IPEC GUIDELINES FOR REMEDIATION OF SMALL BRINE SPILLS

ENERGY ENVIRONMENT ECONOMY

Integrated Petroleum Environmental Consortium

First response to a brine spill

Routine inspections and preventative maintenance can help avoid equipment failures or line breaks. When a release occurs, first assess the situation. Always approach cautiously and resist the urge to rush in. Identify risks based your experience, observations, and senses. Isolate the source and stop the release; contain any fluids; and recover fluids for proper disposal. Once you've done that you can begin to work on restoring the soil conditions needed for revegetation. These guidelines are designed to help you remediate these spills in a cost-effective manner. Start remediation as soon as possible and you'll save even more money.

When can I use these guidelines?

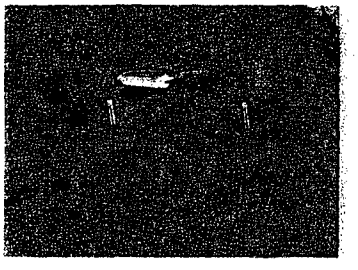
At IPEC we have developed a staged response to remediating small brine spills that may take a little longer than some other methods to implement but should save you money and get the job done. This process works well for relatively recent spills with little erosion of topsoil. Old, eroded brine spills or brine scars are beyond the scope of these guidelines. If you have this problem, we suggest that you seek assistance from a qualified professional.

Soil analysis is necessary for successful remediation

When remediating a brine spill, it will be necessary to take soil samples and analyze them for salt content. Why? You need 1) to see how well you are doing overall and, 2) to identify hot spots that may need extra treatment. You can do this yourself with the *IPEC Soil Salt Analysis Kit* available free from IPEC. But, first, we need to talk about how to take a good soil sample.

Soil sampling recommendations

The salt content of soil impacted by a brine or produced water spill is highly variable over the area of the spill and with depth. The photo below illustrates this important point. Here, two soil samples taken about 18 inches apart at a brine spill site were analyzed separately using the *IPEC Soil Salt Analysis Kit*. These two samples had very different salt contents (8.8 vs. 4.6 on the test strips) – and the sample with the lowest salt content was actually closest to the source of the spill!



Mixing of the soil by tilling helps but no practical amount of tilling will evenly distribute the salt. This variability will exist throughout an entire remediation process. We have to keep this fact in mind when we take a soil sample for salt analysis.

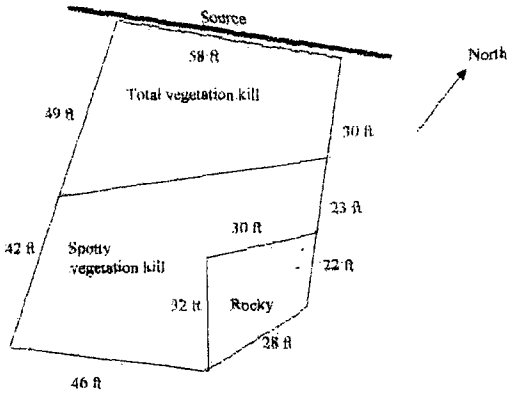
Whenever we analyze brine-impacted soil for salt content, it is the **average** soil salt content or concentration we want to know. No single soil sample will tell us that because of the variability we were just discussing.

An **average** soil salt content can be estimated by doing what is called **composite** sampling. A composite sample is prepared by taking several individual soil samples within the area of a spill, then mixing them together before doing a soil salt analysis.

The following are some specific recommendations for composite sampling of a brine or produced water spill site:

- It is often useful to make a sketch of the spill site. Note on your sketch any easily recognizable features such as:
  - Clearly different soil types
  - Different levels of plant kill (complete kill vs. incomplete or spotty kill)
  - Different slopes
  - Very rocky conditions

  Pace off the different sections of the spill area and add dimensions to your sketch so that you can estimate the areas of the sections in square feet. Turn this card over to see a sample sketch:

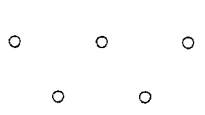


- Each different section of the spill site you noted on your sketch will likely respond differently to remediation efforts and should probably be sampled separately each time the site is sampled.
- To prepare a composite sample in any section of the spill, dig at least 5 holes about 6 inches deep and empty all of the soil from the holes. Now scrape soil from the sides of each hole from the surface to the bottom of the hole, break up clumps, and mix the scraped soil there in each hole. Remove equal amounts of soil from each hole and mix them all together in a clean bucket or pail or even a large Ziploc bag. This is your composite sample – analyze this soil with the *IPEC Soil Salt Analysis Kit* to estimate the average soil salt concentration in the section sampled.

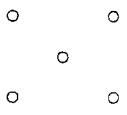
Do you always use 5 holes to prepare the composite sample? If the area being sampled is 5,000 square feet or less, use 5 holes. If larger, increase the number of holes: 6 holes for 6,000 square feet, 7 holes for 7,000 square feet, and so on.

Where should you dig the holes? Dig the holes at random or use a pattern like one of those shown below. Avoid small unusual areas or the edges of the spill.

W-Pattern



5-Spot Pattern



When is the best time to sample? Sample only when the soil is relatively dry. Clumps should be easily broken and the soil easy to mix.

How often should you sample while a site is being remediated? Sample about every 3 months.

Drainage, Drainage, Drainage

Now that you know how to monitor your progress, let's talk about the remediation process. Revegetation can occur if you can cause the salt to move out of the plant root zone. Something you have to always keep in mind though when remediating a brine spill—the salt has to go somewhere. So throughout the remediation process you must have good drainage from the site.

You must give the salt the opportunity to move, but you must also be careful about where it moves to! One option is for the salt to move downward in the soil profile. This can be a good option if there is no shallow barrier like a clay layer or shallow bedrock within six feet of the surface and if there is no shallow groundwater which could be impacted by the salt. You can check with your state regulatory field technician or county agriculture extension agent to find out if this is a good option for your site. Another option is for the salt to move laterally in a general downhill direction by surface leaching during rainfall events.

Look at your site with this in mind. If downward movement will work, you will want to retain rainwater on your site as much as possible. Use soil berms to control water retention. If downward movement is not an option, lateral surface leaching can work well if your site can be made to drain into a natural drainage area where any salt from your site will be distributed over a large area at low concentrations without harming other vegetation.

Whether you use downward or lateral movement of the salt, be careful to protect any downhill water such as creeks, streams, or ponds even if they are dry part of the year.

In some isolated cases it may be necessary to install some type of subsurface drainage system, but this is a last resort when you can't control drainage in any other way! If you use subsurface drains, you may need to collect leachates and dispose of them. If you think you need subsurface drains, IPEC suggests that you seek assistance from a qualified professional.

How do we get the salt to move?

Stage I: Till in organic matter and fertilizer. The decay of organic matter in the soil restores soil structure making it easier for water to move through the soil and carry the salt away.

Hint: Think about hiring the landowner to do this work!

How much? For every 1000 square feet

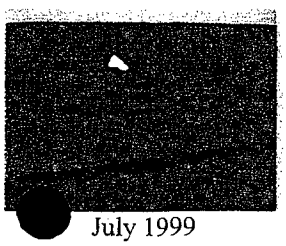
- 5 bales of hay
- 28 lbs of 13-13-13 fertilizer

Once you've worked the area, start monitoring the salt content of the soil every three months or so.

Repeat the tilling and hay and fertilizer addition after about a year. Once salt concentrations are low enough, the site should naturally start to revegetate. This could take a year or two though depending on how much salt you started with!

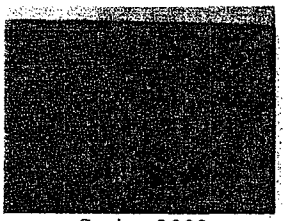
By the way, any kind of vegetation is good to begin with. The plant roots hold the soil together and prevent erosion and also make the soil more permeable to rainwater. It actually speeds up the remediation process. The weedy plants that come first will give way to grasses eventually. You can get an idea about what plants can grow on your site from the table of plant salt tolerances in the *IPEC Soil Salt Analysis Kit.* You may also want to work with your county agricultural extension agent to make sure plant nutrient levels are adequate. Ultimately you will want to work closely with the landowner to establish what he wants on his land.

This Stage I approach may do the job for you as it did in the example you see below. However, if this approach doesn't entirely do the job for you, go to Stage II.

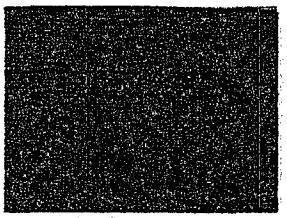


July 1999

Spring 2000

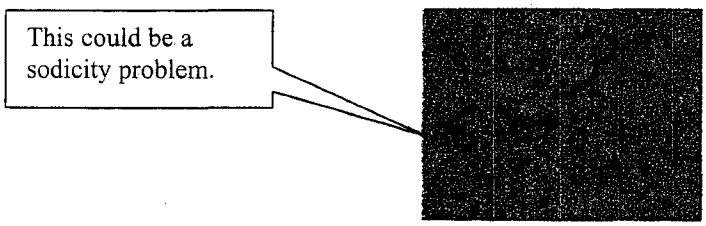


Spring 2002



Spring 2002

Stage II: Once the site starts to revegetate you may sometimes continue to have some bare spots. These may be "hot spots" where the salt concentration was especially high. If that is the case, those hot spots will just take longer to remediate. However, you may have what is called a **sodicity** problem. Sodicity is an excess of sodium in the soils that is often identified by a hard-packed surface that lets water just run off and not penetrate into the soil. If you have this problem, work some gypsum into the bare spot—about 13 lbs per 100 square feet. Repeat this addition if the spot doesn't start to revegetate the next spring.



What if the time required for remediation is more important than cost?

You can speed up the remediation process by going to gypsum application right off instead of hay and fertilizer, but you will be buying a lot more gypsum, and the large loadings of calcium (from the gypsum) can affect the availability of plant phosphorus. If you want to use this approach, contact your state regulatory field technician--they will help you out!

Some common problems to watch for:

Sometimes you might see new vegetation wither and die in dry weather when vegetation in unimpacted areas still look okay! This is caused by upward migration of salt during dry weather. You might even see white salt crystals on the soil surface. What can you do when this happens?

Keep on

- tilling
- adding organic matter
- adding gypsum if necessary

until vegetation returns to the site and remains healthy! The deeper the salt has penetrated the longer this will take.

Another thing to watch for:

A bare spot that doesn't revegetate but has

- acceptable chloride concentrations
- no sodicity problem

probably needs nutrients!

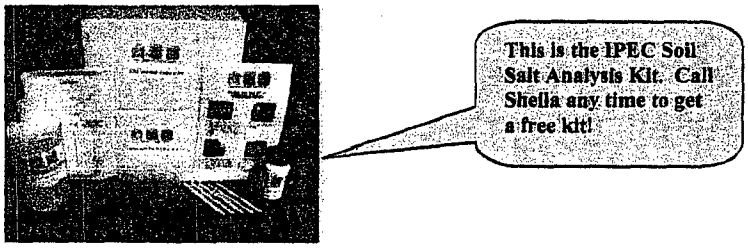
Everything you have done to wash salt from the soil may also wash plant nutrients from the soil. You can contact your county agriculture extension office for assistance if you have this problem.

What about crude oil?

As you know, brine spills often contain oil. In this case you have two contaminants to remediate. What do you do differently? When you sketch the site, label the area with most of the oil stain. Fertilize this area following the *IPEC Guidelines for Bioremediation of Crude Oil Spills*. Where there is little oil staining, use the 28 lbs. of 13-13-13 per 1,000 square feet discussed above. Otherwise, just be careful not to let hydrocarbons wash off the site. Actually, this shouldn't be much of a problem once you till in fertilizer and hay.

We at IPEC hope you will find these guidelines helpful. If you have a spill and choose to remediate the site yourself, let us know how it turns out. We are sure you will be successful.

For more information or to request additional copies of these guidelines, contact Sheila Kumpe at the IPEC office at (918) 631-3284 or sheila-kumpe@utulsa.edu. These guidelines were developed by Kerry L. Sublette, University of Tulsa, who may be contacted at (918) 631-3085 or kerry-sublette@utulsa.edu. Comments are welcome.



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ARKANSAS:

AOGC El Dorado Office
El Dorado, AR
(870) 862-4965

AOGC District Office
Ft. Smith, AR
(479) 646-6611

ADEQ
El Dorado, AR
(870) 862-5941

ADEQ
Little Rock, AR
(501) 682-0744

OKLAHOMA:

OCC District I
Bristow, OK
(918) 367-3396

OCC District II
Kingfisher, OK
(405) 375-5570

OCC District III
Duncan, OK
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IPEC GUIDELINES FOR BIOREMEDIATION OF A CRUDE OIL SPILL

ENERGY ENVIRONMENT ECONOMY

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Why use bioremediation?

Bioremediation is frequently the most cost-effective way to clean up an oil spill on soil and is endorsed by state and federal regulatory agencies. Cleaning up spills quickly will minimize future liabilities and costs by helping you maintain a good relationship with the landowner and regulatory agencies.

When can I use bioremediation?

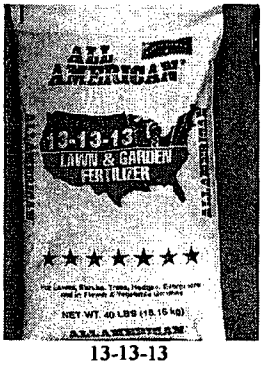
If you have any pooled free oil, it is important to vacuum up the free fluids and, if possible, recycle them back to the stock tank or properly dispose of them. Use absorbent material to pick up any fluid that can't be vacuumed and legally dispose of that material. When that's done, you need to ask two questions: (1) Is the contamination deeper than 8 inches? and (2) Is there shallow groundwater under the contamination?

If you answered "no" to both of these questions, then a basic form of bioremediation called landfarming should work well for you.

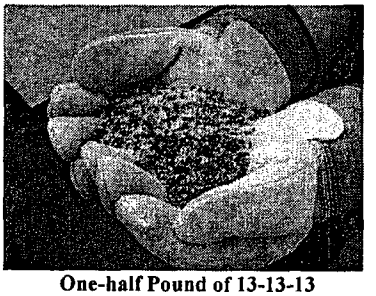
Basic landfarming

When you landfarm a crude oil spill, you are cultivating microorganisms in the soil to eat hydrocarbons. These microorganisms need the same things as crops to thrive: fertilizer, moisture, good soil structure, and warm temperatures. Follow the steps below and you will be on your way to cleaning up that spill:

Step 1. Add fertilizer to the contaminated soil. 13-13-13 is a good choice. Add 1/2 lb per square yard of stained soil if it is a recent spill and 1/4 lb per square yard if it is an old spill. Just step off the site to estimate the size. Don't add too much. You can have too much of a good thing. This wastes money and slows the process down.



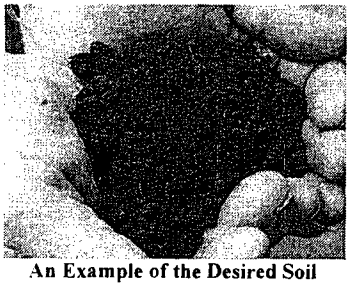
13-13-13



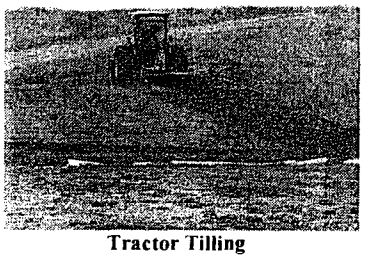
One-half Pound of 13-13-13

Step 2. Add organic matter to the contaminated soil. Organic matter builds soil structure and allows the soil to breathe. Hay or straw works well. Add the equivalent of about 5 square bales of hay per 1000 square feet.

Step 3. Till the fertilizer and organic matter into the soil to a depth of 6 - 8 inches. Was the soil wet with hydrocarbon? If so you need to blend in some uncontaminated soil from around the edges or below the contamination during tilling. After tilling you should be left with a mixture that crumbles in your hand. Try to keep heavy equipment and cattle off the site - compacting the soil slows the process down.



An Example of the Desired Soil Structure in a Landfarm



Tractor Tilling

Step 4. Repeat the addition of fertilizer and tilling every 30 days during the warm months (March through November) until the hydrocarbon odor is gone. Once the hydrocarbon odor is gone revegetate with native grasses to prevent erosion.

April 10, 2002

What about moisture? We can speed up the process of bioremediation by keeping the soil moist but most of the time we just depend on rainfall. If you do water the site, don't saturate the soil - that actually slows everything down.

What is the best time to start a bioremediation project? If you have a spill in December - February go ahead and till in organic matter to keep the hydrocarbon from moving offsite until warm weather returns. If the impacted area is sloped, it may be necessary to construct a low earthen dike at the bottom of the site to prevent runoff. If the spill occurs at any other time of year, go ahead and get started as soon as possible.

How long does it take to bioremediate a site? That depends on a lot of things, some you have control of and others you don't have any control over. You can speed up the process by sticking to the tilling and fertilizing schedule. But you can't control the rain. Another factor that has an effect on the rate of the process is how old the spill is. You can expect that crude oil that has been in the ground for a while will degrade slower than a recent spill. All things considered, you should see significant results in one or two growing seasons.

What if you couldn't answer "no" to both of those questions? If the contamination is deeper than 8 inches but there is no shallow groundwater, following these guidelines should result in at least some restoration of the surface although the deeper contamination will remain. Remediation of all of the contaminated soil would require the soil to be excavated, spread out in a layer less than 8 inches deep, and the four steps of basic landfarming applied.

If there is shallow groundwater under the contamination, you should consult a qualified technical expert to show you how to do landfarming without groundwater becoming contaminated.

What about brine? As you know, crude oil spills often contain brine. In this case you have two contaminants to remediate. Bioremediation will clean up the oil, but the brine must be washed away. Fortunately, the four steps of basic landfarming, which make bioremediation of the oil possible, also make it easier for rainfall to wash brine from the site. When brine is present though, we need to think about drainage of the site—the salt must have a way out. Other IPEC products provide more detail on the process of salt remediation. Contact the IPEC office for these products or a qualified technical expert for help.

For more information or to request additional copies of these guidelines, contact Steve Hall at the IPEC office at (918) 631-2257 or stephen-hall@utulsa.edu. These guidelines were developed by Kerry L. Sublette, University of Tulsa, who may be contacted at (918) 631-3085 or kerry-sublette@utulsa.edu. Comments are welcome.

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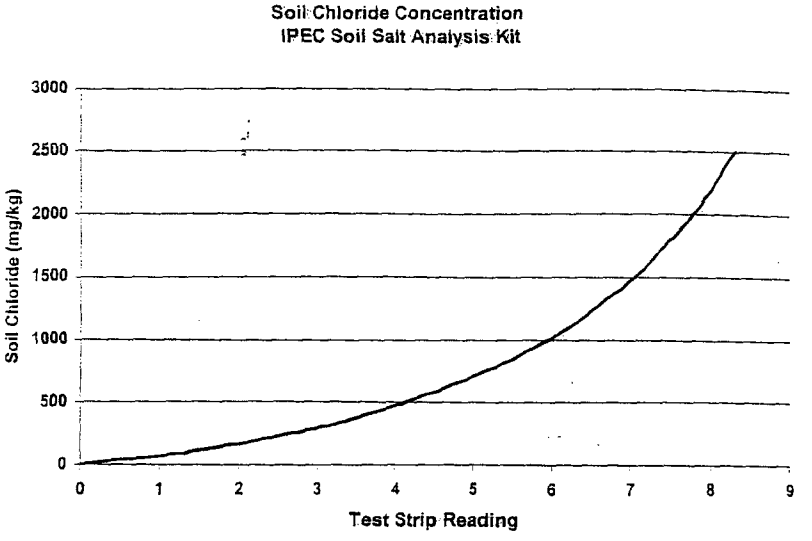
HOW TO INTERPRET TEST STRIP READINGS



For example, a strip reading of 6.0 means the soil chloride concentration is 1000 mg/kg.

Grasses and Forage	Threshold*	IPEC Soil Salt Analysis Kit Strip Reading 50% Yield Reduction
Clover, alsike	2.8	6.0
Clover, Berseem	2.8	7.8
Clover, ladino	2.8	6.0
Clover, red	2.8	6.0
Clover, strawberry	2.8	6.0
Foxtail, meadow	2.8	6.5
Orchard grass	2.8	7.5
Corn (forage)	3.0	7.0
Love grass	3.3	7.0
Alfalfa	3.5	7.0
Trefoil, big	3.5	5.5
Wheat, Durum (forage)	3.5	>10**
Sphaerophysa	3.7	7.4
Sesbania	3.8	7.5
Cowpea (forage)	4.0	6.5
Wild rye (beardless)	4.2	7.8
Vetch, common	4.3	6.8
Sudan grass	4.3	>10
Fescue, tall	4.7	>10
Wheat grass (standard)	4.7	>10
Harding grass	5.3	7.8
Wheat (forage)	5.3	>10
Trefoil, narrowleaf	5.5	7.5
Ryegrass, perennial	6.0	8.0
Barley (forage)	6.2	8.3
Bermuda grass	6.5	>10
Wheat grass (tall)	6.8	>10

* Lowest level at which an effect on mature plants is seen. This is often also the level where seed germination is inhibited.

** Greater than 10; off scale.

3-25-03

Native Grasses	IPEC Soil Salt Analysis Kit Strip Reading 50% Yield Reduction
Bluebunch wheatgrass	Less than 5
Streambank wheatgrass	5.5 - 7
Indian ricegrass	Less than 5
Little bluestem	Less than 5
Alpine Timothy	Less than 5
Thickspike wheatgrass	Less than 5
Idaho fescue	Less than 5
Blue grama	5.5 - 7
Alkali sacaton	7 - Off scale
Basin wildrye	7 - Off scale
Western wheatgrass	7 - Off scale
Prairie sandreed	Less than 5
Big bluegrass	Less than 5
Green needlegrass	Less than 5
Switchgrass	5.5 - 7
Sideoats grama	5.5 - 7
Mountain brome	5.5 - 7
Beardless wildrye	7 - Off scale
Big bluestem	5.5 - 7
Reed canarygrass	5.5 - 7

Soil chloride concentrations determined from the curve provided are approximate only. Salt tolerance data are provided as guidelines to relative tolerance. Absolute tolerances vary depending on climate, soil conditions, and cultivation practices. IPEC does not manufacture the test strips. These are labeled Quantab® and are manufactured by Environmental Test Systems, Elkhart, ID.

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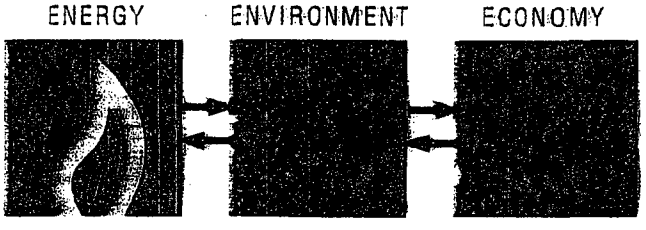

Integrated Petroleum Environmental Consortium

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Basic Landfarming

When you landfarm a crude oil spill, you are cultivating microorganisms in the soil to eat hydrocarbons. These microorganisms need the same things as crops to thrive: fertilizer, moisture, good soil structure, and warm temperatures. Follow the 4 steps below and you will be on your way to cleaning up that spill:

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13-13-13
(Available at most lawn and garden stores)

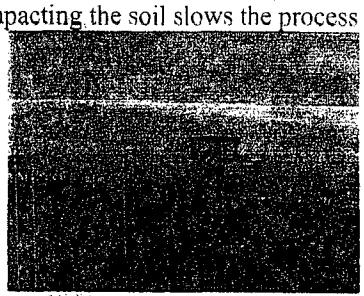
One-half pound of 13-13-13

What we mean by a square bale of hay

Step 2. Add organic matter to the contaminated soil. Organic matter builds soil structure and allows the soil to breathe. Hay or straw works well. Add the equivalent of about 5 square bales of hay per 1000 square feet.

Step 3. Till the fertilizer and organic matter into the soil to a depth of 6 - 8 inches. Was the soil wet with hydrocarbon? If so, you need to blend in some uncontaminated soil from around the edges or below the contamination during tilling. After tilling you should be left with a mixture that crumbles in your hand. Try to keep heavy equipment and cattle off the site; compacting the soil slows the process down.

Soil in the landfarm should look like soil from your garden



Tilling loosens the soil & improves air & moisture penetration

Step 4. Repeat the addition of fertilizer and tilling every 30 days during the warm months (March - November) for the first 3 months of remediation. After 3 months, add fertilizer with tilling every other month--but continue tilling in the months between fertilizer additions. You are done when the hydrocarbon odor from the soil is gone. Once the hydrocarbon odor is gone, revegetate to prevent erosion.

What about moisture?
We can speed up the process of bioremediation by keeping the soil moist but most of the time we just depend on rainfall. If you do water the site, don't saturate the soil - that actually slows everything down.

What is the best time to start a bioremediation project? If you have a spill in December - February go ahead and till in organic matter to keep the hydrocarbon from moving offsite until warm weather returns. If the impacted area is sloped, it may be necessary to construct a low earthen dike at the bottom of the site to prevent runoff. If the spill occurs at any other time of year, go ahead and get started as soon as possible.

How long does it take to bioremediate a site? That depends on a lot of things, some you can control and some you can't control. You can speed up the process by sticking to the tilling and fertilizing schedule. But, you can't control the rain. Another factor that has an effect on the rate of the process is how old the spill is. You can expect crude oil that has been in the ground for a while to degrade slower than a recent spill. (So get started as soon as possible.) All things considered, you should see significant results in one or two growing seasons.

What if you couldn't answer "no" to both of those two questions? If the contamination is deeper than 8 inches but there is no shallow groundwater, following these guidelines should result in at least some restoration of the surface. However, the deeper contamination will remain. Remediation of all of the contaminated soil would require the soil to be excavated, spread out in a layer less than 8 inches deep, and the four steps of basic landfarming applied.

If there is shallow groundwater under the contamination, you should consult a qualified technical expert to show you how to do landfarming without groundwater becoming contaminated.

What about brine? As you know, crude oil spills often also contain brine. In this case you have two contaminants to remediate. Bioremediation will clean up the oil, but the brine must be washed away. Fortunately, the four steps of basic landfarming, which make bioremediation of the oil possible, also make it easier for rainfall to wash brine from the site. When brine is present though, we need to think about drainage of the site—the salt must have a way out. Other IPEC products provide more detail on the process of salt remediation. Contact the IPEC office for these products or a qualified technical expert for help.

For more information or to request additional copies of these guidelines, contact Sheila Kumpe at the IPEC office at (918) 631-3284 or sheila-kumpe@utulsa.edu. These guidelines were developed by Kerry L. Sublette, University of Tulsa, who may be contacted at (918) 631-3085 or kerry-sublette@utulsa.edu. Comments are welcome.

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Visit the IPEC web site at: http://ipec.utulsa.edu

REMEMBER, YOU CAN CONTACT YOUR STATE REGULATORY AGENCY FOR HELP.
SOME USEFUL CONTACT NUMBERS IN OKLAHOMA AND ARKANSAS ARE:

ARKANSAS:

AOGC El Dorado Office
El Dorado, AR
(870) 862-4965

AOGC District Office
Ft. Smith, AR
(479) 646-6611

ADEQ
El Dorado, AR
(870) 862-5941

ADEQ
Little Rock, AR
(501) 682-0744

OKLAHOMA:

OCC District I
Bristow, OK
(918) 367-3396

OCC District II
Kingfisher, OK
(405) 375-5570

OCC District III
Duncan, OK
(580) 255-0103

OCC District IV
Ada, OK
(580) 332-3441