-effectiveness

~~D. Long-term effectiveness~~

~~E. Implementation risk management~~

Knowledge Check: Poll Question 7

In the semi-quantitative PMEP method, what does a lower cost-effectiveness ratio ($/B) indicate?

A. The alternative provides fewer benefits

B. The alternative is more cost-effective

C. The alternative is not practicable

D. The alternative must be eliminated

Answer: Poll Question 7

In the semi-quantitative PMEP method, what does a lower cost-effectiveness ratio ($/B) indicate?

~~A. The alternative provides fewer benefits~~

B. The alternative is more cost-effective

~~C. The alternative is not practicable~~

~~D. The alternative must be eliminated~~

Uncertainty and Best Professional Judgement

Best Professional Judgment (BPJ)

- PMEP evaluations involve uncertainty & require BPJ
- Sources of uncertainty:
  - Limited site data & accuracy
  - Incomplete CSM
  - Treatment performance variability
  - Long-term O&M uncertainty
  - Cost & benefit estimation
  - Community or tribal input
- BPJ uses knowledge, skills, and critical thinking

Where BPJ is needed?

Evaluation of alternatives

Quantitative cost estimates

Ranking/scoring/weighting benefits

Consideration of public and Tribal input

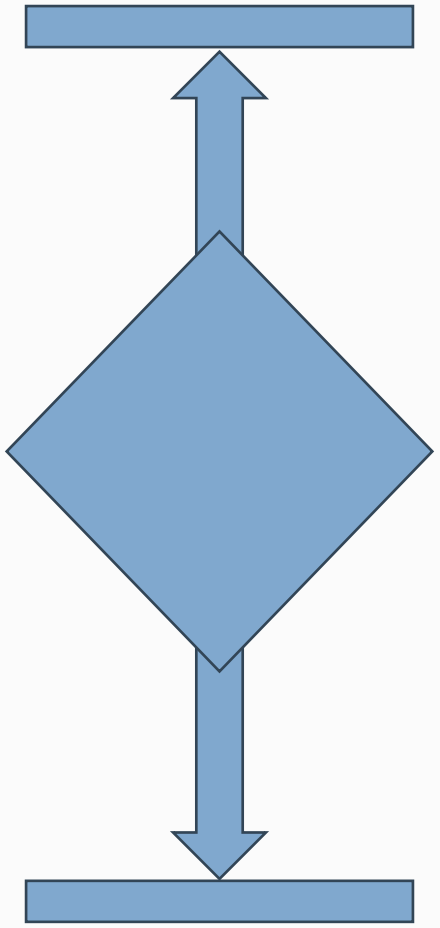
Deciding practicability in DCA

Uncertainty and Sensitivity Analysis

Sensitivity analysis can support BPJ

Use it to:

- Identify important uncertain inputs
- Test reasonable variations of cost or benefit inputs
- See whether outcome changes
- Document robustness of the conclusion



Ecology's Authority

Ecology is the decision maker

- Which alternatives are considered for PMEP

Ecology may use BPJ to:

- Weight benefit criteria
- Favor or disfavor qualitative benefit and cost estimates
- Whether an alternative is practicable

Knowledge Check: Poll Question 8

Which of the following correctly describes the role of Best Professional Judgment (BPJ) in PMEP?

A. BPJ replaces all quantitative analysis

B. BPJ is used only in site selection

C. BPJ helps interpret uncertainties and make decisions when comparing alternatives, especially in DCA

D. BPJ can override MTCA requirements

Knowledge Check: Poll Question 8

Which of the following correctly describes the role of Best Professional Judgment (BPJ) in PMEP?

~~A. BPJ replaces all quantitative analysis~~

~~B. BPJ is used only in site selection~~

C. BPJ helps interpret uncertainties and make decisions when comparing alternatives, especially in DCA

~~D. BPJ can override MTCA requirements~~

Knowledge Check: Poll Question 9

Sensitivity analysis is used in PMEP primarily to:

A. Select the lowest-cost alternative

B. Test how changes in cost or benefit inputs could affect the DCA outcome

C. Rank alternatives by cost only

D. Remove uncertainty from the evaluation

Knowledge Check: Poll Question 9

Sensitivity analysis is used in PMEP primarily to:

~~A. Select the lowest-cost alternative~~

B. Test how changes in cost or benefit inputs could affect the DCA outcome

~~C. Rank alternatives by cost only~~

~~D. Remove uncertainty from the evaluation~~

Example PMEP Evaluation

- Narrative
- Semi-quantitative

Hypothetical Narrative PMEP Evaluation

Case: Simple site with 3 alternatives (A, B, C). ALT C is permanent and ALT A & B are non-permanent

- Step 1: Determine costs and benefits of each alternative
- Step 2: Rank alternatives by degree of permanence.
  - ALT C followed by ALT A, and then ALT B
- Step 3: Identify initial baseline alternative
  - ALT C is the initial baseline alternative since it is first in the ranked list by permanence

DCA Criteria	ALT A	ALT B	ALT C
Costs			
Total cost (in millions)	$2.0 M	$1.5 M	$4.0 M
Benefits	Relative rank of 3 alternatives from 1 (best) to 3 (worst)		
Protectiveness	2	3	1
Permanence	2	3	1
Long-term effectiveness	2	3	1
Management of implementation risks	1	2	3
Implementability	2	1	3

ALT- Alternative

Hypothetical Narrative PMEP Evaluation (2nd slide)

Step 4: Conduct DCA

First DCA Iteration

- Step 4A: Identify alternatives for comparison
  - ALT C (baseline) & ALT A (next most permanent alternative)
- Step 4B: Compare alternatives
- Step 4C: Determine if baseline is practicable
  - Use BPJ to assess if 100% cost increase of baseline ALT C is justified
  - Evaluator determines ALT C is disproportionate (not practicable)
- Step 4D: Identify next steps
  - ALT C is eliminated
  - ALT A becomes new baseline

DCA Criteria	Baseline alternative	Next most permanent alternative	Comparison
Alternative	ALT C	ALT A	
Total cost (in millions)	$4.0 M	$2.0 M	100% increase
Benefits	Relative rank of the alternatives from previous Table		
Protectiveness	1	2	better
Permanence	1	2	better
Long-term effectiveness	1	2	better
Management of implementation risks	3	1	worse
Implementability	3	2	worse

Hypothetical Narrative PMEP Evaluation (3rd slide)

Second DCA Iteration

- Step 4A: Identify alternatives for comparison
  - ALT A & ALT B
- Step 4B: Compare alternatives
- Step 4C: Determine if baseline alternative is practicable
  - Use BPJ to assess if 33% cost increase of baseline ALT A is justified
  - Evaluator concludes ALT A is practical
- Step 4D: Identify next steps
  - ALT A is not disproportionate, it is PMEP
  - Analysis is complete

DCA Criteria	Baseline alternative	Next most permanent alternative	Comparison
Alternative	ALT A	ALT B	
Total cost (in millions)	$2.0 M	$1.5 M	33% increase
Benefits	Relative rank of the alternatives from previous Table		
Protectiveness	2	3	better
Permanence	2	3	better
Long-term effectiveness	2	3	better
Management of implementation risks	1	2	better
Implementability	2	1	worse

Hypothetical Semi-quantitative PMEP Evaluation

DEPARTMENT OF ECOLOGY State of Washington

Case: 6 alternatives (A, B, C, D, E & F). ALT A permanent, others non-permanent

- Step 1: Determine costs and benefits
- Step 2: Rank alternatives by permanence.
  - ALT A has the highest degree of permanence followed by ALT B, C, D, E, and F
- Step 3: Identify initial baseline alternative.
  - ALT A is the initial baseline alternative

DCA Criteria		ALT. A	ALT. B	ALT. C	ALT. D	ALT. E	ALT. F
Costs		Total cost in million dollars					
Total cost ($ in millions)		$35 M	$28 M	$26 M	$ 16 M	$15 M	$14 M
Benefits	weights	Relative benefit scores [1 (least) to 10 (most)]					
Protectiveness	0.20	8.0	10.0	4.0	6.0	5.0	1.0
Permanence	0.20	10.0	9.0	6.0	5.0	3.0	1.0
Long-term effectiveness	0.20	10.0	9.0	6.0	4.0	2.0	1.0
Implementation risks	0.20	1.0	5.0	7.0	6.0	8.0	10.0
Implementability	0.20	1.0	4.0	8.0	7.0	6.0	10.0
Total weighted benefit score (B)		**6.00**	**7.40**	**6.20**	**5.60**	**4.80**	**4.60**

Rank alternatives by degree of permanence

Initial baseline alternative

Alternatives	ALT. A	ALT. B	ALT. C	ALT. D	ALT. E	ALT. F
Permanence Rank	1	2	3	4	5	6

Hypothetical Semi-quantitative PMEP Evaluation (2nd slide)

DEPARTMENT OF ECOLOGY
State of Washington

Step 4: Conduct DCA (1st iteration)

- Step 4A: Identify alternatives for comparison
  - ALT A (baseline) & ALT B
- Step 4B: Compare alternatives
  - Calculate cost effectiveness ($/B)
- Step 4C: Determine if baseline is practicable
  - ALT A is less cost-effective
  - Consider uncertainty & make determination
  - Baseline ALT A is not practicable
- Step 4D: Identify next steps
  - ALT A is eliminated
  - ALT B becomes new baseline & DCA continues

DCA Criteria		Baseline alternative	Next most permanent alternative
Alternative		ALT A	ALT B
Total cost ($ in millions)		$35 M	$28 M
Benefits	Criteria weights	Relative benefit scores on a scale of 1 (least) to 10 (most)	
Protectiveness	0.20	8.0	10.0
Permanence	0.20	10.0	9.0
Long-term effectiveness	0.20	10.0	9.0
Management of implementation risks	0.20	1.0	5.0
Implementability	0.20	1.0	4.0
Total weighted benefit score (B)		6.00	7.40
Cost-effectiveness ($/B)		**5.83**	**3.78**

Hypothetical Semi-quantitative PMEP Evaluation (3rd slide)

DEPARTMENT OF ECOLOGY
State of Washington

Second DCA Iteration

- Step 4A: Identify alternatives for comparison
  - ALT B (baseline) & ALT C
- Step 4B: Compare alternatives
  - Calculate cost effectiveness ($/B)
- Step 4C: Determine if baseline alternative is practicable
  - ALT B is more cost-effective
  - Make determination after considering uncertainty
  - Baseline ALT B is practicable
- Step 4D: Identify next steps
  - ALT B is PMEP
- PMEP evaluation is complete

DCA Criteria		Baseline alternative	Next most permanent alternative
Alternative		ALT B	ALT C
Total cost ($ in millions)		$28 M	$26 M
Benefits	Criteria weights	Relative benefit scores on a scale of 1 (least) to 10 (most)	
Protectiveness	0.20	10.0	4.0
Permanence	0.20	9.0	6.0
Long-term effectiveness	0.20	9.0	6.0
Management of implementation risks	0.20	5.0	7.0
Implementability	0.20	4.0	8.0
Total weighted benefit score (B)		7.40	6.20
Cost-effectiveness ($/B)		**3.78**	**4.19**

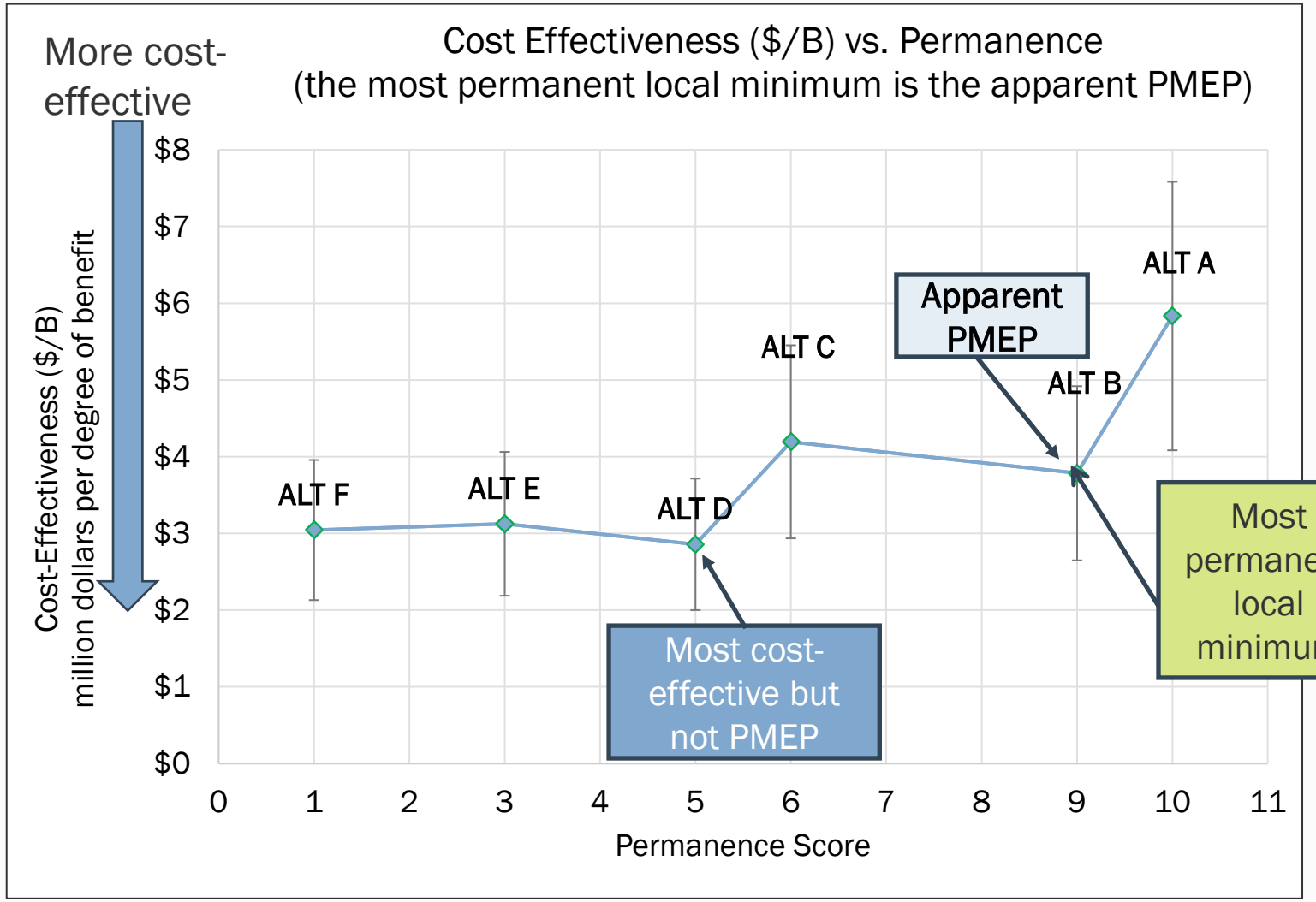
Semi-quantitative PMEP method: Graphical Representation

1. Estimate total costs ($) & total weighted benefit (B) of each alternative
2. Calculate cost-effectiveness ($/B) of each alternative
3. Plot cost-effectiveness vs. permanence score

Alternative Name	Cost ($ in millions)	Total weighted degrees of benefit (B)	Cost Effectiveness ($/B)	Permanence
ALT A	35	6	5.83	10
ALT B	28	7.4	3.78	9
ALT C	26	6.2	4.19	6
ALT D	16	5.6	2.86	5
ALT E	15	4.8	3.13	3
ALT F	14	4.6	3.04	1

Semi-quantitative PMEP method: Graphical Representation

4. The most permanent local minimum is the apparent PMEP
   - First low point (valley) from the right
5. Use BPJ in each DCA iteration to decide which alternative is PMEP. Consider uncertainties.
   - Error bars only show uncertainties in cost estimates



PMEP Excel Tool

How do you use it?

Excel Tool for Semi-quantitative PMEP Method (Input)

Same hypothetical site used for semi-quantitative evaluation

- **Step 1**: Determine the costs & benefits of each alternative
  - Enter data in yellow shaded boxes
  - Tool calculates total weighted benefit score and cost-effectiveness ratio ($/B)

Table 1: Input Data and Cost-Effectiveness Calculations									
Site Information	**Alternative name and present value of total cost of each alternative**								
Site Name	**Alternative Name**	ALT A	ALT B	ALT C	ALT D	ALT E	ALT F	not used	not used
Site ABC	**Cost ($ in millions)**	**$35.00**	**$28.00**	**$26.00**	**$16.00**	**$15.00**	**$14.00**		
CSID	**Cost-confidence Upper (+)%**	30%	30%	30%	30%	30%	30%		
1111	**Cost-confidence Lower (-)%**	30%	30%	30%	30%	30%	30%		
	Benefit Inputs								
DCA Benefit Criteria	**Weight (%)**	**Scores (relative degrees of benefit)**							
Protectiveness	20%	8.0	10.0	4.0	6.0	5.0	1.0		
Permanence (no ties–see cell note)	20%	10.0	9.0	6.0	5.0	3.0	1.0		
Long-term effectiveness	20%	10.0	9.0	6.0	4.0	2.0	1.0		
Implementation Risk Management	20%	1.0	5.0	7.0	6.0	8.0	10.0		
Implementability	20%	1.0	4.0	8.0	7.0	6.0	10.0		
Total weighted degrees of benefit	**100%**	**6.00**	**7.40**	**6.20**	**5.60**	**4.80**	**4.60**	**0.00**	**0.00**
	Cost Effectiveness (million dollars per total weighted degrees of benefit)								
Cost Effectiveness ($/B)		**$5.83**	**$3.78**	**$4.19**	**$2.86**	**$3.13**	**$3.04**		

PMEP Tool Automates Steps 2 & 3

- **Step 2**: Rank all alternatives in order of decreasing permanence
  - Done by the Tool
  - See the green ellipse
- **Step 3**: Identify initial baseline alternative
  - Automated by the Tool
  - ALT A is shown by thick arrow

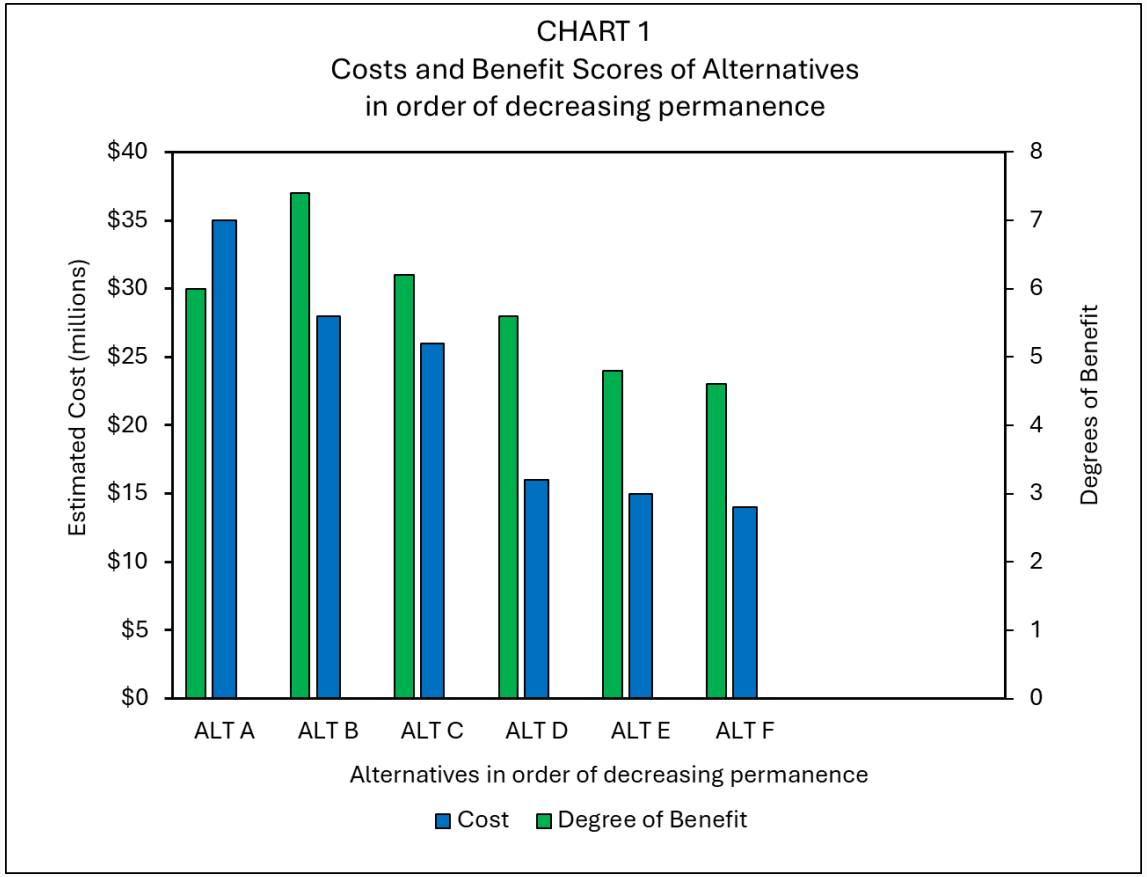
Alternative	Cost ($ millions)	Degrees of Benefit	Permanence		alternatives in order of decreasing permanence ↓
			Score	Rank	
ALT A	**$35.00**	**6.0**	**10.0**	1	
ALT B	**$28.00**	**7.4**	**9.0**	2	
ALT C	**$26.00**	**6.2**	**6.0**	3	
ALT D	**$16.00**	**5.6**	**5.0**	4	
ALT E	**$15.00**	**4.8**	**3.0**	5	
ALT F	**$14.00**	**4.6**	**1.0**	6	
not used					
not used					

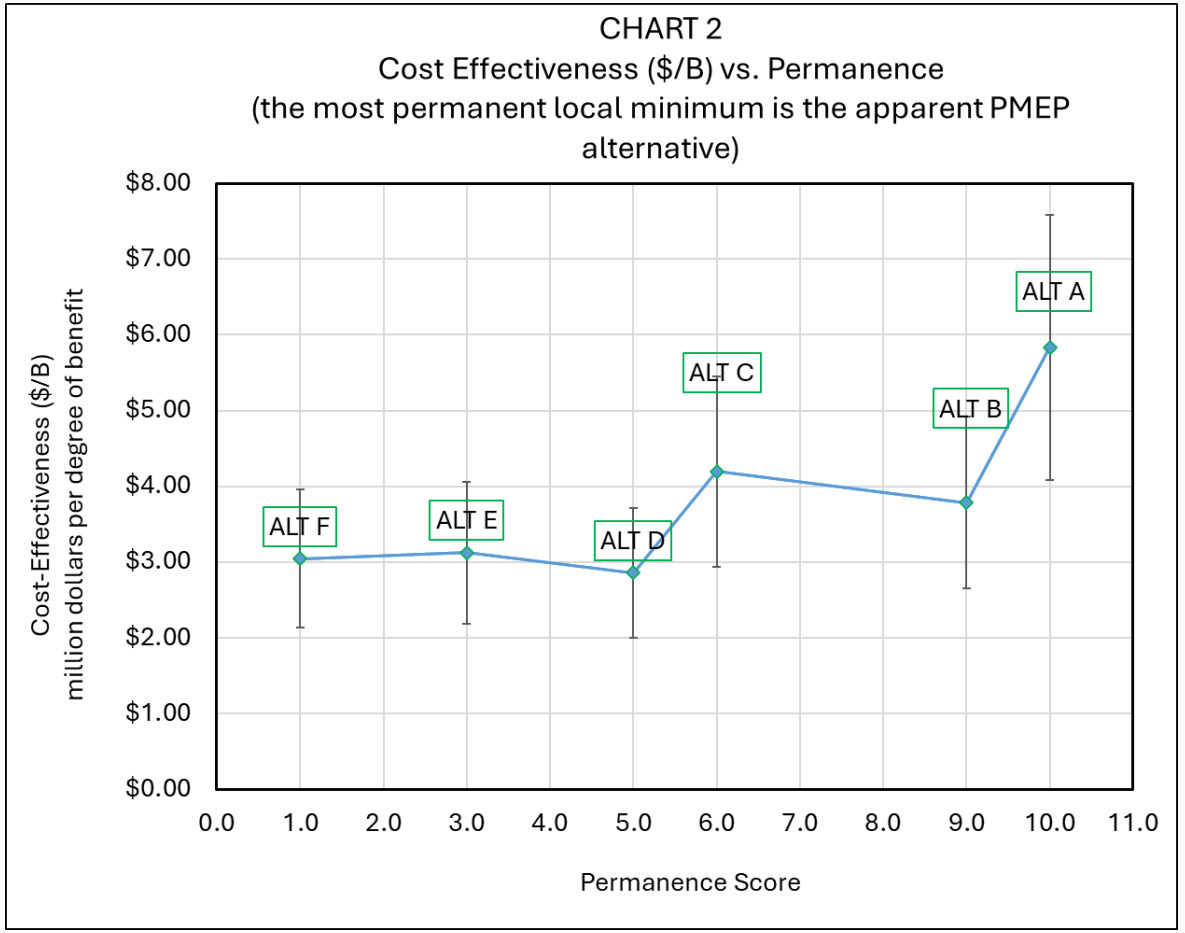
PMEP Tool Finds the Apparent PMEP Alternative

- Step 4: Use DCA iteratively to determine which alternative is practicable
  - Calculated by the Tool
  - ALT B is the apparent PMEP (highlighted in orange)
- PMEP Tool can be used to do sensitivity analysis
- Tool cannot consider uncertainty;
- Use BPJ

DCA Order	Alternative	Permanence Score	Cost ($ millions)	Degrees of Benefit	**Cost Effectiveness ($/B)**	**Apparent PMEP Alternative**
1	**ALT A**	10.0	$35.00	6.0	**$5.83**	**NO**
2	**ALT B**	9.0	$28.00	7.4	**$3.78**	**PMEP**
3	**ALT C**	6.0	$26.00	6.2	**$4.19**	**NO**
4	**ALT D**	5.0	$16.00	5.6	**$2.86**	**NO**
5	**ALT E**	3.0	$15.00	4.8	**$3.13**	**NO**
6	**ALT F**	1.0	$14.00	4.6	**$3.04**	**NO**

PMEP Tool Output Charts





Live Demo of the PMEP Tool

Knowledge Check: Poll Question 10

Can monitored natural attenuation (MNA) alone be considered as an alternative for PMEP evaluation?

A. Yes

B. No

C. May be

Knowledge Check: Poll Question 10

Can monitored natural attenuation (MNA) alone be considered as an alternative for PMEP evaluation?

~~A. Yes~~

~~B. No~~

C. May be

Common Mistakes to Avoid

- Starting PMEP before alternatives are fully developed
- Carrying forward alternatives that should have been screened out
- Underestimating post-construction costs
- Not providing rationale for benefit scores/ranking/weighting
- Not explaining BPJ
- Failing to document consideration of VP/OBCs
- Not considering public/Tribal input where applicable

Ecology Review Expectation: What a strong PMEP submittal should show

Document clearly:

- How alternatives were developed
- How costs and benefits were estimated
- Cost assumptions and unit costs
- Rationale for scoring or weighting benefits
- Key uncertainties
- Sensitivity analysis results
- Any stakeholder considerations
- Clear explanation of the DCA conclusion

Key Takeaways

- PMEP is required unless remedy is permanent or model remedy
- PMEP compares **protective, compliant** cleanup action alternatives
- PMEP follows a clear 4-step rule-defined process
- Two methods available: narrative best for simple and semi-quantitative best for complex sites
- PMEP is not necessarily the most feasible option
- The PMEP Tool is optional but automates the semi-quantitative method
- BPJ and uncertainty analysis are essential
- Strong documentation ensures smoother Ecology review

Q&A
Thank you

Mahbub Alam, PhD, PE

Senior Principal Engineer

Toxics Cleanup Program

Washington State Department of Ecology

mala461@ecy.wa.gov