

Remediation of Petroleum Hydrocarbon Impacted Site - Technology Trends: Past Present and Future

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consultants



A Brief History of PHC Remediation



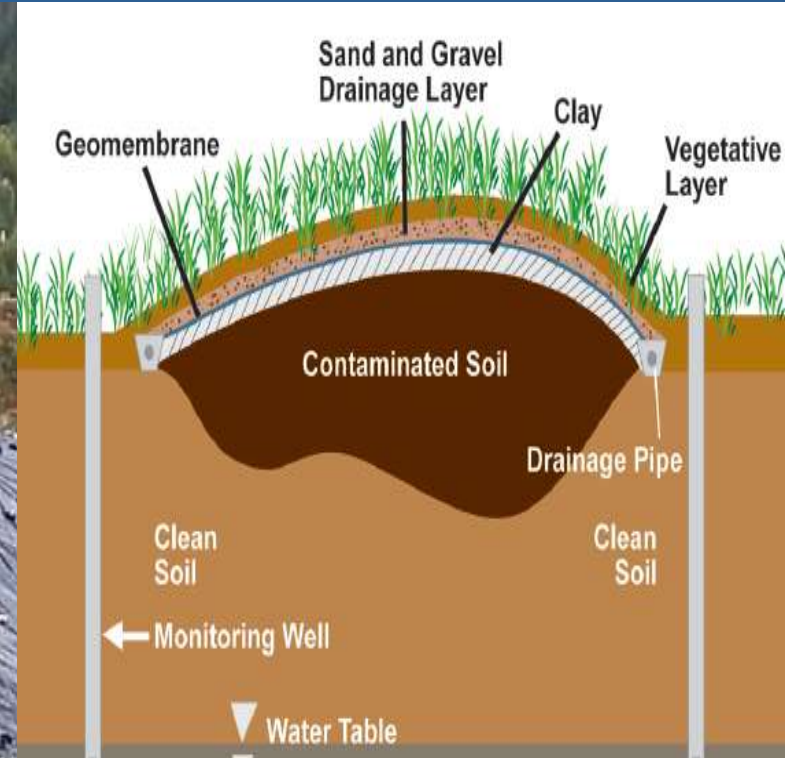
Ready, Set, Dig...and keep digging
Remediation was historically an ex-situ process

A Brief History of PHC Remediation



Not so effective for off site impacts or impacts beneath buildings...so most sites

Off to the landfill...



Land Farming of Excavated Soil



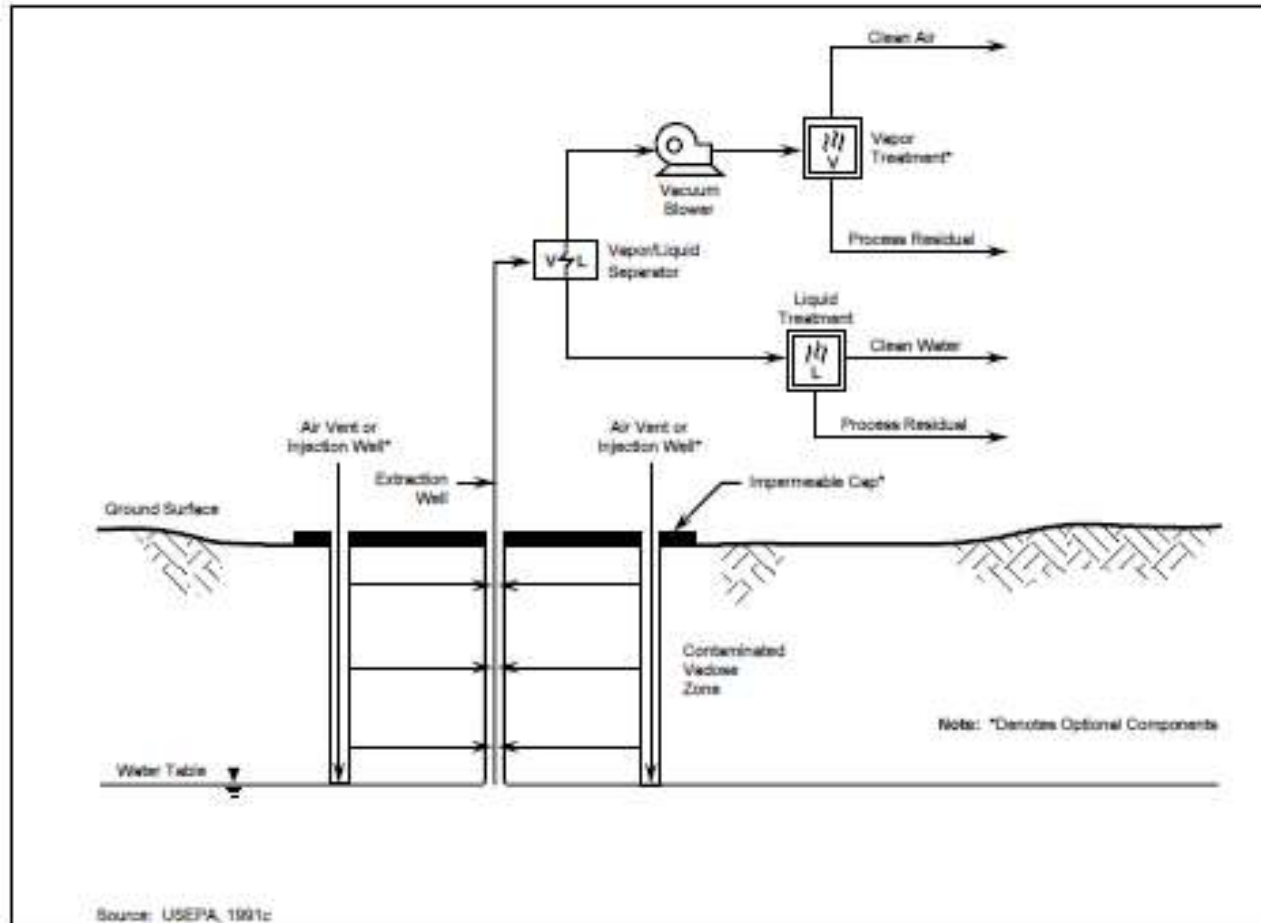


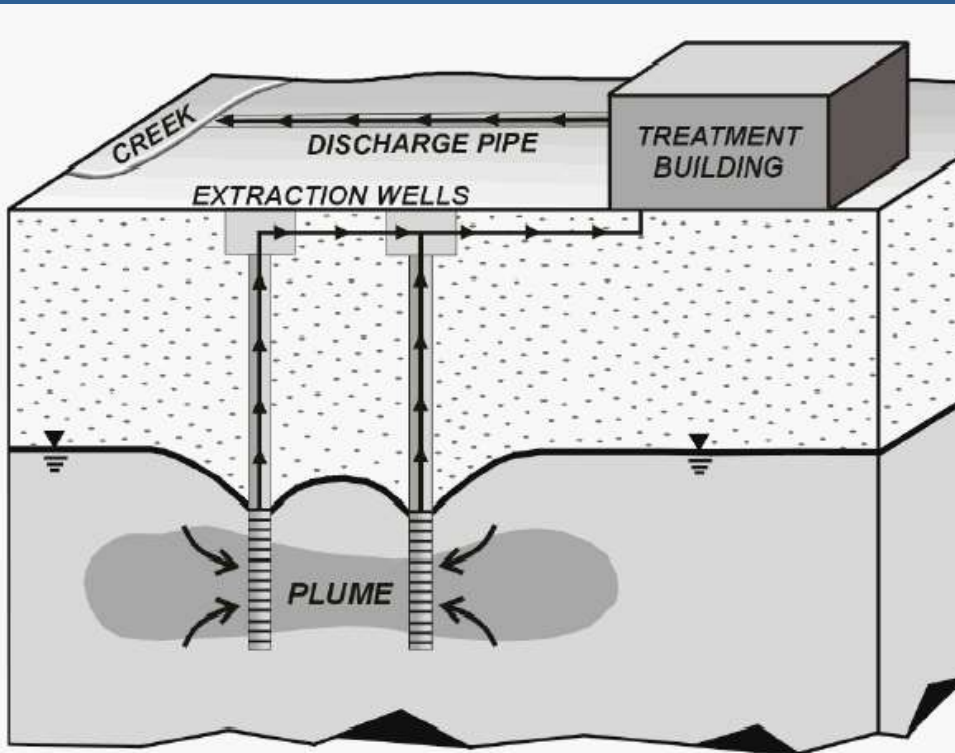
Figure 3-1. Generic soil vapor extraction system.

Soil / Vadose: Soil Vapor Extraction

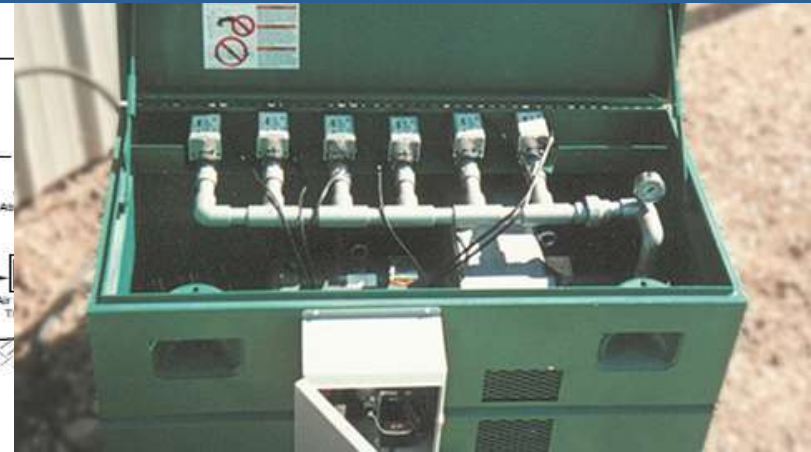
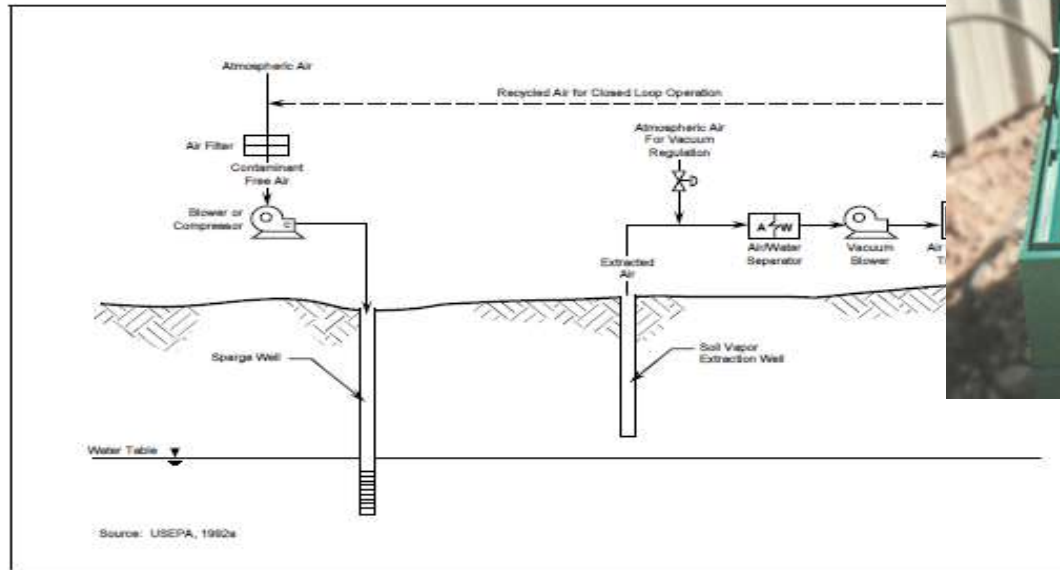


Early systems were small, relatively simple units designed to simply extract hydrocarbon vapor and move that vapor into the atmosphere. Advanced units had knockout separators to remove entrained liquids. Rarely was the vapor treated.

Pump and Treat



Air Sparging

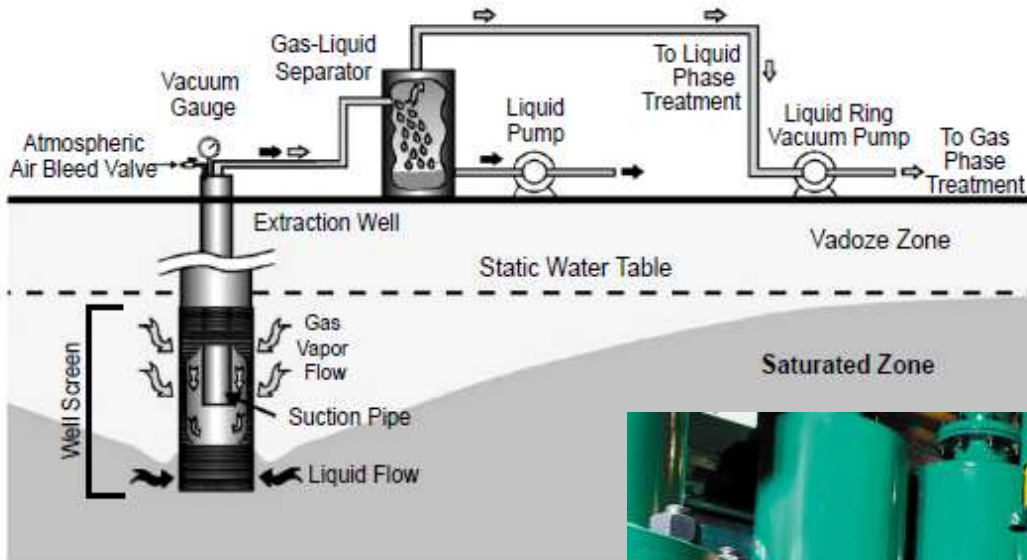


DID YOU
KNOW?

Did you know
Geosyntec is
remediating a NASA
Launch Pad to be
used for future rocket
launches to Mars



Multiphase Vacuum Extraction



M080212



- The International Symposium on In Situ and On-Site Bio-reclamation, held in San Diego, California in March 1991.

Battelle Memorial Institute

– Robert E. Hinchee & Robert F. Olfenbuttel

Industry and Academia began focusing on finding ways to better remediate the huge global inventory of contaminated sites

Battelle

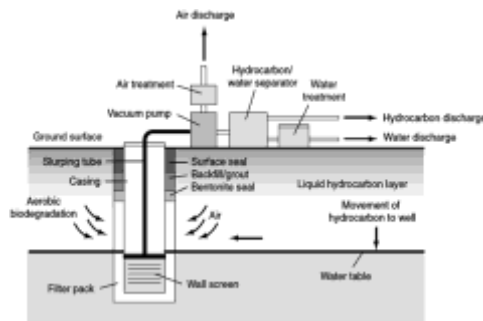
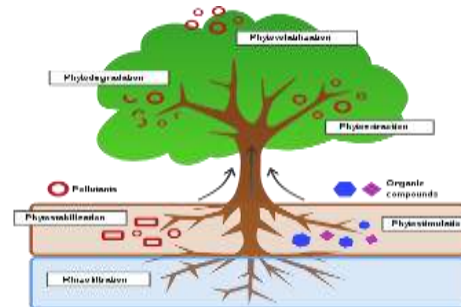
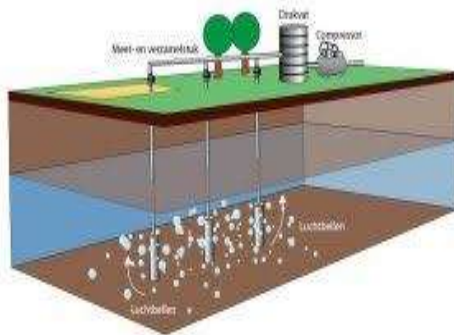
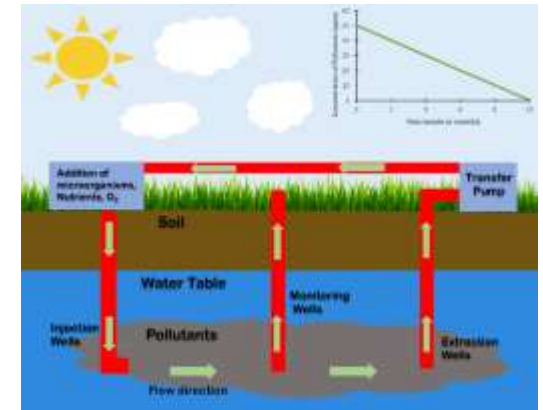
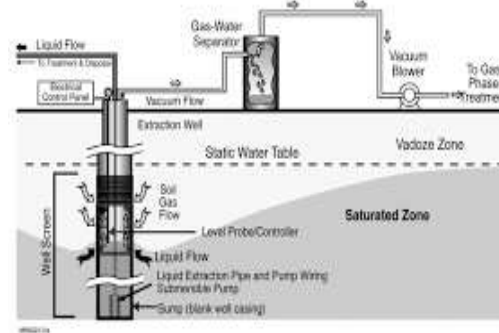
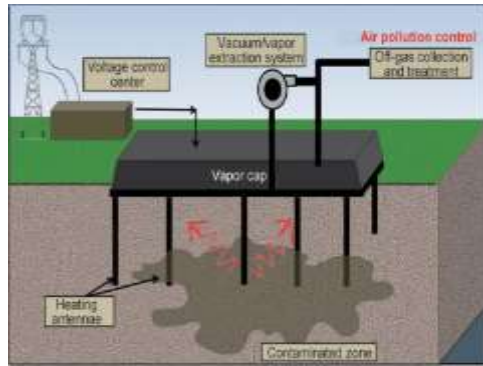
The Business of Innovation



- Have you attended a Battelle remediation focused symposium?
 - A) Yes
 - B) No
- How many excavation-based remediation projects have you been involved in?
 - A) None
 - B) Less than 5
 - C) At least 20



New Technologies Rapidly Came Forward



Bioremediation – O₂ as electron acceptor – via compressors and distribution piping

Bacteria convert hydrocarbons into CO₂ and water when sufficient oxygen supplied

Advantages

- Relatively low cost
- Can be implemented at operating sites

Challenges

- Trace nutrient issues
- Distribution issues
- Vapour escape potential



Bioremediation – SO_4 , NO_3 , NO_2 or oxidized metals (Fe, Ca, Mn, etc.) used as electron acceptors

Bacteria convert hydrocarbons into CO_2 and water when sufficient alternate electron acceptors supplied

Advantages

- Relatively low cost
- Can be implemented at operating sites
- No emissions

Challenges

- Trace nutrient issues
- pH, ORP issues
- Distribution issues
- Regulatory approval



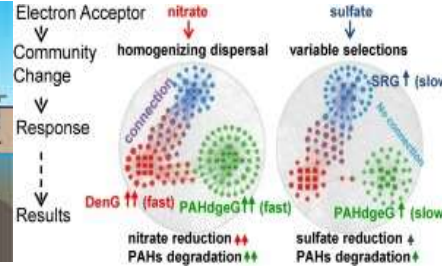
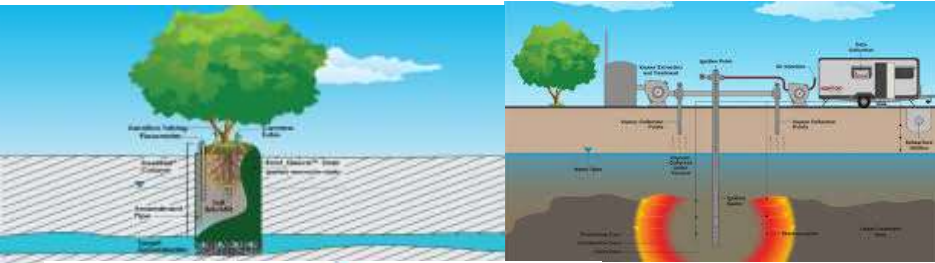
Excavation Still Occurs....



But treatment of soils happens more frequently



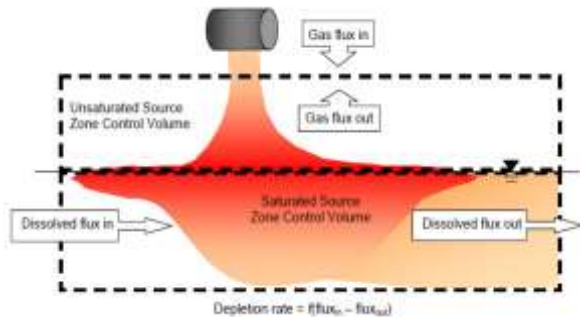
A Rapidly Growing Toolkit of Technologies



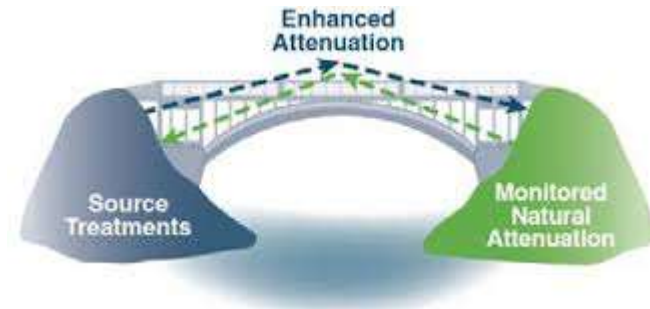
gene & trac[®]

KB-1
PRIMER

treatability
studies



**RISK
ASSESSMENT**



Acceptance of Long-Term and Passive Approaches

Chemical Oxidation

- New techniques for ozone sparging are improving this option for dissolved phase and vadose zone impacts.
- Surfactant enhanced ISCO showing promise in lower permeability geology.
- *In situ* AOP showing promise in degrading compounds that historically were recalcitrant



Bioremediation is continuing to make great strides

- Aerobic processes as well as anaerobic processes are continuing to make gains.



Teams Are a Necessity



Rarely will one professional be able to fill all the roles of a complex project

An Evolution of Thinking

1970s

Today

Project Team



Engineers



Engineers & Scientists As Teams

Regulatory Basis

speculative
philosophy



Empirical Evidence

*is that which is
obtained through
study,
research, and
observation.*



Remedial Philosophy Historically...

Typically measured data was rather simplistic, often being limited to COC concentrations.

Technical decisions related to remediation often based on hunches. Often at “lets give it a try” mentality was used. Risk of project failure was quite high.

Projects were often executed by civil engineers directing technologists and yellow iron contractors.

**LOW
COST**



Remedial endpoints were often arbitrary values with no clear understanding as to what they meant

Regulators were most often viewed as adversaries.

Overall project decisions almost always were based on cost and regulatory demand. Sustainability and social license rarely factored.



Remedial Philosophy Present Day...

Projects are often led by a team of relevant scientists and engineers directing scientist, engineers and technical contractors in the field.

More tools, measuring more parameters, collecting more data.

Remedial decisions are most often data driven and science based.

Remedial options are compared, evaluated, selected and pilot tested. Risk of project failure is low.



Remedial approaches are often stages of a treatment train.

Remedial endpoints are often risk based and make sense.

Regulators are becoming valued members of the project team.

Decisions are more likely to be based on contaminant risk factors, sustainability, safety, cost and social acceptance.



Remedial Philosophy Future State...

Projects are often led by a team of relevant scientists and engineers directing scientist, engineers and technical contractors in the field.

More tools measuring more parameters collecting more data.

Remedial decisions will be assisted by AI and data from similar sites around the world.

Remedial success will become almost certain.

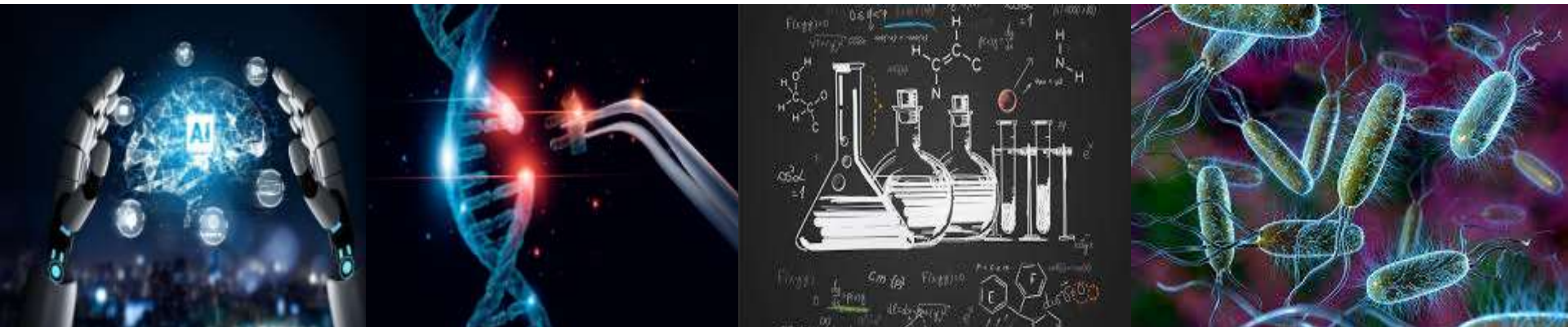


Remedial approaches will be bespoke to the site.

Remedial endpoints will be risk based on existing and future needs.

Regulators will be part of project team.

Sustainability, and social acceptance will drive project decisions. The public will be engaged on most projects.



- Have you been involved in a remediation project where sustainability has factored into the remedy choice selected?
 - A) Yes
 - B) No

- Have you worked on a remedial project where the project failed to succeed in accomplishing its objectives?
 - A) Yes
 - B) No

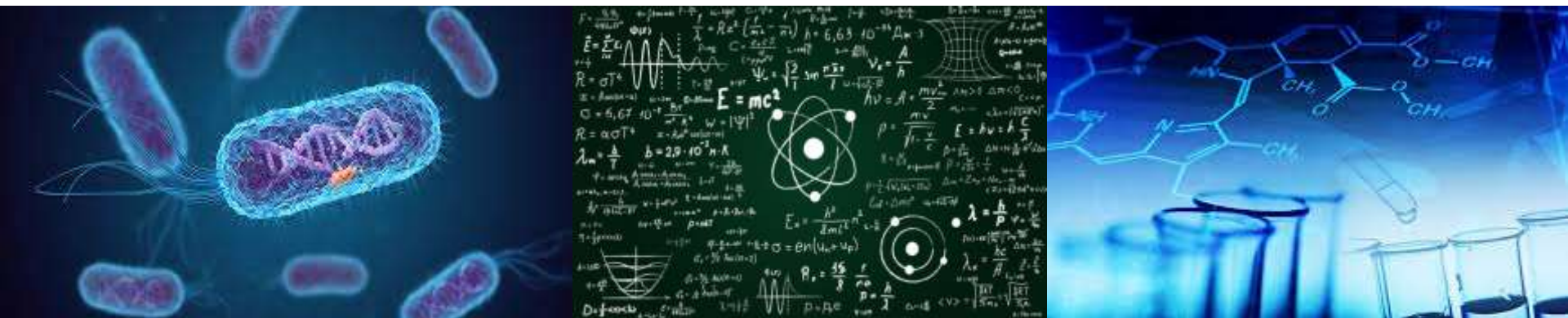


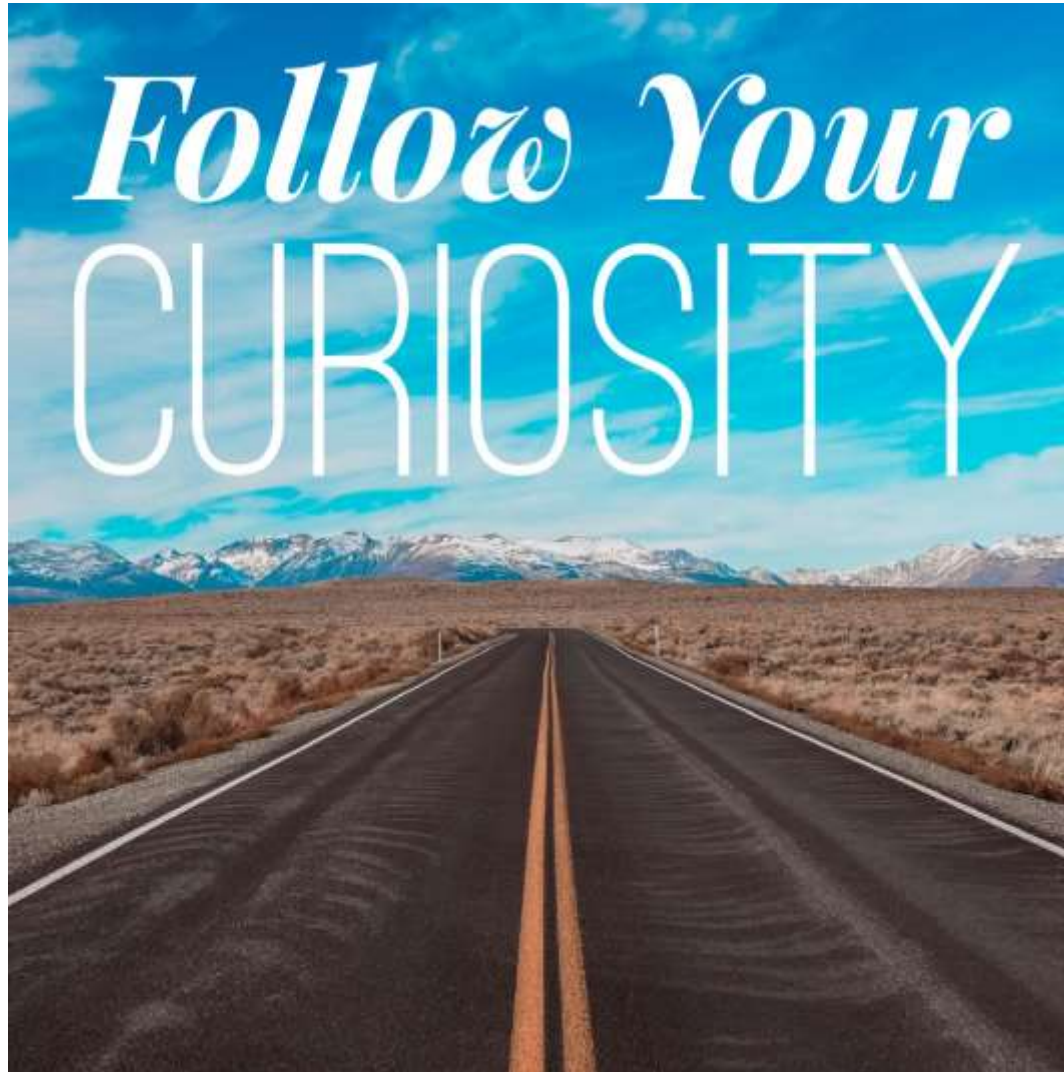


Future Trends

Existing Technologies will Improve

- SVE and variants of SVE will likely continue to be used in the future. Its likely, however that these technologies will be part of the site remedy, not the exclusive remedy.
- Pump and treat will likely continue to be used at certain sites as a control measure, but not likely as a remedy.
- **We should expect to see an evolutional of all of our existing tools and technologies.**
- **We should expect new remedial technologies to emerge**
 - *More Bioremediation – Especially Anaerobic*
 - *New Chemical Processes*
 - *Advances in Physics*

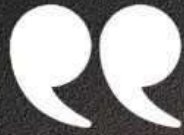




Albert Einstein







I'm in favor of
progress; it's
change i don't like.

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- Mark Twain

