



March 2, 1998

**RAPID COMMERCIALIZATION INITIATIVE
VERIFICATION STATEMENT FOR *Lasagna*TM**

TECHNOLOGY NAME: *Lasagna*TM *in-situ* Soil Remediation Technology
TECHNOLOGY TYPE: *In-situ* Soil Remediation
APPLICATION: Low-permeability soils and clays and sand mixed with these materials.
COMPANY: Monsanto Company
ADDRESS: 800 North Lindbergh Boulevard
St. Louis, MO 63167
PHONE: (314) 694-1464/FAX: (314) 694-1531

REPORT TITLE: Rapid Commercialization Initiative (RCI) Final Report for an Integrated *in-situ* Remediation Technology (*Lasagna*TM)
REPORT NUMBER: DOE/OR/22459-1

ENVIRONMENTAL PROBLEM

This technology addresses the contamination of low permeability soils with trichloroethylene (TCE). During the 1960s - 1980s TCE was used as a degreasing agent for cleaning aircraft, circuit boards, and as a general low-cost inert solvent at DOD and DOE facilities. Currently TCE is thought to be carcinogenic and has a federal drinking water standard of 5 ppbw (or $\mu\text{g TCE/L}$). This technology addresses TCE contamination of soils which is a major source of TCE groundwater contamination at many government and private facilities.

TECHNOLOGY DESCRIPTION

The *Lasagna*TM Soil Remediation Technology is a soil treatment technology for *in-situ* removal of TCE and other chlorinated solvents from contaminated low-permeability soils, thereby reducing or eliminating the generation of hazardous waste and/or toxic air emissions associated with soil removal and treatment. The technology uses electro-osmosis to move contaminated water (the present verification applies only to TCE contamination) through specially-designed treatment zones that degrade the waste *in-situ*.

VERIFICATION SUMMARY

The objective was to demonstrate that the *Lasagna*TM Soil Remediation Technology could reduce TCE concentrations in soil to concentrations below 5.6 ppmw ($\mu\text{g TCE/g soil}$). The demonstration occurred in a treatment cell measuring 21 feet wide by 30 feet long, by 45 feet deep within a larger TCE contaminated volume. The initial soil average concentrations at five locations were 18 (L2A-01), 42 (L2A-02), 52 (L2A-03), 34 (L2A-04), and 34 (L2A-05) ppmw, respectively. After a treatment period of 6 months, concentrations at locations L2A-03, L2A-04, and L2A-05 were reduced to average levels of 2.3, 12.8, and 16.2 ppmw. After a total treatment period of 11 months, average concentrations of 0.87, 24, 0.16, 11, and 9.2 ppmw, respectively were measured at the five corresponding locations. At locations L2A-01 and L2A-03, the data indicate that *Lasagna*TM cleanup met cleanup goals with the upper 95% confidence bound of the mean being less than the 5.6 ppmw action level. At locations, L2A-04 and L2A-05, significant cleanup occurred but it is uncertain whether the cleanup goal was met (i. e. only the confidence bound was below the 5.6 ppmw limit.). No TCE air emissions were detected (<1 ppmv or $\mu\text{g TCE/liter air}$) above the treatment cell.

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DEMONSTRATION DESCRIPTION

- Test Site: This demonstration was conducted at the DOE Gaseous Diffusion Plant in Paducah, KY at a site which was contaminated with trichloroethylene (TCE). The specific site was a former storage cylinder drop test area designated Solid Waste Management Unit (SWMU) 91, comprising approximately 1/2 acre. SWMU 91 has relatively shallow TCE penetration, detailed soil characterization data, and low soil permeability.
- Test Plan Objectives: The objective was to show that the technology could reduce TCE concentrations in low permeability soil to below 5.6 ppmw ($\mu\text{g TCE/g soil}$). This concentration was the cleanup level established by the Commonwealth of Kentucky for SWMU 91. A secondary objective was to confirm that no significant emissions to air or water occur.
- Technology Description (Technology Elements): The *Lasagna*[™] Soil Remediation Technology is an *in-situ* technology for treatment of chlorinated organic solvent contamination in moderate- to low-permeability soils ($<10^{-4}$ cm/sec), which reduces or eliminates the generation of hazardous waste and/or toxic air emissions associated with soil removal. The technology uses electro-osmosis to move water contaminated with TCE and other contaminants (the present verification applies only to TCE) through specially-designed treatment zones that degrade the waste *in-situ*. Electro-osmosis is an electro-kinetic process that causes water to move through low-permeability soils. A consortium (consisting of Monsanto, Dupont, and General Electric) was formed to develop this technology with participation by the Department of Energy and Environmental Protection Agency. Enviro-Chem Systems, Inc. (Enviro-Chem), a wholly-owned subsidiary of Monsanto Company, licenses and provides services for the technology.

The *Lasagna*[™] system includes at least one pair of electrodes (anode and cathode) and at least one treatment zone. The treatment zones are sandwiched between the electrodes forming treatment cells of numerous layers from which the "*Lasagna*[™]" technology derives its name. These layers can be installed in the horizontal or vertical configuration. For the current study, a specially designed mandrel/tremie tube system was used for introducing electrode and treatment zone materials. The length of the mandrel allowed it to be driven to a depth of 45 feet. A crane and a vibratory hammer were used to position and drive the mandrel into the ground. The electrode material consisted of a dry mixture of 50/50 by volume Peerless iron filings and Loresco coke. Six steel rods (3/4" diameter, hot rolled) were inserted into the electrode materials of each electrode, approximately 5 feet apart, to a depth of 40 feet to effect uniform current distribution. A source of alternating current voltage and a rectifier provided direct current voltage to the anode and cathode (steel rods imbedded into iron and carbon zones), thus producing an electric field that causes the water to move away from the anode and toward the cathode. TCE, moving with the water, passes through the treatment zones. The treatment material consisted of Peerless iron filings (60% wt) suspended in wet kaolin clay. When iron filings are used in the treatment zones, the by-products of TCE degradation are primarily acetylene, ethane, and ethylene and chloride and ferric ions. The acetylene, ethane, and ethylene either volatilize, or are transported to the anode(s) or cathode(s). Solvents other than TCE may require the use of materials other than iron filings for treatment. Water recovered from the cathode gravity drains back via subsurface piping to the anode so the soil will not dry out and clean water will flush contaminants into the treatment zone while electro-osmosis occurs. Typical water flow rates result in estimated cleanup times on the order of months or years. Process water flow velocities vary depending on the specific system (soil type, applied voltage, treatment zone spacing, degree of cleanup, etc.) and range from less than 5 to approximately 30 inches/month. The soil temperature at the center of the treatment soil may reach 80°C or higher while the soil temperature near the surface remains at near ambient temperature.

- Technology Demonstration/Operating Parameters: The demonstration occurred in a treatment cell installed in the vertical configuration measuring 21 feet wide by 30 feet long, by 45 feet deep (1,050 yd³) within a larger TCE contaminated area. The power delivery reached a maximum of 200 volts and 218 amps until the center (core) temperature reached 83 °C at which point the power was reduced to approximately 180 volts and 180 amps. At the maximum voltage, the water moved through the soil at a rate of 11 inches/month and produced a volumetric flow rate at the cathode of 18 liters/hr.
- Data Results (Verification of Performance): Under the authority of the Rapid Commercialization Initiative's Memorandum of Understanding, the Participants in this RCI Project verified the performance of *Lasagna*[™] *in-situ* Treatment Technology System licensed by Monsanto's Enviro-Chem subsidiary for treating low-permeability soils contaminated with TCE when the technology was installed, operated, monitored, and maintained according to Monsanto Enviro-Chem's standards and specifications. The Participants reviewed plans, data, and reports generated during a demonstration at U.S. DOE's Paducah Gaseous Diffusion Plant and concluded that there was

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a reasonable basis for rendering a verification decision. The following table compares the soil TCE concentrations measured at five locations in this study to the Commonwealth of Kentucky's accepted site action level:

*Lasagna*TM Process - Compliance with Cleanup Target - Statistical Data Summary for TCE in Soil

Location	BEFORE Mean TCE (ppmw (µg/g))	BEFORE 95% Confidence Bounds (ppmw (µg/g))	AFTER Mean TCE (ppmw (µg/g))	AFTER 95% Confidence Bounds (ppmw (µg/g))	Met KY Action Level?
L2A01	18	4.4 to 32	0.87	0.13 to 1.6	yes
L2A02	42	28 to 56	24	13 to 35	no
L2A03	52	20 to 85	0.16	0.018 to 0.31	yes
L2A04	34	17 to 50	11	5.3 to 16	maybe
L2A05	34	17 to 51	9.2	4.7 to 14	maybe

Since the cleanup objective was attained at two of the five locations and the reductions of the remaining three locations were considered sufficient by the DOE site office and its prime contractors, the *Lasagna*TM Technology was selected as a treatment option for the site's Proposed Plan. After proper approvals, it may become the preferred remedy for the Record of Decision (ROD) for SWMU 91. The Participants verified that the *Lasagna*TM *in-situ* Treatment Technology System may be an acceptable alternative to excavation and above ground treatment that eliminates or reduces the generation of hazardous wastes.

The Participants also evaluated the hazard associated with the air emissions from this system at the Paducah site. During the month of December 1996, 12 flux chambers were placed randomly over the test site. No TCE was observed at concentrations above the detection limit of 1 ppmv (µg/liter). These flux chamber tests addressed only TCE emissions. It is unknown at this time whether other toxic gases may be produced and may need to be controlled.

- **Cost Data:** Total cost for the installation, operation, and maintenance of the *Lasagna*TM Phase IIa test was \$1,375,200, or \$1,310/yd³ of remediated soil. Total cost for installation of electrode and treatment zones only was \$491,800, or \$39.14/ft² of zone emplaced. Core technology costs, which can also be considered direct costs, include equipment, labor, and materials used in site preparation, electrode and treatment zone installation, installation of instrumentation and sampling points and monitoring wells, and operation and maintenance, totaled \$579/yd³ of treatment volume and \$29.50/ft² of treatment zone and electrode zone emplaced. These costs are higher than estimated for a full-scale cleanup and reflect the high level of support given to this test, which was of a relatively small volume (1,050 yd³). Unit costs for full-scale remediations should be less than those for the Phase IIa test because they will be distributed over larger volumes of soil treated and larger surface areas of electrode and treatment zones installed. Phase IIa cost data, applied to the formula derived by the consortium to estimate remediation costs using *Lasagna*TM technology, yielded an estimated total core cost of \$470/yd³, which is within 20% of the actual cost of \$579/yd³. Using this formula for hypothetical remediations from surface to 15 foot or from surface to 45 foot depths, for time periods of one to five years, and for treating 2 and 4 pore volumes of vadose water, yielded results that varied from \$190 to \$260/yd³ for depths to 15 feet and from \$120 to \$200/yd³ for depths to 45 feet. In a Jacobs Engineering Group, Inc study to remediate the Paducah TCE site, the core costs were estimated to be approximately \$175/yd³ for a 4 year cleanup period.

Non-core costs, which can also be considered indirect costs, include oversight management, health and safety, QA/QC requirements, and sampling and analysis requirements for the Phase IIa test, cannot be estimated for other sites as they are site specific and depend upon, to a great extent, the management objectives at these sites.

- **Technical Limitations of the Technology and the Demonstration:**

The verification is strictly limited to the demonstration tests of *Lasagna*TM *in-situ* Treatment Technology System for treating TCE in low permeability soils using iron filings in the vertical configuration as described above. The verification makes no claims concerning the performance or effectiveness of *Lasagna*TM *in-situ* Treatment Technology System to remove chlorinated solvents from low permeability soils at other sites. The Participants do not know all the possible combinations of solvents and soils and other potential contaminants to which the technology may be applied, nor do the Participants know all of the performance specifications required by end-users. Achieving performance specifications involves many variables including the soil porosity; soil hydraulic and electrical conductivity; the type and amount of contamination; the required cleanup levels; the size, depth,

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and shape of the site to be cleaned; etc. These factors all affect the benefit that may be realized from use of the *Lasagna*TM *in-situ* Treatment Technology System.

Additional care must be considered in the construction materials of the anodes. The Phase IIa tests experienced anode corrosion which required replacement of the steel rods after six months of operation. An improved anode design will be used to assure that this does not occur in the full scale cleanup.

Another problem involved migration of TCE from a nearby source into the Phase IIa treatment volume. Highly variable TCE water data, and the lack of complete reduction of TCE concentrations in sampling wells and soil cores, were attributed by the technology holder to DNAPL mobilized from outside the Phase IIa treatment volume. Migration through a porous sand lens at 20 feet below the surface is thought to have caused this phenomenon. However, the technology holder expects that once the whole site is subjected to remediation, this condition will not occur, since all of the contamination will be within the treatment area. Potential end-users must examine their individual processes and product specifications, and work with Monsanto's Enviro-Chem to evaluate and determine whether the *Lasagna*TM *in-situ* Treatment Technology System can meet the end-user's performance specifications and, if so, what emission controls may be required.

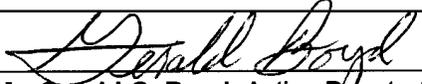
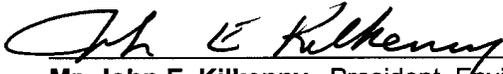
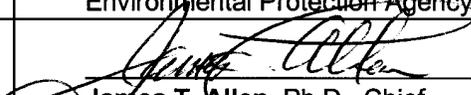
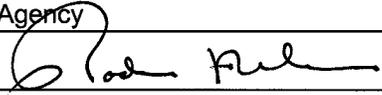
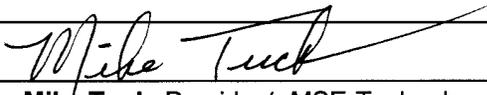
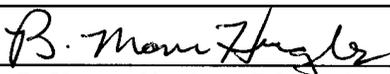
The end-user is ultimately responsible for determining the suitability of the *Lasagna*TM *in-situ* Treatment Technology System for his specific applications and for complying with the applicable Federal, State, Air Quality Management District (AQMD) and local regulatory requirements. For each specific application, the end-user must ensure compliance with all applicable worker health and safety standards established by OSHA, other federal agencies, and other state and local agencies. Due to the highly varied applications and the wide variety of contaminants, soil types, hydraulic and electrical conductivity, hydraulic permeability, and levels of contamination, the Participants in this RCI Project make no specific recommendations regarding the application of the *Lasagna*TM *in-situ* Treatment Technology System. The Participants recommend potential end-users contact the manufacturer for suitability for their specific application. The Participants' verification is based on the technology's performance and by itself does not change the regulatory status of the *in-situ* treatment system. Instead, the verification is meant to facilitate and encourage the acceptance of this technology for *in-situ* remediation and to reduce or eliminate the generation of hazardous waste and/or toxic emissions associated with the excavation and above ground treatment of contaminated soils.

- Demonstration Team Members/Contacts: A list of the Participants' names, addresses, and phone numbers is given at the end of this statement.

**RAPID COMMERCIALIZATION INITIATIVE
VERIFICATION STATEMENT FOR *Lasagna*™**

SIGNATURES

Some of the participants chose to endorse this Verification Statement through separate concurrence letters. These letters are attached immediately following this page.

 Mr. Gerald G. Boyd , Acting Deputy Assistant Secretary for Science and Technology, Office of Environmental Management, USDOE	 E. Timothy Oppelt , Director, National Risk Management Research Laboratory, Office of Research and Development, U. S. Environmental Protection Agency
 Mr. John E. Kilkenny , President, Enviro-Chem Systems, Inc.	 James T. Allen , Ph.D., Chief Office of Pollution Prevention and Technology Development, Department of Toxic Substances Control, California Environmental Protection Agency
 Mr. Kenneth J. Nemeth , Executive Director Southern States Energy Board	 Mr. Rodney Nelson , Assistant Manager for Environmental Management, Oak Ridge Operations
 Mr. Mike Tuck , President, MSE-Technology Applications, Inc.	<p><u>(See attached letter of concurrence)</u> Mr. Robert Daniell, Director Kentucky Division of Waste Management</p>
<p><u>(See attached letter of concurrence)</u> Mr. Bill Neimes, Florida Department of Environmental Protection</p>	<p><u>(See attached letter of concurrence)</u> Mr. Graham Mitchell, Ohio EPA/SWDO</p>
<p><u>(See attached letter of concurrence)</u> Mr. Brian Moran, Branch Chief, Policy and Regulatory Development, Bureau of Waste Site Cleanup, Massachusetts DEP</p>	<p><u>(See attached letter of concurrence)</u> Mr. Robert A. (Andy) Binford, State of Tennessee Division of Superfund</p>
<p><u>(See attached letter of concurrence)</u> Mr. Willie Morgan, Permitting Liaison, EQC Administration, South Carolina Department of Health and Environmental Control</p>	 Dr. B. Mason Hughes , RCI Project Manager, Monsanto Company

**RAPID COMMERCIALIZATION INITIATIVE
VERIFICATION STATEMENT FOR *Lasagna*TM**

JAMES E. BICKFORD
SECRETARY



PAUL E. PATTON
GOVERNOR

COMMONWEALTH OF KENTUCKY
NATURAL RESOURCES AND ENVIRONMENTAL PROTECTION CABINET
DEPARTMENT FOR ENVIRONMENTAL PROTECTION
FRANKFORT OFFICE PARK
14 REILLY RD
FRANKFORT KY 40601

March 24, 1998

Mr. Jimmie Hodges, Site Manager
U.S. Department of Energy
Paducah Site Office
P.O. Box 1410
Paducah, Kentucky 42001

Dr. B. Mason Hughes
Senior Analytical Consultant
Monsanto Company
800 N. Lindbergh Boulevard
St. Louis, MO 63167

Re: Concurrence letter for RCI Final Report for an Integrated In-Situ Remediation
Technology (LASAGNATM) (DOE/OR/22459-1)

Gentlemen:

The Kentucky Division of Waste Management (Division) has reviewed the February 24, 1998, *Rapid Commercialization Initiative (RCI) Final Report for an Integrated in-situ Remediation Technology (LasagnaTM)* (DOE/OR/22459-1) and the *Verification Statement* for the same. This letter, as an attachment to the *Verification Statement* provides the Division's concurrence with the RCI Final Report for LasagnaTM.

The Division staff has followed the demonstration of this technology through review of reports, data, monthly conference calls, and site demonstration tour. In the demonstration at Paducah, significant reductions in TCE concentrations were obtained during the eleven-month test period. The Division recognizes LasagnaTM as a viable technology for the remediation of the low-permeability contaminated soils in Paducah provided the Remedial Action Plan or other design documents incorporating this technology are approved by the Division.

Please note that this concurrence is based on an evaluation of the technology performance under specific, predetermined criteria, and appropriate quality assurance procedures. The



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VERIFICATION STATEMENT FOR *Lasagna*™

Division makes no expressed or implied warranties as to the performance of the technology and does not certify that this technology will always, under circumstances other than those tested, operate at the levels demonstrated. This concurrence is not an endorsement of this technology by the Division and should not be used as such. The end user is solely responsible for complying with any and all applicable federal, state, and local requirements.

If you have any questions about Division's involvement in RCI LASAGNA™ technology, please contact Tuss Taylor at (502)-564-4797.

Sincerely,



Robert H. Daniell, Director
Division of Waste Management

RHD/TT/jkg

cc: Robert Sleeman, DOE
Carl R. Freode Jr., USEPA
Jimmy C. Massey, LMES
Myrna Redfield, DOE
John Morgan, LMES
KDWM-Paducah
DWM Main File #980

RAPID COMMERCIALIZATION INITIATIVE
VERIFICATION STATEMENT FOR *Lasagna*™



Department of Environmental Protection

Lawton Chiles
Governor

Twin Towers Office Building
2600 Blair Stone Road
Tallahassee, Florida 32399-2400

Virginia B. Wetherell
Secretary

February 18, 1998

Mr. B. Mason Hughes
Monsanto Company
800 N. Lindbergh Boulevard
St. Louis, Missouri 63161

Re: Verification Statement
Lasagna™ In-situ Soil Remediation Technology
Rapid Commercialization Initiative

Dear Mr. Hughes:

As an active participant in the review of the Lasagna™ In-situ Soil Remediation Technology and a representative from the Florida Department of Environmental Protection, I am writing this letter as an attachment letter of concurrence to the verification statement. I was privileged to be one of several state representatives who attended the demonstration tour in Paducah, Kentucky on September 17, 1996. Subsequent to this tour I have been involved through the review of reports, monitoring data, and monthly teleconferences detailing the Lasagna™ in-situ soil remediation test site in Paducah.

Working with the RCI participants, I recognize Lasagna™ as a viable technology for the remediation of low-permeability contaminated soils in Florida provided: (a) considerations in the Rapid Commercialization Initiative (RCI) Final Report for an in-situ Remediation Technology (Lasagna™) are taken into account; and (b) a Remedial Action Plan or other design document incorporating this technology is approved by the Department.

While the Department of Environmental Protection does not provide endorsement of a specific remediation process, it does recognize the need to determine acceptability from an environmental standpoint with respect to applicable rules and regulations, and the interests of public health, safety, and welfare. A vendor must then market the process on its own merits regarding performance, cost, and safety in comparison to competing alternatives in the marketplace.

Preparers of a Remedial Action Plan or other design document may include a copy of this letter and a copy of the verification statement in the appendix of plans they submit, and call attention to it in the text of their document. In this way, technical reviewers throughout the state will be informed that the Department of Environmental Protection has determined the environmental acceptability of this remediation process.

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VERIFICATION STATEMENT FOR *Lasagna*TM

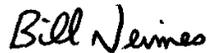
Mr. Mason Hughes
February 18, 1998
Page Two

The Department acceptance of this remediation process does not imply it has been deemed applicable for all cleanup situations, or that it is preferred over other treatment or cleanup techniques in any particular case.

A site specific evaluation of applicability and cost-effectiveness must be considered for any remediation process, whether conventional or innovative, and adequate site specific design details must be provided in a Remedial Action Plan or other design document prescribing the remediation process.

Please incorporate this letter into the verification statement. If you have any questions on this letter or my involvement in the RCI *Lasagna*TM In-situ Soil Remediation Technology review demonstration, please call me at (850) 488-3935.

Sincerely,



Bill Neimes, P.E.
Bureau of Waste Cleanup
Florida Department of Environmental Protection

RAPID COMMERCIALIZATION INITIATIVE
VERIFICATION STATEMENT FOR *Lasagna*TM



State of Ohio Environmental Protection Agency

Southwest District Office

401 East Fifth Street
Dayton, OH 45402-2911

TELE: (937) 285-6357 FAX: (937) 285-6249

George V. Voinovich, Governor
Nancy P. Hollister, Lt. Governor
Donald R. Schregardus, Director

March 3, 1998

RE: LASAGNATM RCI
CONCURRENCE

Mr. B. Mason Hughes
Senior Analytical Consultant
Monsanto Company
800 N. Lindbergh Boulevard
St. Louis, Missouri 63161

Dear Mr. Hughes:

The purpose of this letter is to provide Ohio EPA's concurrence with the "Rapid Commercialization Initiative Final Report for an Integrated In-Situ Remediation Technology (LASAGNATM)". This is a soil treatment technology for in-situ removal of TCE and other chlorinated solvents from low permeability soils. The technology uses electro-osmosis to move contaminated water through specially designed treatment zones.

Ohio EPA staff have followed the demonstration of this technology for the past two years through review of work plans, conference calls, reports, etc. Ohio EPA staff have visited and toured the demonstration site at the DOE Paducah Gaseous Diffusion Plant in Kentucky. In addition, staff have also observed this technology demonstrated at the DOD Rickenbacker Air National Guard Base near Columbus, Ohio.

In the demonstration in Paducah, significant reductions in TCE concentrations occurred during the eleven month test period. Ohio EPA observed that this technology has been adequately demonstrated and that this technology may be applicable to many other contaminated sites.

Please note that this concurrence is based on an evaluation of technology performance under specific, predetermined criteria and appropriate quality assurance procedures. Ohio EPA makes no expressed or implied warranties as to the performance of the technology and does not certify that any technology will always, under circumstances other than those tested, operate at the levels in these demonstrations. This concurrence is not an endorsement of this technology by Ohio EPA, and should not be used as such. The end user is solely responsible for complying with any and all applicable federal, state, and local requirements.

If you have any questions about Ohio EPA's involvement in this RCI LASAGNATM technology demonstration, please contact me at 937-285-6018.

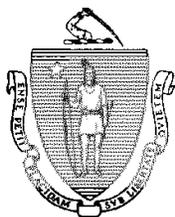
Sincerely,

A handwritten signature in black ink, appearing to read "Graham E. Mitchell".

Graham E. Mitchell
Chief, Office of Federal Facilities Oversight

cc: Catherine Stroup, Legal
Tom Velalis, DERR/CO

**RAPID COMMERCIALIZATION INITIATIVE
VERIFICATION STATEMENT FOR *Lasagna*TM**



ARGEO PAUL CELLUCCI
Governor

COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE OFFICE OF ENVIRONMENTAL AFFAIRS
DEPARTMENT OF ENVIRONMENTAL PROTECTION
ONE WINTER STREET, BOSTON, MA 02108 617-292-5500

TRUDY COXE
Secretary

DAVID B. STRUHS
Commissioner

May 7, 1998

Mr. B. Mason Hughes
Monsanto Company
800 N. Lindbergh Boulevard
St. Louis, Missouri 63161

RE: Verification Statement
LasagnaTM In-situ Soil Remediation Technology
Rapid Commercialization Initiative

Dear Mr. Hughes:

The Massachusetts Department of Environmental Protection (DEP) supports all efforts to encourage the efficient, safe and effective cleanup of waste sites through accelerating the acceptance and commercial use of innovative technologies.

Several staff from the Department's Waste Site Cleanup Program have reviewed the ITRC LasagnaTM In-situ Soil Remediation Technology related documents and participated the conference calls concerning data generated from the test site in Paducah, Kentucky. I concur with the other RCI participants that the technology is viable for remediating low-permeability contaminated soils. The flexibility allowed by the Massachusetts Contingency Plan (MCP) in the implementation of a remedial technology, however, prevents the agency from approving this technology for application at any specific site in Massachusetts. The "privatized" site cleanup program uses Licensed Site Professionals (LSPs), who are senior consultants licensed by a state board, to ensure compliance with the MCP (see 310 CMR 40.0000). Although subject to audits by the DEP, LSPs apply their professional judgment to clean up sites without direct state oversight to meet the MCP performance standards.

Please incorporate this letter into the verification statement. If you have any questions concerning this letter or the Department's involvement in the LasagnaTM In-situ Soil Remediation Technology review process please contact Kendall Marra, Innovative Technology Coordinator, Bureau of Waste Site Cleanup at 617.292.5966.

This information is available in alternate format by calling our ADA Coordinator at (617) 574-6872.

DEP on the World Wide Web: <http://www.magnet.state.ma.us/dep>

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VERIFICATION STATEMENT FOR *Lasagna*[™]

Sincerely

A handwritten signature in black ink that reads "Brian P. Moran". The signature is written in a cursive style with a long horizontal flourish extending to the right.

Brian P. Moran
Chief, Policy and Regulation Development
Bureau of Waste Site Cleanup

RAPID COMMERCIALIZATION INITIATIVE
VERIFICATION STATEMENT FOR *Lasagna*TM



STATE OF TENNESSEE
DEPARTMENT OF ENVIRONMENT AND CONSERVATION

Division of Superfund
4th Floor, L&C Annex
401 Church Street
Nashville, Tennessee 37243-1538

March 5, 1998

Mr. B. Mason Hughes
Senior Analytical Consultant
800 N. Lindbergh Boulevard
St. Louis, Missouri 63161

Subject: *Lasagna*TM demonstration
DOE, Paducah, Gaseous Diffusion Plant

Dear Mr. Hughes:

The Tennessee Department of Environment and Conservation, Division of Superfund (DSF), has participated in several of the *Lasagna*TM RCI activities. These activities included participating in several conference calls; reviewing reports including the Final Quality Assurance Project Plan (QAPP) dated August 20, 1996 and the Rapid Commercialization Initiative (RCI) Final Report for an Integrated *in-situ* Remediation Technology (*Lasagna*TM) dated February 6, 1998; and touring the demonstration site at the DOE Paducah Gaseous Diffusion Plant in Kentucky.

Based on these activities, the DSF concurs that it has been demonstrated that the *Lasagna*TM treatment technology utilizing electro-osmosis in conjunction with treatment cells composed of a mixture of peerless iron filings and kaolin has removed significant amounts of TCE from soil at the Paducah Gaseous Diffusion Plant demonstration site. Pre and post soil sampling data given in Tables F-5 through F-7 and Figures F-1 and F-2, and treatment effectiveness for the zone of contamination given in Table G-2 of the final report demonstrate this TCE removal. The "Summary of C₂ Hydrocarbon Degradation Products Measured in Water Samples" included in Table F-11 of the final report shows that the TCE removal was due to the *Lasagna*TM demonstration since the acetylene, ethane, and ethylene degradation products are present in the *Lasagna*TM treatment demonstration area and are not present in the TCE contaminated control area (MW-160). Figure C-4 shows that MW-106 is approximately 25 feet from the *Lasagna*TM demonstration area.

There is some uncertainty in the demonstration final report associated with the site soil composition. Page C-9 (Table C-1) shows that the soil at the demonstration site is a clay loam with a low (estimated 1X10⁻⁷ cm/sec) hydraulic conductivity. On page F-12 it states that there is a permeable sand layer located at a depth of 20 to 25 feet. On page F-12 it further states that the water samples may not be a good indicator of soil cleanup during the test if the TCE is migrating in from outside the demonstration area. It is therefore unclear how much contaminant migration through the treatment zones

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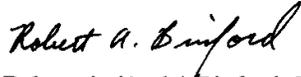
in the sand layer was caused by electro-osmosis and how much was caused by ground water movement through the sand layer.

The DSF believes that with the abundance of low permeability soil in the environment, there are many sites where the *Lasagna*™ technology may be applicable. Each of these sites has unique characteristics including, but not limited to: soil composition, sorting, roundness and porosity; the distribution of soil composition and characteristics in the contaminated area; soil hydraulic and electrical conductivity; the type and amount of contamination; the required cleanup levels; the size, depth, and shape of the contamination; the presence of buildings and structures at the site; etc. The applicability, site specific design specifications, and cost effectiveness of the *Lasagna*™ technology should be determined by the end user and the manufacturer prior to implementation. The end user is solely responsible for determining the suitability of *Lasagna*™ for his specific application and for complying with any and all applicable federal, state, and local requirements.

The DSF makes no expressed or implied warranties as to the performance of the technology and does not certify that any technology will operate at the levels obtained in the demonstration. This concurrence letter is meant to facilitate and encourage the acceptance of this technology for *in-situ* remediation, and to reduce or eliminate the generation of hazardous waste and/or toxic emissions associated with the excavation and above ground treatment of contaminated soils.

If you have any questions, please call me at (615) 532-0911.

Sincerely,



Robert A. (Andy) Binford, Manager
Technical and Contracting Section

RAPID COMMERCIALIZATION INITIATIVE
VERIFICATION STATEMENT FOR *Lasagna*TM



2600 Bull Street
Columbia, SC 29201-1708

March 11, 1998

CERTIFIED MAIL

Mr. B Mason Hughes, Project Manager
Monsanto Company
800 N. Lindbergh Boulevard
St. Louis, Missouri 63167

RE: Rapid Commercialization Initiative (RCI) Verification Statement for the
*Lasagna*TM In-Situ Soil Remediation Technology.

Dear Mr. Hughes:

The purpose of this letter is to provide South Carolina Department of Health and Environmental Control's (SCDHEC) concurrence with the technical approach employed for the development, field testing, and performance of the *Lasagna*TM In-Situ Soil Remediation Technology under appropriate quality control assurance procedure and specific criteria.

As a representative of SCDHEC, I was privilege to actively participate in the review of various documents (work plan and reports), phone conferences for comment discussion, and the field demonstration held at Paducah, Kentucky in September 1996. Working with other State representatives and from the real time field data, it is acknowledged that *Lasagna*TM is a viable technology for remediating the low-permeability soils and clays and sand mixed with these materials contaminated with TCE and other chlorinated solvents.

This concurrence by SCDHEC is not an endorsement for the referenced technology and should not be used as such. The vender while marketing the referenced technology for its performance, costs, acceptability, safety and use, is solely responsible for complying with any federal, state, and/or local regulations that may apply. A vender may include the copy of this letter along with the verification statement while proposing the use of the referenced technology to any SCDHEC representative. This will allow the involved state regulator to communicate with appropriate individuals within the agency and will facilitate the vender in presenting its approach.

SOUTH CAROLINA DEPARTMENT OF HEALTH AND ENVIRONMENTAL CONTROL

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VERIFICATION STATEMENT FOR *Lasagna*[™]

If you should have any questions about my or SCDHEC involvement in the RCI *Lasagna*[™] technology demonstration, please contact me at 896-4088.

Sincerely,

m. p. mehta

Mihir P. Mehta, Environmental Engineering Associate
Federal Facility Agreement Section
Division of Site Assessment and Remediation
Bureau of Land and Waste Management

cc: Keith Collinworth, P.G., Manager (Federal Facility Agreement Section)
J. Keith Lindler, P.E., Director (Division of Site Assessment & Remediation)
Ken Taylor, P.G., Director (Division of Hydrogeology)
Willie Morgan (EQC Administration)

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DISCLAIMER

Notice: This verification is based on an evaluation of technology performance under specific, predetermined criteria and the appropriate quality assurance procedures. The signatories make no expressed or implied warranties as to the performance of the technology and do not certify that a technology will always, under circumstances other than those tested, operate at the levels verified. The end user is solely responsible for complying with any and all applicable Federal, State and Local requirements.

For more information, you may contact any of the following *Lasagna*TM Soil Remediation Technology Participants:

<p>Mr. Grover (Skip) Chamberlain DOE Project Coordinator USDOE, 19901 Germantown Road, Mail Stop EM 53 CL, Germantown, MD 29874 <u>Voice:</u> (301) 903- 7248 <u>FAX:</u> (301) 903-7457 <u>FAX2:</u> (301) 903-7234 grover.chamberlain@em.doe.gov</p>	<p>Mr. Thomas J. Holdsworth Federal EPA Representative USEPA, NRMRL ,Mail Stop 489, 26 W. Martin Luther King Drive, Cincinnati, OH 45268 <u>Voice:</u> (513) 569-7675 <u>FAX:</u> (513) 569-7676; alt. (513) 569-7620 holdsworth.thomas@epamail.epa.gov</p>	<p>Mr. Stephen Antonioli MSE Cost Coordinator Manager, Integrated Economic Analysis Project, MSE-TA, 200 Technology Way or P. O. Box 4078 Butte, MN 59701 or 59702 <u>Voice:</u> (406) 494-7343, <u>FAX:</u> (406) 494-7230, e-mail: santonio@in-tch.com</p>
<p>Mr. Tuss Taylor Kentucky EPA Kentucky Div of Waste Manag, 14 Reilly Road, Frankfort, KY 40601 <u>Voice:</u> (502)564-4797, <u>FAX:</u> (502)564-5096 tmtayl1@service1.uky.edu and Dan Moore ext. #295, djmoor1@service1.uky.edu Mr. Daniel Moore, U. of Kentucky-FFOU P. O. Box 776, Frankfort, KY 40602 Mr. Jayant Gotpagar, UK-FFOU, jayant@enr.uky.edu</p>	<p>Dr. Jerry Hill SSEB Representative 6325 Amherst Court Norcross, GA 30092 Voice: (770)242-7712, FAX: (770)242-0421 e-mail: hill@clever.net and Ted Joy, joy@clever.net, Voice: (770)242-7712, FAX: (770)242-0421</p>	<p>Dr. B. Mason Hughes RCI and Phase IIa Project Manager Monsanto Co. 800 N. Lindbergh Boulevard St. Louis, MO. 63167 <u>Voice:</u> (314) 694-1466 <u>FAX1:</u> (314) 694-8080 <u>FAX2:</u> (314) 694-1531 b.mason.hughes@monsanto.com</p>
<p>Mr. Brian Moran Branch Chief, Policy and Regulatory Development, Mass. DEP/BWSC 1 Winter St., 7th Floor Boston, MA 02108; <u>Voice:</u> (617)292-5767 <u>FAX:</u> (617)292-5530</p>	<p>Mr. Bill Neimes Florida DEP 2600 Blairstone Road Tallahassee, FL 32399-2400 <u>Voice:</u> (904)921-9986 <u>Fax:</u> (904)922-6657</p>	<p>Mr. David Carden DOE Verification Entity USDOE, 55 Jefferson Avenue Oak Ridge, Tenn. 37831 <u>Voice:</u> (423) 576-9262, <u>FAX:</u> (423) 576-6074, e-mail: cardendm@oro.doe.gov</p>
<p>Mr. Carl Froede Region IV EPA 100 Alabama St. N. W., Atlanta, GA 30303, <u>Voice:</u> (404) 562-8550, <u>FAX:</u> (404) 562-8518, e-mail:carl@epamail.epa.gov</p>	<p>Mr. Willie Morgan EQC Administration SCDHEC, 2600 Bull Street Columbia, SC 29201 <u>Voice:</u> (803)734-5179, <u>Fax:</u> (803)734-9196</p>	<p>Mr. Graham Mitchell, OEPA/SWDO 401 East 5th Street Dayton, Ohio 45402 <u>Voice:</u> (937)285-6018, <u>FAX:</u> (937)285-6249</p>
<p>Mr. Jim Haynes, PE Tenn. Environmental Policy Office, Dept. of Environment and Conservation 20th Floor, L&C Tower, 401 Church Street Nashville, Tenn 37243-0454 <u>Voice:</u> (615)532-0227, <u>FAX:</u> (615)532-0740, jhaynes@mail.state.tn.us</p>	<p>Mr. Sam Hayes QAPP Reviewer for Federal EPA USEPA, NRMRL , 26 W. Martin Luther King Drive, Cincinnati, OH 45268, <u>Voice:</u> (513) 569-7514, <u>FAX:</u> (513) 569-7585, e-mail: hayes.sam@epamail.epa.gov</p>	<p>Mr. Robert A. (Andy) Binford State of Tennessee Division of Superfund 4th Floor LNC Annex, 401 Church St. Nashville, Tenn. 37243-1538, <u>Voice:</u> (615)532-0911, <u>FAX:</u> (615)532-0938</p>
<p>Mr. Mihia P. Mehta SCDHEC 2600 Bull Street Columbia, SC. 29201 <u>Voice:</u> (803)896-4088 <u>FAX:</u> (803)896-4001</p>	<p>Mr. Ronald E. Lewis, PE Cal/EPA Representative DTSC (HQ-27), P. O. Box 806 Sacramento, CA 95812-0806, or 301 Capitol Mall, Sacramento, CA 95814 <u>Voice:</u> (916)322-6872, <u>FAX:</u> (916)324-3107</p>	

**RAPID COMMERCIALIZATION INITIATIVE
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DESCRIPTION OF RCI

Rapid Commercialization Initiative (RCI) is a component of the federal Administration's efforts to build cooperative interactions between the private sector, states, and federal agencies to advance a national environmental strategy and bring environmental technologies to market more rapidly and efficiently. As a result of RCI, a Memorandum of Understanding (MOU) was written to accelerate private sector commercialization of innovative environmental technologies and to facilitate regulatory acceptance across state and federal jurisdictions. The desired product of the MOU is multi-state acceptance of innovative environmental technologies following verification of the performance of those technologies.

The MOU was made and entered into by and between the following parties:

U.S. Department of Commerce, U.S. Department of Energy, U.S. Environmental Protection Agency, Southern States Energy Board, Western Governors' Association, and the State of California Environmental Protection Agency.

Concurrence and sign off of the MOU was completed August 14, 1995.

The MOU resulted in a federal/state/private cooperative effort (the RCI Program or the Program) to expedite the application of new environmental technologies. The RCI Program identifies barriers to the acceptance and use of new technologies and makes use of cooperative demonstration projects to remove these barriers, if possible. The Program includes 10 individual demonstration projects, each of which will involve a different environmental technology.

Implementation of an MOU between Monsanto, the technology holder, and the U.S. Department of Energy is authorized by Cooperative Demonstration Agreement number 96-RCI-02. For *Lasagna*[™], participating federal agencies include the Department of Commerce, Department of Defense, Department of Energy and the Environmental Protection Agency. Participating states and state organizations include the State of California Environmental Protection Agency, Southern States Energy Board, and the Western Governors Association. Additional participants and also signatory states for this verification of the *Lasagna*[™] *in-situ* Treatment Technology are Florida, Kentucky, Massachusetts, Ohio, South Carolina, and Tennessee.