



### **How does the treatment process work?**

The soil may be treated *in* or *ex situ*. Large debris and or objects that may impede the soil tilling and mixing process should be removed. Terramend treatment is typically conducted by thoroughly mixing the Terramend into the soil, adjusting the moisture content, and maintaining regular tillage to enable oxygen penetration into the soil.

For *in situ* or *ex situ* soil treatment to depths of up to two feet (or in windrows), Terramend is tilled into the soil and water is added to achieve the target moisture content. The soil is then tilled frequently (2-3x/week at the outset for high hydrocarbon soils, and then weekly in the last half of the expected treatment duration). Process moisture content, oxidation reduction potential (ORP) and pH are monitored.

For thinner soil layers (6-8"), less tilling may be required because oxygen can diffuse sufficiently far into the soil matrix. In these cases, tilling of 2x per month may be suitable.

### **What soil characteristics are required to use the technology?**

All true soils can be treated with this technology. Terramend has been successfully applied to soils with a wide range of physical and chemical properties, including wide variations in soil texture (i.e., sand/silt/clay content), organic matter content, and pH (from about 5.5 to 8.5). Even relatively saline/sodic soils have been effectively treated. Non-soils may also be treatable, but results are much less predictable. On occasion, we have worked with soils that have high bioavailable Arsenic and/or Cyanide concentrations that may impede the biotic treatment component. Where this is suspected as a possible problem, some relatively simple biological activity testing may be conducted.

### **How large should a pilot test be?**

Pilot tests may range from a few cubic yards with a manually operated roto-tiller to several hundred cubic yards implemented with full-scale equipment. Larger pilots better mimic the full-scale equipment and conditions to be used.

### **What equipment do you recommend for tilling and mixing the soil?**

We recommend and have specialty agricultural soil tillers and related equipment available for rental. The tillers are capable of tilling soil to a depth of 2 feet, making them well-suited to effectively treating large areas either *in* or *ex situ*, depending on site needs and treatment approach. Our experience with TERRAMEND® shows that proper soil mixing using these tillers is an essential part of the treatment process. In terms of tilling rate and equipment needs, the tillers can each till approximately 2 acres per day in the very low gear (creeper gear) required for good mixing and to avoid damage to the tillers.

Other equipment that we have seen successfully used includes deep soil spaders from Imants (Netherlands). This is expensive equipment, and models that can till to 24", 36" and even 56" depth are available.



Excavators are not generally recommended for soil treatment, as a great deal of care and time will be required to get the very thorough mixing that is needed. If looking at excavators, either a great deal of patience and time should be used and/or some of the excavator bucket mixing heads from Allu and others should be considered.

#### **What about deeper soils and soil thicknesses?**

These may be treated *ex situ* or in lifts. Deeper soil mixing equipment from Allu, Alpine, and others may be suitable for deeper soil applications. However the economics of repeated mixing of soils may make this impractical.

#### **What treatment removals do we anticipate?**

The rate at which aerobic soil treatment proceeds is variable and can be strongly influenced by soil type, contaminant chemistry, and temperature. Removals of up to 95% are generally achievable. For hydrocarbons such as crude oil, gasoline range organics (GRO) and diesel range organics (DRO) - the lighter hydrocarbons, both aliphatic and aromatic, have the more rapid rates of degradation. Larger and heavier hydrocarbons take longer, and removal rates are generally slow (on the order of six months for up to 25,000 mg/kg of <C29). Depending on concentration, one to two warm seasons may be required to achieve targeted removals. Oil range organics (ORO, or those >C29) take more time to treat because of lower solubility and bioavailability.

For, phthalates, PAHs, and chlorophenols treatment times vary considerably depending on starting concentrations and remedial goals.

Ask us for an estimate specific to your site by providing basic data on our [Site Evaluation form](#).

#### **Any special considerations for clay soils?**

Clay soils can be challenging to work when wet, and it is important that the tilling and mixing processes result in the breaking up of soil clods. Thus, in wet environments, additional time may be required for drying, or the soil may need to be treated *ex situ* to be covered and kept out of seasonal rains.

#### **Can you provide us with testing and sampling plans?**

We can provide you with specific guidance in terms of treatment process monitoring needs. When it comes to sampling numbers for regulatory acceptance, it is strongly driven by local regulatory requirements. We have seen acceptance sampling requirements based on everything from each batch of soil (various sizes) up to ½ acre or more in treatment area.

#### **What about treatment process temperature?**

Warmer air temperatures (daily highs of 20°C or more) work the best. This relates, of course to warmer soil temperatures (15°C or more). However, we have worked successfully even in far northern Canada by timing the work for the warmest part of the season, covering the soil, and the like.



### **How important is the moisture content?**

Excessively high moisture content will slow the process down by restricting oxygen flow into the soil, both by diffusion, and through the absence of regular tillage. It is essential that the soil be dry enough for the equipment to get on the soil and do the tilling. Too low of moisture content will not allow enough moisture for the aerobic biodegradation process to occur, and too much will enable anaerobic conditions to develop. The moisture content should be kept between 50-60% WHC. Establishing and maintaining this condition as if you're growing a crop (such as tomatoes) is the best approach. Short excursions are not too detrimental, but need to be corrected or the yield (soil treatment, in this case) will suffer.

### **How is water delivered / supplied if the site is far away from a water resource?**

Many methods may be used, including spray irrigation systems with sprinklers, drip irrigation systems, and the addition of water using tanker trucks. If water is particularly scarce, it may be useful to cover the soil to limit evaporation. It is important to add the water slowly to avoid ponding and allow for slow infiltration.

### **How much water is required?**

This is very site and soil-specific. The target moisture content is 90% of the soil water holding capacity (WHC). Thus, both the initial moisture content and target moisture content must be known. Additional water will be required for each treatment cycle.

The target is determined through a WHC test, which can be conducted in a very basic portable field laboratory (scale, microwave, and some other basic supplies).

### **What are the water quality requirements?**

We do not have specific constituent thresholds. Rather we offer the general recommendation that water that is suitable for growing vegetable crops in the local area will likely be well suited to TERRAMEND treatment. Seawater and excessively brackish water are unlikely to be suitable.