Update Report on Analytic Element Ground-Water Modeling as a Research Program (1980-2006)

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Athens, GA

International Conference on the Analytic Element Method, Manhattan, KS

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Notice

Although this work was reviewed by EPA and approved for presentation, it may not necessarily reflect official Agency policy. *Mention of trade names or commercial products does not constitute endorsement or recommendation for use.*

Research Programs

- Irme Lakatos (1922-1974), Hungarian philosopher of science
- Research program has hard core (assumptions, methods, acceptance criteria)
- Program strength – leads to natural predictions or solves new problems
- Progressive or degenerating phases

Proposition

The AEM research program, while relatively young in comparison to FEM, FDM, is active and progressive.

AEM Research Program

- Limited to groundwater model for this paper
- Core established by Professor Otto Strack and others
- Superposition of closed-form analytic functions in infinite domain
- Functions representing hydrologic performance
- 2D (Dupuit) or 3D, steady or transient
- Internal or external b.c.
- Water balance, continuity of flow

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James Metzler (M.S.C.E. in progress)
Dazhi Mao (M.S.C.E. in progress)

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Henk Haitjema, Ph.D
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Melinda Erickson, M.S.

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Andrea Kolhoff: (M.S. in progress)
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2003

AEM Family Tree

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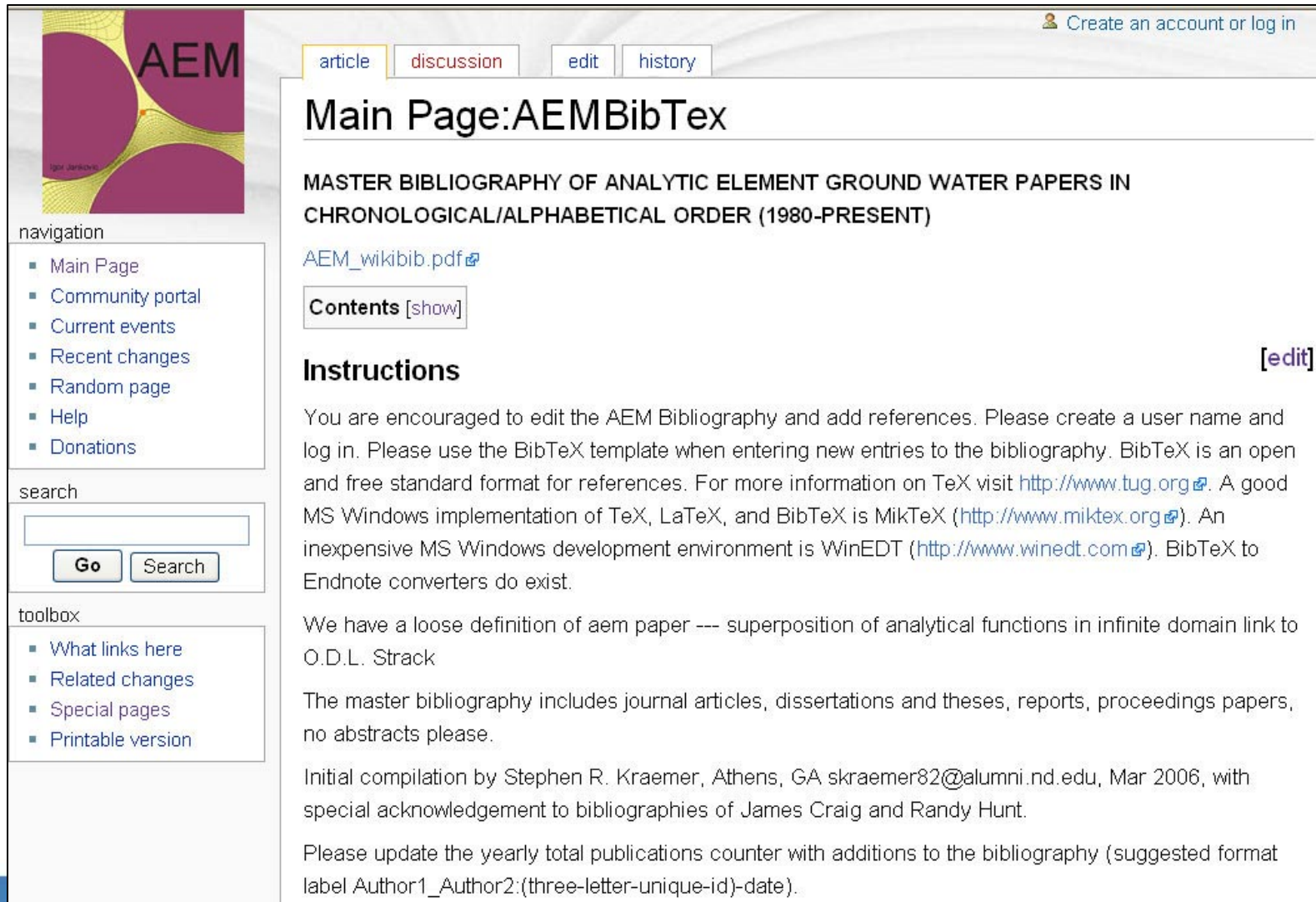U. Waterloo
Dept. Civil Engineering

The evidence for progressive program

- Citation records
- ISI web of science
- Dialog Corporation SciSearch database
- Google Scholar
- ICAEM proceedings
- Randy Hunt, James Craig literature reviews

Assembled a master bibliography www.analyticelements.org/wiki

AEM wikibib – BibTeX format

2006 [edit]

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% (61 total publications: 23 journals, 37 proceedings, 0 dissertation/thesis, 1 reports, 0 book)
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@article{Anderson_Mesa:bar-2006,

Author = {E.I. Anderson and E. Mesa},

Title = {The effects of vertical barrier walls on the hydraulic control of contaminated groundwater},

Journal = {Advances in Water Resources},

Volume = {29},

Number = {1},

Pages = {89-98},

Keywords = {groundwater; analytic; remediation; vertical barriers; conformal mapping; capture zone; WELLS; CONTAINMENT; AQUIFER},

Year = {2006}

}

@article{Bakker:int-2006,

Author = {M. Bakker},

Title = {Analytic solutions for interface flow in combined confined and semi- confined, coastal aquifers},

Journal = {Advances in Water Resources},

Volume = {29},

Number = {3},

Pages = {417-425},

Keywords - {interface flow; analytic solution; semi-confined; seawater intrusion; submarine groundwater discharge systems}

RESEARCH & DEVELOPMENT

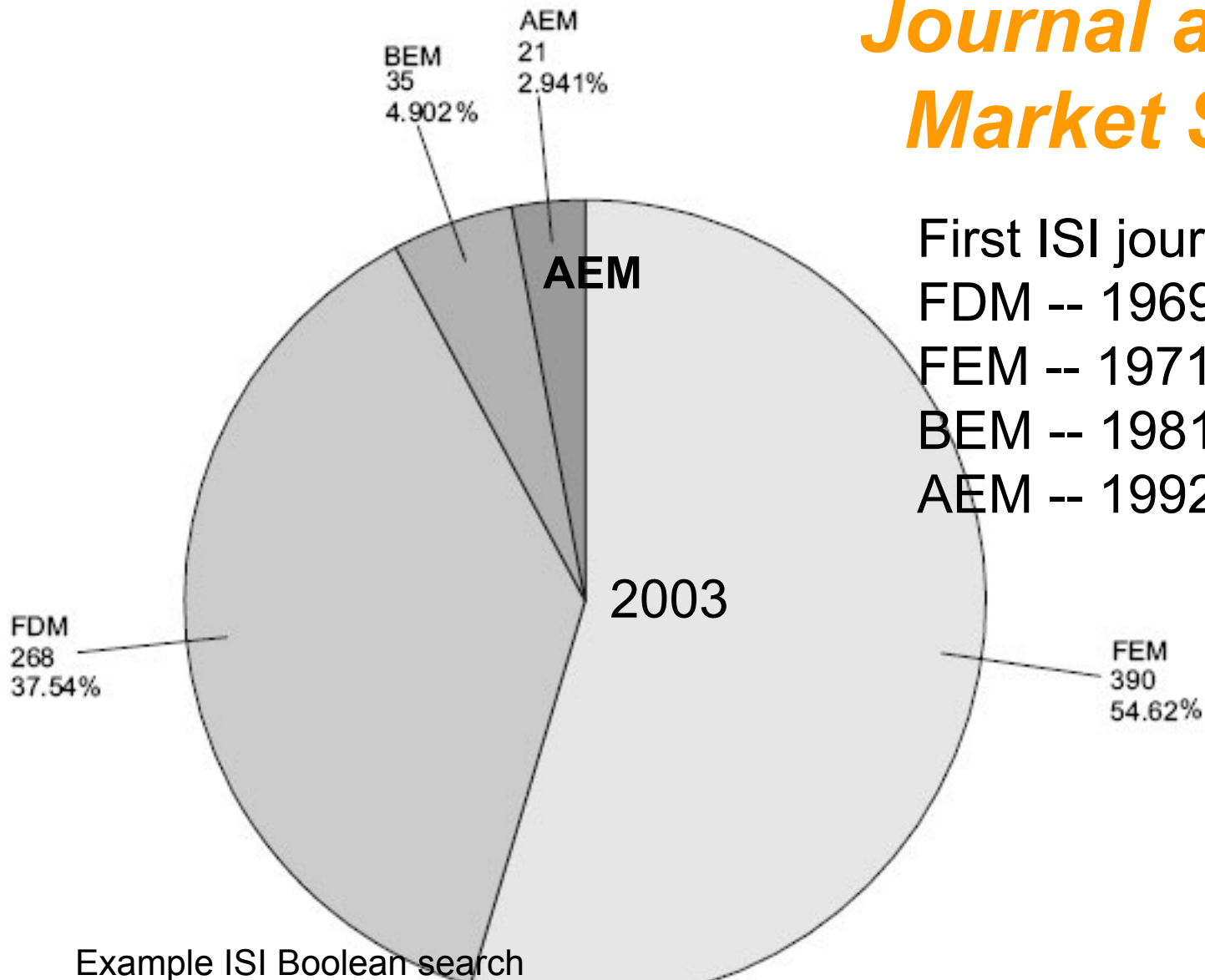*Building a scientific foundation for sound environmental decisions*

AEM wikibib

pdf master bibliography

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Journal articles Market Share

First ISI journal reference:
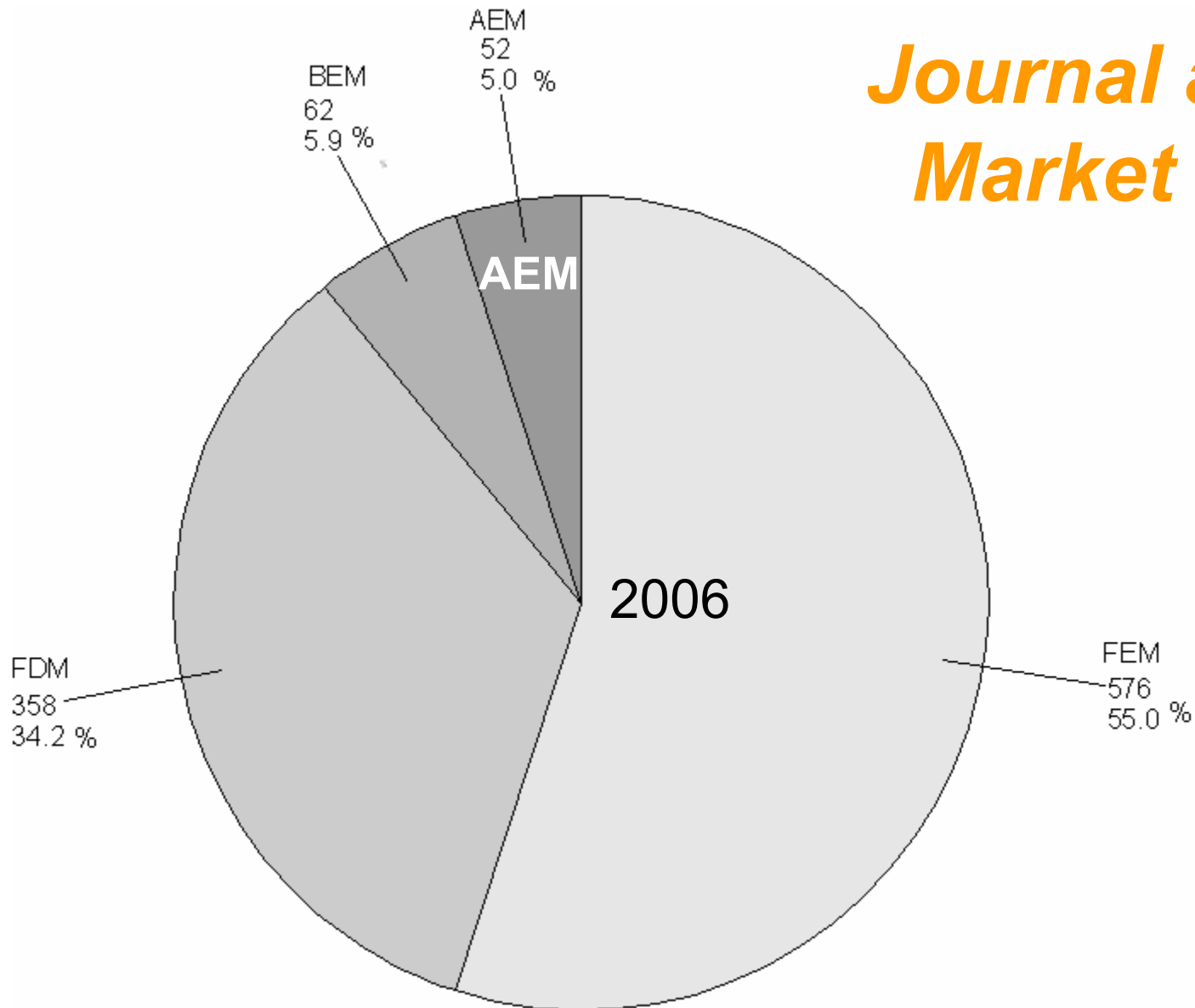FDM -- 1969
FEM -- 1971
BEM -- 1981
AEM -- 1992

Pie chart labels:
- AEM 21 2.941%
- BEM 35 4.902%
- AEM
- FDM 268 37.54%
- 2003
- FEM 390 54.62%

Example ISI Boolean search
analytic element AND (groundwater OR ground water OR ground-water)

Journal articles Market Share

AEM
52
5.0 %

BEM
62
5.9 %

AEM

2006

FDM
358
34.2 %

FEM
576
55.0 %

Example ISI search
analytic element AND (groundwater OR ground water OR ground-water)

Publications trends
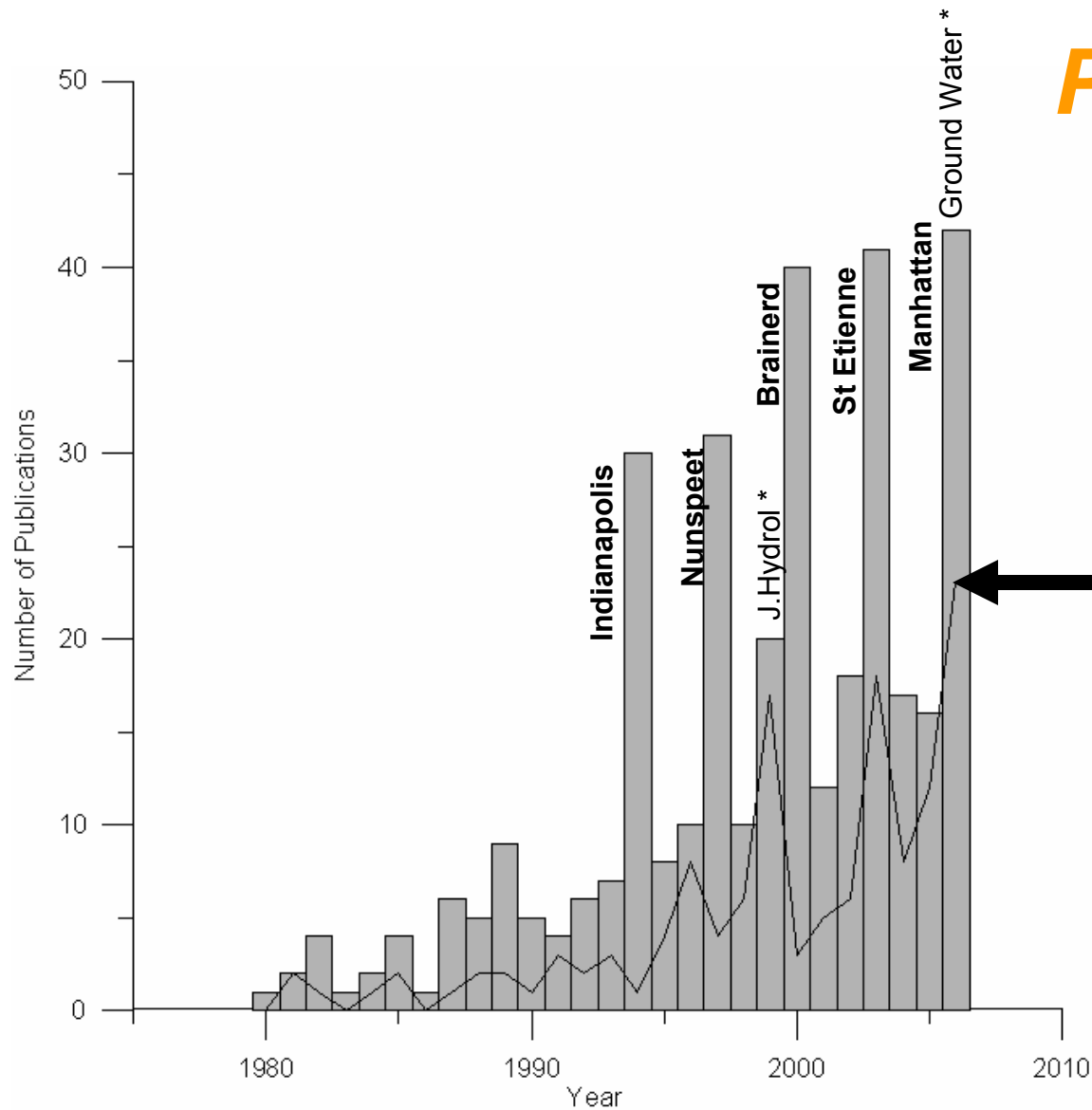
journal articles

* special journal issue that year

Citation	Times Cited	Citations per year	Description
(Strack 1989b)	182	10.7	book Groundwater Mechanics
(Haitjema 1995a)	57	5.2	book Analytic Element Modeling of Groundwater Flow
(Haitjema 1985)	36	1.7	article Modeling 3D flow in confined aquifers
(Strack 1984)	34	1.5	article 3D streamlines in DF model
(Strack and Haitjema 1981b)	32	1.3	article Modeling double aquifer flow using distributed singularities 2.
(Jankovic and Barnes,1999)	29	4.1	article 2D flow thru large no. inhomogeneities
(Barnes and Jankovic 1999)	27	3.9	article 3D flow thru large no. spherical inhomogeneities
(Strack and Haitjema 1981a)	20	0.8	article Modeling double aquifer flow using distributed singularities 1.
(Haitjema and Kraemer1988)	20	1.1	article Analytic function for modeling partially penetrating wells
(Bakker and Strack 1996)	19	1.9	article Capture zone delineation in 2D groundwater flow models

AEM Top Ten

www.analyticelements.org

Take Home Message

Once again, the AEM research program, while relatively young in comparison to FEM, FDM, is active and progressive.

"All things excellent are as difficult as they are rare."
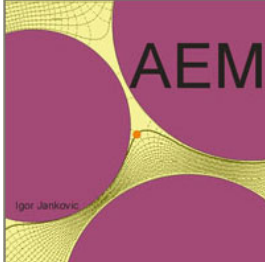--- Baruch Spinoza
17th Century Dutch Philosopher

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AEM

Igor Jankovic

AEM wikipedia
USEPA CEAM
USACOE RDC
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Haitjema Consulting LLC
Wittman Hydro Planning Associates
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NAGROM (in Dutch)

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Webmeister: Stephen Kraemer Ph.D.

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ANALYTIC ELEMENT MODELING COMMUNITY HOMEPAGE

News

The 5th International Conference on the Analytic Element Method (ICAEM) will be held at Kansas State University in Manhattan, KS, USA, from May 14 to May 18, 2006. Go to ICAEM website.

Look for the special issue of the journal GROUND WATER with an analytic element theme to be published in January 2006 (Vol 44, No. 1). Go to
National Ground Water Association.

Our Mission

The Analytic Element Community is a group of researchers and government agencies that are working together to create mathematical models using the Analytic Element Method (AEM). The AEM is a technique for solving problems in continuum mechanics that is based on the superposition of analytical functions and requires no discretization of the model space. AEM was originally created for use in **GROUNDWATER FLOW** modeling.

The goals of the Analytic Element Community website are to encourage the application and development of the analytic element method by:

- Providing a center of information exchange for AEM researchers, developers, and users.
- Providing links to the latest AEM codes, including open-source efforts.

RESEARCH & DEVELOPMENT

Building a scientific foundation for sound environmental decisions