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Nov 17, 2006

Dr. John Richter
Jordan Valley Animal Clinic
800 W. Water Street
East Jordan, MI 49727

Dear Dr Richter;

Enclosed please find a draft proposal for our work on the Jordan River. Sorry this has taken so long but it has been a chaotic semester for the three of us, Murphy's Law is alive and well! Please look over the proposal to insure that we have addressed your questions. If not please get back to us and we will modify the proposal.

Note that we have **NOT** passed this through the MSU Grants and Contracts Office, as we wanted to insure that we addressed all of your questions first and additionally we have assumed a 20% overhead in our preliminary budget. University overheads typically range for 10 to 50% so we are not assured of this 20%. If you have had other contracts with specific overhead values please let us know so we can use that information to negotiate the lowest possible value.

Looking forward to your response.

Cheers,

Warren

Warren W. Wood Ph.D. (MSU 59, 61, 69)
John Hannah Professor of Integrative Studies
Visiting Lecturer, Oxford University Centre for the Environment,
School of Geography, Oxford, UK
Scientist Emeritus -- U. S. Geological Survey, Reston, VA, USA

JORDAN RIVER WATERSHED PROPOSAL

RESEARCH TEAM

- Dr. David W. Hyndman – Hydrogeologist; land use and climate impacts on hydrologic cycle.
- Dr. Remke L. Van Dam – Geophysicist; reconstruction of delta sedimentary architecture.
- Dr. Warren W. Wood – Hydrogeochemist; dating methods.
- A highly motivated and skilled graduate student.

SUMMARY OF PROPOSED RESEARCH

The Jordan River Watershed of Michigan is a unique natural laboratory to examine the influences of land cover and climate changes on a stream ecosystem. In the mid 1800's this region was dominated by mature old-growth forests, and the river had large quantities of Grayling trout, which rely on a gravel bottom channel for spawning. Based on anecdotal records we know that the area was logged and experienced significant fires from the 1880's to the 1920's. During this period, there were also many attempts to develop agriculture in the basin. The Jordan River system is now transporting large quantities of sand, which brings into question whether this sand mobility is a post-development phenomenon, and if so what are the sediment sources. In this research study, we propose to first evaluate the historic sediment loads by characterizing the deltaic deposits in the South Arm of Lake Charlevoix. We will then measure actual sediment and water fluxes throughout the watershed. We will use this information to test hypotheses about the causes of any observed changes in sediment transport regime including deforestation, fires, landslides, agricultural development, and irrigation.

RESEARCH OBJECTIVES

In the proposed research we will address several questions of interest to the Friends of the Jordan:

1. *What did the predevelopment channel look like and what were its characteristics?* To answer this question we will use a combination of stratigraphic studies and dating of deltaic sediments. We also plan to collect cores to identify dateable material from locations further offshore and in the wetland directly southeast of the current delta. This will allow us to predict the sediment load of the Jordan River in both pre- and post logging periods.

2. *What is the rate of sediment movement through this system (upper vs. lower)? How much is transported at different flow rates? How much bedload is there in this system? What is the operation or stream potential (how much sediment can the stream carry)?* We will measure the velocity structure and channel geometry for different flow stages in several reaches of the river, and during select flow measurements we will measure sediment transport using bedload and suspended sediment samplers. At key points of selected river reaches we will install pressure transducers for continuous monitoring of flow stage. We will resurvey a

transect along the entire river bed to improve the gradient estimates that are currently available from the DNR. Using the known variability in flow velocity and discharge we will quantify the maximum transport capacity of different stretches of the river. This combination of model estimates and data on flow characteristics and sediment transport, and will be used to evaluate historical sediment transport rates in the Jordan River.

3. *Has the amount of bedload transport been affected by development?* Development in the Jordan River watershed was dominated by forestry and logging. In addition, the watershed has experienced fires and landslides (both of which can have natural and anthropogenic causes). We will use models of hillslope erodibility to estimate the effect of logging on sediment availability. In addition we will investigate the potential effects of landslides and fire on sediment load to the river.

4. *What are the origins of the sediments (boiling springs, road development, agriculture, deforestation, forest fire, landslides, Great Lakes levels, etc...)?* Some research suggests that the Jordan River occupies part of an extensive system of subglacial tunnel valleys (Lundstrom et al., 2004) in (Farrand and Bell, 1982); other research indicates that the material is gravel and sand of lacustrine (lower reaches) and outwash (upper reaches) origins (Hay and Meriwether, 2004). In either case it seems likely that the sediment in the current riverbed largely has a glacial or glaciofluvial origin. We will look at historical records, local quarries and exposures to study potential human impacts on the sediment availability to the river. We will also use models to quantify the effect of different anthropogenic influences on the sediment availability.

5. *What can the sediments tell us about the past?* The relative small size of the Jordan River catchment and the presence of a clearly defined depositional area at the mouth allow us to characterize and date material that has been transported by the river. The relative location of deposits in the lake and the river valley will give us information about the paleo-levels of Lake Charlevoix and Lake Michigan. The internal structure of the deltaic deposits will allow us to delineate different stages of sediment deposition and evaluate potential linkages between deposition rate and development events or stages across the watershed. We will use C14 and OSL dating techniques to constrain the timing of depositional events. We also hope to analyze pollen from cores collected from shallow and sheltered areas of Lake Charlevoix or from inland wetlands, to provide a pilot dataset containing information about changes in regional vegetation and landcover. If this pilot test is successful, it would provide the basis for additional work in the Jordan River watershed funded by other agencies.

6. *Did a natural or stable river ever exist - did a gravel bottom river exist some time period - predevelopment - 1800's? If humans have had an effect on the transport of sediments, can it be reversed? If so, how?* Our proposed research will provide the foundation of knowledge necessary to address these questions with future research. We plan to seek additional funds from research agencies such as the National Science Foundation for such efforts.

7. *What could a future state of the system be under different management?* Through the proposed research, we would gain knowledge about past environments and conditions. This would provide the necessary basis of knowledge to evaluate the effects of recent changes in

the system. We believe that the proposed research would allow us to make recommendations that would improve the management of the Jordan River watershed.

WATERSHED DESCRIPTION

The Jordan River watershed covers approximately 329 square kilometers of Antrim and Charlevoix counties. The 37 kilometer length of this river experiences a vertical drop of approximately 148 meters. Based on landforms, elevations, surficial geology, and riparian characteristics, the watershed can be divided in three sections: The Upper Jordan River, the Lower Jordan River, and Deer Creek, which is the largest of 29 named tributaries (Hay and Meriwether, 2004). The Jordan River is dominated by influx of groundwater due to the large recharge rates in the sandy and gravelly glacial sediments of the watershed. This recharge results in relatively constant temperatures and steady baseflow throughout the year (Wiley et al., 1997).

Based on published research on the glacial and postglacial evolution of Northern Michigan we can categorize four main stages in the development of the Jordan River valley and surrounding areas: 1) subglacial drainage, 2) proglacial drainage, 3) lacustrine environments, and 4) groundwater-fed streams.

Subglacial drainage

Towards the end of the last glaciation, when Northern Michigan was still covered with ice, meltwater accumulated underneath the glaciers and transported it towards the ice margin in the southeast. The subglacial tunnel valleys that were formed scoured out deep valleys, now partly occupied by many of the lakes in the Charlevoix region (Figure 1). Major parts of the Jordan River valley (probably at least up to the change in direction E-W to S-N near Pinney Bridge Rd and M-66) form part of this subglacial drainage network. It is expected that due to the large stream power of these rivers the bottom texture would have been gravels (sand-size and finer sediment would have been transported and deposited further downstream).

Proglacial drainage

As the glaciers receded, large volumes of sediment were deposited in glaciofluvial outwash plains that contain gravelly and sandy sediments, deposited by braided channels. In the Jordan River watershed the broad, flat area southeast of the upstream portions of the river can be characterized as outwash plain deposits. Isostatic rebound of the glacial terrain followed glacial retreat, which may have incised streams such as the Upper Jordan River.

Lacustrine environment

Proglacial lake deposits during Lake Algonquin stage inundated significant portions of current Lake Charlevoix and the Jordan River valley (Farrand and Bell, 1982). In addition, Holocene high stands of Lake Michigan may have caused the Jordan River valley to drown again. It is now well documented that during the Nippising Stage, Lake Michigan Valley was several meters higher than its current level (e.g., Fisher and Loope, 2004). Detailed stratigraphic studies of wave-cut cliffs, terrace levels, and internal structures of the sediments in the lower reaches of the Jordan River valley document this stage in more detail.

Groundwater-fed stream

The current Jordan River seems to be an underfit stream (the stream is too small for its large valley). Based on our current understanding of the evolution of the Jordan River Valley, it seems likely that the current stream occupies a valley that was largely shaped during late-glacial and early post-glacial time. We will explore whether the current Jordan River is in disequilibrium with its bed. We will also conduct detailed surveys of the bed height / thalweg / water level across different segments of the channel, which will provide insight into flow and sediment transport mechanisms.

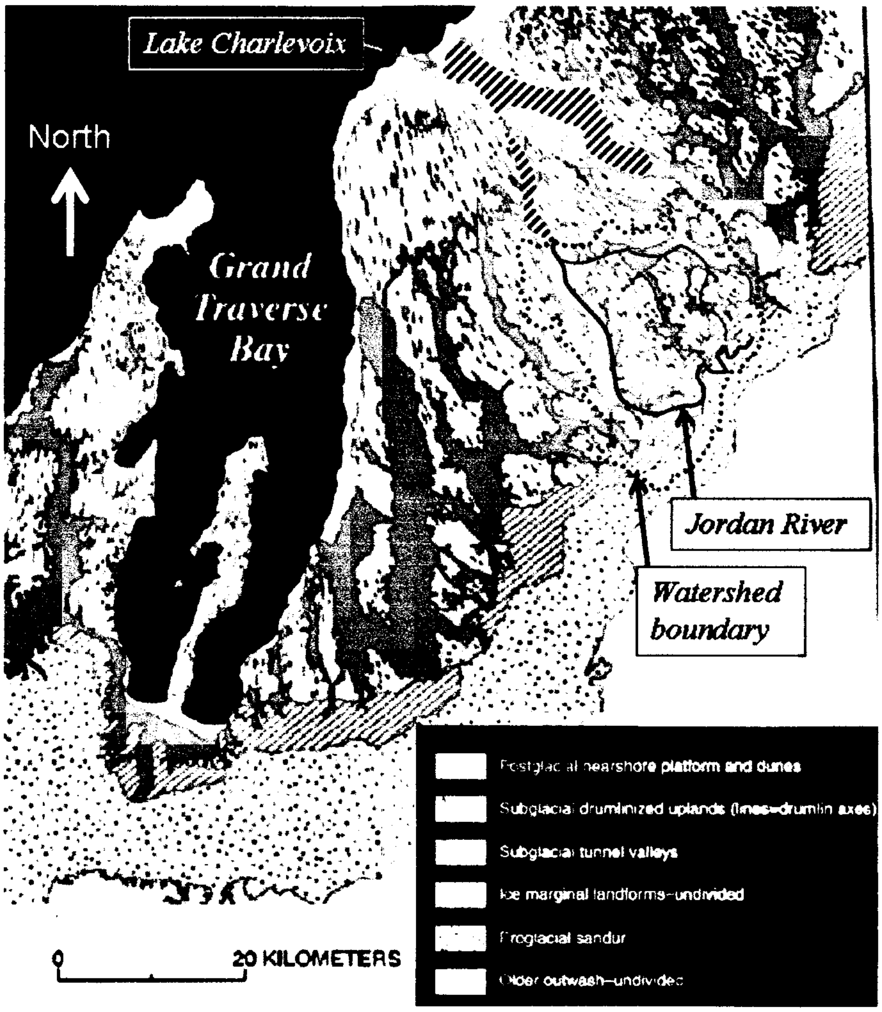

Figure 1. Map of the geomorphological units in the Grand Traverse Bay region, including the Jordan River watershed and Lake Charlevoix (after Lundstrom et al., 2004).

TASKS

Characterize Watershed and Sediment Sources (Year 1)

The first phase of the project will be to perform an extensive literature study and data mining to provide constraints on the late-glacial and early post-glacial history of the watershed, including isostatic rebound. In addition, we will use agriculture census data, air photos, and other information to evaluate changes in land management and irrigation. We will enter these data into a regional GIS database, in order to facilitate data integration in later stages of the project. One component of this is task is to digitize and rectify all available air photos for the area beyond those that have already been processed in this manner. We will also engage local citizens to help document the historical land use and hydrology of the region.

An important component of this first task of the project involves the characterization of the sediment sources. We will evaluate the geomorphology of the sand sources - including landslides - and investigate why there are trees in only some sections of the channel. Also, we will examine the sedimentology of quarries in the watershed, and the significance of a potentially burnt layer or soil horizon that we recently identified in a deposit that is exposed in the gravel pit off Old State Road.

Characterize Deltaic Sediments (Years 1 and 2)

Sediments transported along river channels normally get deposited in locations where the transport capacity significantly decreases. The deltaic sediments at the mouth of the Jordan River in the southern tip of the South Arm of Lake Charlevoix, provide access to a significant and important portion of the historical record of the Jordan River watershed. Characterizing these deposits will help us understanding changes in the historical behavior of the river. We will use electrical resistivity tomography to estimate the depth to bedrock and the volume of Wisconsin age sediments in the tunnel valley underlying the current delta. In recent deltaic deposits, we will identify major stratigraphic units and estimate sediment volumes within each deposit using three-dimensional ground-penetrating radar surveys, interpretation of vibracores, with selective dating of stratigraphic boundaries using optically stimulated luminescence (OSL) and C-14 AMS techniques. Similarly, further offshore in the central portion of the South Arm of Lake Charlevoix, we will collect a few cores from a pontoon boat or the ice surface when the lake is frozen to help constrain the timing of significant periods of sediment flux, as well as the effect of lake level variations on the history of the delta and river sedimentation (Fisher and Loope, 2005).

To link the depositional record in the delta with processes in the headwaters of the Jordan River watershed, we will use hillslope erosion models to estimate how much sediment is transported from the hillslopes to the channel after events like deforestation, fire, or landslides in different areas of the watershed or delta (Ahnert, 1987; Lane et al., 1995; McNabb and Swanson, 1990). These models combine slope characteristics (steepness, vegetation type, soil type) with transport variables (runoff amount, time) to calculate erosion. In addition, we will estimate long-term watershed-wide sediment yield using the early postglacial landscape as input (Lane et al., 1997; Luo et al., 2004). Discrepancies between estimates of river transport rates and the corresponding offshore deposits will be examined to determine if additional anthropogenic events need to be incorporated into the models to account for the observed sediment volumes in the delta. In these comparisons we will consider the option that a significant portion of the delta deposition in recent decades is related to a decline in lake level since the 80's.

Characterize Channel Sediments and Flows (Years 1 and 2)

To characterize and understand processes of water flow and sediment transport in the channel we will conduct several monitoring campaigns. We will develop the baseline for the study by surveying the entire length of the channel and some cross sections with a survey grade GPS system. This will provide the detailed information necessary to identify breaks in the channel slopes, some of which may be caused by recent events, such as landslides and diversions.

We will measure the velocity structure and channel geometry using an Acoustic Doppler Current Profiler (ADCP) and standard USGS wading techniques in several reaches of the river during a range of flow stages. At some of these locations with distinct characteristics, pressure transducers will be installed to continuously monitor water level on an hourly basis. This will allow us to develop stage discharge relationships for each site. During our survey campaign, we will also collect multi-parameter data on temperature and pH throughout the stream channel. We will acquire records through time from the USGS gage station and cross section and integrate the data from newly installed stream level and temperature gages.

At different times during the year and various locations in the stream we will collect data using bed- and suspended sediment samplers to estimate the rate of sediment transport at key reaches of the Jordan River. We will also photograph and survey the Pinney bridge sand trap before and after major flood events, and before and after the annual sediment removal. Using information from Antrim County, we will quantify the mass of sediment removed since the construction of the sand traps.

Based on the measurements of water flow and sediment flux and channel geometry, we will develop simple models of sediment flux through the watershed (source areas, channel, and depositional area) to understand and quantify behavior. This will be achieved during years 2 and 3 using field data obtained in Years 1 and 2.

Develop Integrated Model of Water Flux from Precipitation to Streamflow (Years 1, 2, 3)

We will develop an integrated model of the hydrologic cycle for the entire Jordan River groundwater and surface water source areas to evaluate changes in stream flow that occurred in response to historical changes in land cover. We have recently developed the Integrated Landscape Hydrology Model (ILHM) in order to examine the influence of both land cover and climate changes on groundwater recharge rates and stream flows. This proposed research would use this code to test hypotheses of the influence of forest clearing, agricultural development and irrigation on historic stream flows in the Jordan River (Hyndman et al., in press). The model is a fully distributed and process-based simulation that uses readily available climate, geology, soils, and land cover information to predict the temporal and spatial variations in flows to groundwater and directly to streams. By examining the modeled response to different land covers based on historical information, we will be able to assess the effect of anthropogenic alterations to the landscape on streamflow, which is related to its ability to transport sediment. The predicted water flows will also be used in the simple sediment transport models discussed above. In addition, this model provides a tool to project the influence of future changes in climate and land use under different management scenarios, on stream flows in the Jordan River.

Integrate Findings (Year 3)

In the final phase of the project we will integrate data from all stages of the project (regional geology, late-glacial and post glacial evolution, sedimentary record, and models of water flux and sediment transport) to present a coherent image of the effects of recent changes on the behavior and characteristics of the Jordan River. The results of our research will ultimately allow us to understand the likely influences of land use changes on the sediment budget for the Jordan River Watershed.

Results from the project and new research questions developed during this research will be used to apply for additional grants from national funding agencies to continue work in the Jordan River. We expect this project will result in a Masters thesis or several chapters in PhD student dissertation. We will also publish several articles using the results from our research in the Jordan River watershed in peer-reviewed scientific literature, and will present the work at international and regional conferences. In addition, we hope to hope to address several broader issues including:

- How do longer term cycles in climate influence stream stability and transport rates? Are there links between these transport rates and indices such as the North Atlantic Oscillation (NAO) and El Nino?
- Can we better interpret trends of post-glacial isostatic rebound and lake level variations using organic material from the South Arm of Lake Charlevoix
- How do the results from this study apply to surrounding areas of Michigan and the Great Lakes region?

BUDGET

	'07 Rate (starting 2007)	Year 1 2007-2008 Units	Year 1 2007-2008 Total	Year 2 2008-2009 Units	Year 2 2008-2009 Total	Year 3 2009-2010 Units	Year 3 2009-2010 Total	GRAND TOTAL Total
Salaries								
David Hyndman (Sum Sal)	$90,300	33.3% of US07	$10,033	33.3% of US08	$10,535		$0	$20,568
Remke van Dam (Sum Sal)	$68,250	33.3% of US07	$7,583	33.3% of US08	$7,963		$0	$15,546
Graduate student (1/2 time, 12 mo yr 1 & 2)	$10,092		$20,184		$21,193		$0	$41,377
Student Hourly			$2,000		$2,100		$2,205	$6,305
Total Salary			**$39,801**		**$41,791**		**$2,205**	**$83,796**
Fringe benefits								
Remke van Dam (Sum Sal)	7.65%		$580		$806		$0	$1,386
David W Hyndman (Sum Sal)	7.65%		$768		$609		$0	$1,377
PhD student (fixed rate)			$1,770		$1,912		$0	$3,682
Student Hourly (AY only)			$0		$0		$0	$0
Total Fringe			**$3,118**		**$3,327**		**$0**	$6,445
Total Salaries & Fringes			**$42,918**		**$45,118**		**$2,205**	$90,241
Equipment								
Echo depth sounder			$2,000		$0		$0	$2,000
Pressure temp samplers (4 @ $270)			$1,080		$0		$0	$1,080
Total equipment			**$3,080**		**$0**		**$0**	$3,080
Materials and Supplies								
Geophysical equipment maintainance			$1,500		$2,000		$0	$3,500
Boat rental			$500		$0		$0	$500
Field supplies			$3,000		$2,000		$500	$5,500
Dates (C14 and OSL) =(20*$200 + 12*$750)			$9,000		$4,000		$0	$13,000
Vibracore supplies (core tube)			$2,000		$0		$0	$2,000
Publication Costs			$0		$500		$1,000	$1,500
Total Materials and Supplies			**$16,000**		**$8,500**		**$1,500**	$26,000
Travel:								
Travel EL-JR: 8 trips Year 1 and 6 trips in year 2								
Each 3 day trip for 2 people =(500miles *$0.42)+$405								
food and lodging			$4,920		$3,690		$0	$8,610
Domestic Travel - Present results at conferences			$0		$1,500		$2,000	$3,500
Total Travel			**$4,920**		**$5,190**		**$2,000**	$12,110
Tuition Waiver								
PhD & MS (9 credit/semester/student)			**$8,430**		**$9,062**			$17,492
Total direct cost			$75,348		$67,870		$5,705	$148,923
Indirect Cost (20%-Negotiating Rate)								
minus equipment minus tuition waiver			$12,768		$11,762		$1,141	$25,670
Total Cost			$88,116		$79,631		$6,846	$174,593

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Wiley, M. J., S. L. Kohler, and P. W. Seelbach, 1997, Reconciling landscape and local views of aquatic communities: lessons from Michigan trout streams: Freshwater Biology, v. 37, p. 133-148.

BIOGRAPHICAL SKETCH – DAVID W. HYNDMAN

Department of Geological Sciences, Michigan State University, East Lansing, MI 48824
Ph: (517)353-4442 FAX:(517)353-8787 email: hyndman@msu.edu

EDUCATION:

Ph.D.	Stanford University,	Dept. of Geological & Environ. Sciences	Hydrogeology	1995
M.S.	Stanford University,	Dept. of Applied Earth Science	Hydrogeology	1993
B.S.	University of Arizona,	Dept. of Hydrology and Water Resources	Hydrology	1989

PROFESSIONAL EXPERIENCE:

Associate Professor	Michigan State University, Dept. of Geological Sciences	2000 - present
Assistant Professor	Michigan State University, Dept. of Geological Sciences	1995 - 2000
Research Assistant	Stanford University, Hydrogeology Research Group	1990 - 1995
Hydrologist	United States Geological Survey, Water Resources Div.	1988 - 1992

AWARDS:

Elected Fellow, Geological Society of America	2006
Darcy Distinguished Lecturer (National Ground Water Association)	2002
Team member – NGWA Outstanding Remediation of the Year Project Award	2002
Ronald W. Wilson Teaching Award	2001
Editors Citation for Excellence in Refereeing for Water Resources Research	2000
Lilly Teaching Fellow, Michigan State University	1997
Superior Performance Award, U. S. Geological Survey	1989
Special Achievement Award, U. S. Geological Survey	1988

SELECTED PROFESSIONAL ACTIVITIES:

Panel Member for both DOE and NSF	2006
Associate Editor: Ground Water	1997 - present
American Geophysical Union, Near Surface Geophysics Committee	2006-present
American Geophysical Union, Hydrogeophysics Committee	2004-present
Executive Committee, MSU Water Science Center	2004-present
Associate Editor: Water Resources Research	2000 – 02 & 2004-05
Darcy Lecturer Selection Committee (chair, 2005)	2003-05
Accreditation Review Expert, Center for Hydrogeology, Neuchâtel, Switzerland	2004
AIH Distinguished Lecturer, One week short course in Novi Sad, Serbia	2004
Scientific Advisory Committee, MODFLOW 2004 Conference, Carlsbad, Czech Republic	2004
Consortium of Universities for Hydrological Sciences, Board Member	2002-04
Technical Committee, MODFLOW 2003 Conference, Golden Colorado	2003
NATO Hydrogeophysics ASI workshop, Invited presentation, Trest, Czech Republic	2003
Panel Participant (Complexity vs. Simplicity in models), Golden, Colorado	2003

SELECTED PUBLICATIONS:

Hyndman, D.W., K. Singha, and F. Day-Lewis eds., 2007, *Data Integration in Subsurface Hydrology*, AGU Monograph.

Jayawickreme, D. H., and D.W. Hyndman, (in press), *Evaluating the Influence of Land Cover on Seasonal Water Budgets using NEXRAD Rainfall and Streamflow Data*, Water Resources Research.

Kendall, A. D., and D.W. Hyndman, (in press), *Examining Watershed Processes Using Spectral Analysis of Hydrologic Time Series*, AGU Monograph, Data Integration in Subsurface Hydrology.

Bennett, G. L., G. S. Weissmann, G. S. Baker, and D. W. Hyndman, 2006, *Regional-scale assessment of a sequence bounding paleosol on fluvial fans using ground penetrating radar, eastern San Joaquin Valley, California.*, GSA Bulletin, 118, p. 724–732; doi: 10.1130/B25774.1.

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SYNERGISTIC ACTIVITIES:

- I developed active learning strategies for large undergraduate courses that are currently being used to teach between 800-1200 students per year at MSU.
- I integrate my research into graduate and undergraduate courses, by presenting students with field and lab data and having students evaluate rates and processes based on the data.
- I involve undergraduate and graduate students in all aspects of my research from field data collection to numerical model development and testing.
- My Darcy Lecture tour allowed me to share our multidisciplinary approach and our important research results to diverse audiences in 58 locations across 12 countries.

BIOGRAPHICAL SKETCH – REMKE L. VAN DAM

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Michigan State University
East Lansing, MI 48824
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EDUCATION:

Free University Amsterdam	Earth Sciences	Ph.D.	2001
Utrecht University	Physical Geography	M.Sc	1996
Binghamton University	Semester of Fluvial Sedimentology		1996
Utrecht University	Physical Geography	B.Sc.	1991

APPOINTMENTS:

Assistant Professor	Michigan State University, Dept. of Geological Sciences	2006 - present
Postdoc. Res. Assoc.	New Mexico Tech, Dept. of Earth & Environmental Sc.	2002 - 2005
Visiting Scientist	University of Auckland, New Zealand	2002
Research Assistant	Free University Amsterdam, The Netherlands	1997 - 2001
Staff Scientist	Royal Boskalis Westminster, The Netherlands	1997
Internship	National Geologic Survey (TNO), The Netherlands	1995 - 1996
TA/RA	Free University Amsterdam, The Netherlands	1997 - 2000
TA/RA	Utrecht University, The Netherlands	1994 - 1996

SELECTED PUBLICATIONS

Young, R.A., Staggs, J.G., Slatt, R.M. and Van Dam, R.L. Submitted. *An Application of 1-D Convolutional Modeling to Interpretation of GPR Profiles - Turbidite Sandstone Channel 1, Lewis Shale, Wyoming.* Journal of Environmental and Engineering Geophysics.

Van Dam, R.L., Borchers, B., and Hendrickx, J.M.H. 2006. *Effect of magnetite on GPR detection of buried landmines.* The international Society for Optical Engineering, SPIE.

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EDUCATION:

Michigan State University	Geology and Hydrogeology	Ph.D.	1969
Michigan State University	Geology and Geophysics	M.S.	1961
Michigan State University	Geology	B.S.	1959

APPOINTMENTS:

2003-09 John Hannah Professor of Integrative Studies, Mich. State Univ.
2000-09 Visiting University Lecturer, Oxford University, UK
2003-09 Scientists Emeritus US Geological Survey, Reston, VA
2002 -06 Guest Professor, China University of Geoscience, Beijing, China
1996-02 Editor-in-Chief, *Ground Water*
1981-03 Research Hydrologist, U. S. Geological Survey, Reston, VA
1978-81 Associate Professor, Dept. of Geosciences, Texas Tech Univ., Lubbock, TX
1977-78 Assistant Chief, Office of Radiohydrology, USGS, Reston, VA
1972-77 Adjunct Professor, Dept. of Geosciences, Texas Tech Univ., Lubbock, TX
1970-77 Hydrologist, U. S. Geological Survey, Lubbock, TX
1964-70 Hydrologist, U. S. Geological Survey, Lansing, MI
1961-63 Geophysicist, Michigan State Highway Department, Ann Arbor, MI

SELECTED PUBLICATIONS

RICH, J., STOKES, S., WOOD, W.W., and BAILEY, R., *2003, Optical dating of tufa via in-situ aeolian sand grains: A case example form the Southern High Plains, USA*, Quaternary Science Reviews v 22 p. 1145-1152.

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WOOD, W. W., and IMES, J. L., 2003, *Dating of Holocene ground-water recharge in the Rub al Khali of Abu Dhabi: constraints on global climate-change models*; in Water Resources Perspectives: Evaluation, Management and Policy, A. S. Alsharhan and W. W. Wood, Eds., p379-385, Developments in Water Science 50, Elsevier, Amsterdam 385p.

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WOOD, W. W., RAINWATER, K. A, and THOMPSON, D. B., 1997, *Quantifying macropore recharge: examples from a semi-arid area;* Ground Water, v. 35, no. 6, p. 1097-1106.
WOOD, W. W., and SANFORD, W. E., 1995, *Eolian transport saline lake basins, and groundwater solutes*; Water Resources Research, v. 31, p. 3121-3129.
SANFORD, W. E., and WOOD, W. W., 1995, *A paleohydrologic record from lake brine on the Southern High Plains*; Geology, v. 23, p. 229-232.
WOOD, W. W., and SANFORD, W. E., 1995, *Chemical and isotopic methods for quantifying ground-water recharge in a regional, semi-arid environment*; Ground Water, v. 33, no. 3, p. 458-468.
WOOD, W. W., and IMES, J. L., 1995, *How wet is wet? Constraints on late Quaternary climate in southern Arabian Peninsula;* Journal of Hydrology, v. 164, p. 263-268.

SYNERGISTIC AND PROFESSIONAL ACTIVITIES:

Advisory/Review Academic

Chair, Review Committee King Fahd University of Petroleum & Minerals (KFUPM) 2005
Advisory Committee to Dept. of Geological Sciences, Virginia Tech (2000 to 2003)
Advisory Committee of the Dept. of Geosciences, Michigan State Univ. (1988-2000)
Scientific Review Committee, Center of Excellence, Univ. of Waterloo (1988-92)
Reviewer of NSF, NSERC, Israel Academy of Science and other (2 to 4/year)

AWARDS AND HONORS SINCE 1990

2005 Christiansen Fellow, St. Catherine's College, Oxford University, UK
2002 M. King Hubbert Medal, National Ground Water Association.
2002 Invited Speaker, Water Resources in the Third Millennium, Dubai, United Arab Emirates
2001 Invited Speaker, Festival of Ideas, Adelaide, Australia
2001 Adrian Smith Distinguished Lecturer, Univ. of Waterloo, Canada
2000 Commencement Address, Virginia Tech Univ., Dept. of Geological Sciences
2000 Invited Speaker, Zayed Conference on Desertification, Dubai, UAE
1999 Distinguished Service Award in Hydrogeology, Geological Society of America
1998 Christiansen Fellow, St. Catherine's College, Oxford University, UK
1997 Elected Life Membership, National Ground Water Association
1992 Keith Anderson Award, Association of Ground Water Scientists and Engineers
1991 Meritorious Service Award, Department of Interior