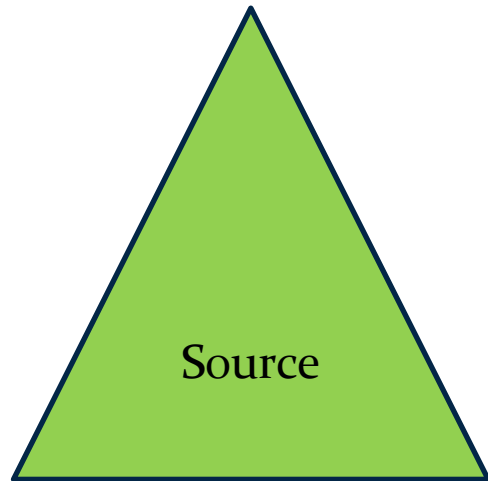


The Story Arc Model: Remediating a Gasoline-Impacted, Downstream Site in Central Alberta

Brent Lennox
Senior Hydrogeologist



Conceptual Site Models



Timelines: Regulatory Guidance

- Risk management plans must contain:
 - “timelines for milestones or program endpoints”
 - “time needed to complete remediation... to meet remediation and regulatory closure guidelines.”



Alberta Risk Management Plan Guide

October 31, 2017



Geologists Love Talking About Time!

Geologic Time

10s of thousands to millions of years

Political Time

4-year terms

Corporate Time

Quarterly to annually or greater?

Active Remediation

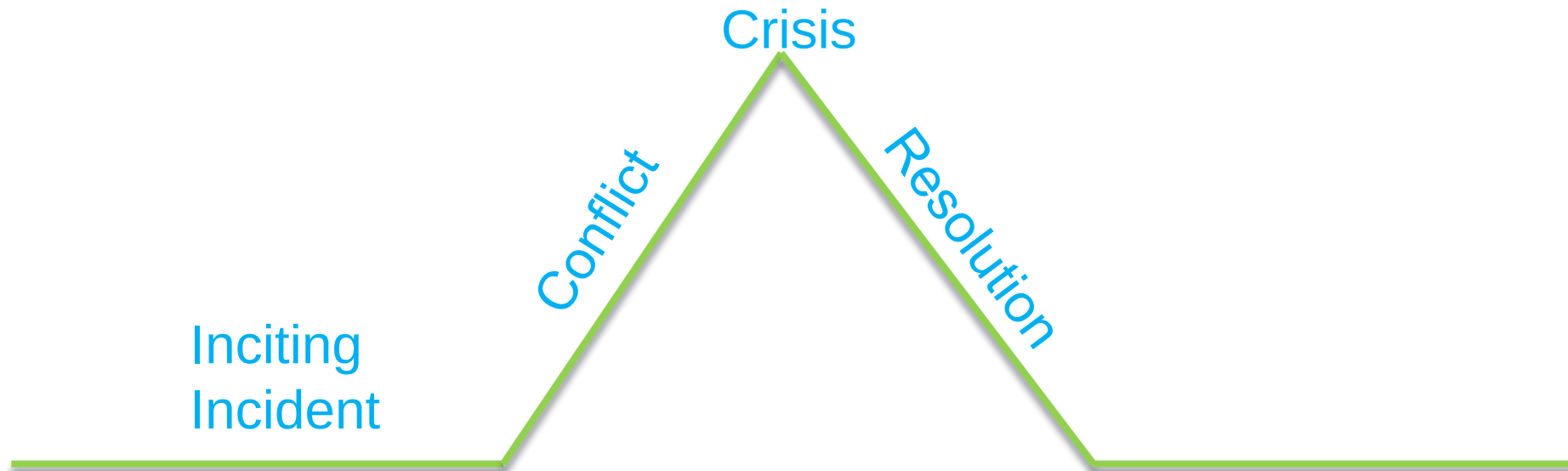
<1 year to decade(s)

Natural Attenuation/Risk Mgmt

Decades to hundreds of yrs



Story Arcs in Fiction Writing



The Freytag Pyramid:
In use for 1000s of years

Story Arcs: A Semi-Fictional Hiking Example

Crisis: This is terrible! I hate everyone, especially my partner!

How does writing fiction and going on hiking trips differ from science?

Conflict:
Wow, this is hard.

Resolution:
Almost there
But why is it snowing?

Inciting Incident:

I want to climb a mountain!

I summited the peak. Now how do I get down and why do I do this in my spare time?



I want to climb a mountain!



Wow, this is a bit harder than I expected



Ok, what's next?

A Good Scientific Report Tells a Story

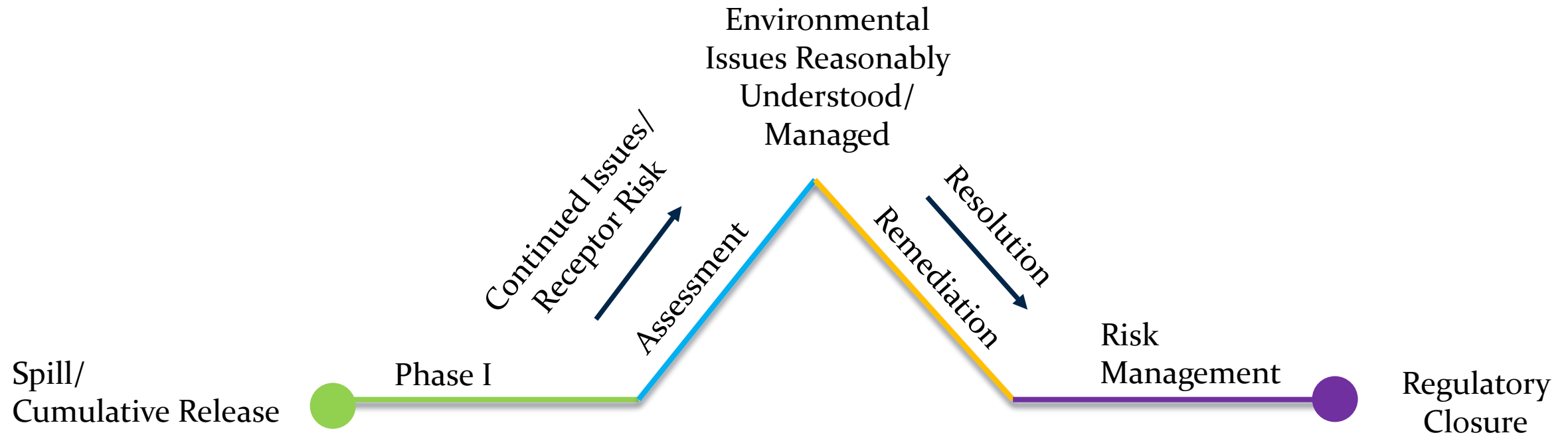
...but cannot be fiction

1. Must be data driven
2. Conclusions are supported by data
3. Willingness to consider new data

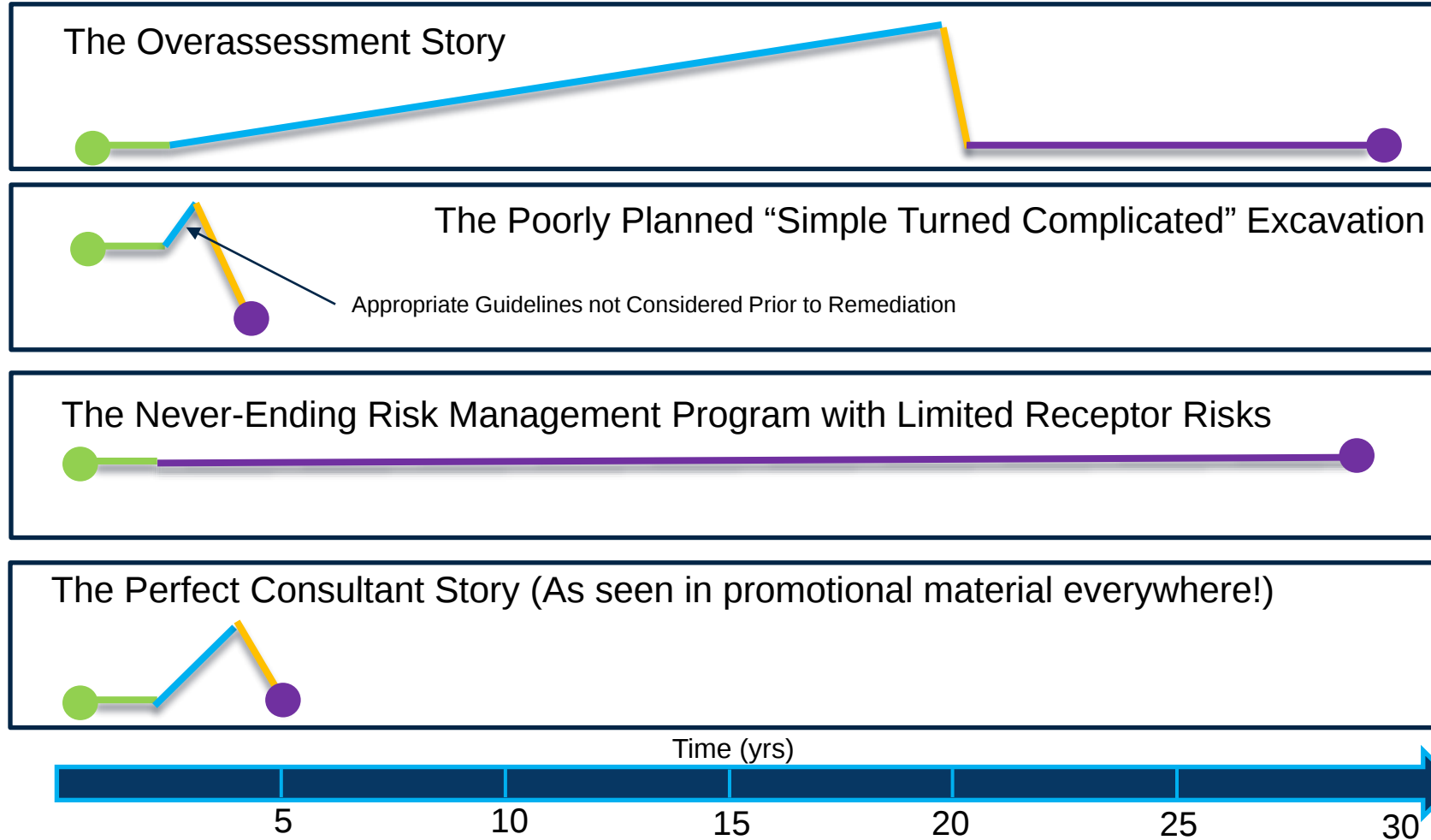
...but cannot be a hiking story

1. Try not to get to “conflict” or “crisis” stages
2. Lots of hiking-like stories that never make it into the report
3. Factual, not emotional

Story Arc Model for Environmental Programs



How Many Story Arcs Exist for Environmental Programs?

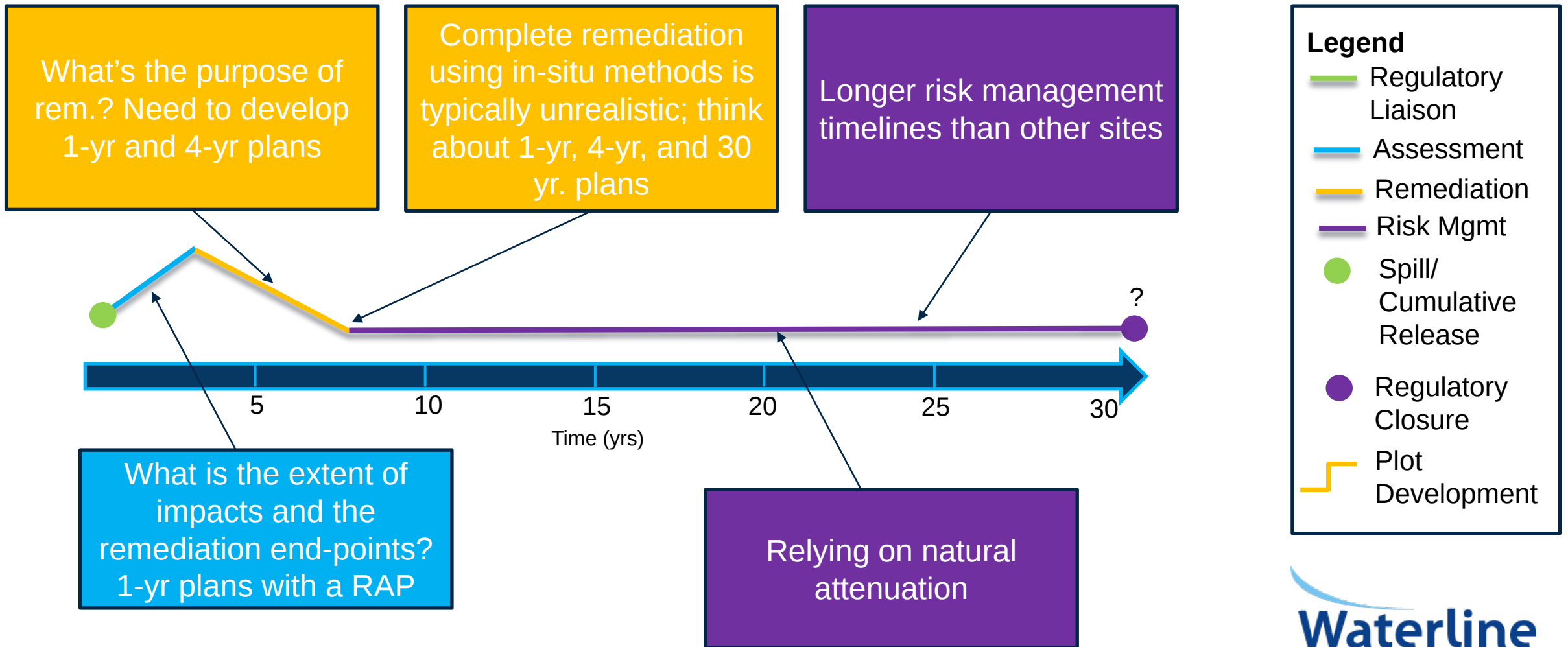


Legend

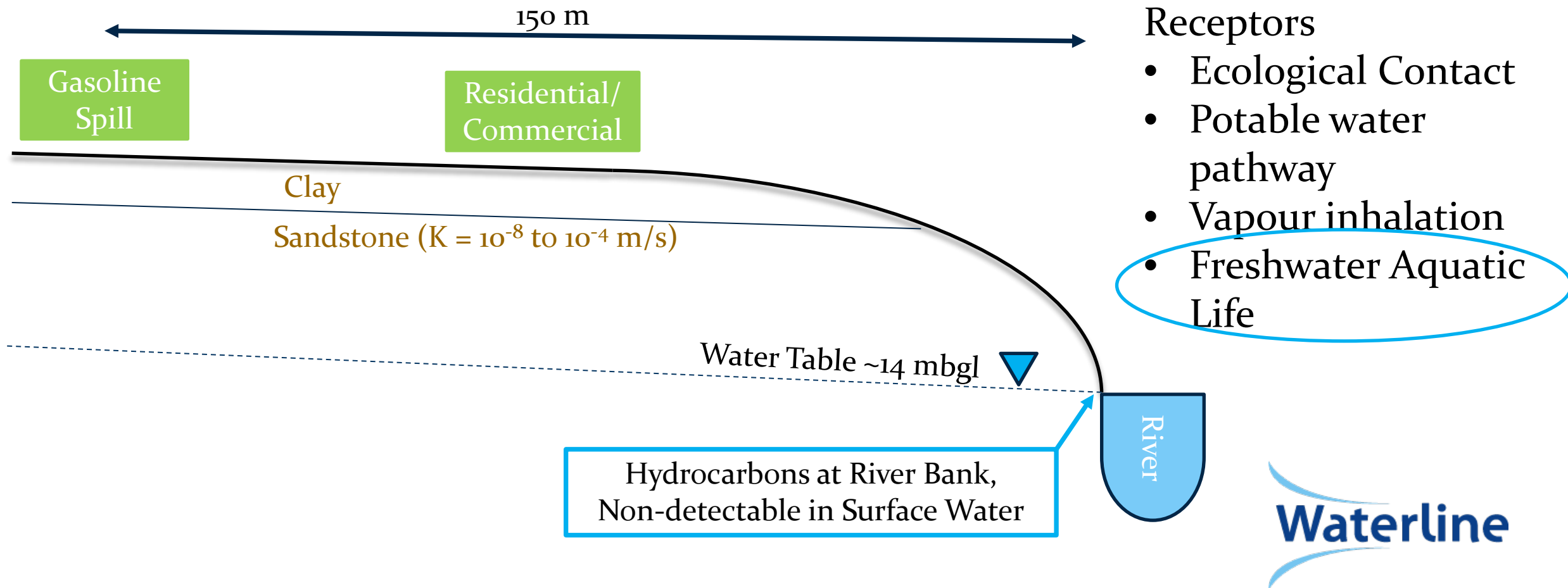
- Regulatory
- Liaison
- Assessment
- Remediation
- Risk Mgmt
- Spill/
Cumulative
Release
- Regulatory
Closure
- Plot
Development

For fiction: The Emotional Arcs of Stories are Dominated by Six Basic Shapes
(Reagan et al., 2016)

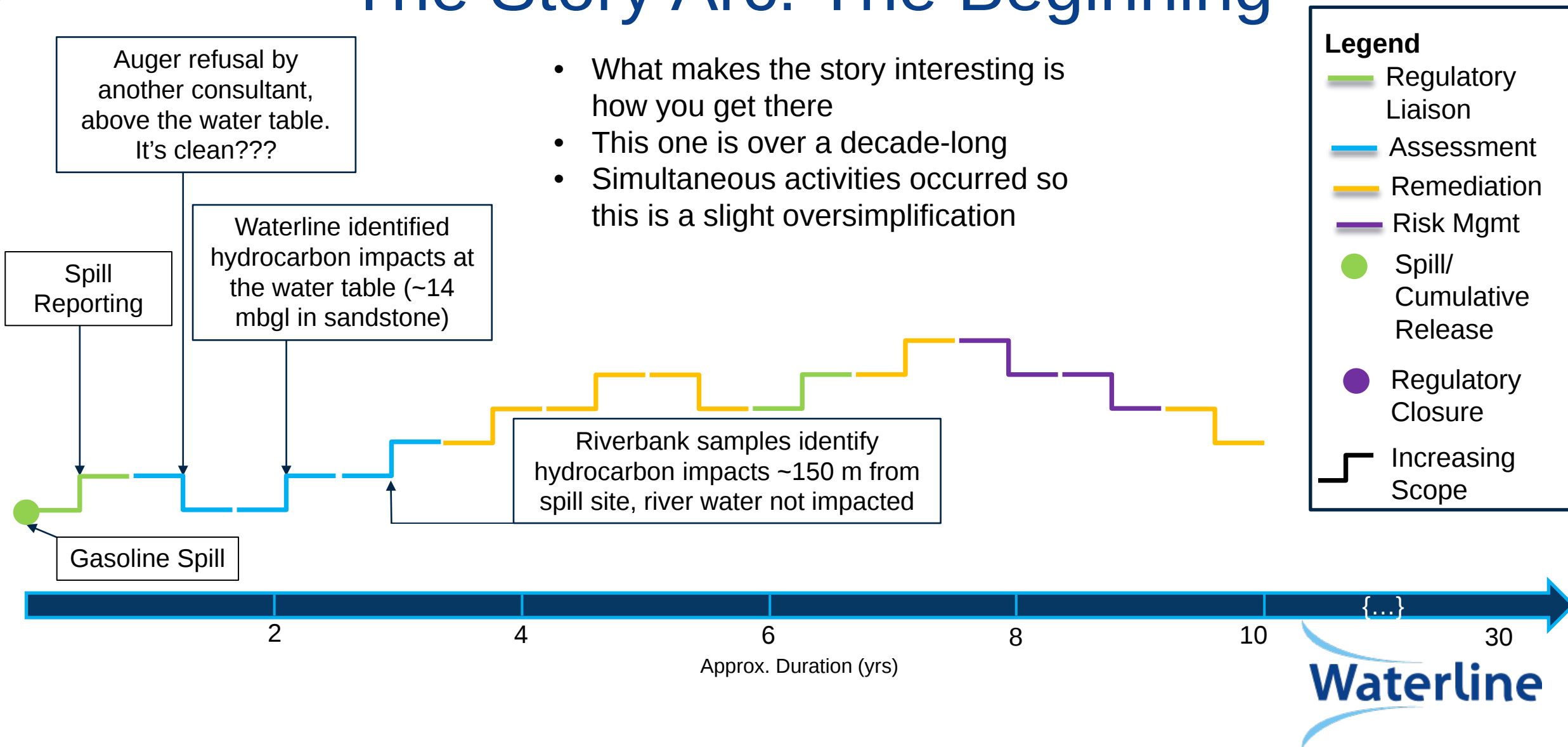
The Realistic Fractured Bedrock/In-Situ Program Story Arc



Example Site: Downstream Gas Station in Central Alberta



The Story Arc: The Beginning

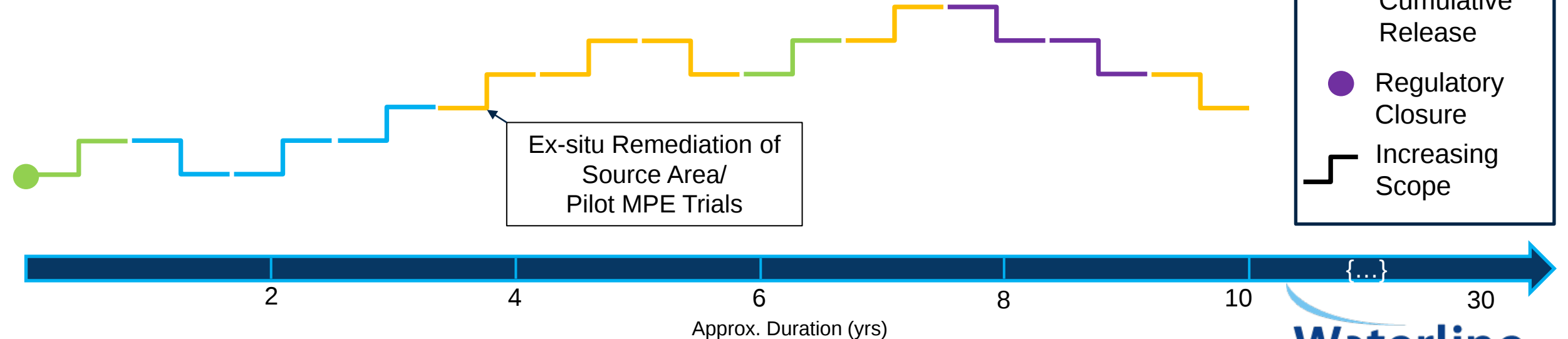


The Story Arc: Source Removal and Pilot In-Situ Trials

- **Source Area Removal:** 250 tonnes of soil landfilled beneath the decommissioned pump island
- **Multi-Phase Extraction (MPE) Trials**
 - Selected based on spill type (gasoline), hydraulic properties, presence of minor LNAPL, option for containment
 - Vapour concentrations in LEL range
 - Suitable groundwater extraction yields
 - Heterogeneous results consistent with fractured bedrock setting

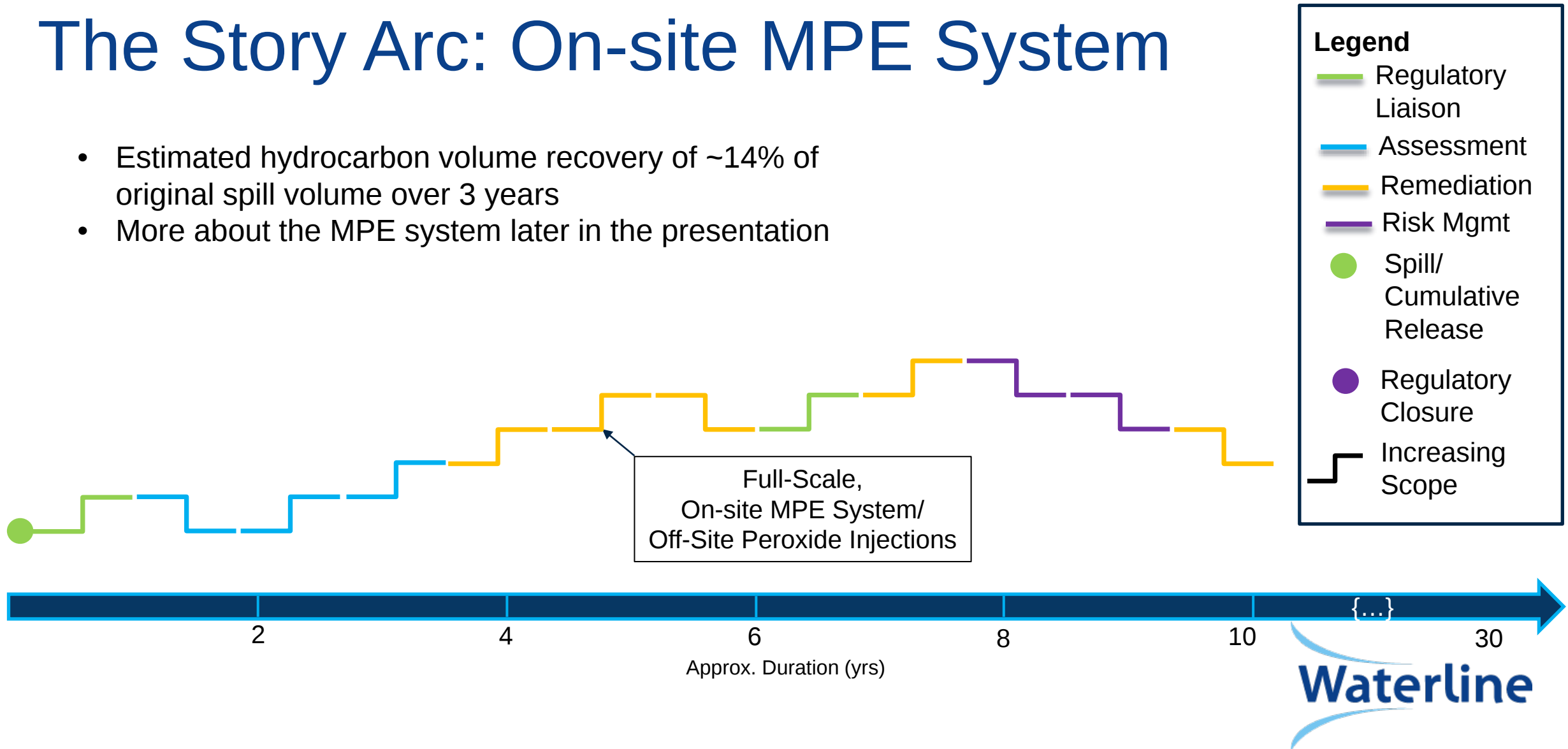
Legend

- Regulatory Liaison
- Assessment
- Remediation
- Risk Mgmt
- Spill/ Cumulative Release
- Regulatory Closure
- Increasing Scope



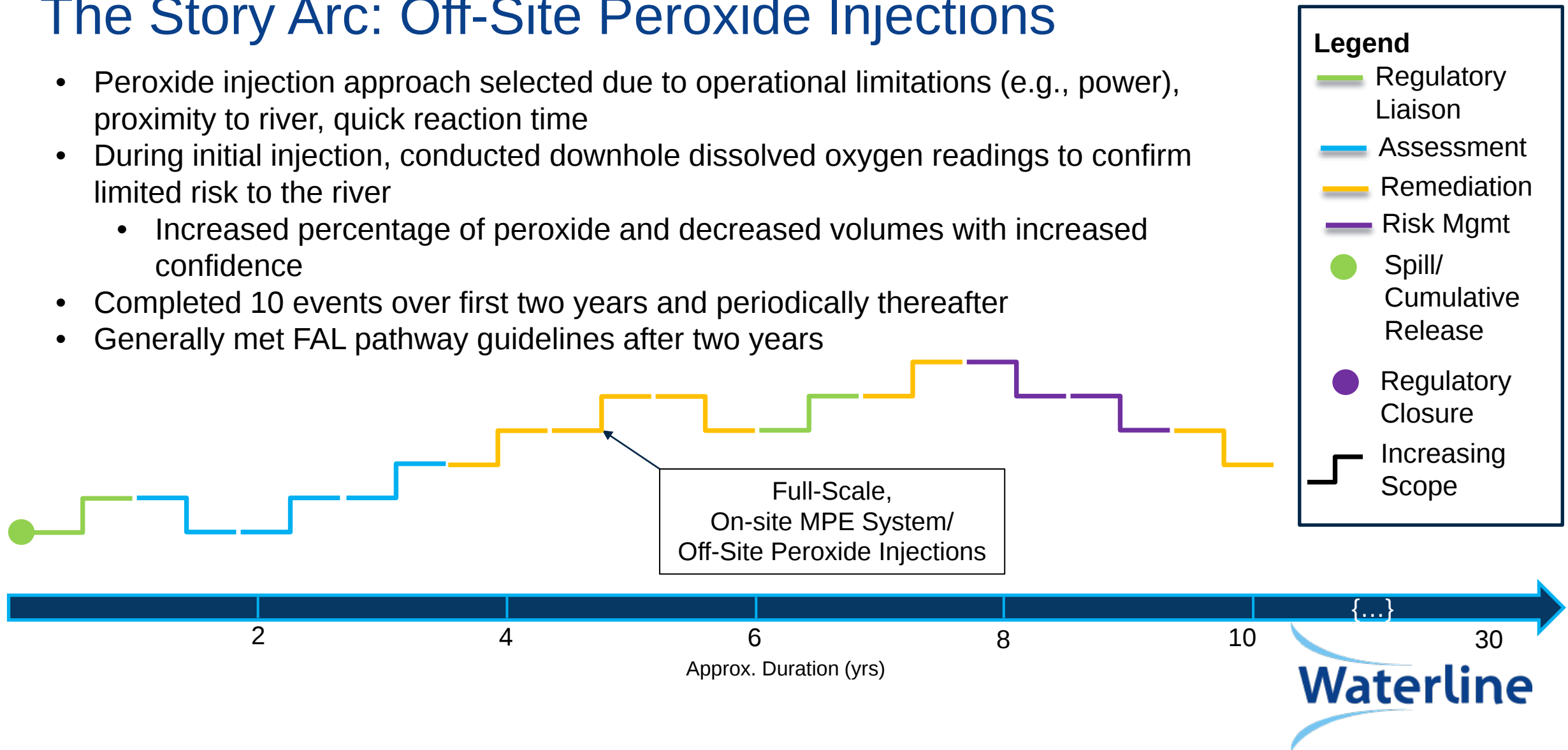
The Story Arc: On-site MPE System

- Estimated hydrocarbon volume recovery of ~14% of original spill volume over 3 years
- More about the MPE system later in the presentation



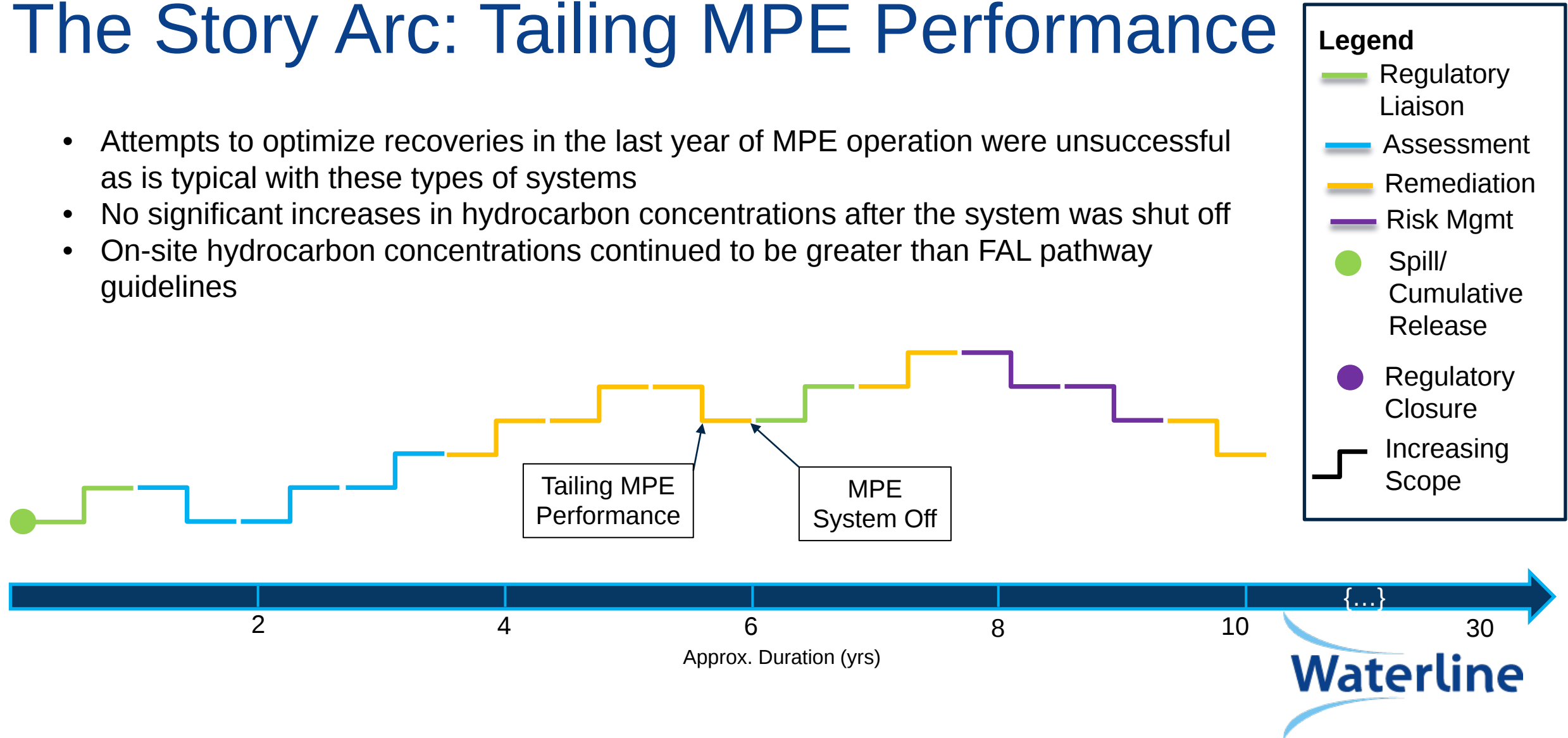
The Story Arc: Off-Site Peroxide Injections

- Peroxide injection approach selected due to operational limitations (e.g., power), proximity to river, quick reaction time
- During initial injection, conducted downhole dissolved oxygen readings to confirm limited risk to the river
 - Increased percentage of peroxide and decreased volumes with increased confidence
- Completed 10 events over first two years and periodically thereafter
- Generally met FAL pathway guidelines after two years



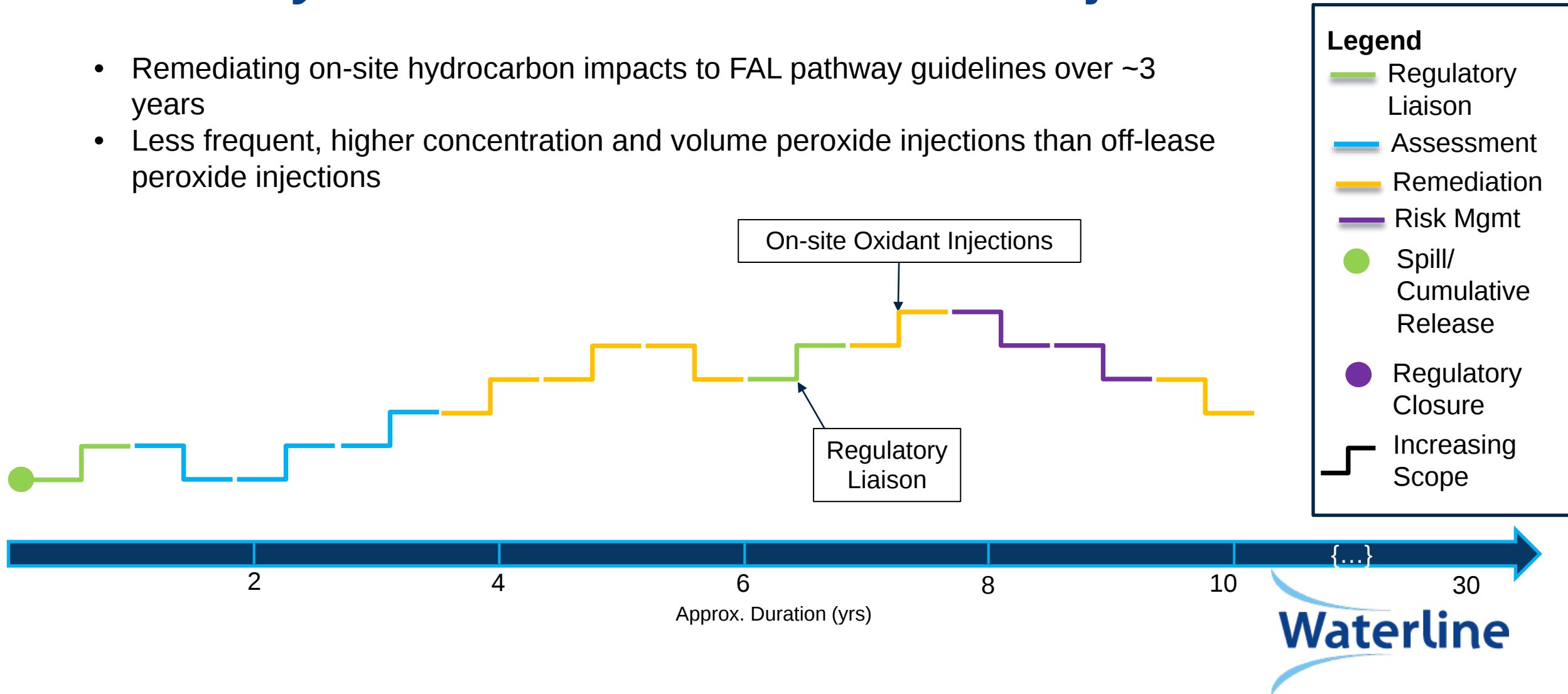
The Story Arc: Tailing MPE Performance

- Attempts to optimize recoveries in the last year of MPE operation were unsuccessful as is typical with these types of systems
- No significant increases in hydrocarbon concentrations after the system was shut off
- On-site hydrocarbon concentrations continued to be greater than FAL pathway guidelines



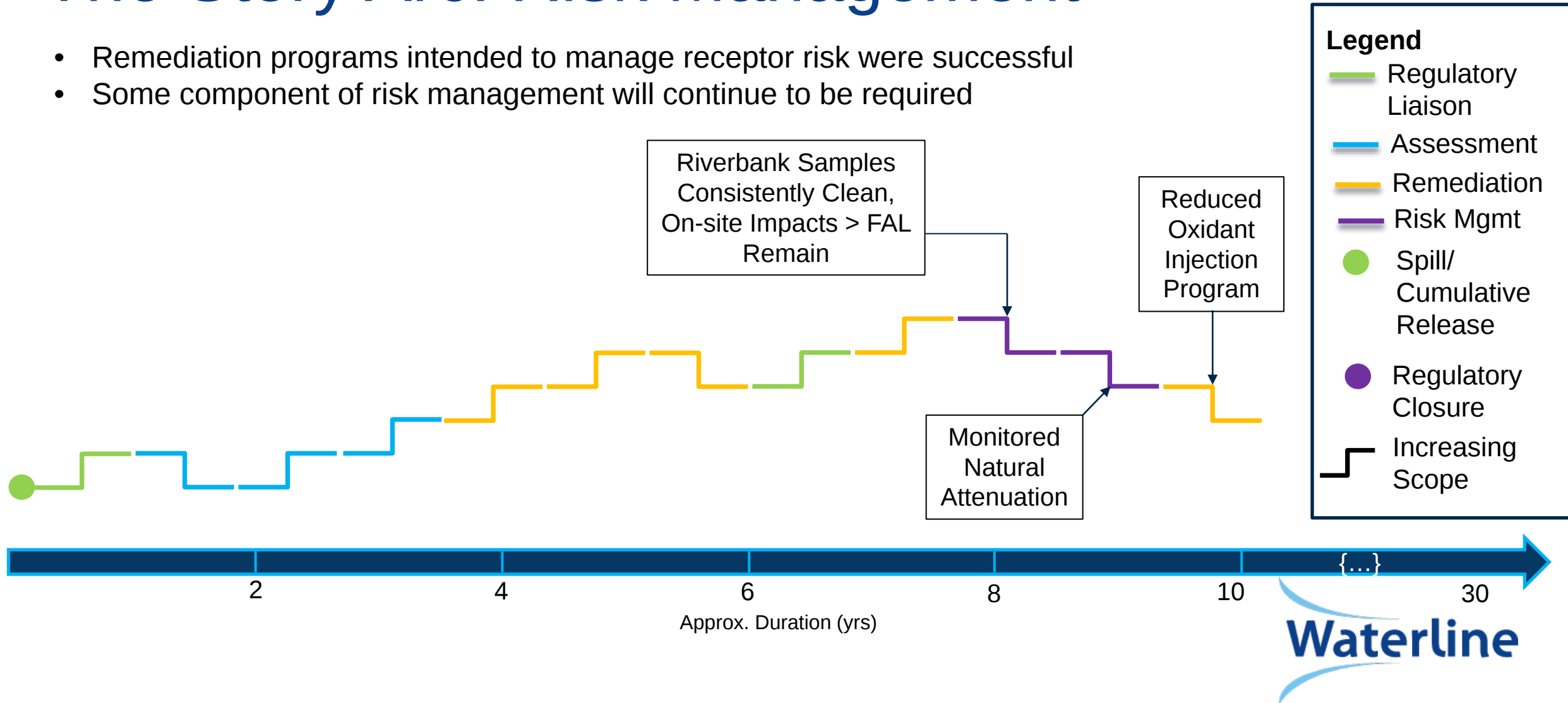
The Story Arc: On-site Peroxide Injections

- Remediating on-site hydrocarbon impacts to FAL pathway guidelines over ~3 years
- Less frequent, higher concentration and volume peroxide injections than off-lease peroxide injections

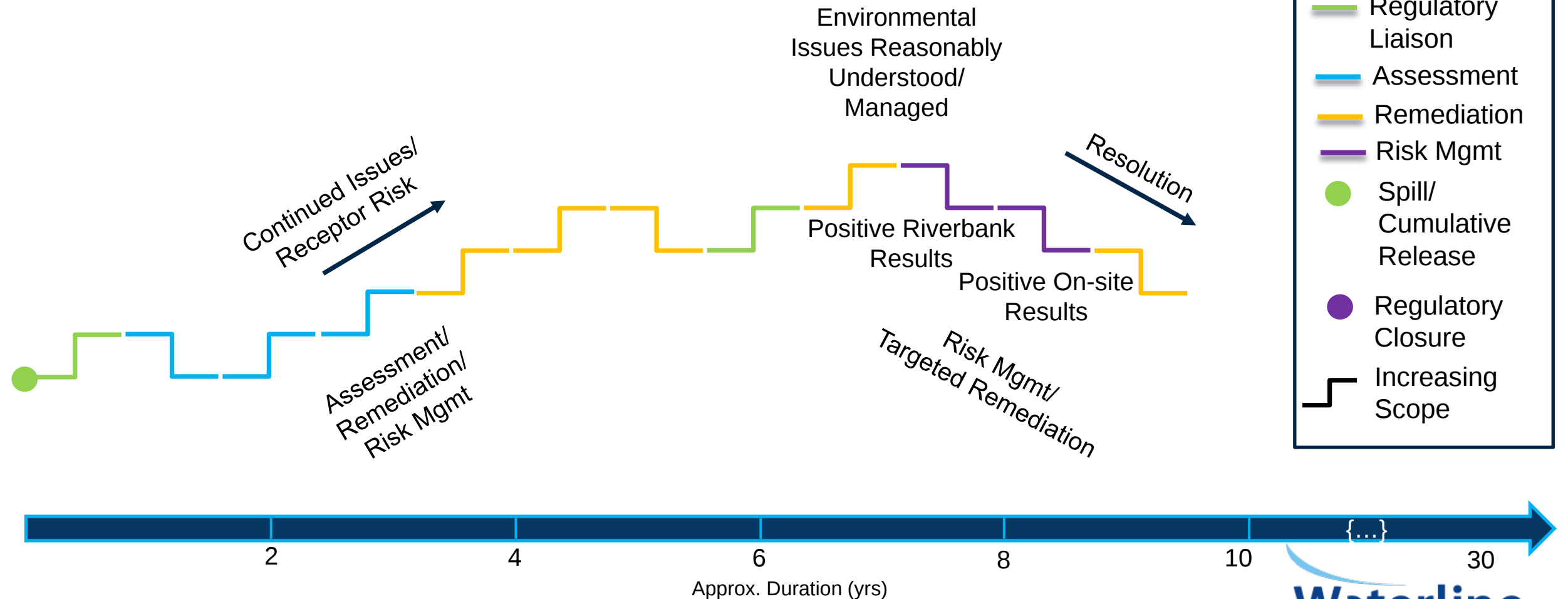


The Story Arc: Risk Management

- Remediation programs intended to manage receptor risk were successful
- Some component of risk management will continue to be required



The Complete Story Arc



How Do We Get the Timing Right?

- Frame the objectives
 - Don't get lost in the details
 - Be realistic with remedial goals
- Be open to re-evaluating the objectives frequently, particularly during the assessment/remediation phases
- Consider multiple timescales when developing yearly programs
 - e.g., 1-yr, 4-yr, 10-yr, 30-yr

