A Brief Introduction to Decision Analysis

Adaptive Management Working Group
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This is a proposal

- How to provide meaningful and substantive involvement in the LTEMP EIS for stakeholders

- The proposal is to use some specific methods from decision analysis
  - "Multi-criteria decision analysis"

- We are very interested in your suggestions

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Humans

- We're evolved to be good decision-makers
  - In the settings in which we evolved
- To tackle the need to make quick decisions in complex settings
  - We've developed short-cuts (heuristics)
- The problem is
  - We now make decisions in settings that are very different from the environment we evolved in

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Two Branches of Decision Theory

- **Descriptive decision theory**
  - From the fields of psychology and sociology
  - How humans do, in fact, make decisions

- **Prescriptive decision theory**
  - From the fields of economics, operations research, business management, and others
  - How humans should make decisions

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Alternatives-focused Thinking

- We've evolved to focus on alternatives
  - Our innate tendency is to jump straight to alternatives, without first thinking about what our objectives are

Conflict

- We often argue about alternatives
- But what's really behind this?
  - Conflict over objectives
  - Disagreement about science
    - Incomplete communication
    - Actual uncertainty
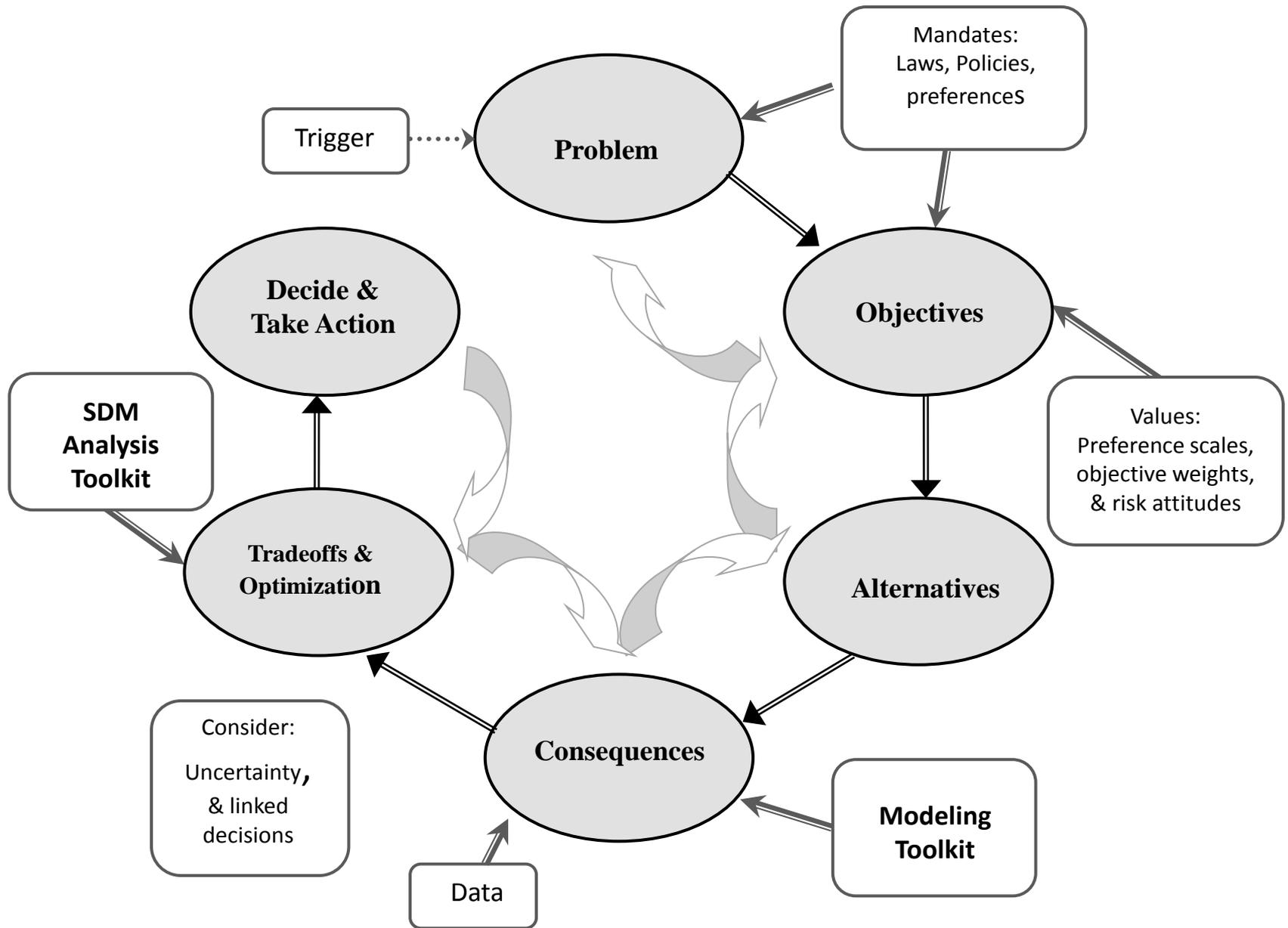   - Conflict over objectives

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Values-focused Thinking

- Turns our innate tendencies around

- Encourages us to identify our values first

  - And keep those central in the development and evaluation of alternatives

What is Decision Analysis?

"A formalization of common sense for decision problems which are too complex for informal use of common sense."

-Ralph Keeney, 1982

Source: Jean Fitts Cochrane

Some particular tools

- I think the LTEMP EIS would benefit greatly from two specific tools
  - Multi-criteria decision analysis (MCDA)
  - Expected value of information
- I want to walk you through MCDA, to show you what we propose for your involvement

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1. Objectives

- The stakeholders of LTEMP care about many things
- How do we make sure that all the objectives are given due consideration?

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2. Performance Metrics

- We value what we can measure
- Being able to clearly express our objectives is important
  - Particularly so we can assess alternatives against these metrics

3. Balancing Objectives

- When our objectives compete with each other
  - There is no alternative that performs best on all objectives
  - How do we find the right balance?
- One way is to weight the objectives
  - To reflect the relative importance of our many values
  - Noting this may be bounded by legal guidance

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Proposal

- We would solicit structured input from individual agencies, Tribes, and NGOs in two phases:

  - Now: performance metrics. Is the draft set complete and well developed?

  - June: tradeoff analysis. How would individual agencies balance the objectives?

- This then serves as input for the joint lead agencies to consider, as they make a recommendation to the Secretary

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Example & Exercise

Little Brown Bats, New York.   Photo credit: Nancy Heaslip, NYSDEC

The Setting

- A land manager has responsibility for an important cave
  - Winter bat hibernaculum
  - Spelunking
  - Other ecological & cultural values
- White-nose syndrome has appeared in this cave
- There are neighboring caves that do not yet harbor the disease

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Fundamental Objectives

- Prevent spread of the disease to neighboring caves

- Minimize direct take of bats

- Provide recreational opportunity (spelunking)

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Possible Actions

- No action

- Place a gate on the cave entrance to prevent human access

- Install a winter exit trap, which catches bats trying to emerge during winter

- Institute preventative culling of the bats in the cave

Consequence analysis

- The decision-maker needs to know how the four alternatives will perform against the three fundamental objectives

  - Has experts who can conduct this analysis

  - Those expert groups build models to make these predictions

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Performance metrics

- Prevent spread of the disease to neighboring caves
  - Probability that the disease will arrive in any of the neighboring caves in the next two years
- Minimize direct take of bats
  - Number of bats killed as a direct consequence of management efforts
- Provide recreational opportunity (spelunking)
  - Visitor-days per year

Consequence Evaluation

	Probability of spread	Take	Recreation	
No action	0.8	0	500	
Gate cave	0.475	0	0	
Exit trap	0.5	1000	250	
Local cull	0.35	20,000	300	

Swing Weighting

	Probability of spread	Take	Recreation	Rank	Score
Hypothetical Scenarios					
Baseline	0.8	20,000	0	4	0
1	0.35	20,000	0		
2	0.8	0	0		
3	0.8	20,000	500		

All Actions are Rational

		Minimize Take (weight)					
Minimize Spread (wt)		0	0.2	0.4	0.6	0.8	1
	0	No Action	No Action	No Action	No Action	No Action	No Action
	0.2	No Action	No Action	No Action	Exit Trap	Gate	
	0.4	Cull	Exit Trap	Exit Trap	Gate		
	0.6	Cull	Cull	Gate			
	0.8	Cull	Cull				
	1	Cull					

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Some Notes

- The quality of the analysis depends on having

  - A complete set of objectives

  - Meaningful performance metrics

  - A credible evaluation of the alternatives (using the best available science)

But what about uncertainty?

Uncertainty

- The bat SME group notes that it is difficult to predict the performance of the alternatives against the disease spread objective, because of a critical uncertainty

  - H_1: bats have high fidelity to winter hibernacula (thus, the primary means of spread is anthropogenic)

  - H_2: bats have low fidelity to winter hibernacula (thus, the primary means of spread is local bat movement)

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Consequence Table

	Probability of spread		Take	Recreation
	H_1	H_2		
No action	0.8	0.8	0	50
Gate cave	0.2	0.75	0	0
Exit trap	0.55	0.45	1000	25
Local cull	0.5	0.2	20,000	30

Issues:
- How to deal with the different objectives
- How to deal with the uncertainty

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Value of Information

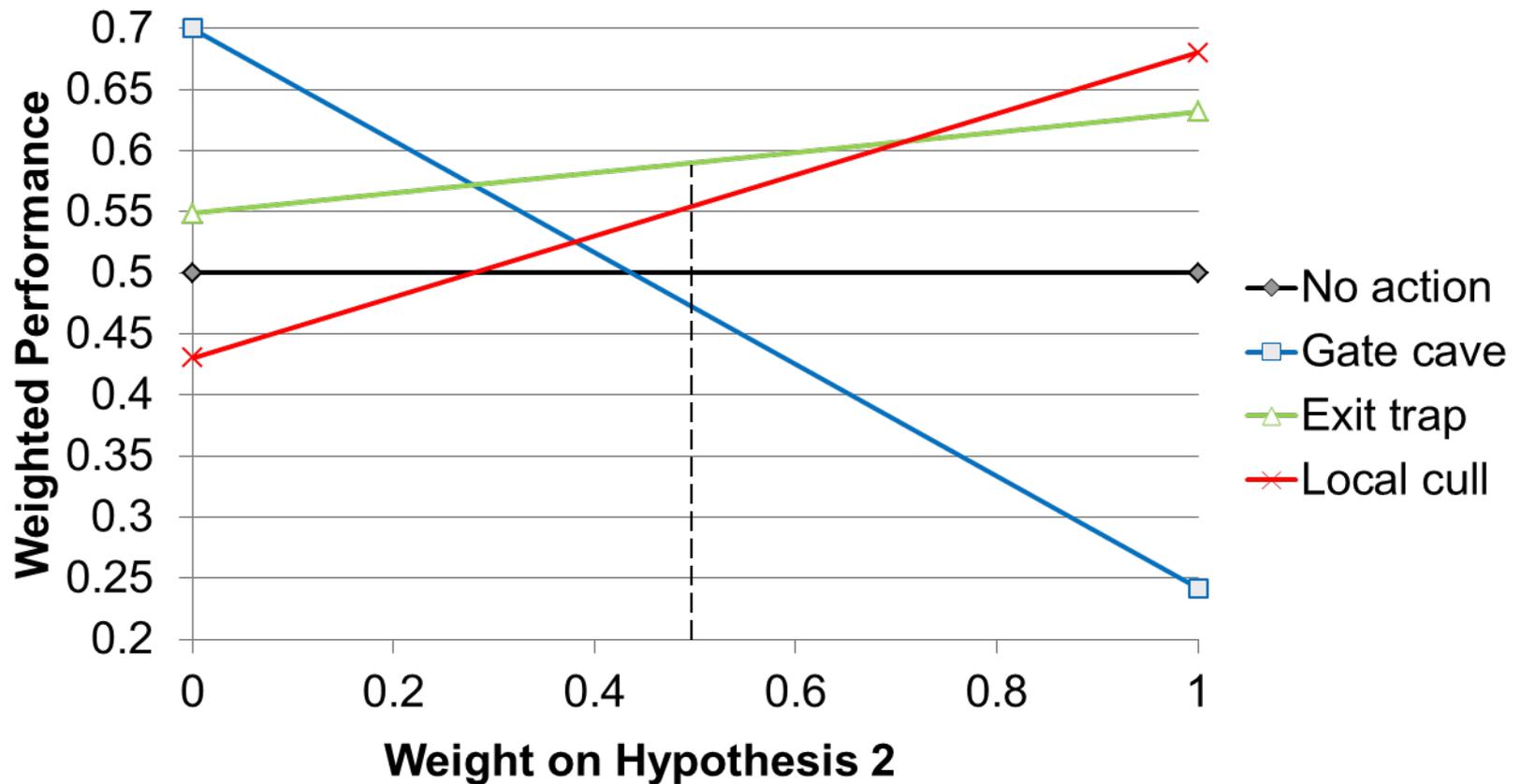|	H$_1$	H$_2$	Average
No action	0.50	0.50	0.5
Gate cave	0.70	0.24	0.47
Exit trap	0.55	0.63	0.59
Local cull	0.43	0.68	0.56
Best	*0.70*	*0.68*	*0.69*

These are now the weighted performance across the three objectives (50/20/30)

The expected value of perfect information is 0.10 (a 17% increase): 0.69 – 0.59.
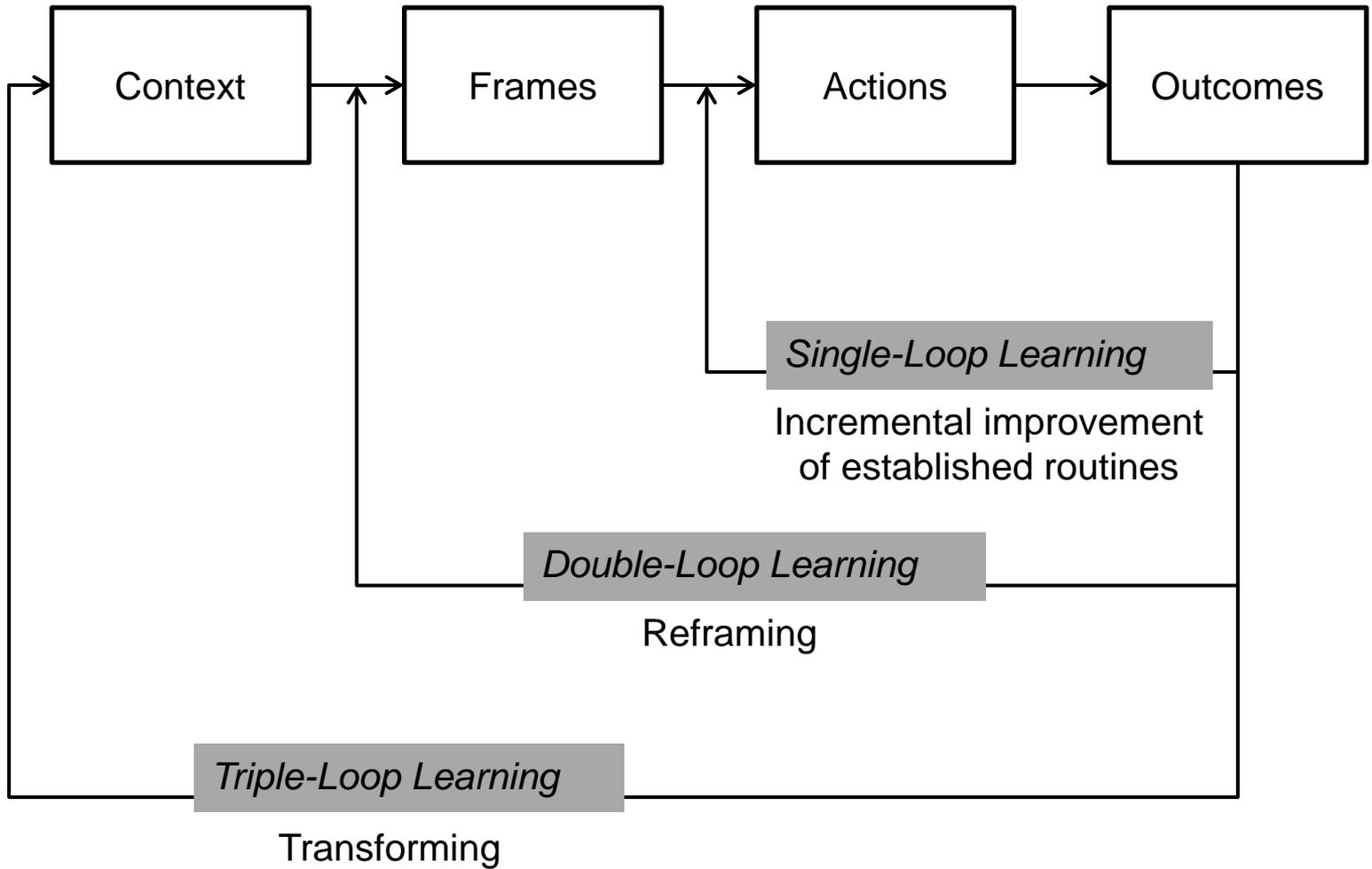
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Value of Information

Decision?

- In the face of uncertainty
  - Installing an exit trap is a sensible strategy
- But, there's a high value in resolving the uncertainty
  - If that information can be resolved before a decision has to be made, it's valuable
  - If not, perhaps an exit trap in the interim, while studies are underway

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Multiple Schools of ARM

- Decision-theoretic school
  - Focus is on reduction of uncertainty that can be explicitly articulated (known unknowns)

- Experimental Resilience school
  - A worry about unknown unknowns leads to experimental implementation of alternatives
  - In absence of hypotheses, seek to induce resilience

- Collaborative adaptive management
  - Focus on monitoring feedback to revise framing and perhaps even governance

- others...

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| Context | | Frames | | Actions | | Outcomes |

Single-Loop Learning

Incremental improvement
of established routines

Double-Loop Learning

Reframing

Triple-Loop Learning

Transforming

from Pahl-Wostl (2009)

Where we are with the LTEMP EIS

And what we propose

We have drafted

- Resources goals ("fundamental objectives") and performance criteria
- Alternatives
- A list of critical uncertainties
- Methods for analysis are in active development

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Next Steps

- (1) Performance criteria
  - Advice on how to complete quantitative statements of the fundamental objectives (March 15)
- (2) Evaluation, phase 1 (Feb-Apr)
  - Preliminary evaluation of the alternatives against the performance criteria, taking account of critical uncertainties (Argonne)
- (3) Multi-criteria Decision Analysis (June)
  - June workshop to understand the preliminary assessments and provide input to the joint-lead agencies via MCDA
- (4) Further development and assessment of alternatives (June-Aug)
  - Including experimental or adaptive design, monitoring & science program
  - More detailed assessment (Phase 2)
- (5) Joint-lead agencies recommend a preferred alternative (Aug-Sep)
- (6) Draft EIS (Dec-Jan)

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Performance Metrics

DRAFT

Hierarchy

- **Desired Future Conditions**
  - Resource Goals (specific to LTEMP context)
    - Performance Metrics (specific scales on which to assess achievement of the resource goals; note these do not contain thresholds). Related to Phase II of DFC development.