

Planning Treatment Trains and Concurrent Remedies

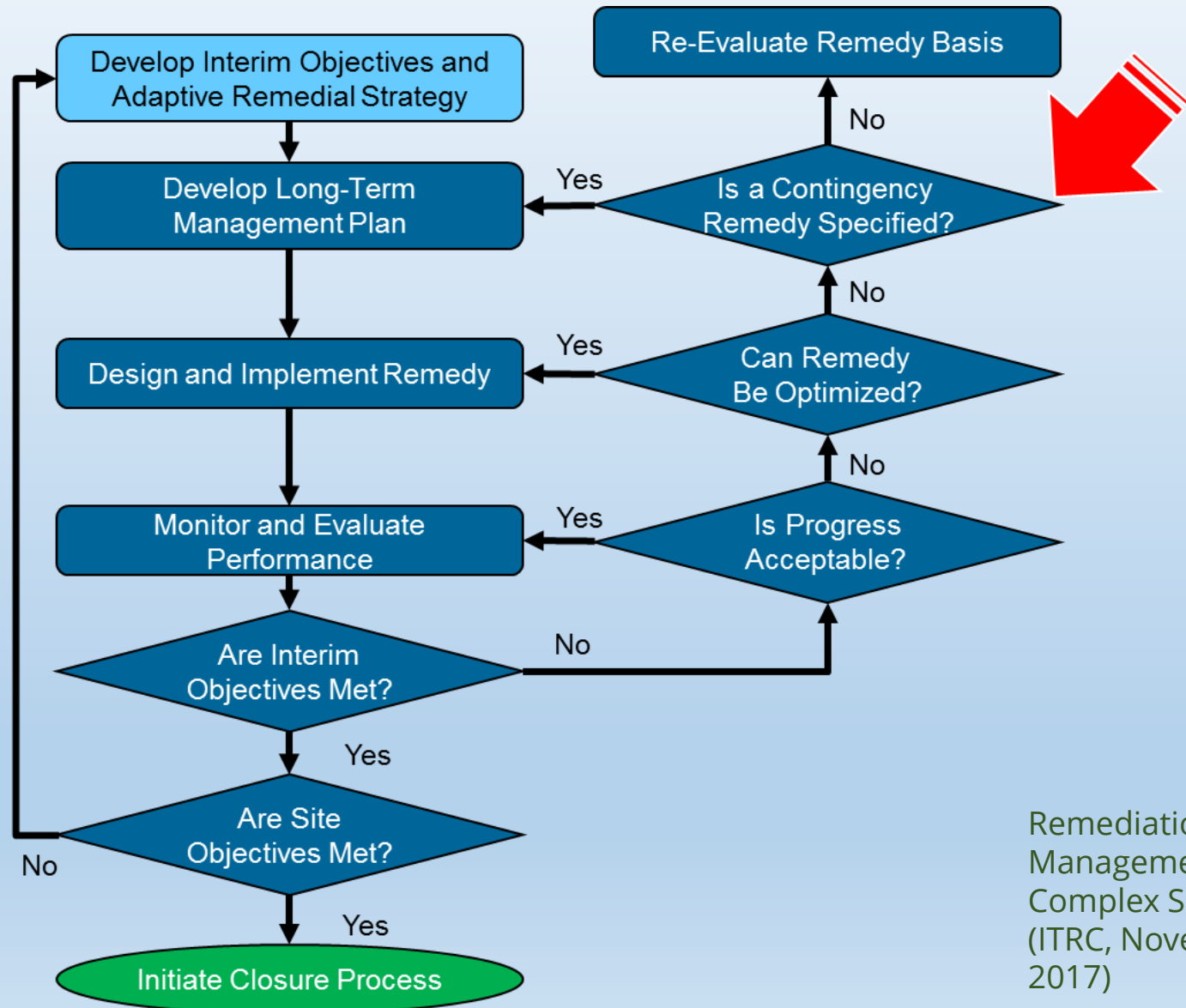


Failing to plan is...planning to waste a lot of _____ (fill in the blank).

“CAP to Closure”

- Does your state require one?
- What does this mean?
- Do you usually reach NFA in one try?
- Is the CAP ever updated?
 - How are modifications made?
 - How are costs reconciled?
- How do you judge remedial progress?

Adaptive Site Management



Remediation
Management of
Complex Sites
(ITRC, November
2017)

21 Technology “Tools”

1. Excavation
2. Skimming
3. Vacuum enhanced skimming (LNAPL & vapor)
4. Total liquid extraction (LNAPL & water)
5. Multi-phase extraction (LNAPL, water, & vapor)
6. Water/hot water flooding
7. Surfactant-enhanced subsurface remediation
8. Cosolvent flushing
9. Steam injection
10. Electrical resistance heating
11. Air sparging / soil vapor extraction (AS/SVE)
12. In-situ chemical oxidation
13. Natural source zone depletion (NSZD)
14. Physical or hydraulic containment
15. In-situ soil mixing (stabilization)
16. Thermal conduction heating
17. In-situ smoldering
18. Biosparging / bioventing
19. Enhanced anaerobic biodegradation
20. Activated carbon
21. Phytotechnology

Not Included in Technology Tables

- 1) Manual Bailing
- 2) Periodic or Short-term Vacuum Truck Events
- 3) Passive Skimmers
- 4) Absorbent Socks

WHY NOT?

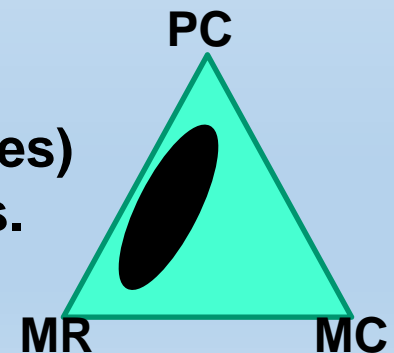
The mass recoverable is insignificant compared to the whole
(but it may be required by regulation)



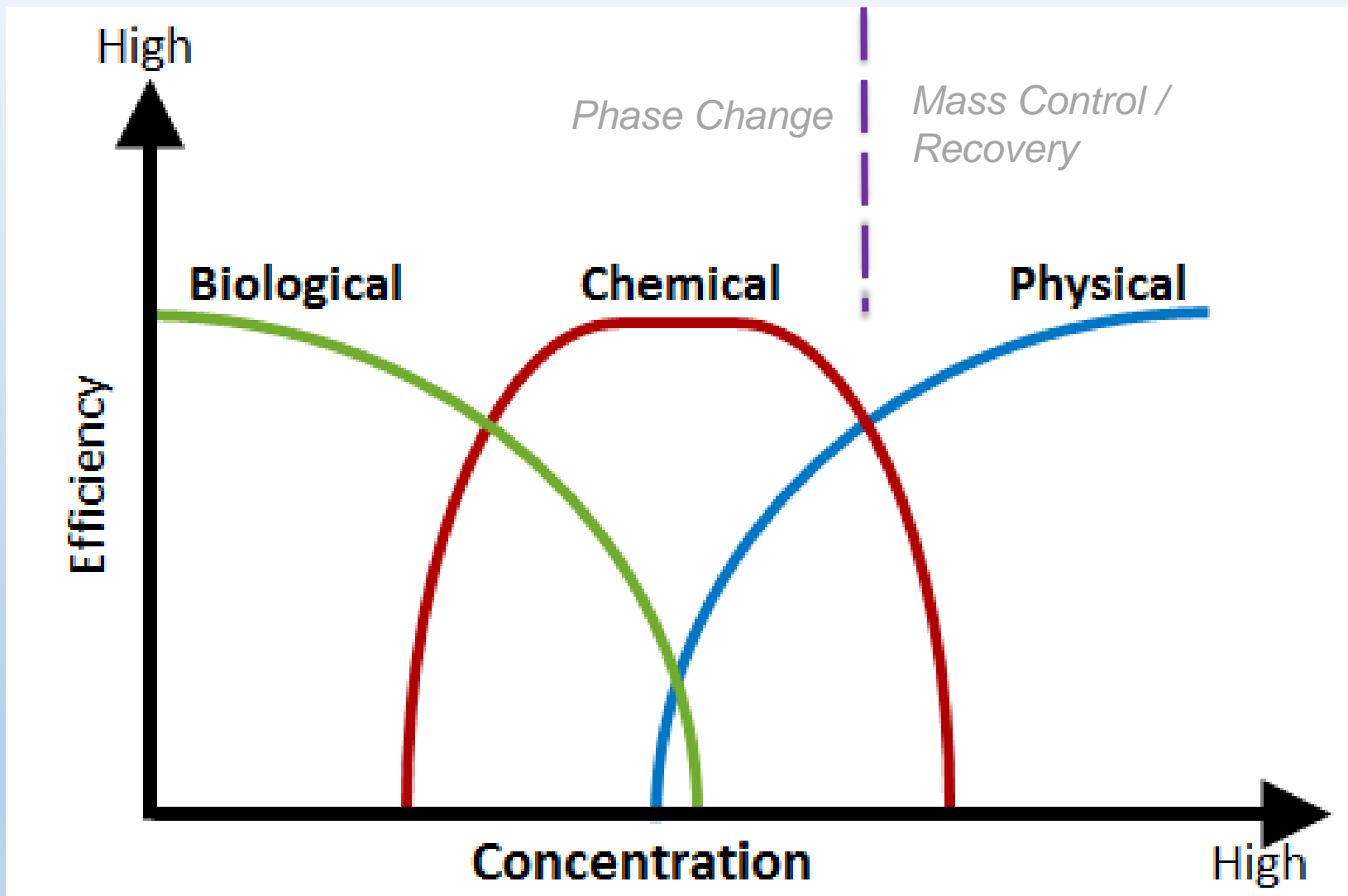
LNAPL Remedial Technology Groups

- Mass Control - Contain LNAPL at a defined boundary
- Mass Recovery - Remove LNAPL mass to limit migration
- Phase Change - Abate unacceptable COCs

Technologies (i.e. processes)
sometimes overlap groups.



Processes



Remedial Process Overlap

PHYSICAL

Excavation
Skimming
Total Liquid Extraction
Physical or Hydraulic Containment
In Situ Soil Mixing
Water flood

Biosparge/Biovent
Activated Carbon

SESR
Cosolvent Flushing
Electric Heat
Thermal Heat
Steam Injection

MPE
AS / SVE
Vacuum-
Enhanced
Skimming

BIOLOGICAL

Phytotechnology
NSZD / MNA

Enhanced
Anaerobic
Degradation

CHEMICAL

ISCO
Smoldering

Technically Achievable

Examples Include:

Remedial Mechanism

Technically Achievable Limit

- | | | |
|--|---|---|
| 1. LNAPL Recoverability | ➔ | LNAPL Transmissivity
(0.1 to 0.8 ft ² /day) |
| 2. Volatilization <ul style="list-style-type: none">• AS• SVE | ➔ | Vapor Pressure (> ~1 kPa at 15° C)
PID emissions stable (<xxx ppm) |
| 3. Injection <ul style="list-style-type: none">• ISCO• Carbon | ➔ | Soil texture limits delivery of
oxidant / other media |
| 4. Biodegradation <ul style="list-style-type: none">• Biovent / Biosparge• NSZD/MNA | ➔ | Rate of degradation won't achieve
goal in timeframe |

“Treatment Train”

(Consecutive Remedies)

- PLANNING to use multiple remedial technologies *in sequence* to achieve closure
- Sequence remedial technologies based on contaminant concerns and remedial objectives
 1. Start with a **primary** technology (excavation?) tailored for higher contaminant mass
 2. Continue with a 2nd treatment technology (ISCO?) and possibly a 3rd polishing step (CBI?) for remaining contaminant mass

Treatment Trains

Bad

- ▶ Unplanned, lack SMART objectives, no or poor metrics for transition, milestones and endpoints uncertain
- ▶ “Throwing” more technologies at the problem

Good

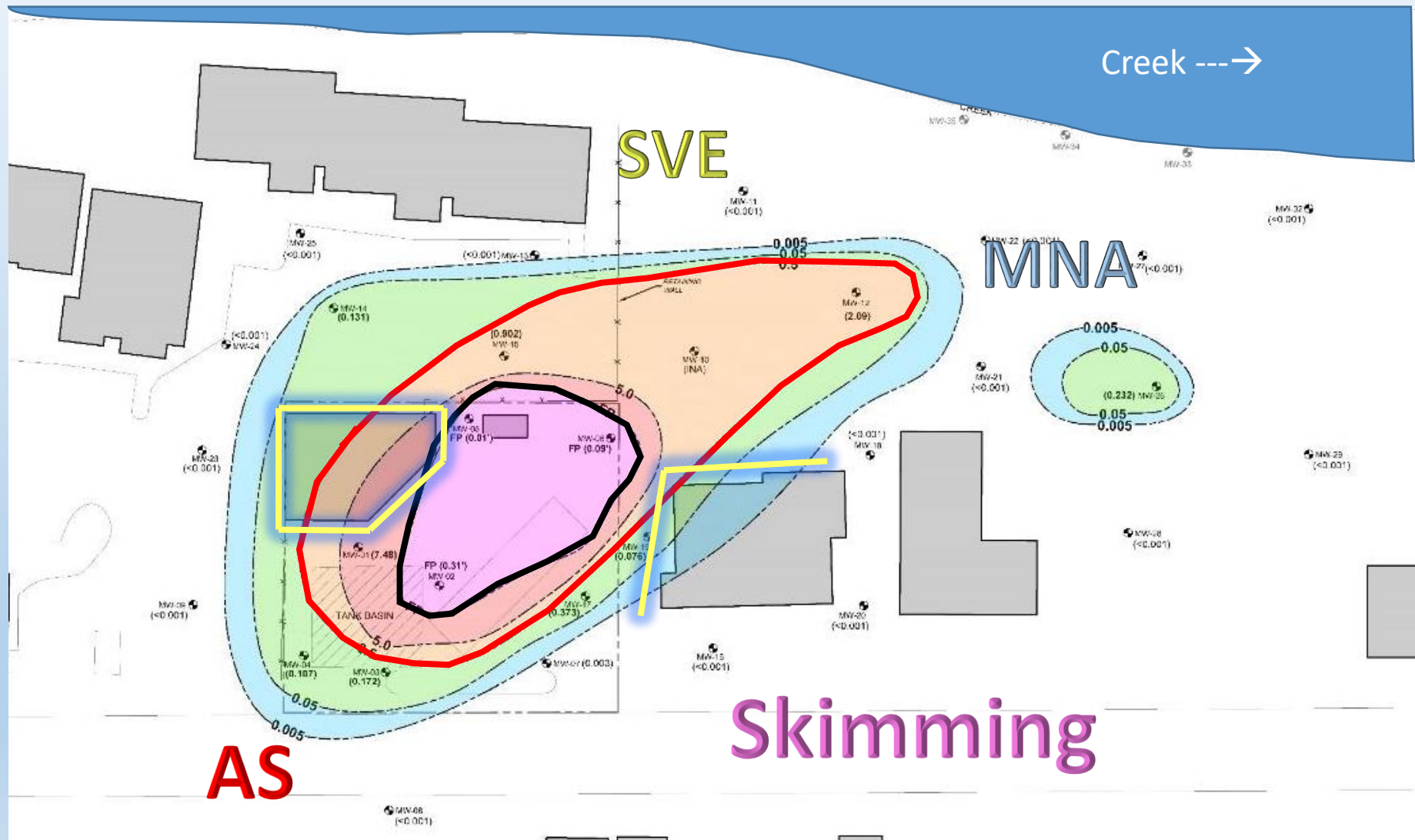
- ▶ When planned with SMART objectives; metrics for transition, milestones and endpoints defined
- ▶ Orderly implementation



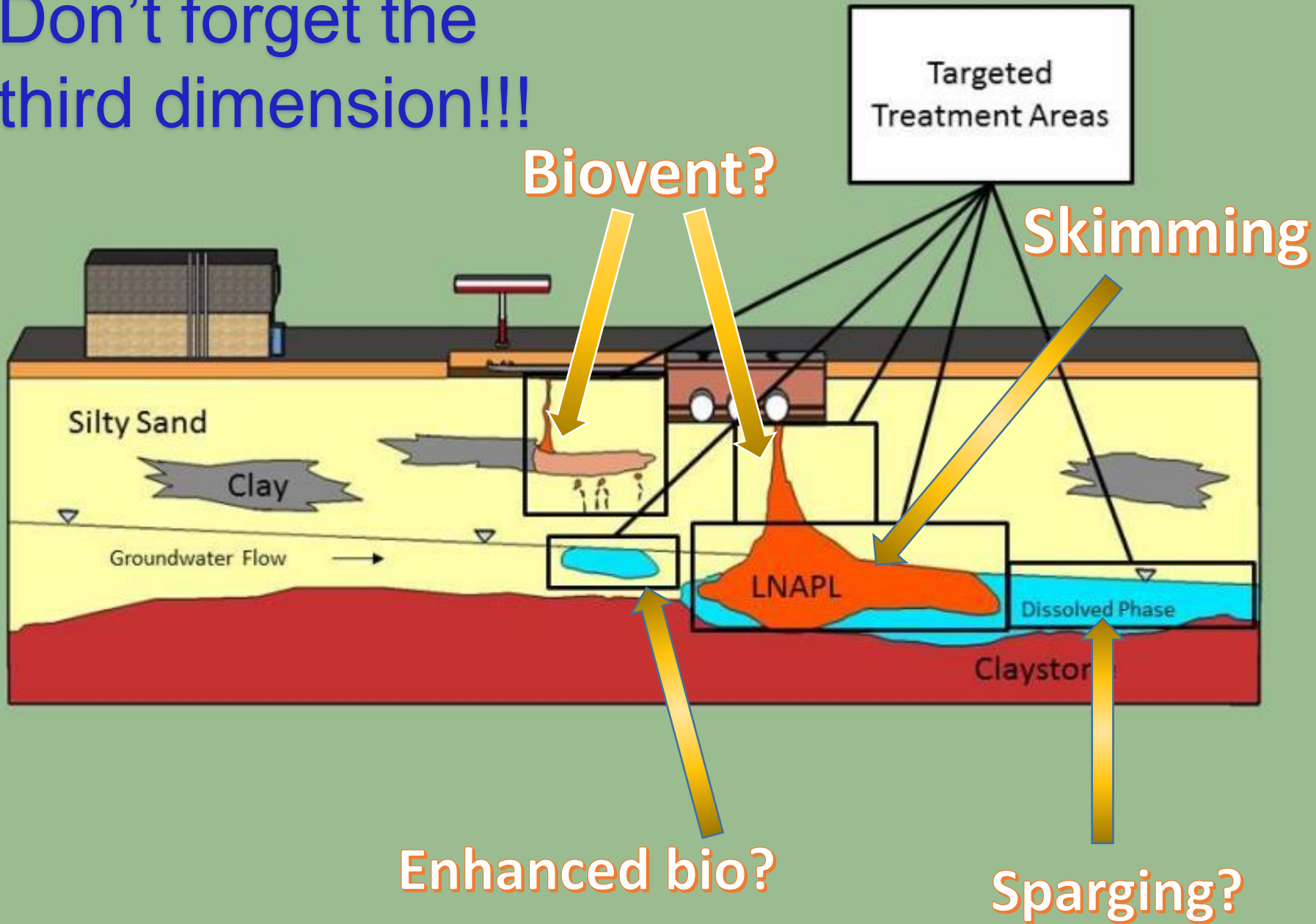
Concurrent Remedies

- Using multiple technologies on a site at the same time, in *different target zones* due to differing contaminant concentrations
 - Use primary technologies in the source area (e.g. excavation).
 - Use secondary or tertiary technologies on periphery of contaminated area, and in deeper zones.
- Still rely on SMART performance metrics to measure remedial progress

Example: Treatment Areas



Don't forget the third dimension!!!

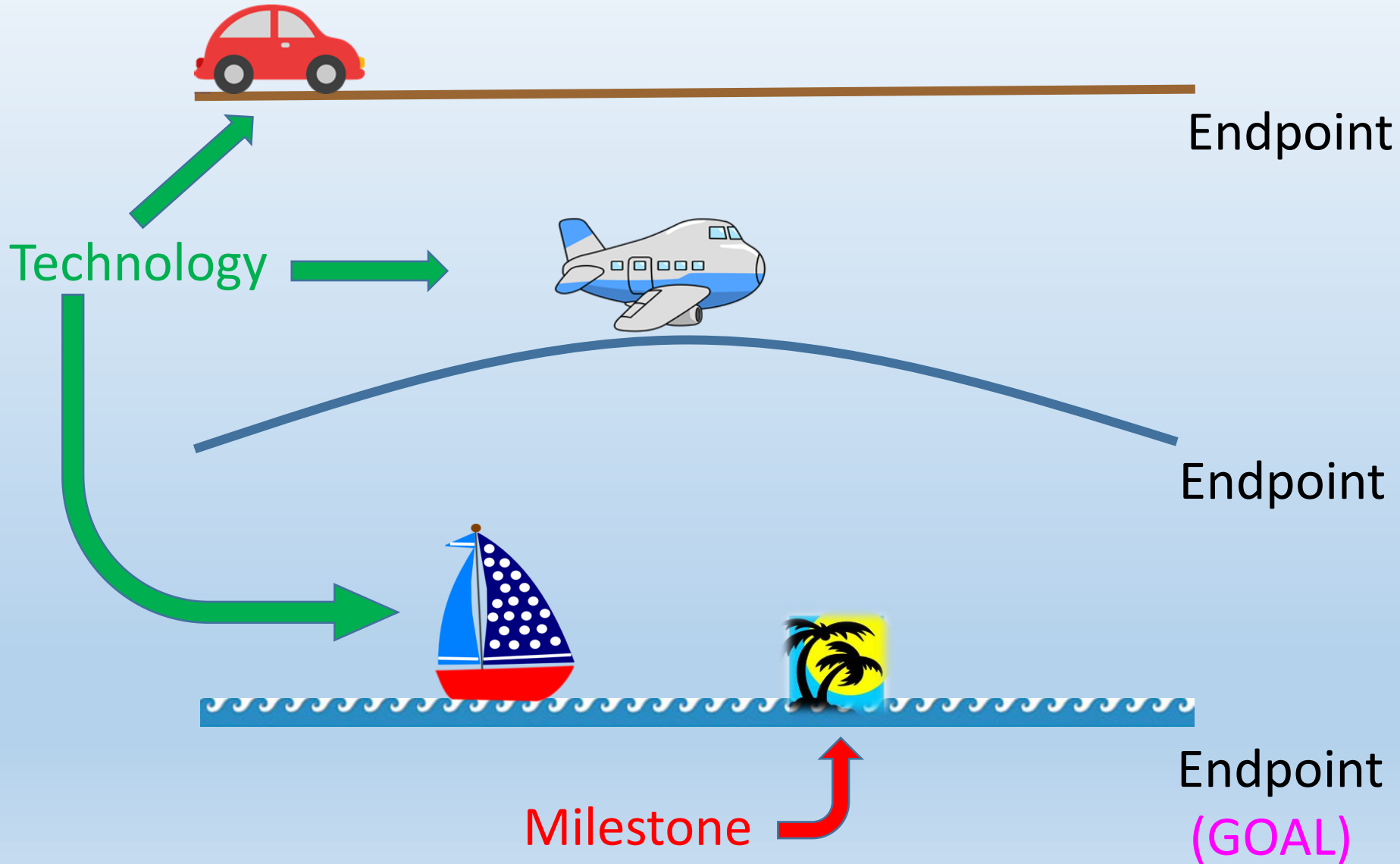


Metrics?

Milestones?

Endpoints?

"My Vacation"



GETTING *SMART*

- **S**pecific - Targeted treatment area and technology-specific endpoints are clearly stated
- **M**easurable – Performance metrics that demonstrate progress towards the endpoint
- **A**greed Upon – Concerns, goals, objectives, treatment areas, metrics, endpoints
- **R**ealistic – Demonstrated ability to achieve objective
- **T**ime-Based – Target date of remedial endpoint being achieved

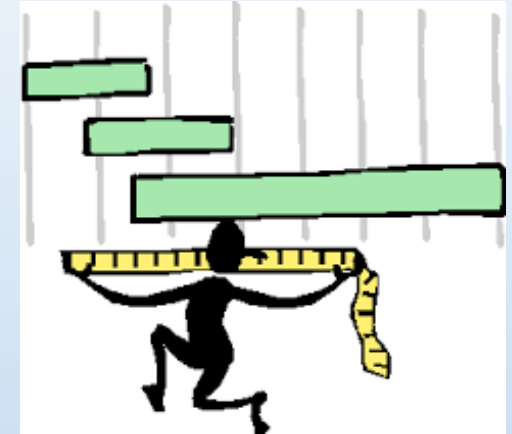
Performance Metrics

Measurable characteristics that track the progress of a *selected technology* to achieve a remedial objective and abate a contaminant concern

ASK: What conditions do you expect to change as you remediate the site? And how quickly?

Performance Metrics

- Technology-specific!
- Track progress toward endpoint
- Verify that remedy is being implemented effectively
- Allow for mid-course corrections
- Allow for CSM updates



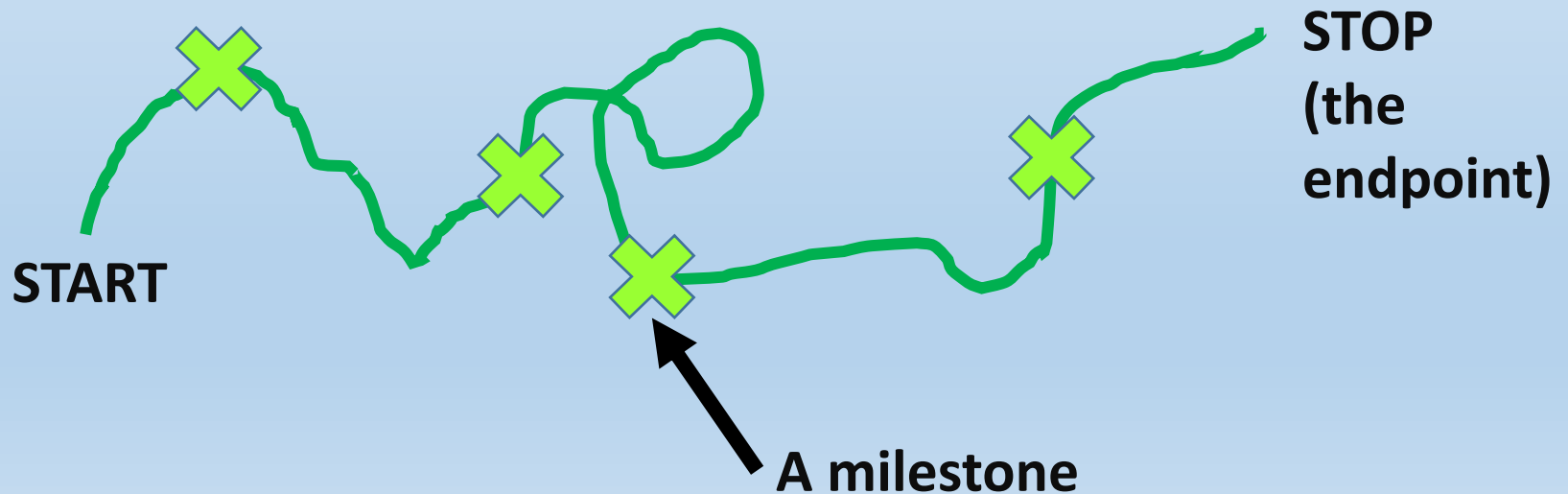
Performance Metrics Examples

(What you can measure)

- AS/SVE – Concentrations in emission samples (e.g. PID, benzene, CO₂, CH₄)
- ISCO - Data to evaluate distribution of an in-situ application (e.g. pH, ORP, DO, SO₄⁻²)
- SVE - Interim or final soil confirmation samples
- MNA – Organic/ inorganic/ biological samples

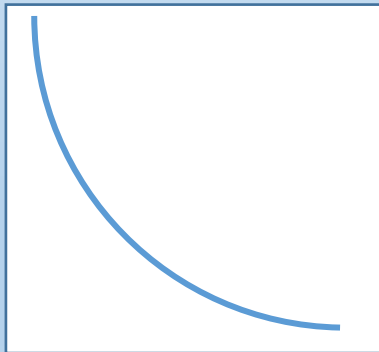
Remedial Milestones (Interim Objectives)

Points to evaluate progress towards a
remediation technology endpoint
(a schedule)



Remedial Milestone Examples

- LNAPL reduction = 10% of volume estimate per quarter / per month
- Emissions decrease 25% per quarter / per month
- Dissolved phase concentrations remediated to 25%, 50%, 75% of endpoint (with timeframe)



Remember!

Declines are exponential, not linear
(90% of the result takes 10% of the time?)

Endpoints

- Also technology-specific!
- Defined as:
 1. LNAPL concern has been addressed, or
 2. Practicable limit of the technology reached



The technology's endpoint may not be your site goal!