

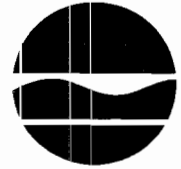
New York State Department of Environmental Conservation

Division of Solid and Hazardous Materials

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CERTIFIED MAIL - RETURN RECEIPT REQUESTED

January 29, 2008

Mr. Brian McGinnis
FMC Corporation, Remediation Department
1735 Market Street
Philadelphia, Pennsylvania 19103

Dear Mr. McGinnis:

Re: FMC Corporation, Middleport, NY
EPA ID No. NYD002126845
AOC Docket No. II-RCRA-90-3008(h)-0209
FMC's Proposed Arsenic Phytoremediation Pilot Study Work Plan; and
FMC's Proposed Modification to the 2007 Work Plan for the Wooded Parcel

The United States Environmental Protection Agency (USEPA) and the New York State Department of Environmental Conservation (NYSDEC), hereafter referred to as "the Agencies", in consultation with the New York State Department of Health (NYSDOH), have reviewed the following FMC submissions:

1. "Arsenic Phytoremediation Pilot Study Work Plan" (submitted by FMC letter dated December 5, 2007); and
2. "Request for Modification of the 2007 Work Plan for the Wooded Parcel" (submitted by FMC letter dated November 29, 2007).

With regard to the first listed submission, "FMC's proposed Work Plan for conducting an Arsenic Phytoremediation Pilot Study", the Agencies have discerned that this work plan contains two major components. The first of these is a laboratory "bench-scale" study, the results from which are to be used to further develop the second, a pilot field study. The Agencies have addressed these two work plan components separately, as described below.

Laboratory "Bench-Scale" Study - Task 2, Section 4.2 of the work plan indicates that Cornell University will conduct a laboratory study to determine the most effective combination of plants and possible soil amendments. From our review, the Agencies have determined that this laboratory "bench-scale" study meets the requirements of Task VI in Attachment I of the above referenced AOC, and as such the Agencies are hereby approving Task 2, Section 4.2

of the December 2007 Arsenic Phytoremediation Pilot Study Work Plan in accordance with Item 2 in Section XI of the AOC. This work plan activity should be implemented in accordance with the schedule in Section 5.0 of the work plan. The "letter-report" mentioned in Section 4.2 of the work plan containing the results of this laboratory "bench-scale" study, must be submitted for Agencies' review and should provide information on the plant species tested, the physical and chemical properties of the Middleport soils used in the testing, the types and quantities of any soil amendments, as well as the laboratory study results and any recommendations for the field study.

Field Pilot Study - From the Agencies review of the other tasks/sections of the proposed work plan which primarily constitute the field pilot study procedures, it appears these procedures are generally acceptable. However, some work plan modifications and additional details are needed, before the Agencies can approve the field pilot study portion of this work plan. These modifications / additional details are presented in the Agencies' enclosed comments. In response to these comments, FMC must take at least one of the actions specified by Section XI Item 1 of the above referenced AOC.

With regard to the second listed submission, "Request for Modification of the 2007 Work Plan for the Wooded Parcel", the Agencies have evaluated this proposed modification. This modification entails including a portion of the Wooded Parcel (Coe Property) adjacent to residential property P10 in the Arsenic Phytoremediation Field Pilot Study. FMC has indicated that they are proposing this modification in an attempt to reduce elevated arsenic concentrations in the soil on this portion of the Wooded Parcel. FMC has indicated this action would replace the excavation and cover installation required by the current 2007 Work Plan, since FMC believes that these corrective measures would detrimentally effect a tree on the adjacent P10 property which the owner wants preserved. FMC has also stated in this request that they may propose additional corrective measures for the soils in this area in the event that arsenic levels are not sufficiently reduced by phytoremediation, however they will not propose excavation.

The Agencies have no objection to the inclusion of this Wooded Parcel area adjacent to the P10 property in the phytoremediation field pilot study. The Agencies would agree that should this phytoremediation succeed in reducing arsenic in the soil to levels deemed acceptable to the Agencies, it would be a satisfactory substitute for the excavation and covering activities required by the work plan. However, since the effectiveness of such phytoremediation is not currently known, the Agencies do not consider it appropriate to approve FMC's modification request at this time. Nonetheless, the Agencies consider it prudent to defer the corrective measures currently required by the work plan (i.e., excavation and covering) until results from the phytoremediation field pilot study conducted on this area are available. Once these results are in, the Agencies will reconsider FMC's work plan modification request, or an alternative FMC modification request, based on the phytoremediation's effectiveness in reducing arsenic levels in the area's soil. Therefore, to facilitate deferment of the corrective measures currently required by the work plan, the Agencies are hereby approving an extension of FMC's revised October 31, 2007 implementation schedule (approved by Agencies' letter dated November 1, 2007) for the portion of the Wooded Parcel adjacent to residential property P10 until the results of the phytoremediation field pilot study are available and the Agencies make a determination to approve or disapprove FMC's currently proposed modification request or an alternative FMC modification request.

In response to FMC's statements in the November 29, 2007 work plan modification request that they may propose additional corrective measures if phytoremediation proves ineffective, however they will not propose excavation, the Agencies would like to make clear our position with regard to these statements. In response to the first FMC statement, if the Agencies determine that FMC's phytoremediation does not effectively reduce arsenic levels in the soil on the portion of the Wooded Parcel adjacent to property P10, the Agencies will require FMC to propose an alternative modification to the work plan. Regardless of the fact that an Environmental Easement may be put in place to restrict usage of this property, additional corrective measures will still be necessary in this area to address the potential for exposure to elevated arsenic levels in shallow soils. In response to the second FMC statement, the Agencies cannot agree to exclude excavation as a possible corrective measure for this area. Data from this area indicate that elevated arsenic levels appear to be limited to the upper 9 inches of soil. Careful hand excavation techniques, seasonal timing of excavation activities, segmenting the area so that only a portion is being excavated each year and addition of plant nutrients, should all be evaluated to determine whether the upper 9 inches of soil can be removed and replaced without damage to the adjacent tree.

If you have questions concerning this letter or its enclosures, you may contact either Mr. Matt Mortefolio (NYSDEC) at (518) 402-8594 or Mr. Michael Infurna (USEPA) at (212) 637-4177.

Sincerely,

Matt Mortefolio, P.E.
NYSDEC Project Coordinator
Bureau of Solid Waste & Corrective Action

Michael Infurna
USEPA Project Coordinator
Environmental Planning and Protection Division

Enclosure

cc: w/enc. - M. Hinton, NYSDEC Region 9 Buffalo
T. Girard, NYSDOH
D. Watts, New Jersey Institute
D. Seaman, Seaman, Jones, Hogan & Brooks

bcc: w/enc. - M. Mortefolio, NYSDEC Albany
M. Infurna, USEPA

bcc: wo/enc. - D. Radtke, NYSDEC Albany
R Quail, NYSDEC Albany
G. Sutton, NYSDEC Region 9 Buffalo
J. Ridenour, NYSDOH
W. Mugdan, USEPA
J. Reidy, USEPA
E. Dassatti, NYSDEC Albany
D. David, NYSDEC Region 9 Buffalo
G. Litwin, NYSDOH
R. Fedigan, NYSDOH

ENCLOSURE

Agencies' Modifications / Additions to FMC's December 2007 Arsenic Phytoremediation Pilot Study Work Plan January 2008

Specific Comments:

1. Section 3.0: **Pilot Study Objective**

Two additional study questions should be included in this objectives' section as described below:

- A. One of the potential applications of this phytoremediation technology which may be evaluated in an FMC Corrective Measures Study (CMS), is the removal of arsenic from shallow soils in the root zone of residential trees, with the intention of avoiding detrimental impacts on the trees. While FMC's pilot study includes field testing in the root zone of some residential trees, it does not include any evaluation of these trees for possible detrimental effects from activities associated with this phytoremediation technology (e.g., soil cultivation (disking), planting, soil amendments, etc). Although, detrimental effects may not be considered likely, it is still important that the condition of the trees be evaluated in this pilot study, since it is critical that the application of this phytoremediation technology be demonstrated to result in tree preservation. Therefore, the following study question should be added to this section:

“Does this phytoremediation process have any discernable effect on trees?”

Details regarding monitoring activities necessary to answer the above study question, are discussed in Comment #6 on Section 4.6 of the work plan.

- B. Previous studies have demonstrated that the area of arsenic uptake is limited to the plant's root zone. As a result, the spacing of plants which are not broadcast seeded, is a critical factor in determining whether the root zones sufficiently cover and effectively take up arsenic over the entire soil area requiring remediation. This is especially important in the western New York region where perennial growth of some plants is not possible and the root spread is limited to that which can occur in one growing season. Therefore, the following study question should be added to this section:

“For non-broadcast species, what is the maximum plant spacing that can effectively reduce arsenic levels over the entire soil area?”

Details regarding planting and evaluation activities necessary to answer the above study question, are discussed in Comment #5 & 6 on Sections 4.5 & 4.6 of the work plan.

2. Section 4.1: **Task 1 - Evaluating Existing Soil Data**

All existing soil data applicable to each study site should be included in an appendix of this work plan so that the data is conveniently accessible.

3. Section 4.3: **Task 3 - Soil Sampling and Evaluation for Design**

This section indicates that FMC proposes to collect baseline soil samples at points on a 10-foot by 10-foot grid at depth ranges of 0 to 6 inches, 6 to 12 inches and 12 to 24 inches. The Agencies have three modifications of this sampling strategy described below:

Sampling Grid - In reviewing Figure 3 which shows the layout for one of the study sites, the plots for the different plant species appear to be 6-foot by 40-foot (or 7.5-foot by 40-foot if there are no “other plants”). This does not seem to agree with the proposed 10-foot by 10-foot sampling grid in that it does not appear to equally distribute the sample points between the plots of the different plant species. The Agencies consider it important that there be a sufficient and equal number of samples for each plot, and that the sampling grid fit the plot layout so that sampling results can be easily correlated to each plot. Therefore, the size of each grid square should be adjusted in the work plan to 6-foot by 10-foot (or the width of each plot by 10-foot, if plot widths vary from the depicted 6 feet). This will provide for 4 equal grid squares for each plot based on Figure 3 and allow for correlation between sample results and plant species.

Sampling Method - FMC has proposed collecting grab samples from the grid points at each depth interval, and analyzing these discrete samples. However, an ongoing pilot study performed using a brake fern species in the Spring Valley community of Washington, D.C. has indicated that the inherent variability of arsenic in soil makes it difficult to discern trends in arsenic levels after each growing season. Using a small sample size in terms of soil quantity, such as a grab sample from a particular point, greatly increases this difficulty. Initially the above referenced study composited 5 aliquots into a single sample from each 20-foot by 20-foot grid square. The results of this sampling failed to indicate any discernable trends in arsenic levels over time, since they were randomly higher, lower or the same when pre & post growing season sample results were compared for each grid square. Since the results showing an increase in arsenic levels seemed to indicate that inherent differences in arsenic levels over the geographic areas of each grid square were producing the inconclusive results, the study increased the compositing to 30 aliquots into a single sample from each 20-foot by 20-foot grid square. The results from this sampling method produced a far more consistent discernable decreasing trend in arsenic levels over time, and seemed to alleviate the effects from geographical differences in arsenic levels over the area of each grid square [contact information for this study is provided at the end of the Agencies’ comments]. Therefore, based on the results of this similar study, the proposed collection of a grab sample at each of the 4 grid square points at each depth interval, should be replaced in the work plan with a procedure which requires the collection of around 15 aliquots from each grid square, at each depth interval (aliquots obtained from evenly spaced points over each plot width by 10-foot grid square), and compositing of these aliquots into a single sample for each grid square at each depth interval. The work plan should present a detailed sampling procedure which includes, at a minimum, how the aliquot sampling points will

be laid out within each grid square, how the aliquot samples will be obtained for each depth interval, how the grid square aliquots for each depth interval will be adequately homogenized and how the composited grid sample for each depth interval will be obtained from the homogenized aliquots.

It should be noted that the Agencies are requesting sample compositing in this case to make it easier to discern trends in arsenic levels over time based on the results of the Spring Valley study. However, this does not change the Agencies' position that grab sampling is the more appropriate method for field investigations where it is important to discern "hot" spots.

Sampling Depth Intervals - The depth intervals used for the sampling should be revised to more closely reflect the sampling intervals used in Middleport investigations. Specifically, the depth intervals should be 0 to 3 inches, 3 to 6 inches, 6 to 12 inches and 12 to 18 inches. This will provide for better correlation to existing Middleport arsenic data and likely enhance in determining the depths at which the plants are effecting arsenic levels. The Agencies have no objection to adding on sampling of the 18 to 24 inch depth interval if FMC considers it necessary for this study.

In addition to the above, the baseline sampling procedures in this work plan should indicate that the baseline sampling be performed subsequent to any soil preparation activities (e.g., disking, etc.) and the addition of any soil amendments. This will prevent these activities from potentially influencing the baseline sample results, thereby insuring that any trends in arsenic levels indicated by subsequent post-growing season sample results are likely due to plant effects and not pre-planting soil preparation activities. Also, these procedures should indicate that all holes produced from the collection of sample aliquots be filled in with native soil from the study site and not with commercial topsoil. This will avoid the possibility of unintentionally sampling the imported topsoil during subsequent post-growing season sampling events. The work plan must also include a detailed soil Sampling and Analysis Plan (SAP) similar to previously submitted FMC SAPs but reflective of the above project specific details.

4. Section 4.4: **Task 4 - Field Pilot Study Design**

Figures of the test plots for all study sites, similar to the referenced Figure 3, should be included in the work plan. Also, the figures should be revised as necessary subsequent to obtaining the results of the laboratory "bench-scale" testing to depict any additional plants to be tested and/or any soil amendments to be used.

For the primary (agricultural) study site, the work plan should indicate that the plots will be located in up-gradient areas which are not known to be susceptible to flooding.

5. Section 4.5: **Task 5 - Pilot Study Implementation**

As stated in Comment #1B, this study should also evaluate plant spacing for non-broadcast species to determine the maximum spacing which can still reduce arsenic levels over the entire soil area. Recent laboratory "bench-scale" results from testing performed by the Rochester Institute of Technology on brake fern species provides some helpful guidance on

the topic of plant spacing. Ferns were planted in a laboratory setting using a 1-foot spacing and allowed to grow for 7 months to simulate a typical northeast growing season. At the end of the 7 months it was observed that the root spread from individual plants typically extended about 0.3 feet (3 to 4 inches) away from the plant crown, suggesting that the 1-foot spacing may leave un-affected soils between the plants [contact information for this study is provided at the end of the Agencies' comments]. Therefore, the work plan for the FMC field pilot study should indicate that the brake ferns will be planted at different spacings, with at least some plots or portions of plots (i.e., sub-plots) planted at a 0.5-foot spacing based on the results of the above referenced laboratory study. The work plan should indicate that wider fern spacings will be used at other plots or sub-plots to help determine the maximum plant spacing that can effectively produce a root zone which will cover the entire area of soil to be remediated under field conditions. Also, for other non-broadcast species involved in this pilot study (e.g., sunflower), the work plan should indicate that a number of different plant spacings will be tested on plots with the actual spacings established by the anticipated spread of the species root zone over a typical northeast growing season. The different plant spacings should be indicated on the figures in this work plan.

For the primary (agricultural) study site, the work plan states it be graded to promote drainage (if needed). The Agencies consider that these grading activities would mix surface soils from one area into another or mix surface and shallow soils, in a manner which could unduly alter arsenic levels in the shallow soils. Such grading activities should be avoided if at all possible. Therefore, the work plan should be revised to state that the primary study site plots should be established in a well-drained area with drainage controls established outside the perimeter of the study site plots, if needed.

The work plan should indicate that during dry conditions, real-time air monitoring for particulates (i.e, dust) will be performed during soil-intrusive activities such as, but not necessarily limited to, cultivation (disking).

For the non-broadcast species (e.g., ferns, sunflowers, etc.), which are to be planted from seedlings, the work plan should state that some seedlings will be used for baseline biomass sampling. The work plan should indicate that the above ground portions of some seedlings will be sent for analysis to determine the baseline arsenic concentrations in the above ground portions of these plants. The Agencies consider that the comparison of this biomass baseline data to harvest data will provide valuable information that can be used to evaluate the plant's seasonal arsenic uptake. Also, see Comment #7 regarding biomass sampling and analysis.

The work plan must include a more detailed set of planting procedures. For instance, with regard to broadcast planting, details indicating seeding density and how seeds will be spread should be included. With regard to the non-broadcast planting, details indicating the depth and size of each hole and the specific drilling equipment and procedures to be used should be included. Also, details on what, if any, soil amendments or fertilizers will be added, what they are, where they will be added, and how they will be applied, should be included.

Based on information from previous research, the plants proposed to be used in this field pilot study are likely to hyper-accumulate arsenic in their fronds. There currently appears to be insufficient information to determine whether human exposure to the fronds or other parts of these plants presents a potential risk of adverse health effects. This section of the work

plan states that a fenced enclosure for the test plots to prevent wildlife and vandals from damaging the plants is “anticipated”. Given the uncertainty associated with potential human exposure to elevated levels of arsenic in these plants, adequate fencing is a must, especially for the residential study sites where the potential for exposure is the greatest. Therefore, the work plan must be revised to indicate that all study sites will be completely enclosed with fencing. The work plan must describe the fencing to be used which must be adequate to effectively prevent unintentional public access, and must include appropriate signs to advise the public. Also, the work plan must state that the fencing will be installed far enough beyond the perimeter of the actual test plots so that there is no possibility of the matured plants being able to extend to or beyond the fenced perimeter.

6. Section 4.6:

Task 6 - Monitoring and Reporting

As stated in Comment #1A, this study should also evaluate whether this phytoremediation technology has any discernable effect on trees. To accomplish this, the work plan should indicate the specific observations and other assessment techniques that a qualified arborist will use to evaluate the condition of trees associated with the residential study sites, prior to, during and after each plant growing season. The work plan should also indicate that if there are any discernable detrimental effects on the tree(s) identified by the arborist, such effects will be investigated to determine if the cause may be related to phytoremediation activities.

The work plan indicates that weekly inspections will be conducted of each study site during the growing season to determine if irrigation is needed. The work plan should also indicate the optimum soil moisture content for each plant species and describe how soil moisture will be evaluated during weekly inspections to determine if irrigation is needed. If irrigation is performed it should be recorded along with the amount of water used at each study site. In addition, a rain gauge should be used to facilitate the measuring and recording of precipitation events.

The work plan should indicate that the type and quantity of any fertilizer used during the growing season will be recorded during weekly inspections, along with which plots it was applied. The growth of plants should be observed during weekly inspections and periodically measured to evaluate the extent of the above ground biomass and any growth differences between plants grown in predominantly sunny verses shady locations. The work plan should indicate that weekly inspections will be used to evaluate the condition of the fencing around each study site, identify any fencing defects and repair any such defects. The work plan should indicate that weekly inspection reports will be prepared which shall include all observations made by the inspector and any photos or measurements taken. A compilation or summary of these weekly reports should be provided to the Agencies on a monthly basis during the growing season.

For reasons discussed in Comment #5 regarding public exposure to the plant’s in this study, the work plan should state the area surrounding each study site will be inspected weekly for evidence of any wind blown plant parts outside of each fenced study site. Also, the work plan should describe the measures that will be taken to correct any current, and prevent any future wind blown migration of such plant parts beyond the fenced area.

As stated in Comment #1B, this study should also evaluate plant spacing for non-broadcast species to determine the maximum spacing which can still reduce arsenic levels over the entire soil area. To perform this evaluation, the work plan must include some additional plant harvesting activities. A number of plants in each plot should be selected at random to determine their seasonal root spread and density. Soil should be carefully removed from around each such plant to reveal its root system. Qualitative observations of the plant's root density should be made and recorded, along with measurements from the plant stalk of the horizontal and vertical extent of plant's root zone. Also, as stated in Comment #5, plots or sub-plots should have plants grown at different spacings. To determine which spacing, or spacings, may have reduced arsenic levels in soil at the mid-point between plants, at least one plot or sub-plot for each plant spacing should have their soil sample aliquots collected from the mid-points between plants (i.e., each aliquot collected from the center of a square that is delineated by 4 plants on its corners, at each depth interval). The result should be that at least one composite soil sample should be collected in this manner for each plant spacing at each depth interval. Soil sample aliquots on remaining plots or sub-plots should be collected at various points within plant root zones. In addition, Comment #3 regarding the pre-planting soil sampling and analysis also applies to the post-harvest soil sampling and analysis indicated in Section 4.6 of the work plan.

This section states that the duration of the study may be extended based on the findings after the first growing season. However, a similar field pilot study performed using a brake fern species in the Spring Valley community of Washington, D.C. did not have conclusive results after the first growing season and has been ongoing for a number of years now. Based on this ongoing study it may not be appropriate to conclude that this phytoremediation technology is ineffective after a single growing season, even if results after the first season suggest little, if any effect on soil arsenic levels. Also, it is possible that some plants may perform better or worse than others, indicating that some should continue in the study, while others may not warrant further consideration. In addition, FMC has indicated its intention to use this phytoremediation technology in some field pilot study sites as a corrective measure to remediate the soils in these areas, which may likely require more than one growing season to accomplish. For all of these reasons, the Agencies view this field pilot study as likely being a multi-year project which should be assumed to continue beyond the 2008 growing season. Therefore, the work plan should be revised to state that this phytoremediation field pilot study shall go on until FMC receives approval from the Agencies to discontinue the study. It should be stated that with the submission of each year's end-of-growing-season monitoring and sampling report, FMC may request approval from the Agencies to modify, curtail (remove some plants from further study) or discontinue the study, prior to the subsequent growing season.

7. Section 4.7:

Task 7 - Plant Uptake Evaluation

There are clearly two objectives in the analysis of the harvested above ground biomass, the first being to determine how much, if any, arsenic is in this biomass so as to assess the plant's arsenic uptake, and the second being to provide information necessary to make a biomass disposal determination. The work plan should include a Biomass Sampling and Analysis Plan (SAP) which provides sampling and analytical details for each of these two separate and distinct objectives. For determining plant arsenic uptake, details must be included indicating which parts of the plant will be separately sampled; how samples of like

parts of the plant will be composited to achieve sufficient volume for a single sample; how many samples will be obtained at each study site; and that at a minimum, a total arsenic analysis will be performed on each sample. For determining biomass disposal, details must be included indicating how the biomass will be sampled; how many samples will be obtained at each study site; and that at a minimum, a Toxicity Characteristic Leaching Procedure (TCLP) [EPA Method 1311] for arsenic will be performed on each sample. The work plan should also list the biomass disposal options.

Related Phytoremediation Studies - Contact Information:

1. Study of Arsenic Phytoextraction in the Mid-Atlantic Area Using *Pteris* Ferns -

Location - Spring Valley community of Washington, D.C.

Project Contacts - Michael J. Blaylock, Edenspace System Corp.

Tel: 703-961-8939, Email: blaylock@edenspace.com

Mark P. Elless, Edenspace System Corp.

Tel: 703-961-8700, Email: elless@edenspace.com

Myles Bartos, USEPA

Tel: 215-814-3342, Email: Bartos.Myles@epamail.epa.gov

2. Study of Plant Spacing for Optimal Phytoremediation Using *Pteris cretica* Ferns -

Location - Rochester Institute of Technology (RIT), Rochester, NY

Project Contacts - Joshua Goldowitz, RIT

Tel: 585-475-7018, Email: jxgctp@rit.edu

Sean O'Neil, RIT

Tel: 585-314-1175, Email: swo1834@rit.edu