CUMULATIVE EFFECTS
CONNECTING THE STRESSORS

Connecting the Dots : Muskoka Stewardship Conference

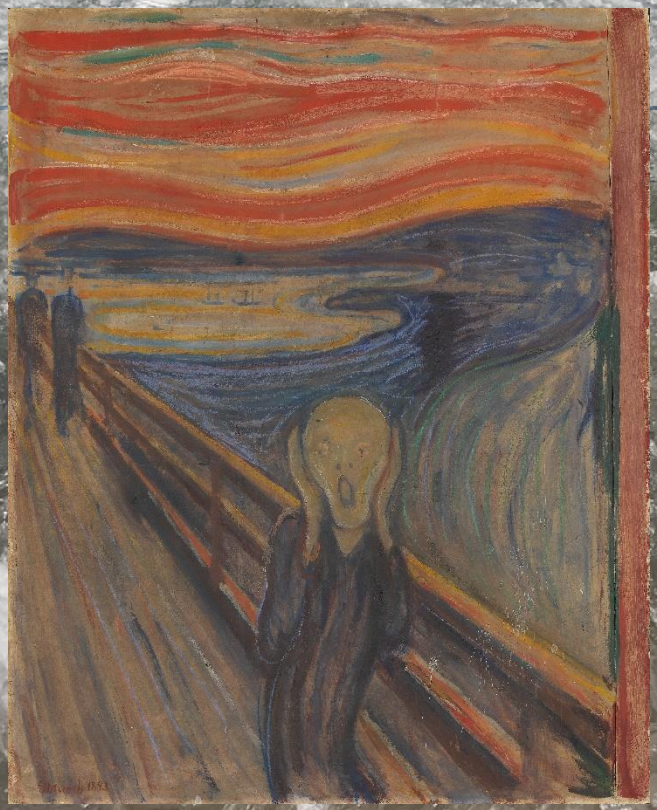
April 26, 2019

Hutchinson

Environmental Sciences Ltd.

WARNING !!

ACRONYMS WILL BE ENCOUNTERED



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What are Cumulative Effects?

Easy to define

Harder to detect

Hard to Interpret

Canadian Environmental Assessment Act CEAA

Cumulative effects are changes to the environment that are caused by an action in combination with other past, present and future human actions.

- an effect on the environment that results from the incremental and accumulating impact of an action when added to other past, present, and ***reasonably foreseeable*** future actions
- Effects can result from individually minor but collectively significant actions taking place over a period of time and space

What are Cumulative Effects?

Example from recent EA
Mackenzie Valley Resource Management Act

Paragraph 117(2)(a) of the *Act* requires the Review Board to consider cumulative effects. Cumulative effects are the combined effects of the development in combination with other past, present, and reasonably foreseeable future human activities and natural processes. For this assessment the consideration of cumulative effects will include, at a minimum, the effects of the project in combination with the effects of the past, present, and future activities at the Diavik and Ekati mines. The Review Board supports Diavik's proposal to base its cumulative

The scope of a cumulative effects assessment is not clear cut. Proponents and/or review agency need to define the scope

Classes of Cumulative Effects

- Similar impacts repeated over time
  - contaminant spills – Courtalds Fibers case
- Similar impacts repeated over space
  - Multiple WWTP effluent discharges along a river

Too much is happening within too small an area and in too brief a period of time.

A threshold is exceeded and the environment may not be able to recover to pre-disturbance conditions.

This can occur quickly or gradually before the effects become apparent.

- Multiple sources of the same nature of impact
  - WWTP effluent + land clearing + agricultural runoff + septic systems - nutrient loading to Lake Simcoe
- Impacts that change system function to amplify effects (positive feedback)
  - Nutrient induced anoxia induces internal phosphorus loading
  - Warmer summer and earlier lake stratification induces internal phosphorus loading

How Can They Occur ?

- Physical-chemical transport: a stressor is transported away from its source where it then interacts with another stressor
- Nibbling loss: the gradual disturbance and loss of individuals and habitat – no one significant action occurs at once
  - clearing of forest for a new subdivision and direct loss of wildlife habitat as subdivision grows
- Induced Effects from Nibbling loss
  - Wildlife sensory disturbance from increased traffic and human activity as subdivision grows
  - Human tolerant species displace intolerant species (pigeons, gulls, raccoons, coyotes)
- Growth-inducing potential - “positive feedback or spin off”
  - Subdivision grows with added recreational and commercial uses
  - Warming climate melts ice – decreased albedo and increased warming
  - Warming climate melts permafrost – increased loss of methane and carbon dioxide to atmosphere accelerate warming

Multiple Stressors and Cumulative Effects

Very hard to predict interaction

Muskoka example – many changes happening together

Nutrients + Ca decline + Cl increase + invasive species + hydrology + climate

Additive (1 + 1 = 2) – joint action by same mode of effect

- Acid rain - hydrogen ion + Aluminum - joint action (ionoregulaiton) in aquatic life

Synergistic (1 + 1 = 3) – one stressor increases sensitivity to another

- Ca loss (acid rain) increases Cl toxicity (road salt runoff)
- Nutrient losses decrease Cl tolerance in Daphnia

Antagonistic(1 + 1 = 0.5) - “hormesis”

- nutrient enrichment (WWTP) increases Cl tolerance in Daphnia
- Previous exposure to sublethal metals stress increases subsequent tolerance

What Are They Not ?

- Not a special class of effect – more an accumulation of effects
- Focus on “effects” , not changes
- Environmental assessment requires that a project have an significant effect before looking for cumulative effects (CEAA 1999 – CEA Practitioners Guide)
- A Cumulative Effects Assessment (CEA) for a single project under regulatory review, should fundamentally do the following:

  1. Determine if the project will have an effect on a Valued Ecosystem Component (VEC) .

  2. If such an effect can be demonstrated, determine if the incremental effect acts cumulatively with the effects of other actions, either past, existing or future

  3. Determine if the effect of the project, in combination with the other effects, may cause a significant change now or in the future in the characteristics of the VEC.

- An accumulation of stressors is not necessarily an indication of cumulative effects
  - The system may be doing quite well in an environment of multiple stressors OR//
  - We are not capable of discerning any effects

Approaches to CEA

- Formal CEA most frequently seen as a required component of environmental assessment for a new or expanded project (“a-priori” analysis)
  - predictive and cautionary process to predict system response to a new activity
- Formal CEA can be used to design a study to understand its current state
  - Interpret response of a system to multiple stressors
- CEA can be used to guide regional or watershed planning to a desired future state
- CEA may be seen as an afterthought or response to an expected or unexpected change in the environment (*OMG – what have we done now!*)

As stated in the CRP Section 5.12.3 (CIRNAC and GNWT 2019b), the cumulative effects assessment in Chapter 11 of the DAR identified that the GMRP would not contribute to significant cumulative effects in the downstream receiving environment (INAC and GNWT 2010). However, increased activity in the Yellowknife area outside of GMRP activities and new research of the aerial extent of deposition from historical mining in the Yellowknife area suggests cumulative effects monitoring in the surrounding area should be considered. Further, the GMRP

Approaches to CEA

Two Schools of Thought – Apply to any environmental monitoring program

- **Stressor Based (physical/chemical)**
  - Look for change in stressors (i.e. water quality or quantity)
  - No change – no potential for effects
  - Small change - (> from baseline, < guideline) unlikely potential for ecological effects
  - Greater change – (>baseline > guideline) some potential for ecological effects but not certain
  - Multiple changes - interpretative challenge, “weight of evidence”

  - Considerations
    - Need to determine action level or significance threshold
    - Easier to determine causation
    - Assumes you are measuring the right things
    - May not be ecologically relevant

Approaches to CEA

Two Schools of Thought – Apply to any environmental monitoring program

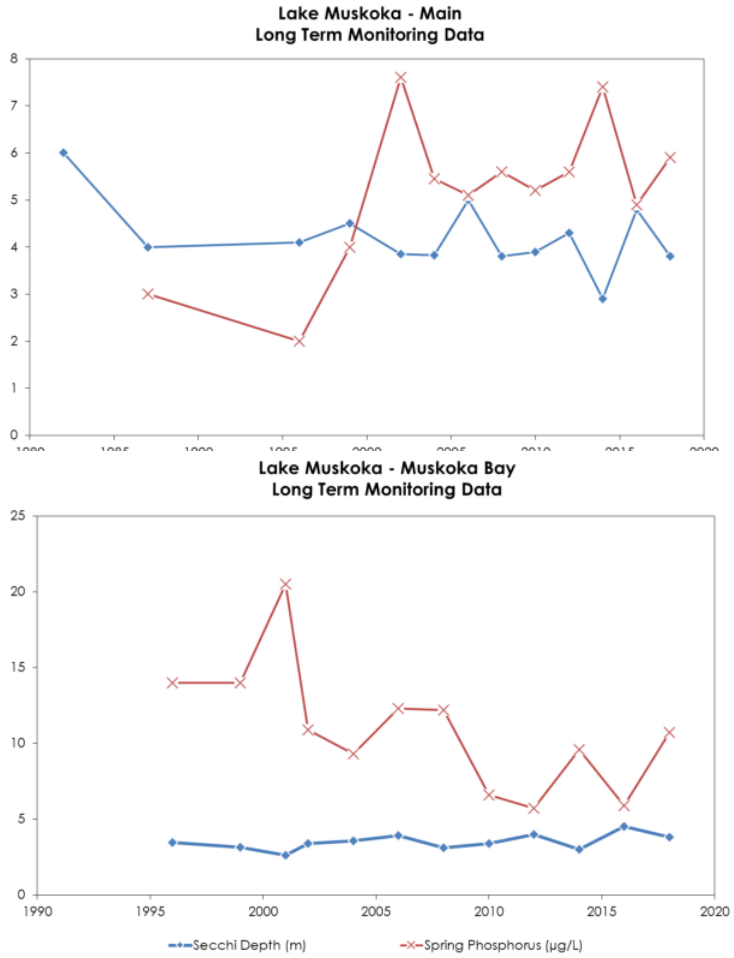
- **Effects Based (ecological)**
  - Look for change in receptors (biota)
  - Define normal range in absence of stressors
    - recognize that the natural environment in variable on its own
  - Look for changes beyond normal range - “significance threshold”

  - Considerations
    - Need to determine action level or significance threshold
    - Easier to determine significance
    - Harder to determine causation
    - How to choose ecological receptors or measure everything
      - – focus on upper trophic levels (fish)

Interpretation of Change

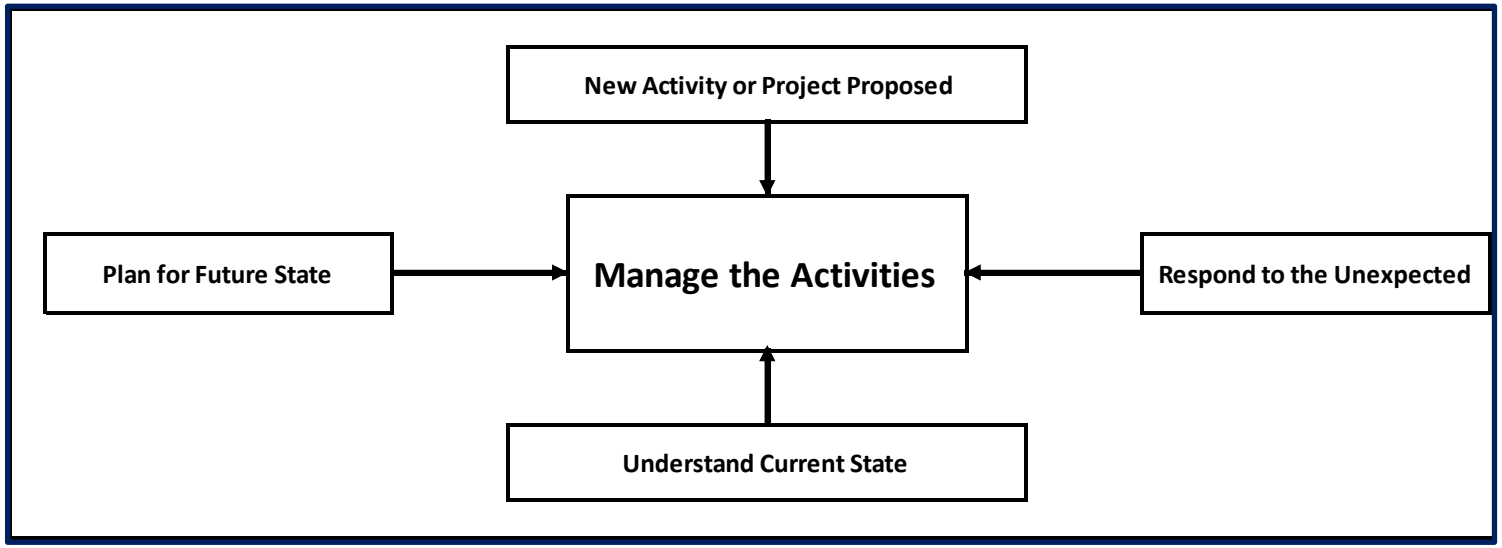
Applies to any environmental monitoring program

- A change can occur without an associated stressor
  - Variable climate
  - Sampling error
  - Measurement error
- A change may not be significant
  - Natural variance
  - Time scale of observation
- A change is not an effect – “So What?”
- An effect may not be ecologically significant
  - Need to understand the threshold of significance
  - Long standing ecological question
    - Water quality protects 95% of sensitive species (CCME)
    - +/- 2 Standard Deviations from the mean (MDMER-EEM
  - Philosophical Approaches
    - “No Substantial Alteration” (NLCA, MVRMA, not OWRA)
    - “Pollute Up To” – MOE/CCME WQOs
    - No Use Impairment



End Goal – Management

- Predictive and cautionary process to predict system response to a new activity
  - – manage the future
- Understand current state - interpret response of a system to multiple stressors
  - – manage it / mitigate it
- Guide regional or watershed planning to a desired future state
  - – manage the future
- Response to an expected or unexpected change in the environment
  - - manage it / mitigate it / restore it



Requirements for CEA

- Baseline Conditions (historic or current ?)
- What has changed since then ?
- What changes are proposed ?
- How will we measure change ?
- What is the desired state ?
- What is acceptable threshold of change ?
- What will the future look like ?

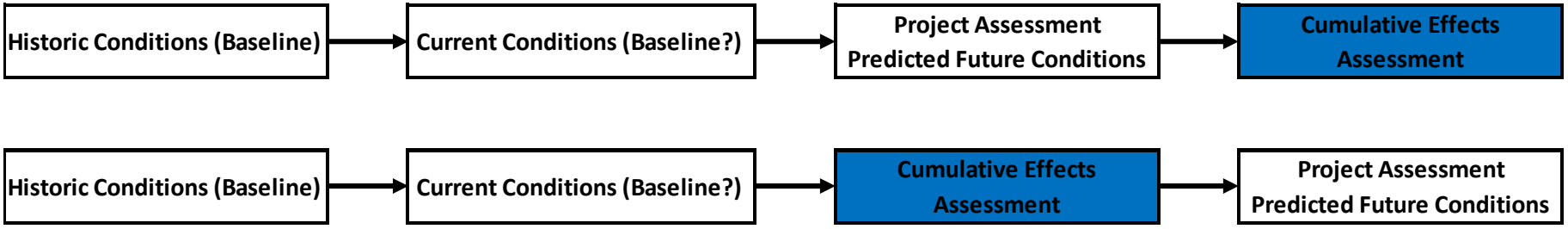
Requirements for CEA

Or Really

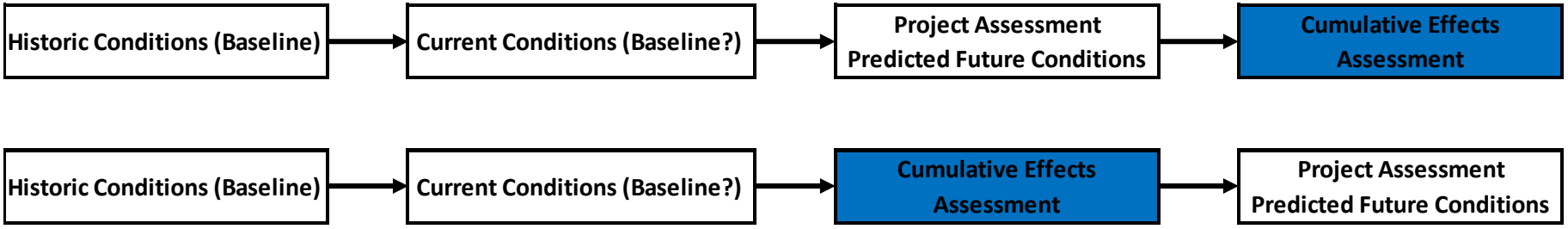
Any Planning Exercise

- Baseline Conditions (historic or current ?)
- What has changed since then ?
- What changes are proposed ?
- How will we measure change ?
- What is the desired state ?
- What is acceptable threshold of change ?
- What will the future look like ?

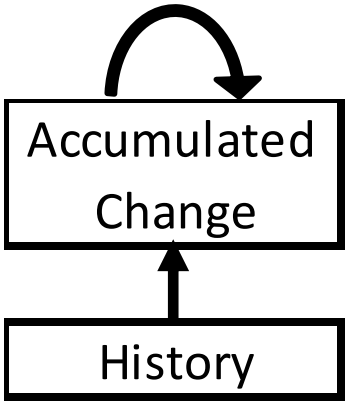
Putting it Together
Order of Assessment



Putting it Together
Order of Assessment



Add Departure from Baseline



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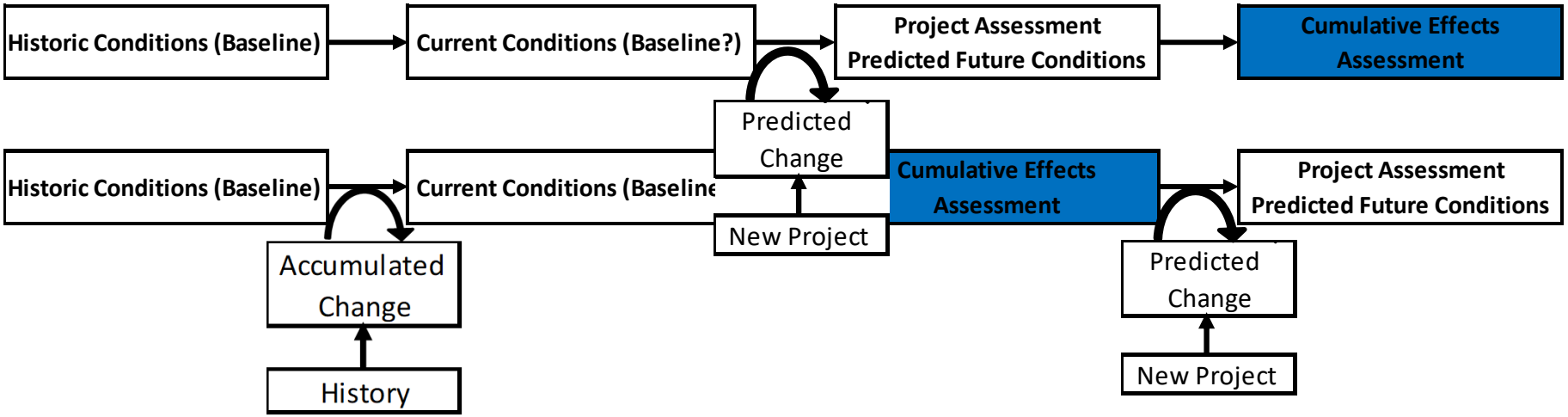
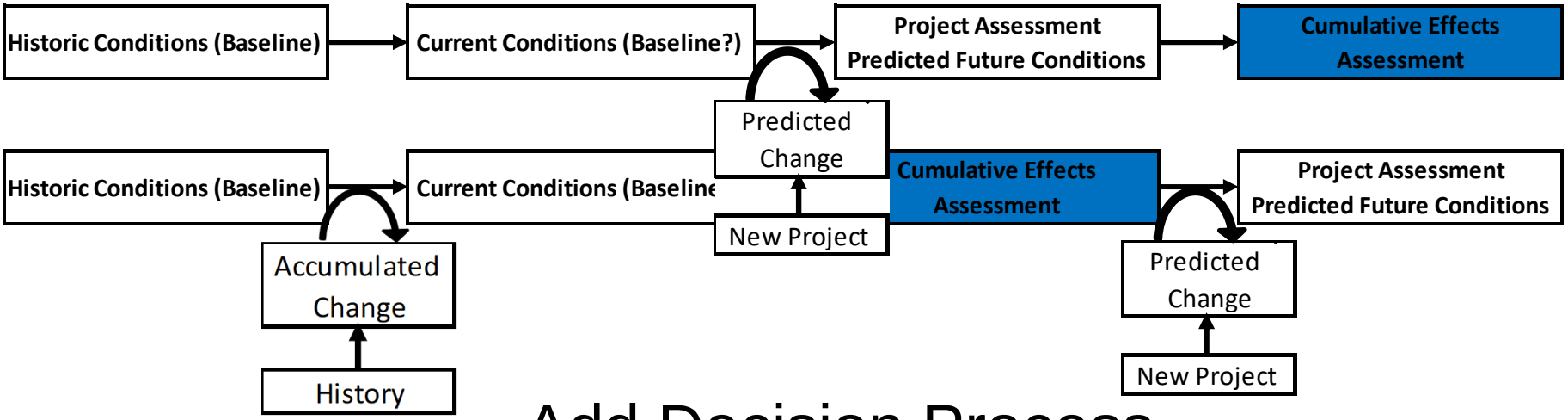
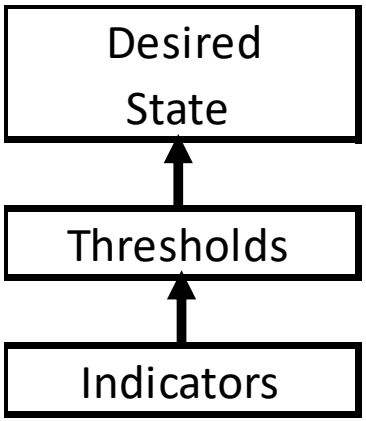


Add Departure from Current Conditions

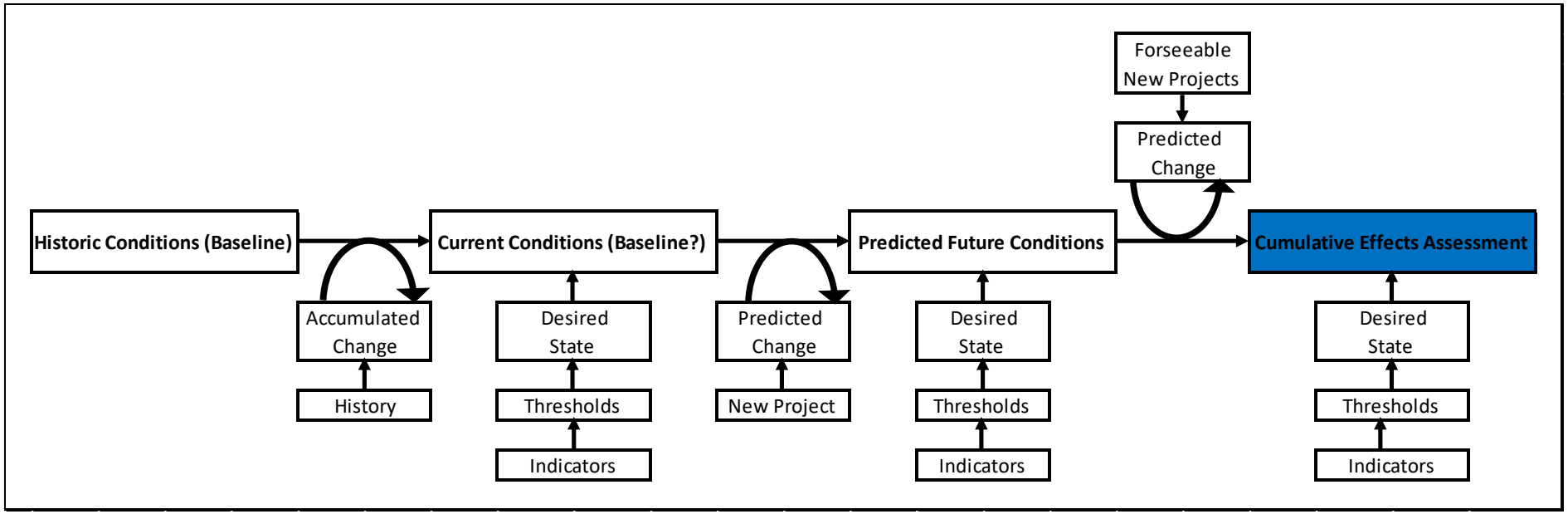
Putting it Together
Order of Assessment



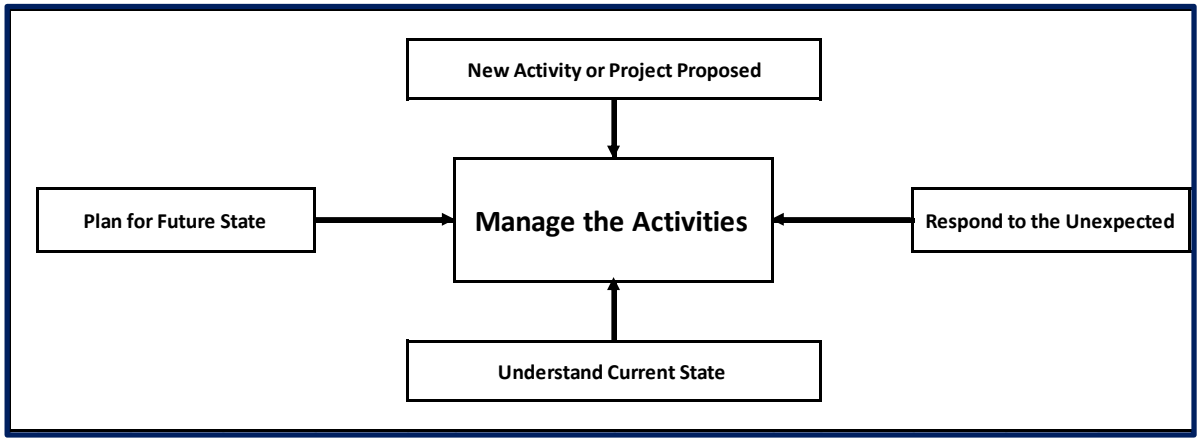
Add Decision Process



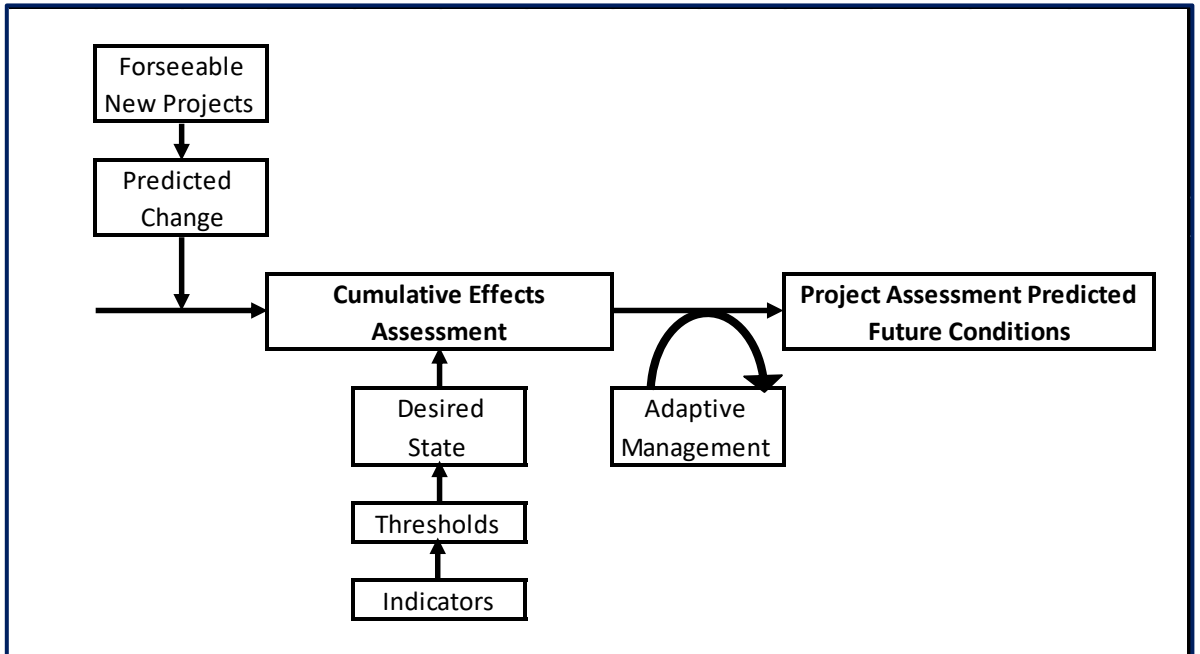
Assessment Process



End Goal – Management

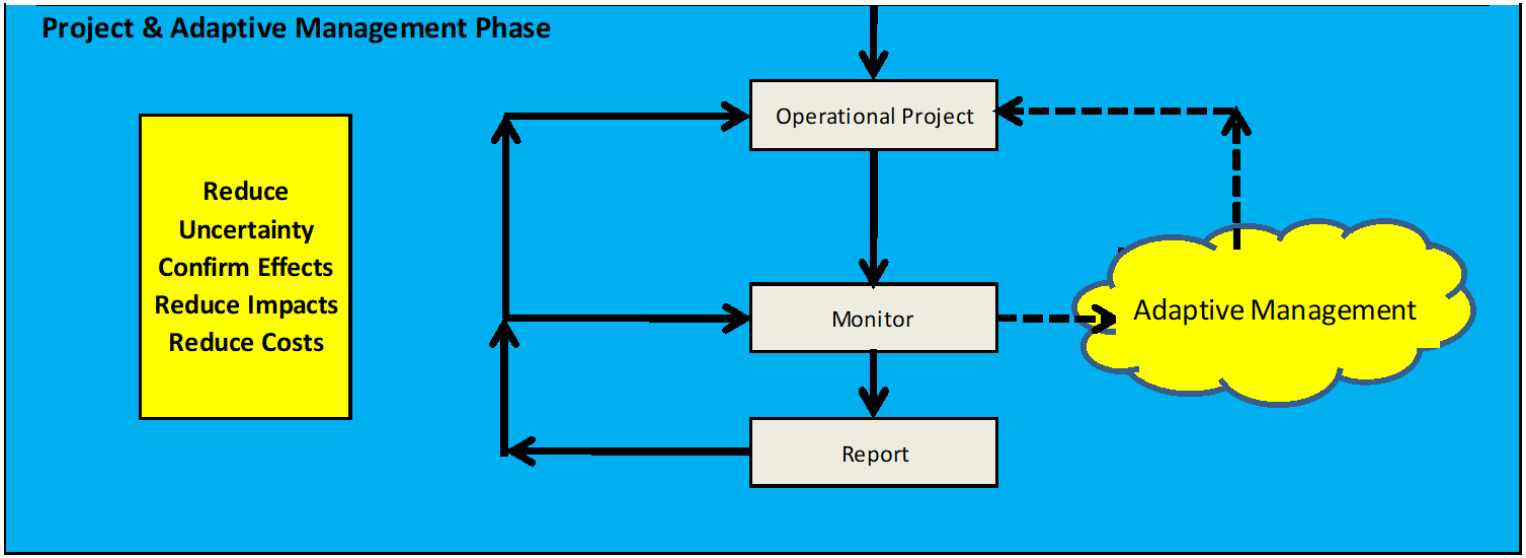


Links Predictions to Outcomes



Adaptive Management

- Prevents an unexpected change from becoming a significant adverse effect
- Allows for continual improvement
- Popular element of EA process
- Required element of Regulatory process



Adaptive Management

- Changes exceed predictions
- Unpredicted changes
- Unpredicted interactions, multiple stressors or cumulative effects

Adaptive Management

- Detect and monitor change
- Assess its significance
- Manage or mitigate the changes

Adaptive Management Strategy

Two Approaches to Adaptive Management

- Fuzzy and general
  - learning by doing - *“we’ll figure it out if it occurs”*
- Prescriptive
  - Develop a response to all possible eventualities

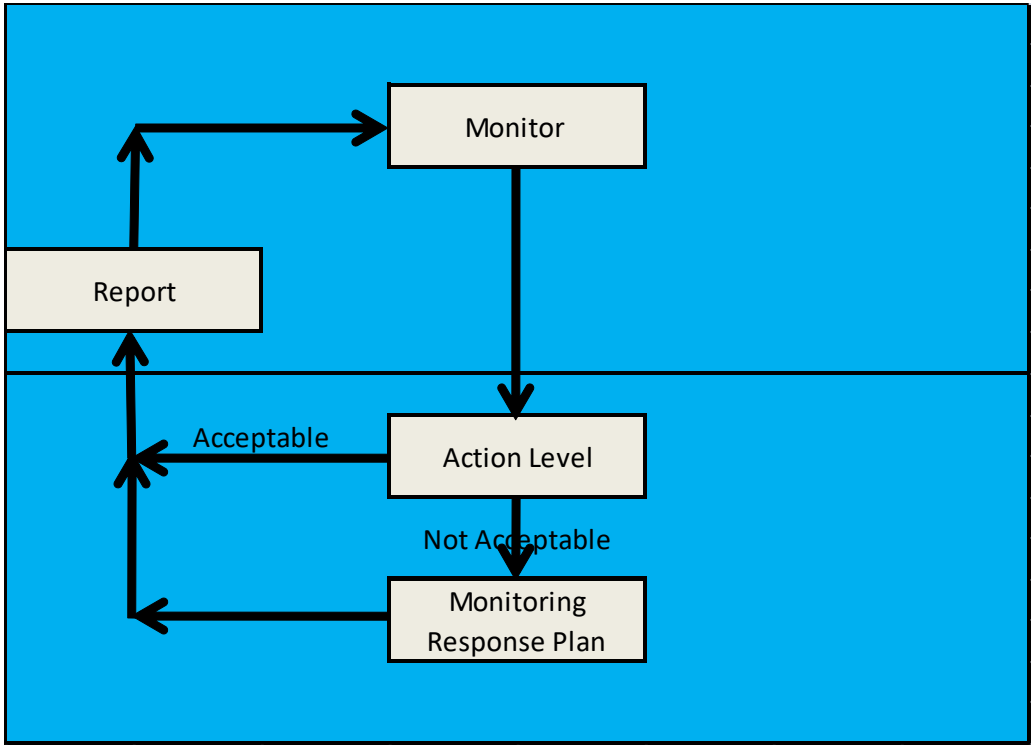
A Better Approach Based on Project or System Understanding

The Response Framework

The Response Framework

Starts with a comparison to a predetermined “Action Level”

Action Level (predetermined)
triggers
Monitoring Response Plan
(adaptive)



The Response Framework
Management Action Tailored to Response

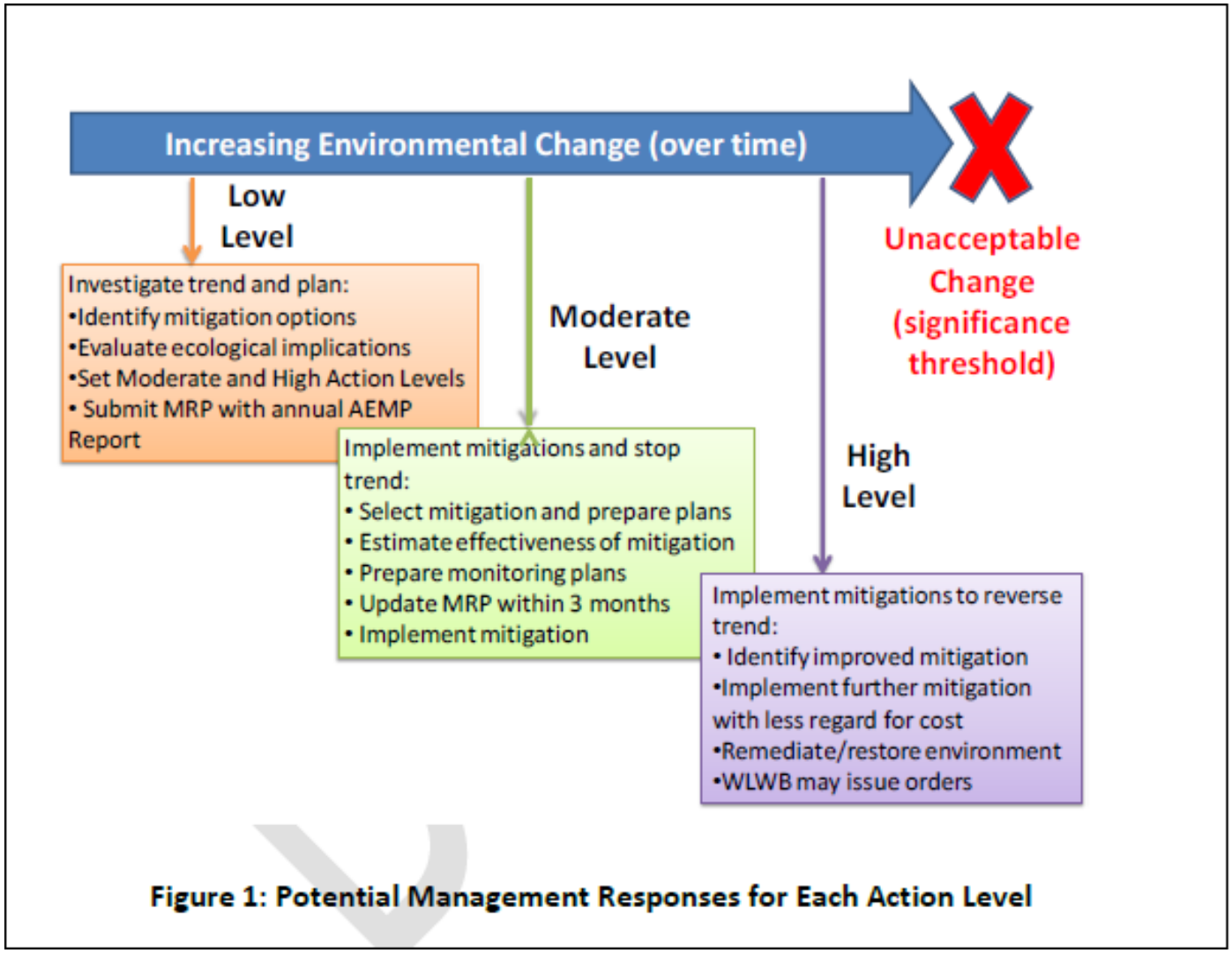
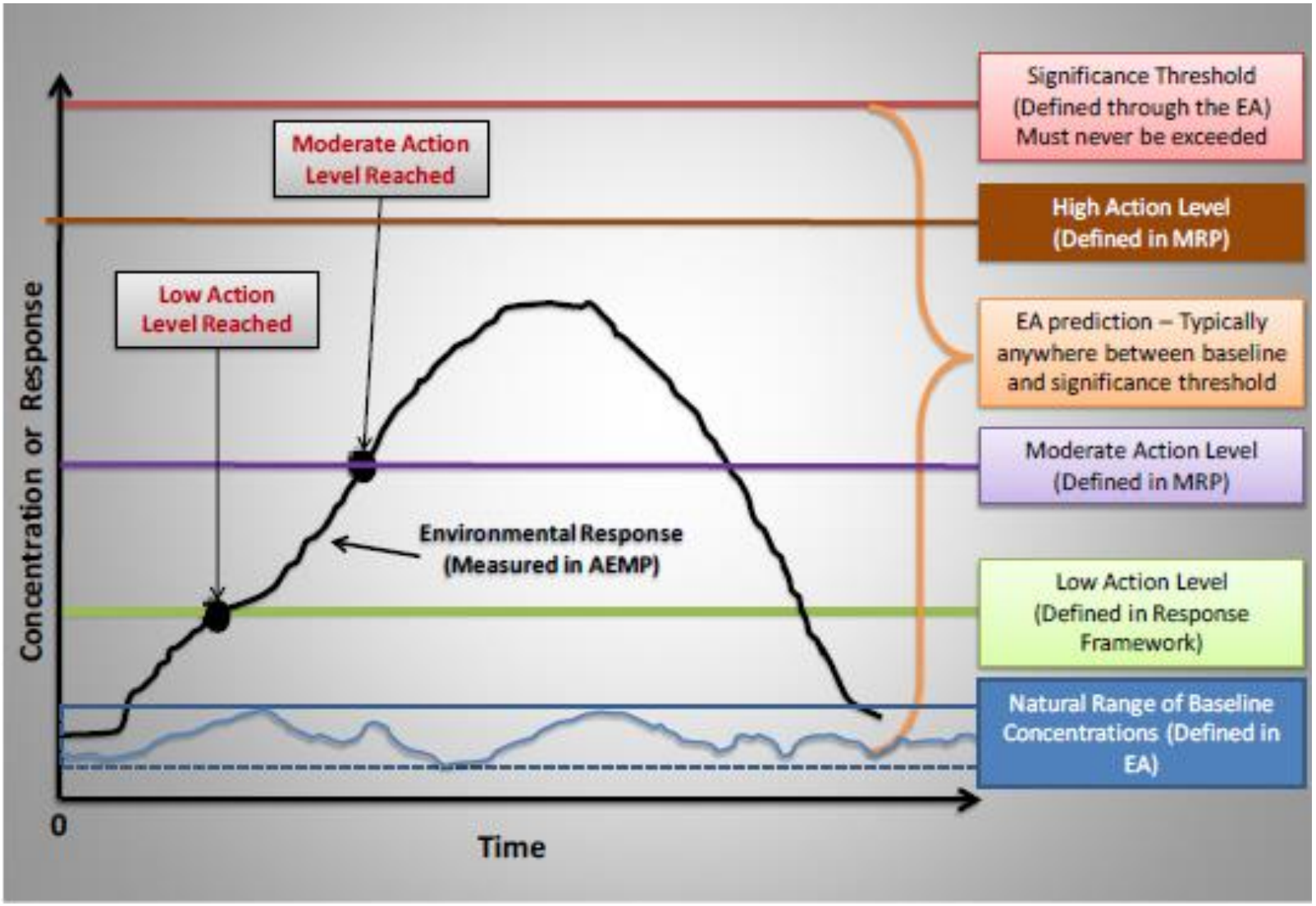


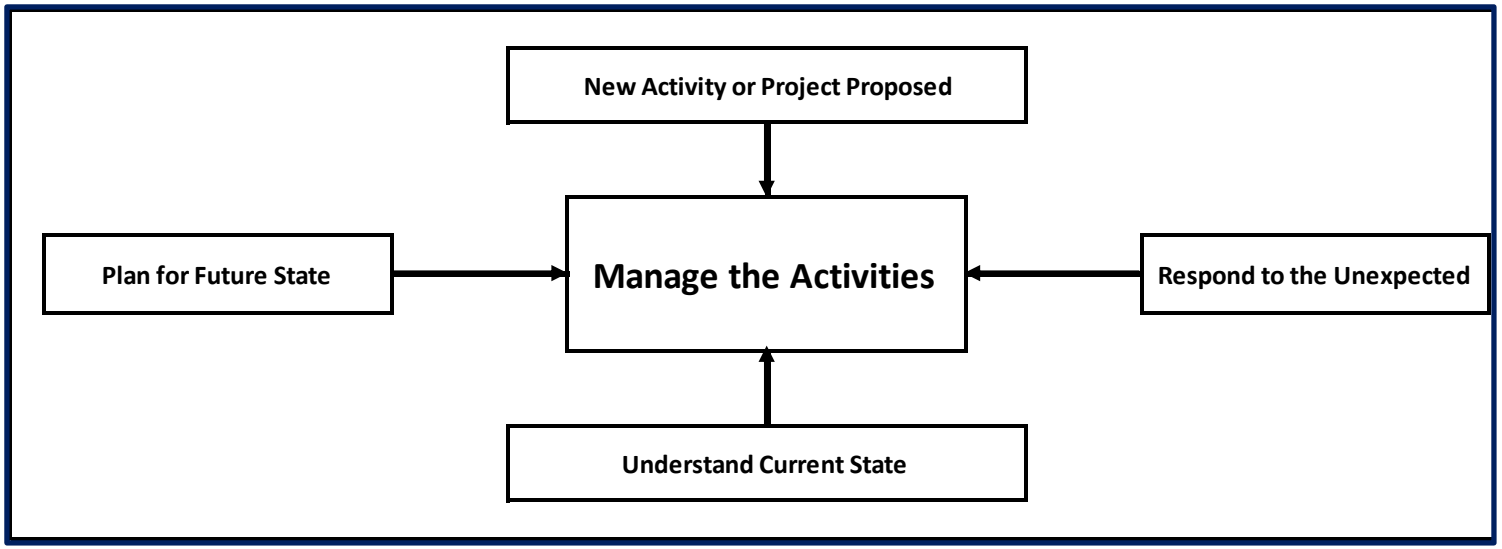
Figure 1: Potential Management Responses for Each Action Level

The Response Framework Process



Cumulative Effects Assessment

- Another more complex form of environmental management
- Easy to talk about – hard to implement
  - "there is no universally accepted definition of a cumulative effect" (Gunn and Noble (2011), in Sheelamore et al. 2013) – can be defined by stressor or outcome
- Easy to understand (retroactively !! – OMG what have we done!!)
- No good examples of effective pre-emptive implementation in Canada
  - DMM/MOE Water Quality Model can manage cumulative phosphorus loading but limited by assumption of phosphorus mobility and accuracy of model
- It is a great topic for academic papers
  - "there is no universally accepted definition of a cumulative effect"

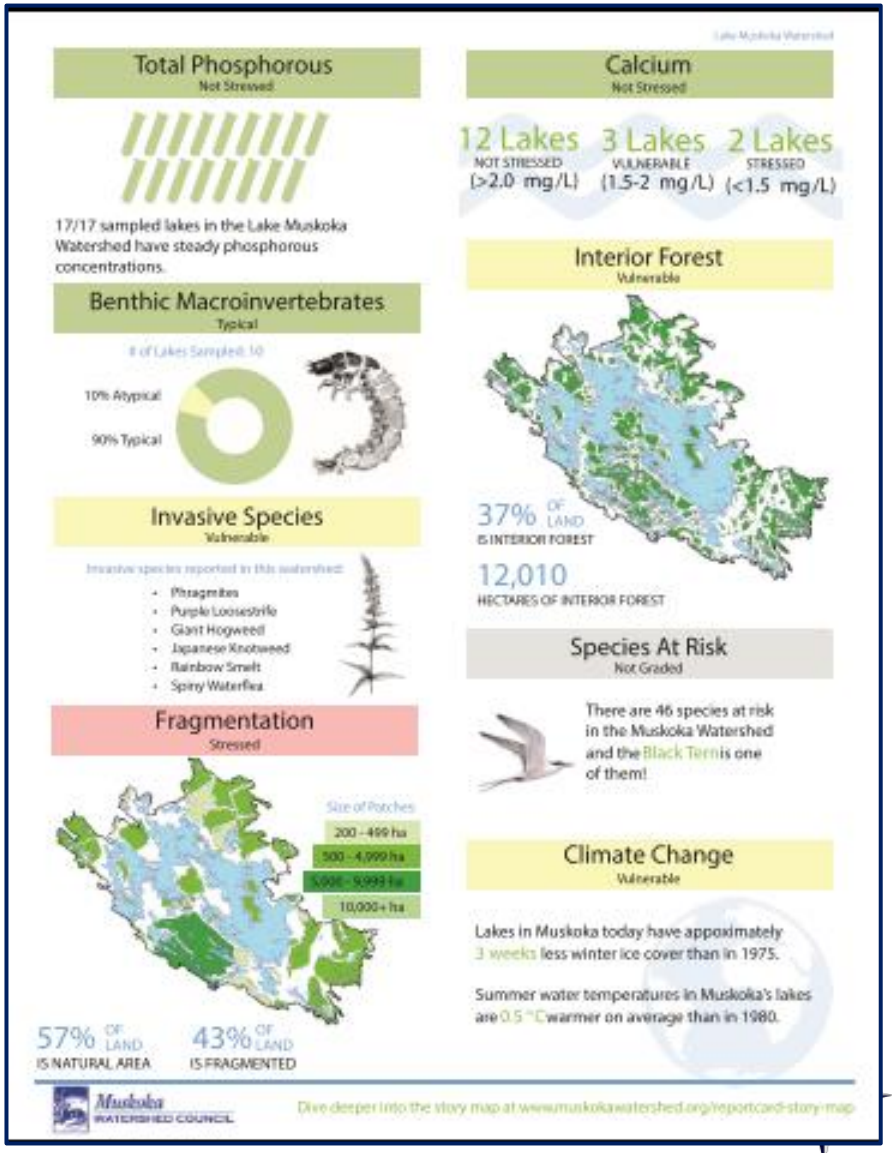


Requisites of Effective Watershed Cumulative Effects Assessment and Management

(Sheelamore et al. 2013. Land Use Policy 30)

- Lead agency to administer – with mandate to monitor and ability to manage land use
- Multi Stakeholder Collaboration – with a framework to define roles and responsibilities
- Watershed Baselines, indicators and thresholds – science based
- Multi-scaled monitoring – project (site and land-use specific) and watershed level
- Data management and coordination – available, common formats, well described, QA/QC, trusted
- Vertical and horizontal linkages- management policies and plans to science, project level to watershed level, conclusions to decisions
- Enabling legislation – to implement CEA and enforce its outcomes
- Financial and human resources – monitor, model, report, communicate implement over the long term

Steps Towards Effective Watershed Cumulative Effects Assessment and Management in Muskoka



Cumulative Effects Assessment and Management in Muskoka

Thank you – Chi miigwetch