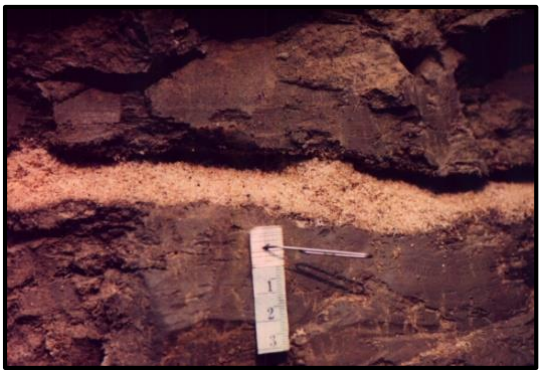
Controlled Jet Injection

TECHNICAL BRIEF

Sites Where Injections Have Been Exposed and Explored by Excavation

EPA Projects

Injections have been created at several sites where excavation equipment afterwards exposed the injections so that form (size, shape, and orientation) could be documented thoroughly. The reports have been published in a variety of formats.



Elda Landfill, Cincinnati Ohio. This work was done as part of the research and development projects sponsored by the US EPA and conducted by the University of Cincinnati during the late 1980s and early 1990s. These projects also created injections at other venues in the Cincinnati area:

- Goettle Construction yard, Fairfield, Ohio
- Center Hill Experimental Stations (adjacent to the ELDA Landfill)
- The CECOS Landfill, Batavia, Ohio

While the projects, in aggregate, led to several publications, with each project contributing a portion of the findings, the most famous images, obtained from the ELDA Landfill, are not contained in any one specific publication, but, rather, exist as images on the web. These are presented above.

1. Murdoch, L. C. (1990) "A field test of hydraulically fracturing glacial till." 15th Annual USEPA Research Symposium, Cincinnati. vol: EPA/600/9-90/006 pages 164-174.USEPA

2. Murdoch, L. C. (1991) *Hydraulic Fracturing of Soil*. A Thesis Submitted to the Department of Geology, University of Cincinnati, Cincinnati, OH

3. Murdoch, L. C. (1995) "Forms of hydraulic fractures created during a field test in fine-grained glacial drift." Quarterly Journal of Engineering Geology 28 (23-35.)

4. Murdoch, L. C. and W. W. Slack (2002) "Forms of Hydraulic Fractures in Shallow Fine-Grained Formations." Journal of Geotechnical and Geoenvironmental Engineering 128:6 (479-487.)

http://www.frx-inc.com/images/Forms_of_Hydraulic_Fractures_In_Shallow_Fine-Grained_Formations,_Murdoch_Slack_2002.pdf

5. Rajaram, V. and P. Banerjee (1993) Hydraulic Fracturing Technology - Applications Analysis and Technology Evaluation Report. EPA/540/R-93/505. US EPA Office of Research and Development, Cincinnati, OH. http://www.frx-inc.com/images/1._EPA_SITE_Report_USEPA540R93505.pdf

6. Frank, U. and N. Barkley (1995) "Remediation of low permeability subsurface formations by fracturing enhancement of soil vapor extraction." J Hazardous Materials 40 (191-201.)

API Project – Sarnia, Ontario

As part of a series of projects to examine fate and transport of non-aqueous phase contaminants in low permeability material, injections were created at a test site near Sarnia, Ontario. A description of the injections can be found in an appendix to a PhD thesis submitted to the Oregon Graduate Institute.

1. Grady, D. E. (1997) *Remediation of LNAPL in a Naturally Fractured Clay Till: Physical and Numerical Modeling*. Ph.D. Dissertation, Oregon Graduate Institute, Beaverton, Oregon.

2. Johnson, R.L., D.E. Grady and T. Walden, 1997. Remediation of a Fractured Clay Soil Contaminated With Gasoline Containing MTBE. Proc. of the Petroleum Hydrocarbons and Organic Chemicals in Ground Water Conf., Houston.

3. Johnson, R.L. and D.E. Grady, 1998. Remediation of a Fractured Clay Till Using Air Flushing: Field Experiments at Sarnia, Ontario. API, Publ. No. DR 225.

Clemson Experimental Station

1. Richardson, J. R. (2003) *Forms of Hydraulic Fractures at Shallow Depths in Piedmont Soils*. A Thesis Submitted to the Department of Geological Sciences, Clemson University, Clemson, SC

2. Richardson, J. R., Q. Tan and L. C. Murdoch (2003) "The Form of Hydraulic Fractures at Shallow Depths in Piedmont Soils." 11th Annual Hydrogeology Symposium, Clemson, SC. pages 23-24.Dept. Geo. Sci., Clemson University

3. Murdoch, L. C., J. R. Richardson, Q. Tan, S. C. Malin and C. Fairbanks (2006) "Forms and Sand Transport in Shallow Hydraulic Fractures in Residual Soil." Canadian Geotechnical Journal 43:10 (1061-1073.) http://www.frx-inc.com/images/Forms_and_sand_transport_Canadian_Geotech_Journal_Richardson_Murdoch.pdf

STRESOIL Project – Kluczewo, Poland

A project sponsored by the European Union examined the use of sand-filled lenses during thermal stimulation of hydrocarbon removal. The web site presents all of the reports, including photos of exposed injections. www.stresoil.com

Injection Method Comparison – Vasby, Denmark

Hydraulic injection, pneumatic injection, and direct injection were compared.

1. Christiansen, C.M. (2010) *Methods for Enhanced Delivery on In Situ Remediation Amendments in Contaminated Clay Till*. A Thesis Submitted to the Department of Environmental Engineering, Technical University of Denmark. http://www2.er.dtu.dk/publications/fulltext/2010/ENV2010-066.pdf

Jet-Injection – Taasrup, Denmark

Two injections were created and the entire site excavated to a depth of eight meters. This work was conducted in November 2011 and is not yet published.