PC Bioremediation
Remediation with Science

Case Study: Garden City, Texas
Produced Water Spill in Cotton Field

At a Glance

Location: Near Garden City, Texas
Setting: Actively farmed cotton field
Release Type: Brine produced water spill loaded with hydrocarbons
Treatment Method: In-situ application of microbial and biosurfactant solution (no dig & haul)
Monitoring: Multiple soil sampling points at the surface and 12" depth
Key Contaminants: Chlorides and petroleum hydrocarbons (light and heavy fractions)
Outcome: Over 99% reduction in hydrocarbons, free chlorides reduced to agronomic levels, field returned to cotton production

Problem

A produced-water line failed in an actively farmed cotton field near Garden City, Texas. The line released high-salinity brine produced water containing residual hydrocarbons, directly into the furrows. Within days, the spill path was clearly visible as a discolored strip running across the field. Cotton plants along the release area were stressed, stunted, or dead, while adjacent unaffected rows continued to grow normally.

Produced water is very different from fresh water. It typically contains:

- High levels of chloride and sodium can cause "salt burn" in crops and permanent soil damage if concentrations are high enough.
- Dissolved and emulsified hydrocarbons that coat soil particles decrease oxygen in the root zone and can form a thin, oily layer on the surface. Hydrocarbons are toxic contaminants that can contaminate plant products.

At Garden City, the concern was not just cosmetic. The spill:

- Destroyed the current season's cotton along the flow path, decreasing yield and directly affecting the landowner.
- Elevated salt and hydrocarbon levels persist in the root zone, posing a risk to future crops if left unaddressed.
- Created a potential regulatory issue if contaminants migrated further into the soil profile or off-site with stormwater.

At Garden City, the operator effectively had three choices: leave the spill in place and hope it "grew out," excavate the impacted rows and haul the soil to a landfill, or treat the contamination in place using a microbial and biosurfactant solution. The comparison below summarizes the long-term consequences of no action, in-situ treatment, and traditional dig-and-haul for the land, the landowner, and the regulator.

If Left in Place (No Treatment)	In-Situ Microbial Treatment	Traditional Dig & Haul
Persistent low-yield strip in the cotton field; crops remain stunted or fail year after year.	Full vegetation recovery in the spill path; the field returned to normal cotton production without losing topsoil.	Impacted soil is removed but replaced with fill that may not perform as well, leading to foreign seed contamination and uneven yields for several seasons.
Salt damage increases over time – chlorides and sodium build up in the root zone, driving chronic stress and poor germination.	Free Chlorides are reduced to agronomic levels in place, allowing normal root function and water uptake.	Salts are physically removed from the excavated area, but salinity issues can remain at the excavation limits or in smeared areas if not over-excavated.
Soil structure declines – spill area becomes tight, crusted, and poorly draining.	Soil structure preserved – no excavation, minimal disturbance, improved biological activity.	Soil structure is disrupted; excavation and backfill can create compaction layers, poor drainage, and grading issues.
Hydrocarbons remain in the soil, coating particles and reducing oxygen in the root zone.	Hydrocarbons biologically degraded – light hydrocarbons reduced to ND and heavy hydrocarbons cut by >90–99% (per lab data).	Most hydrocarbons in the excavation are removed, but residual contamination can remain at the edges or base if the footprint is not fully captured.
Contaminants migrate deeper and sideways over time with rainfall, expanding the problem.	Impacts are contained and reduced in place, limiting vertical and lateral migration.	Contaminants are removed from the excavated area, but spreading can occur during excavation (tracking, runoff) if not tightly controlled.
Ongoing regulatory and liability risk – visible damage plus elevated lab results.	Regulatory closure supported by data – pre- and post-treatment sampling documents restoration.	Regulatory closure is possible, but often requires more extensive documentation.

Higher eventual cost if forced to remediate later, when impacts are deeper and larger.	Lower total cost and disruption – no disposal fees, fewer truck movements, and the landowner keeps their soil.	High upfront cost – excavation, hauling, disposal fees, imported backfill, more equipment time, and increased truck traffic.

Solution / Approach

To preserve productive topsoil and avoid excavation, the operator and landowner chose an in-situ biological treatment over a traditional dig-and-haul method.

1. Site Characterization and Sampling Plan

First, the visible spill path across the cotton rows was mapped and divided into four sampling points along the release.

- At each location, soil was collected at two depths:
  - Surface (0–2") – where salts and hydrocarbons were visibly concentrated.
  - 12" depth – to understand how far contaminants had migrated toward the root zone.
- Each sample was analyzed for:
  - Chlorides, representing the salt load from produced water.
  - Light hydrocarbons (C6–C12) are similar to gasoline-range components.
  - Heavy hydrocarbons (C12–C35), similar to diesel and heavy oil.

This baseline verified the problem:

- Several surface samples contained very high levels of heavy hydrocarbons (tens of thousands of mg/kg).
- Chloride levels were sufficient to harm crops and soil structure in the affected rows.
- Some deeper (12") samples already showed detectable chloride and hydrocarbon impacts.

2. In-Situ Microbial & Biosurfactant Treatment

Instead of excavating, the team used a combined microbial and biosurfactant solution designed for petroleum-impacted soils.

- **Microbial consortium** – naturally occurring population of oil-degrading microorganisms that utilize hydrocarbons as a food source, converting them into harmless end products (CO_2, water, biomass).
- **Biosurfactants** – natural surface-active compounds that:
  - Loosen and break up hydrocarbon films on soil particles.

- Assist in emulsifying and dispersing hydrocarbons for more effective degradation.

The treatment was applied using low-pressure spray equipment to maximize spray volume, as the soil was soft and the contamination area was large.

- The affected rows were sprayed along the visible spill path and slightly beyond it to ensure thorough coverage.
- Application rates were designed to provide sufficient microbial and biosurfactant loading to match the observed contaminant levels without over-saturating the soil.

This method enabled the operator to address the release within the existing planting without removing soil or heavily disturbing the field.

3. Moisture Management and Soil Conditions

Because biological treatment depends on living organisms, soil conditions were actively managed during the treatment period:

- Existing soil structure and aeration were preserved by avoiding heavy equipment traffic on the treated rows.
- No chemical oxidants or harsh reagents were used, which protected both the microbial population and the long-term health of the soil.

This helped the microbes colonize the impacted zone, attach to soil particles, and begin degrading the hydrocarbons while the biosurfactants improved their access to the contamination.

4. Follow-Up Sampling and Verification

After treatment, the specific sampling locations and depths were used to verify performance.

- Repeat soil samples were collected at the four locations, again at the surface and at 12 inches.
- The laboratory re-analyzed chlorides, light hydrocarbons, and heavy hydrocarbons using the same methods as the baseline.

Results showed:

- Light hydrocarbons (C6–C12) were reduced from thousands of mg/kg to 'Not Detected' or near-detection-limit levels, with >99% reductions across all locations.
- Heavy hydrocarbons (C12–C35) were reduced to ND or below reporting limits at most sites, with remaining values declining by more than an order of magnitude.

- Free chloride levels were reduced from high levels to acceptable ranges for ongoing cotton farming.

These data, along with visible vegetation recovery in the spill path, enabled the operator and landowner to:

- Document closure of the release with defensible lab data.
- Keep the existing soil in place to protect field grading and topsoil.
- Return the field to normal cotton production without long-term disruption or truck-intensive soil removal.

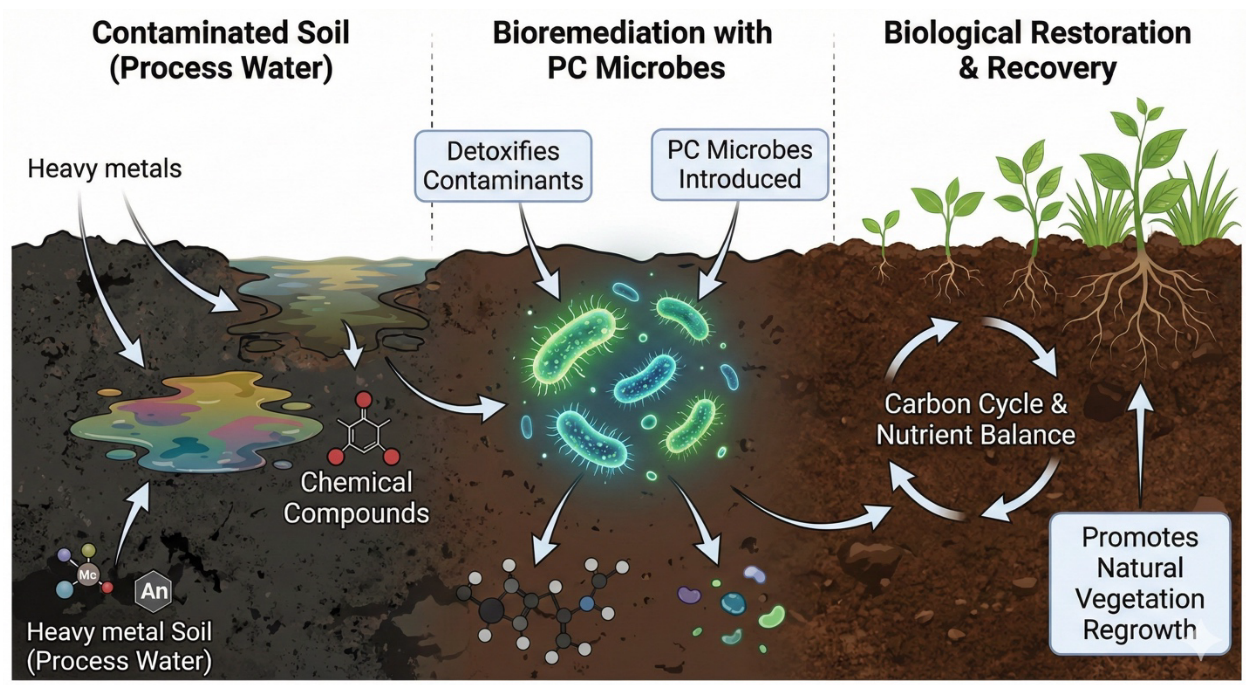
Garden City, Texas – Cotton Field Spill Test Results

Chlorides					
Sample	**Depth**	**Matrix**	**Before (mg/kg)**	**After (mg/kg)**	**Reduction (%)**
1	Surface	Soil	6600	2.17	100%
1	12"	Soil	<20.0	2.9	86%
2	Surface	Soil	7640	22	100%
2	12"	Soil	6600	69	99%
3	Surface	Soil	377	109	71%
3	12"	Soil	<20.0	126	N/A
4	Surface	Soil	94	12.1	79%
4	12"	Soil	5470	3.35	100%

Light Hydrocarbons (C6-12)					
Sample	**Depth**	**Matrix**	**Before (mg/kg)**	**After (mg/kg)**	**Reduction (%)**
1	Surface	Soil	1470	ND	100%
1	12"	Soil	<50.0	ND	100%
2	Surface	Soil	1290	109	99%
2	12"	Soil	353	ND	99.52%
3	Surface	Soil	1300	ND	100%
3	12"	Soil	112	ND	99.20%
4	Surface	Soil	<50.0	ND	100%
4	12"	Soil	<50.0	ND	100%

Heavy Hydrocarbons (C12-C35)					
Sample	Depth	Matrix	Before (mg/kg)	After (mg/kg)	Reduction (%)
1	Surface	Soil	13100	<5.00	99.96%
1	12"	Soil	<50.0	<5.00	90.00%
2	Surface	Soil	42200	109	99.99%
2	12"	Soil	1040	ND	100.00%
3	Surface	Soil	25400	1150	95.47%
3	12"	Soil	625	ND	100.00%
4	Surface	Soil	<50.0	ND	100.00%
4	12"	Soil	<50.0	ND	100.00%

- **ND** = Not Detected.
- "<x" = Below the reporting limit of x mg/kg.



Results

Post-treatment sampling confirmed that the spill was not only cleaned up visually but also properly closed out technically.

- Light hydrocarbons (C6–C12): reduced from gasoline-range levels in the thousands of mg/kg to "Not Detected" at all locations after treatment.
- Heavy hydrocarbons (C12–C35): reduced from tens of thousands of mg/kg in some surface samples to ND, below reporting limits, or significantly lower values, indicating a 90–99% reduction.
- Chlorides (salts): lowered from high spill levels to agronomically appropriate low levels for cotton production at the sampled locations and depths.

The following growing season, the area of the previous spill, which had dead and stunted cotton rows, was covered with uniform, healthy vegetation. From the fence line, the spill zone no longer stood out from the rest of the field.

Perspective: PC Bioremediation / Our Team

From our standpoint, Garden City demonstrated exactly what this technology is designed to do:

- Transform a visibly damaged strip affected by salt and hydrocarbons back into productive farmland without excavation.
- Show measurable reductions in contaminant levels at multiple locations and depths, not just a "good-looking picture."
- Provide a solution that can be consistently repeated and documented for other agricultural and right-of-way releases.

This case provides a clear, data-backed example to show agencies and operators that in-situ biological treatment can meet or exceed cleanup expectations while preserving the soil.

Perspective: Regulators

From a regulator's view, this project is a success because:

- There is clear baseline and follow-up data: exact locations, same depths, same analytes.
- Hydrocarbons and salts are lowered to safe, manageable levels rather than moved around or hidden for appearances' sake.

- The solution reduced off-site risk by treating contaminants on-site instead of transporting them through public roads.
- The field shows complete vegetative recovery, consistent with the lab results.

In a file review, this reads as a well-documented, low-impact remedy: the release was identified, characterized, treated, and verified with data and photographs. That reduces long-term questions, re-openers, and enforcement risk.

Perspective: Landowner / Farmer

For the farmer, success is simple and practical:

- The bare, low-yield strip vanishes; cotton reappears across the rows.
- Topsoil remains on the farm rather than being sent to a landfill.
- There's no long-term "dead patch" in the middle of a producing field that they have to work around or explain.
- There is no contamination of foreign seeds from foreign soil that could spread, impacting crop viability and productivity, and preventing the use of herbicides to control.
- There's less disruption from trucks, equipment, and delays during planting and harvest.

From their perspective, the project was successful because the field is once again usable and productive, and the fix didn't complicate their daily operations.

Perspective: Operator

For the operator, Garden City hits the key priorities:

- They achieved full closure on a produced-water release, rather than just performing a cosmetic surface cleanup.
- They avoided the costs and liabilities of digging and hauling—no waste profiles, landfill fees, or long truck lines.
- They maintained a good relationship with the landowner by restoring the field rather than tearing it up.
- They can reference this project as an example of employing a lower-impact, science-based solution when engaging with regulators and other landowners in the future.

Conclusion

The Garden City, Texas project serves as a definitive validation of in-situ microbial and biosurfactant treatment as a superior alternative to traditional excavation for produced water spills in agricultural land. By treating contamination in place, the project successfully transformed a visibly damaged, nonproductive strip of land into a fully operational cotton field.

Technical Validation
The post-treatment sampling confirmed that the remediation met rigorous technical standards across all key metrics:

- **Hydrocarbon Elimination:** Light hydrocarbons (C6–C12) were reduced from thousands of mg/kg to "Not Detected" (ND) levels. Heavy hydrocarbons (C12–C35) showed reductions of 90–99%, with many samples also reaching ND levels.
- **Salinity Reduction:** High chloride levels resulting from the brine spill were successfully reduced to agronomic levels, preventing permanent salt burn and allowing root function to return.
- **Vegetative Recovery:** The biological data were visually confirmed by the complete return of uniform, healthy cotton vegetation in the spill path during the following growing season.

Strategic Value
Beyond the environmental success, the project delivered distinct value to all stakeholders involved:

- **For the Operator:** The solution eliminated the high costs and logistical burden of "dig-and-haul" disposal, including landfill fees and trucking, while providing a science-based solution to present to regulators.
- **For the Landowner:** The method preserved the farm's valuable topsoil and prevented the long-term disruption of a "dead patch" or the introduction of foreign soil and seeds.
- **For Regulators:** The project provided a defensible, data-backed closure with clear "before and after" metrics, reducing long-term enforcement risks and verifying that contaminants were treated rather than simply moved.

Ultimately, the Garden City case study shows that operators don't have to choose between regulatory compliance, cost control, and protecting farmland—properly designed in-situ biological treatment can deliver all three without a single truckload of soil leaving the field.

Before Photo (Garden City – Spill in Cotton Rows)

Garden City, Texas – Produced-water spill in an active cotton field. Note dead and stressed cotton rows along the release path before treatment.

Applying Bio Solution - (Garden City – Spill in Cotton Rows)

Garden City, Texas – A produced-water spill occurred in an active cotton field. The solution is being actively sprayed onto the contaminated area.

After Photo (Garden City – Restored Field)

Exact location after in-situ microbial treatment. Vegetation has recovered, and the field has returned to productive cotton farming. No excavation or soil replacement was required.