This transcript was auto-generated by the webinar. Please forgive typos.

0:03
Hello, my name is Amy Blyth and I'm with Trihydro Corporation. I'd like to welcome you to our presentation today, Efficient LNAPL Site Management Using NSZD today.

0:16
Our three speakers are Lloyd Dunlap, who will be covering the effective application of NSZD, Louis Racchini, who will be discussing a case study using an NSZD at a former refinery and Ben McAlexander will talk to us about NSZD rates and site characterization. Before we get started, I'd like to go over a few housekeeping items. This webinar is being recorded and will be available via our website after the webinar. All attendees are in listen only mode. If you have questions at any point, please use the question tab in your goto Webinar Attendee panel will save time at the end of the webinar for Q&A after our speakers have presented. If we're unable to address any questions, and our hour together we'll answer them via e-mail after the webinar.

1:09
Also in your goto Webinar Attendee panel, we've included a copy of today's presentation in the Handouts tab. Finally, you will have an opportunity to complete a very short survey. when you exit the webinar. It will take just a minute of your time, and we hope you can participate as your response responses. Help us create valuable Webinar experiences for you in the future.

1:33
Also, please place your topics you'd like to hear about in the future for Webinars in the questions panel. Now, let's get started.

1:43
Today.

1:44
we will like to give you one hour on benefits of measuring NSZD at your site. We will cover NSZD what it is. And how do you measure it at your site? The benefits of better site management through NSZD, and why you should consider NSZD and including it as a component of your remedy or, in some cases, the primary remedy at your site.

2:09
With that, I'd like to introduce our first speaker Lloyd Dunlap, professional geologist, geologists, hydrogeologist at Trihydro. He is an instructor for the popular Interstate Technology and Regulatory Counsel. ITRC LNAPL technical Guidance document since 2018. He has taught over 3000 webinar participants on the ITRC approved remediation techniques, one of which is NSZD. Mr. Dunlap past successive, successfully advocated the use of NSZD to multiple clients, plus State and federal regulators. Mr. Dunlap has over 35 years of experience with ... for active enclosed refineries, public relations, advocacy with regulars, EPA, headquarters and states, organizing teams for strategic solutions, facilitating senior level strategic planning sessions, project management, and public speaking.

3:13
Lloyd will be sharing insights with us on effective application of NSZD Lloyd, with that, I'll turn it over to you.

3:23

OK, well, thank you Amy, and welcome, everybody.

3:26
So, like Amy said, what we're going to cover today is just the effective application of in NSZD.

3:32
How do you use NSZD for your site management?

3:36
I'm going to give you some actual examples from refineries that we've worked on.

3:42
We're going to talk about, at the end, the key benefits and the takeaways. issue.

3:46
We think are the benefit for NSZD like Amy said, we're going to have time for questions and answers at the end.

3:55
You want to go to the next slide?

3:59
OK, so what exactly is national source on depletion?

4:04
This is a diagram from the IT RSA guidance in 20 18. So it is C D processes, or the example of ... in Dissolution Empire Degradation.

4:17
What happens here is that you reduce your own apple mass saturated and mobility over time.

4:23
Elda Apple, as you know, is really the acronym for light, non aqueous phase liquids, such as Petroleum, what we have here. We're going to talk about today.

4:33
Number two.

4:35
NASD is awake used to measure and demonstrate the rate of hydrocarbon removal. So NSZD is basically just measuring that rate.

4:44
Now, NSZD is not new.

4:47
It was first talked about Johnson and others.

4:51
Back in 2006, He used the chemical gradient method. He measured vapor and whales for methane and CO2 and oxygen.

5:03
Then IT or she discussed in NSZD back in 2009 in their guidance document.

5:09

And then in 20 11, Kyoto and others talked about in a CD, CO2 fluxus by the Chamber method, and most recently, we've seen increased regulatory acceptance of the concept of NSZD.

5:27
Next slide.

5:31
OK, now we'd like for you to think about your conceptual site model, how effective the application of ... enter your conceptual OSI model. Now, we think we'd like to think of our conceptual model in three different phases.

5:50
The initial phase, your initial CSM, you're a remedial, see your sam, and also your performance, your sam.

5:59
So how can you use ..., whatever one there you can use in NSZD as a benchmark huge to measure the effectiveness and the efficiency of your current remedial systems as you may have at your site already.

6:15
Number two, ...

6:17
can be that final step in a remedy treatment train to achieve the remedial objectives for the site, or number three, in NZD, it can be your primary remedy or a portion of your site.

6:31
Especially, if you have large sites, number four, in HD, it can be up as a component, the remedy at aside.

6:42
Number five, in Hasidic, even be your final remedy.

6:47
for the entire side, where the risks are managed, in are acceptable.

6:52
So you can see, you need to have a good understanding of your remedial CSM and your performance CSM and where, does ... fit in?

7:01
If at all, OK, next slide.

7:07
OK, so let's focus on the effective application in a CT and this time, in your remedial CSM What you can do is you can take a look in a CD reducing the mass within your own apple zone to achieve apple stability. For example, that you haven't still have a migrating plume or is it stable? Also for your dissolved plume, you said, Margaret ... table.

7:35
Number two, uh, are ...

7:39

processes in the Annapolis Zone, are they achieving the mass losses comparable or even better than your current remedial systems at your site? And we'll talk more about that in just a little bit, and give you some examples.

7:54
And number three, just natural attenuation and ..., mitigating the migration of your dissolve, hydrocarbon alone at the site.

8:04
So this is a picture of colors used in the use information in NSZD, using the Dynamic Closed chamber. And Ben's going to talk about that here in just a few minutes.

8:20
Next slide.

8:22
So these are our Trihydro perspectives.

8:26
Now, many regulators consider ..., a bible, remedial approach, and I know we have several regulators on the call today.

8:36
Now number two, ... is acceptable only if receptors are protected.

8:42
And of course, that goes with any engineered remedial system, or your ... protected out there.

8:49
Number three, ... is a good option when the existing engineered remedy is approaching and important.

8:58
So as we know, there's some are active remediation systems, are just going to have to reach this technological endpoint, and it's going to end.

9:10
Now add in a CD may be a good option.

9:13
two. When your existing ...

9:15
system is originally an endpoint, the stakeholders are looking for justification to continue.

9:23
Something instead of completely transitioning out in S.g.d. may fit in that aspect.

9:30
In a CD is supposed accepted, we're all stakeholders, including your regulators already see the large body at aside there's something that's pretty tragic.

9:40
Well, that isn't trackable problem will not go away in, NSZD may be a good option to look at.

9:48

And number four, often in CD is not the sole remedy for an entire held Apple side early on.

9:57
We think that, you know, you should be measuring ...

10:00
early on, But most often, on your first part of your action recovery for your reveals Sam, baby in a CD is not the only thing going on out there. Active systems may be going on also.

10:14
Number five: hotspot remedies can be enhanced in s.v.d..

10:19
What I mean by that, that there are people out there looking at ways to enhance and has CT.

10:24
People are looking at warming, blankets, gypsum, low air pulsing, or low air panting the picture of the windmill.

10:34
It's actually a Trihydro side where we're pulsing air into the system into the subsurface to enhance the ... CD.

10:44
Next slide.

10:47
This is some things to try. How do we learn?

10:50
Some states out there have an M and a fact sheet that regulators use the reference when accepting when setting a transition out of actually remediation an M&A fact sheet.

11:03
Now try Hard Rock has shown that in some of these cases, NSZD meet each of the criteria in that ... a fact sheet. In other words, we're using the ... a fact sheet as an explicit checklist for them.

11:17
Now many states have been amenable to using MSD's certification to shut down inefficient remediation systems.

11:26
Using number two, using ... is an intervention or interventions at a residential area.

11:32
So all these receptors are protected such as groundwater users restricted.

11:38
Or there's no promise.

11:40
I've told you vapor intrusion.

11:42
And lastly, there, you can also use ... as a site wide remedy for large NAPL sites.

11:49
We've actually seen there such sites may have localized accurate remediation assistance that will phase out and transition all to s.v.d..

12:03
OK, all right, next slide, please.

12:10
OK, so here's an example of using NSZD in your Performance CSM the top pie chart and bar chart is from an actual site.

12:23
And for a 15 acre comparison what we did, we went to the interior of the site at this former refinery, and measured a 50 acre comparison.

12:34
Now, we found out the NSA day in this 50 acre area was reducing approximately 240 kilograms per day.

12:45
Now adjacent to this, there was a active SVE system going on.

12:50
In this ASPE system also had a comparable footprint of approximately 50 acres.

12:56
What that SVE system was removing 38 kilograms per day.

13:02
And then the center one there.

13:04
The groundwater bar remediation, hydrocarbons are being lost in there for her bar remediation, approximately 5 to 10 kilograms per day.

13:14
So you can see here in that chart on it on the upper right, they're predominantly in NSZD was the removing more mass at that site in the active remediation system.

13:26
Now on the upper left, this R pie chart here, this is simply another way to show it.

13:33
on what how you compare the removal of, uh, LNAPL Mass from in NSZD two removal by SBA. And you can see there, this is just a way to show that you are predominant removal is why it is CD.

13:51
Now, if you look at the bottom of this, the pie chart and also the bar chart, this is 2022. Certainly this is just a hypothetical way of looking at it, poor performance CSM.

14:04
But, as we all know, that remediation systems, especially here as I get older, tend to reduce their effectiveness year by year until it is too really not technologically available to actually continue to even use them.

14:22
So, if we assume that the SP system continues to decrease in the amount they recovered and that the NSZD being thought to be a zero order magnitude stays the same.

14:36
The pie chart on the On the Left shows you. If you were to compare year by year by year, the dark pie chart will become increasingly more.

14:45
LNAPL lost, my inner CD, and the active system, really showing you this, because this may be a very good way to show and demonstrate the effectiveness of ... LNAPL, massive loss of ... compared to active systems. It will paint a good picture for you and your stakeholders to show how in NSZD is removing compared to your active system.

15:14
OK, so, Amy, I'd like for you to bring up the first poll.

15:25
OK, so here's a poll we'd like for you to answer, You can be clicking on this, in your opinion, significant, A role, does ...

15:33
play extra petroleum, hydrocarbons sites, either insignificant, potentially significant, significant, or I don't know much about NSZD?

15:57
All right. It looks like we have a majority of our folks that have voted so I'm gonna go ahead and close the poll.

16:06
Then I will share the results with you all and Lloyd the way it's looking.

16:12
We have a majority of folks, about 41%, said, Significant, looks like 39% said potentially significant, 20% said, I don't know much about NSZD and then we didn't have anybody say insignificant, OK.

16:34
Well, thank you very much for that thank you.

16:39
Alright, so, appreciate all the information, Lloyd, and I think now it's time to handed over to Ben, or excuse me, Louis? My apologies. I'm just a reminder for the folks on the phone. We're holding questions until the end. So, if anything, Lloyd covered, sparked a question, please submit your question in the attendee panel at any time. Next up is Louis Racchini. Louis will discuss a case study at a former refinery in Wyoming, A little bit about Louis. He has 28 years of professional experience and Environmental consulting. serving as a project manager and a senior hydro geologist.

17:23
His primary responsibilities have included designing and implementing soil and groundwater quality assessment and remediation programs evaluating that contain contaminant, environmental fate and transport, remedy, evaluation, and construction and operation and

maintenance of long term soil and groundwater remediation product projects. Excuse me. Mr. ... has also participated in negotiations with regulatory agencies and has provided oversight for closure of a number of petroleum release sites and chlorinated solvents, release sites. And let's add, Louis, I'll turn it over to you.

18:06
OK, thanks, Amy.

18:09
We're gonna look at another example of a former refinery where tried row has demonstrated the effectiveness of any CD to the regulatory agency.

18:21
And I'll start by providing some site background, in general, on Apple information, for context.

18:29
You're looking at an aerial photo here from 19 47.

18:33
You can see the former refinery, it has an orange outline.

18:39
And it's approximately 30 acres.

18:41
The property to the south of that with the purple outline is a former tank farm, that's 55 acres.

18:50
Only the northern portion of that is shown.

18:55
So the refinery operated from 1917 to 19 56, the tank farm Pumping station operated from a started a little bit later than the refinery, but operated through the mid 19 nineties.

19:13
Next slide.

19:19
All right, so here we're looking at footprint of the smear zone, or L now or zone that was, that resulted from releases from the former refinery and pumping station.

19:41
It's approximately 134 acres. So pretty sizable.

19:45
Um, and it's the maximum historical extent, is really what you're seeing here.

19:56
So you can see the refinery outline again in orange there, just for scale, and for orientation of how the... zone relates to the refinery in and pumping station.

20:12
You can also see a black line on the north-west corner, or outside of the north-west corner of the former refinery.

20:21

And that is a L now full recovery trench system.

20:26
I'd also point out that there's a river, right?

20:29
at the top of the of the map there, You can just see the river where the LNAPL plume eventually reached.

20:42
So the trench on the north-west corner of the refinery, has been operating for 16 years, and recovery is waning.

20:51
Um, as the performance CSM predicted, it's the topography of the land, slopes downward to the north or the river and obviously, or predictably, so, does the hydraulic gradient.

21:10
So, when LNAPL was released, it migrated generally north toward the river until at some point it reached at historically.

21:20
Project actually started in 1994.

21:26
When a sheen was observed on the river and it began under EPA.

21:34
The smear zone that you're looking at who was delineating using Ross' probes.

21:41
And well borings, primarily, the color ramp on that smear zone indicates thickness. So the outer edges, where, where it's green, it's one foot in.

21:55
In the interior, where it's red. It's approximately 20 feet thick.

22:01
The composition of the LNAPL, it's a mixture, it's a blend of petroleum, intermediates, diesel, gasoline, other fuels that were produced.

22:14
OK, next slide.

22:20
The current NPAL plume is shown in green in light green on this slide.

22:27
And it's it's approximately 30 acres.

22:32
But that can vary with water table fluctuations as the water table goes up through the the mobile LNAPL tends to decrease and the plume appears to be smaller.

22:48

And as the water table goes down, it appears to be larger because mobile L now pool enters the wells.

22:55
And that's what this, this figure is showing is mobile L now, all that's measured in wells.

23:03
Um, the maximum amount. Recent.

23:10
LNAPL plume that we've seen, has been about 70 acres. The one, as I said, it's pictured here, is about 30 acres.

23:20
So, this maximum L now, for whom is approximately half the size of the smear zone indicating that in the preceding decades, since the refinery closed substantial depletion of mobile L now, Paul, by NF CD processes in the smear zone has occurred since its maximum extent. So this is a This is a pretty huge reduction.

23:47
And, granted, it does, it does take some time, but it really illustrates well what NSZD is capable of.

23:59
So knowing that we'd want to NACJD to be part of our remedy at this site and considered by the regulatory agency as a significant component of the overall site remedy, we began monitoring for anti CD in 20 18, before the Remedy Agreement and Remedial Action Plan for this site were prepared.

24:23
During remedy discussions with the regulatory agency, regulators were interested and open to NSC D being incorporated into the Remedy Agreement and Remedial Action Plan.

24:36
because they understood its potential for high rates of depletion in source areas, and that it would be effective for residual and on apple when other active remedies would not be.

24:50
Next slide.

24:54
All right, So the overall objective for, for collecting NSZD data is to provide the necessary information to decision makers to allow them to manage the site remediation in the most efficient manner possible.

25:09
Which is very important when you have a site that's large.

25:13
More specifically, though, the objectives include characterizing and quantifying and a CD at the site to allow for efficient site management.

25:24
It's important to quantify degradation rates and volumes.

25:29
So, that NSZD can be compared to other potential remedies, whether those are existing remedies, existing systems, or other possible, remedial options for the future for the future for this site.

25:48
Once NSZD has been characterize and quantify, we can understand what its role in the future remediation of the site could be.

25:57
It might be only one component, as laid mentioned earlier, of the site remedy, along with one or more other kinds of active remediation. Or it could be the sole remedy if plume containment and other conditions are met.

26:14
In any case, having an NCD characterized and quantified gives the decision makers the information that they need for effective site management.

26:26
At this point, I'm going to turn it over to Ben to discuss some specifics about anti CD collection.

26:34
Let's see data collection and interpretation.

26:39
Thank you Louis. Again, don't forget to enter your questions in the questions panel on your goto Webinar pop out. Now Ben ..., Alexandra will share NSZD results for this case study. Mr. McAlexander is a contaminant hydraulic just for Trihydro. His primary role is development of site conceptual models that petroleum affected sites, and their application to management decisions. She conducts remedy performance monitoring on hydrocarbon attenuation processes, including and NSZD and green enhancements to natural hydrocarbon losses. She regularly publishes his work in academic journals and present environmental conferences, and we look forward to hearing more.

27:30
Thank you very much, Louis. Set us up with context for this case study of a large former refinery and why NSZD data were collected. I'm now going to talk to you about on the next slide.

27:46
Powers. How were NSZD the data collected for that site? How are they converted to hydrocarbon removal rates? And how are we using that data?

27:56
So we will start with on this next slide. What are some methods for measuring and SAD rates?

28:04
We have four that are shown on this slide. The first one, number one, is a concentration gradient method.

28:11
This is where we place soil gas probes in the subsurface and measure profiles for gasses like methane, oxygen and CO2.

28:21

The reason we do that, it gets back to the conceptual site model that Lloyd introduced, where hydrocarbons, LNAPL and the subsurface.

28:31
Those hydrocarbons are lost from the el an apple over time. And a lot of that occurs by bio degradation.

28:38
In the area near an own apple body, a lot of that degradation is by my fellow, Genesis. So if we see methane showing up in soil gasses near the full body in the beta zone, then that's a good indicator that MACD is occurring.

28:55
As those that methane moves upwards in the subsurface, eventually it contacts zone where there's a good amount of oxygen.

29:03
And there aerobic micro-organisms are able to consume that methane and maybe other hydrocarbons and that generates carbon dioxide.

29:15
So if we see decreasing oxygen concentrations with depth, or we see increasing CO2 concentrations with depth, we can use those profiles or gradients. And does gas concentrations to estimate an MSC D rate? So that's one method we can use to do that.

29:36
Also all of that CO2 that is generated in the subsurface by hydrocarbon bio degradation. It's gotta leave somehow. It's gotta leave the subsurface. And when it does, it leaves the ground and you can measure that rate of CO2 exiting with pass it flux traps. That's number two on this figure here. These are sorbent media that can collect CO2. You place them out in the field and they sit for about two weeks or so. And you can then send the trap off to a lab. And they can quantify the amount of CO2 that came out of the ground. If you can quantify the amount of CO2, then you can estimate the amount of hydrocarbon degradation that was associated with it.

30:18
There's also the dynamic, closed chamber. That's number three on this slide that also measures CO2 coming out at the ground, but it's a real-time measurement. It's an instrument that you can carry around your site measure CO2 fluxes. And instead of being a two week measurement, it's a 2, 2 minute measurement.

30:37
So you can get a lot of samples in a short amount of time with a dynamic closed chamber.

30:44
And then finally, there's the biogenic heat method with all of that methane getting degraded aerobically in the subsurface, that generates a lot of heat. And so you can measure the heat signature and convert that over to a hydrocarbon attenuation rate.

31:02
So there are four methods out there. For this site, we use item one, item three, an item four, and for this example, we're going to share with you we're gonna emphasize item three: the dynamic closed chamber.

31:14
So on the next slide, here's why we're emphasizing that dynamic closed chamber.

31:20
Like I said, because it's a two minute measurement, you can get a lot of measurements in a short amount of time.

31:26
And Lewis mentioned that that for ... Zone, the Smear zone for this site is A is large. And so we went ahead and grid it up the site and we got a lot of CO2 flex measurements over that for ... Goldstone Footprint.

31:42
And you can see those little points on the figure on the left here, as well as color flood, the CO2 effects measurements with higher flex's as darker colors.

31:55
So, what we saw when we did this, we measured site wide fluxus in 20 18 and 2020 and we're showing 2020 data here is that we've got a good range of measured fluxes from less than one micro molar of CO2 leaving the gram per square meter per second to more than 10 micro moles per square meter per second. So, it's a good range. We also went to a background area of the site and we're measuring CO2 E fluxes there.

32:24
The reason we do that is because just plants in the ground their root zones, also exhaled CO2. So, we want to measure the CO2 fluxes in a background area to compare it to what's occurring in the over the l-dap or zone. So, we have a feel for the additional CO2 effects, which is the indicator of the NSZD rate.

32:48
What we saw in that background area was that the fluxes were less than three micro molar per square meter per second on average. So, that's a lot lower than what was measured over the zone.

32:59
And so, that does zero point two hydrocarbon biodegradation occurring over the ....

33:08
We can subtract that background, CO2 efflux from the value the average value that was measured over the ...

33:16
zone, and then we can convert that over to a hydrocarbon bio degradation rate.

33:22
And what it comes out to is 690 gallons of hydrocarbons or ...

33:29
being removed per acre per year.

33:33
That's a lot of hydrocarbons being lost by natural processes over one acre. But, this is a big site. It's 134 acres for the ... footprint.

33:43

And so, over that big footprint, it's out even more hydrocarbons, it's more than 90,000 gallons of hydrocarbons being removed in a year.

33:54
So, that sounds like a lot.

33:56
It is a lot that LNAPL Recovery trench, recovered in that same year, 20 20, about 4800 gallons of LNAPL. And so, over the full footprint of this ... zone, a lot more hydrocarbons were removed by natural processes, were removed by engineered remediation.

34:17
So on the next slide, we can see, well, how can we use this for site management?

34:23
one way is, we can start breaking up the data into specific parts of the site and seeing how things shake out.

34:32
So Lewis emphasized that LNAPL Recovery is occurring at this site and that there is an area of the site where LNAPL does enter monitoring wells about 3000 acres in 20 20.

34:45
So we went ahead and put that as a dashed pink line on the map on the left side of this slide. That's the zone where our map was entering monitoring wells. And you can see the little black bedrock, recovery trench. That's where that goes recovered.

35:03
We can look at CO2 fluxes there versus the site map also.

35:08
So, what we see on the bar graph is the site ... zone.

35:12
The full average CO2 E flux is about four micro moles per square meter per second being lost. That is greater than backgrounds. So as a whole, the ... zone is removing hydrocarbons, it's higher than background.

35:31
But in the area where LNAPL enters monitoring wells, the CO2 fluxes were even higher. They're higher than background. They're higher than fluxes over the site as a whole.

35:43
And so that's helpful because that's the area where an apple is in wells and probably we have more of a source for hydrocarbon degradation and we get those better fluxes.

35:56
But currently the site is being remediated by that LNAPL Recovery trench. And as Louis mentioned, the recovery from that trenches getting lower and lower as time goes on. We, now, that we have collected this data, understand that that's not the only remediation that's occurring.

36:12
While active remediation is removing hydrocarbons by own LNAPL Recovery, natural processes are also removing hydrocarbons, and they're removing a lot of them.

36:22
They are a part of the remedy now, even though we didn't realize it before, but also looking into the future future.

36:30
Eventually, that an Apple Recovery Trench is going to not really be able to get much more an apple out of the ground, and yet NSZD will probably continue to occur.

36:40
So, ... is a part of the remedy now and potentially, in the future, it could be the sole remedy for this area.

36:49
So that's one way you can look at. This sort of data is this place where an apple enters wells.

36:55
On the next slide, we look at another important part of the site. This is the Alluvial part of the site that Lewis talked about the area adjacent to the river.

37:06
LNAPL does not enter wells there anymore, but LNAPL is still present in the subsurface there as residual.

37:14
Well, we can look at CO2 influxes there and that's what's shown on the bar graph here.

37:19
You see the middle bar, that's the bedrock smear zone. That's basically where ... entering wells and we do have higher fluxes there.

37:25
But in the alluvial area, we still have substantial CO 2 CO 2 E flexes. They are higher than background.

37:34
NSZD is occurring there, hydrocarbons are being removed by those natural processes and that gives us some understanding of why LNAPL is entering the river anymore. There was a time when Apple migrated to this area, that the releases were to the south at the former refinery and even further south that there is an LNAPL is able to migrate. But it is not migrating now, it really doesn't even enter monitoring wells there now.

38:04
And that LNAPL body's stability is achieved at least in part by these hydrocarbon removal processes that are natural.

38:15
So it helps us understand what's going on there and currently we don't have an active remedy for this. Move your area. The NSZD data pry provide evidence that perhaps this could be the case long term.

38:29
So that was an example of how sought NSC data can be. Can be used to start looking at site management.

38:37
And on the next slide, we hope that it emphasized a few things about benefits of collecting LSAT data.

38:46
one is the NSZD often outpaces mechanical LNAPL system recovery for late stage element of sites?

38:55
That's been our experience is that especially when you look at the full footprint of hydrocarbon impacts and count those hydrocarbon losses that are occurring naturally that they are substantial and if you've got a system that's not really getting a lot and not pull out of the ground, that's an engineered system, it might be beaten by NSZD This was a former refinery, it's not operating anymore. We work a lot of those sites, but we also work operating facilities, large refineries, pipeline sites, and our experiences that NCD is occurring at those sites as well. And it can occur pretty soon after a release occurs.

39:39
We've been to, what, I can think of one pipeline release site where we got out there within a year after the release occurred and measured CO2 fluxes there versus a background area.

39:51
And that place where NAPL was in the subsurface had higher fluxes.

39:56
NSZD had ramped up pretty early on, and that helped us understand what was occurring naturally and what remediation options were. Not there, that Sandy was the sole remedy at the beginning for such an early site, but at least we had a full picture of what was going on.

40:17
Also, this site that Lewis introduced to us has four seasons, and two of those seasons are really cold.

40:26
NSZD is occurring. Even then we've seen this at that site and other sites that in the code parts of the year that hydrocarbon attenuation even bio degradation is occurring. It may not be as fast. At a rate that is, when it's warmer out, microbes that consume hydrocarbons do respond to temperature, but it is occurring in the winter, and if you want to characterize that seasonal variability, you can go out each of their seasons and measure those rates.

40:59
But also, if you're interested in just measuring a site wide annual average NSZD rate, we have found that going out in one of those moderate seasons, especially the fall, is a great time to go out and measure and get an approximate indicator of the annual average and NSZD rates.

41:19
And then a final benefit of measuring NSZD rates is this was baseline for this facility. Understanding what hydrocarbon removal is occurring naturally.

41:30
If in the future hotspot remediation is desired, the same types of measurements can be taken to know whether additional treatment has an effect. If you add oxygen to the subsurface and it

increased hydrocarbon attenuation rate, it will generate heat. It will increase CO2 generation and flexes and you can measure by these same methods.

41:54
So it's useful for measuring in enhanced and NSZD.

42:02
So on the next slide, before we get to our next poll, we are often asked what about the cost of NSZD measurements?

42:13
So we wanted to give you some ideas about that and first just list out some factors that can affect the cost. So these are factors for sites that aren't just like a simple, little UST site. So a moderately large are really large site. Those are really the types of sites that we tend to work. And factors that we have found to be of import include are you trying to measure an annual or a site wide in NSZD rate? Or Can you get sufficient data by going to ... stations. And measuring an ICD in localized areas?

42:54
If you can just find key parts of your site and confirm the NSZD is occurring there and measure those rates, then that can help you get the costs down because you're not doing site wide evaluation.

43:06
That's especially the case for some of those subsurface methods that can have, where you have to install monitoring infrastructure set up stations.

43:15
Another is, what frequency of monitoring is needed?

43:19
As I mentioned, if you have a site with multiple seasons, you may want to go out each season and measure NSZD rates.

43:25
That can affect the cost.

43:27
But if you're even if you're going out site wide and getting trying to get an annual average, if you go out stay in the fall, you'll you may get a good estimate of the annual NSZD rate.

43:40
And then a final factor is, how many methods are you going to use to measure these rates? We tend to use more than one method at a given site, because we want to have multiple. We want to have confirmation that what we're measuring by one method does align with what is measured by another independent method. And it gives us more confidence. It's that whole idea of multiple lines of evidence.

44:04
But, of course, when you use multiple methods, that means a higher cost.

44:09

So with those factors in mind, we can say that it is our experience that a cost for a baseline assessment of NSZD rates could be in the 10 to $50,000 range for baseline and maybe could decrease thereafter. Maybe sometimes more than $50,000, maybe, sometimes less, but that's just the ballpark that we've seen over time.

44:36
So now we get to see our next poll question.

44:44
And it is, what are your concerns with using or considering NSZD for your sites?

44:51
So it's multiple choice, but you could get to check all that apply.

45:23
Right, it looks like the votes are coming in. We'll close it off in just a few seconds.

45:32
Alright, thank you, everybody, for participating. And I'll go ahead and close the poll right now, and then launch the results.

45:45
OK, so it looks like we've got about 13% of people interested, but not familiar, and need to know more if we've got 17 that are uncertainty of long term results, 4% as C D is insignificant, says ... again for the site, needs for cleanup, 35%, time to reach cleanup is too long, and 31%. I have no concerns using or considering an S C D.

46:16
All right. With that, I'll pass it back to Lloyd to wrap this up today.

46:25
OK, thank you, Amy.

46:27
So, um, so anyway, why has NSZD not used?

46:35
And more sites?

46:36
Remember that in a CD was first promoted back in 2006 by Johnson and others.

46:43
Now last year, Jacobs did a similar poll question that we just did. And they presented it at a ram tech conference.

46:52
So the top three answers, and the people who participated in the poll was really were 44 of them were consultants or for site owners, two regulatory staff, and the top answers that they gave last year.

47:09
Regulatory hurdles are present.

47:12

Perception is NSZD, a slow past evenness efficient, and that was kind of indicated on the poll we just did, or they are unfamiliar with ....

47:23
There were several answers, but these were the top three that the REMTechWebinar Series promoted.

47:29
So, anyway, the fifth thing is, though we want here, try harder, we want to continue to tell the story about in a CD.

47:40
We have found that regulators are becoming increasingly more interesting to it or working.

47:48
We'll consider NSZD, which is kind of what we saw in our poll also.

47:55
We have found that it was mentioned in soil passive insufficient, but we found that ...

48:00
LNAPL removal rates can be quite large compared to inactive systems, which we showed you there.

48:09
In talking about the familiarity with ...

48:12
really hope that these webinars in other conversations, we have increased familiarity with NSZD. Why?

48:20
It should be at least considered warriors side.

48:25
OK, next slide.

48:29
So let's just talk about things to consider when using NSZD research. We're kind of wrapping it up here, and the key takeaways.

48:42
Number one, you want to evaluate the risks to receptors.

48:46
But that's the case when using any technology just to understand what your risks to receptors are.

48:51
Number two, you want to understand and monitor the progress of own NAPL mass removal.

48:58
That means because some of the pie charts and bar charts that I showed and Ben showed, just understand and monitor the progress up in a CD. And maybe you can even do it just annually.

49:10
Number three, you want to compare the ...

49:14
Removal Rates with other active remedies at the site.

49:18
You may be surprised how much ... is removing compared to your reactive remedy like we showed you.

49:24
And number four, so, yesterday, typically, occurs across the entire site.

49:31
Were LNAPL on this?

49:32
That means, even though you have site where you don't have an active system, NSZD is probably occurring all cross your side. You have LNAPL in the subsurface, either through residuals, or even in monitor, measure, and monitor wells.

49:52
So it is important to, it isn't number five.

49:57
So it's important to remove, evaluate the removal rates of NSZD and determine based on all the factors at the side and you're remedial CSM: Is it acceptable with the removal rates you are seeing from NSZD?

50:15
OK, next slide.

50:19
OK, let's talk about some key takeaways here, so, uh, you want to think about, we suggest you think about, Include early collection of ... removal rates like Ben talked about. You can have a recent spill after just a few months or several months, go out there and find the NSZD is actually already starting to occur, and we're pretty much seen that an IT or C or C and that pretty much all across the country.

50:49
Number two.

50:52
You want to consider the feasibility of a CD and compare it to your active remediation systems, if you have one out there.

51:03
Number three, we suggest that you consider identify early on, inner city is significant.

51:12
And that's your risk to receptors are acceptable.

51:17
Number four, with you, we suggest you think about, including in NSZD and establishing extra points for your remedial and performance CSM.

51:28
So, what do I mean by that?

51:30
Or maybe you want to establish with your stakeholders, including your regulators, a decision tape diagram on what conditions would be out there. There was a huge start considering is ..., as he leads tech component of her remedy or even your entire remedy.

51:48
Just depending on what those decision trees are, very good exercise should do upfront and get agreement with your stakeholders and regulators on what those might be.

51:58
OK, next slide.

52:02
So, here are our high level perspectives, the benefits of NSZD as a remedy.

52:09
You don't want number one, you want to understand your cost and benefit differential NSZD, Empirica Inactive System.

52:16
What does it cost for industry, the measurement period to operate an interactive system?

52:22
Number two: like Ben talked about, ... is easily measured and easily monitored, and you may be able to get by with monitoring once a year in the fall, like Ben mentioned.

52:36
Number three: ... is only one of a few remedies that's going to remediate LNAPL residuals.

52:43
And possibly, if you're trying to remediate your natural residuals, unless you have an extremely small site, just as CD is possibly the most cost effective.

52:54
And also within a CD, your own apple bass is reduced in the subsurface without having to manage recovered groundwater, and our ... from active systems.

53:05
This doesn't even mention the possibility of having to manage any excavated soils out there, OK? So make sure when you have this, just make sure that she is approved for all of your stakeholders.

53:22
Number five. Next line.

53:28
So who are pouring thoughts?

53:32
If you manage the site with ..., do you know the amount of apple mass that's actually being removed?

53:38
Buy in, CD?

53:41
If so, how does that compare to your active remedial assistance?

53:47
The next one, now, the parting thought is, should you include in a CD, at least as a component of your remedy, along with your active systems?

54:01
OK, any in the next one, OK, so that is, Yeah, Amy, I'll turn it back over to you.

54:09
Great. Thank you. Now let's move on to our Q and A We have a couple minutes left together. Thank you for all of those people that have submitted your questions. And if you haven't done so already, please feel free to put them in the questions panel. And if we don't get to them during our time together, will be sure and follow up with an e-mail. Our first question is for Ben. Is N S Z D different than MNA?

54:40
OK, so I am on an ASTM Standards Committee that's writing a guidance document or standard for NSZD measurements. and in that definitions section of that document, there's going to be one for M&A and for NSZD. So the answer I'm about to give you is what that standard will say.

55:03
And then a monitor natural attenuation is a broad or umbrella term.

55:09
Natural attenuation occurs to apple it occurs to hydrocarbons and soil gas, it occurs to hydrocarbons in groundwater, and NSZD 's focus just on attenuation or hydrocarbon removal from the LNAPL.

55:24
So from that perspective, NSZD is one type of natural attenuation. And if you're monitoring NSE to be one part of M&A. Now, historically, most people, when they think of M&A, they think of groundwater is all face plans and so from the perspective of M&A being abroad term, the reason that M&A has typically been applied in the past to groundwater and is all phase plumes is because for two reasons. one is that that is what was measurable in the past.

55:59
Some of these other methods that we share with you about NSE the measurements are new, but in the past people could watch Constituent concentrations hydrocarbons decreasing in groundwater over time and look at groundwater geochemical indicators have natural attenuation. So, that's one reason for the focused on groundwater. Another said, that's where compliance, because largely focused, Are we getting to cleanup levels in groundwater over time? And so, we focused on that for M&A. The M&A could be applied more broadly and NSZD, then is a type of M&A.

56:34
Great, thanks for that information, Ben. For here's a question for you: How does s.g.d. change the composition of the petroleum, especially Henri, Freind products?

56:49
OK, great question.

56:50
So we're finding an IPRC is finding in the consortium we have there, that is pretty much all across the spectrum, from the light hydrocarbons to the heavier hydrocarbons.

57:04
Now, not so much, maybe, on the they're very dense hydrocarbons. But if you think about the hydrocarbon ranges into gasoline, diesel kerosene area seems like in a CD is effectively fire degrading. All the straight chain hydrocarbons there plus the aromatics also.

57:22
So it's not really specific to any one particular hydrocarbon.

57:28
There's pretty much all of the hydrocarbons across the change between gasoline through diesel mmm hmm.

57:38
Great, thank you.

57:40
All right, back to Ben. These are two questions combined. We received a couple similar questions to this one. but did you measure the CO2 flux in different seasons? And the second part of the question was how do Flux rates vary with changes in ambient temperature, barometric, pressure, etcetera?

58:04
OK, so for this site, ... by CO2 E, Fluxus was measured in one season, I believe. Is that right, Lewis, for site wide?

58:13
Well, actually, we did a couple of semi-annual events initially.

58:20
I will say they're at a site very near here. UK and I looked at stopping groundwater monitoring and remediation.

58:27
Maybe, like 2019 or something, we looked at monthly CO2, E fluxes and compared it to precipitation. This is a semi arid site, precipitation temperature and groundwater elevation. You could imagine that as water table comes up, it might submerge snapple and make it less degradable.

58:48
So we did that and looked at it from a multivariate perspective statistically. And the answer for a semi arid site is that actually precipitation was the main factor that affected hydrocarbon removal rates. Probably because the micro-organisms are limited in in moisture in the beta soon, when they get it, they really use it.

59:11
Temperature came in. Second. It does matter what the temperature is in the subsurface they like the warmer weather. Groundwater elevation did not matter.

59:20

They did not care. The hydrocarbons didn't care whether the water table is high or low. Probably, meaning that NSZD is occurring below the water table insubstantial amounts, even though methane bubbles out of the out of that groundwater and eventually gets the ground surface. It may have occurred largely below the water table.

59:38
So that's what has been demonstrated and what we have demonstrated in the past and written up.

59:46
Well, thank you, Ben. Great information. Unfortunately, we're reaching our end of time. We do have some more questions that were asked and like I mentioned, we will follow up with those in an e-mail with our insight and answers after the webinar. At the end of the webinar, when we enter our time together, there will be an exit survey. We hope that you can take a minute or so to answer those 4 or 5 questions to help us target our webinars better for you in the future. There's also some time to request one-on-one time with our subject matter experts here.

1:00:25
So, make sure if you're interested in talking with our guys today on the phone, that you let us know that there will be a link to today's webinar recording, along with the PDF of the PowerPoint that will be sent to you tomorrow. If you'd like to receive a certificate of completion for Continuing Education hours, or credits, please contact us, and we'll be happy to provide that for you. Well, a very big thank you to our speakers, and thank you to all of you for joining us today. We hope you join us for future webinars. And feel free to include some topics in the questions panel, if you'd like, to hear about something in the near future. Again, thanks so much.