

Water Resources Center

Annual Technical Report

FY 1999

Introduction

The Water and Environmental Research Center (WERC) at the University of Alaska Fairbanks (UAF) utilizes the funds from the U.S. Geological Survey, Water Resources Institute Program primarily to support graduate students on projects that have the potential of developing into larger, more comprehensive research efforts. Each year we attempt to fund research projects that will support three to four graduate students. We advertise these opportunities at the three University of Alaska campuses (Fairbanks, Juneau, and Anchorage) and a private school, Alaska Pacific University, in Anchorage. Since the University of Alaska Fairbanks is the primary research university in the state, most research is done on its campus (in the past we have supported students at all campuses).

Expenditures by WERC during the 1999 and 2000 State of Alaska fiscal years (July 1 to June 30) are shown in Table 1. It can be seen that the State of Alaska contribution to the WERC greatly exceeds the 2:1 match required by the U.S. Geological Survey (the required match is \$136,356). State expenditures are spent on the Director's position, partial support for faculty, partial support for five technicians (two for nine months, one for six months and two for three months) and for everyday operation of the Center.

Table 1: Research expenditures by WERC during the 1999 and 2000 State fiscal years.

Fiscal Year	State Expenditures	Restricted Expenditures	Total Expenditures
1999	\$250,054	\$1,889,261	\$2,139,315
2000	\$484,197	\$1,361,200	\$1,845,397

Information dissemination at WERC takes many pathways. First, we actively maintain a website that contains a mission statement, faculty and staff listing, publications, student opportunities, relevant conferences, and WERC seminars (see <http://www.uaf.edu/water/>). Most of our publications are journal articles and are listed in our reprint series on the internet. We also have a report series for those projects that require a final report. We have also sponsored seminars, workshops, and conferences. In May 2000, we co-sponsored the American Water Resources Association conference on "Water Resources in Extreme Environments" in Anchorage, Alaska.

We have added three new research faculty to the WERC in the past 18 months: Dr. Daqing Yang, with expertise in hydrology; Dr. Matt Nolan, with expertise in glaciology and remote sensing; and Dr. Kenji Yoshikawa, with expertise in permafrost hydrology and periglacial geomorphology. In addition, we also have two new faculty members in the Civil and Environmental program that are working in WERC: Dr. David Barnes, with expertise in waste treatment and management, and Dr. Robert Perkins with expertise in human health and chemicals in cold environments. The facilities of WERC are presently undergoing major renovation (May 1, 2000 to August 1, 2001). WERC will have all new offices, work areas, laboratories (including chemical storage and handling) and walk-in environmental rooms from below freezing to above room temperature. In 1998, we received an

equipment grant of \$300,000 from the M.J. Murdock Charitable Trust, with \$115,000 matching funds from the University of Alaska Fairbanks, for the purchase of new analytical equipment. With our new facilities and new analytical equipment, WERC will have the tools to continue with first class water related research.

Research Program

Basic Project Information

Basic Project Information	
Category	Data
Title	Technology to Help Alaskan Mines Clean-up Cyanide Contaminated Water - Pilot Scale Testing of a Sequencing Batch Biofilm Reactor (Year 2)
Project Number	B-02
Start Date	03/01/1999
End Date	02/29/2000
Research Category	Water Quality
Focus Category #1	Hydrogeochemistry
Focus Category #2	Toxic Substances
Focus Category #3	Treatment
Lead Institution	University of Alaska-Fairbanks

Principal Investigators

Principal Investigators			
Name	Title During Project Period	Affiliated Organization	Order
Daniel M. White	Assistant Professor	University of Alaska-Fairbanks	01

Problem and Research Objectives

The purpose of this project is to develop an inexpensive, biological process with which Alaskan mines can detoxify cyanide contaminated water.

Methodology

In 1997 we developed a biological process for treating water contaminated with cyanide. The original research was funded by Ryan Lode Mines. The Ryan Lode Project resulted in a laboratory scale bioreactor (2-liter volume) which was fed cyanide laden wastewater and produced treated water with no measurable cyanide. The results from this study were published in the scientific journal "Water

Research”(White and Schnabel, 1998).

As part of the FY1998/99 Alaska Water Resources Research Institute Programs, this project was funded for two years to test a pilot-scale plant for treatment of cyanide contaminated water. During the first year of the project, the primary goal of “scale-up” was successful. The results from the start-up and operation of a 2000 liter pilot-scale system were presented at the 9th International Conference on Cold Regions Engineering and were published in the conference proceedings (Pilon and White, 1998). Presentations were made to a joint meeting of the Alaska Water Wastewater Management Association and the American Water Resources Association on December 9, 1998 and to the Water and Environmental Research Center on October 16, 1998. In addition, a manuscript was published by the journal “Water Research” on pilot-scale operation of the cyanide treatment system (White, Pilon and Woolard, 1999). In January 2000, the most recent results on the project were presented at the International Symposium on Cold Regions Development in Hobart, Tasmania (White, Zhang and Woolard, 2000). Final results were presented at the American Water Resources Association (AWRA) Spring Specialty Conference, May 1-4, 2000.

Principal Findings and Significance

Overview

Tasks 1 and 2 (except 2.2 and 2.4) have been thoroughly described in a series of four publications (see references). Only the summary conclusion from each task is described below.

Task 1: Determine the feasibility of scale-up for a bench-scale sequencing batch biofilm reactor (SBBR) for the treatment of cyanide.

The bench scale SBBR was tested at a scale factor of 1000 times (2000L). The scale-up testing was successful in that similar rates of cyanide destruction were achieved at the bench and pilot scales with the same basic operating strategy. The tests demonstrated, however, that in order to maintain a sufficiently robust culture of organisms at the pilot scale, a secondary carbon source (glucose) was needed. Although glucose was not observed to increase cyanide removal rates at the bench scale, a similar rate of cyanide destruction was not observed at the pilot scale until supplemental glucose was added to the feed.

Task 2.1: Determine the effect of influent waste stream temperature on the rate of cyanide removal.

The influent temperature of wastewater was varied to determine how the organisms would respond to seasonal and diurnal temperature changes. As expected, the rates of cyanide destruction varied greatly with temperature. The cyanide removal rate was calculated for temperatures of 5, 8, 15 and 20 degrees C. Increases in temperature resulted in an increased cyanide removal rate. The increase in cyanide removal rate, however, was most dramatic for the temperature change from 20-25 ° C. Temperature changes from 5 to 20 ° C resulted in a minor increase in the cyanide degradation rate. The conclusion from this study was that heating cyanide leachate is only practical if the temperature can be increased to 25 ° C.

Task 2.2 Determine the effect of metals on the performance of the reactor.

A few studies have shown that the organisms in biofilm systems accumulate metals to the point of toxicity. Iron, chromium, copper, managanese, and zinc were added to the feed solution of the bench

scale bioreactor at 10 mg/L each for 10 days. The metal concentrations were based on expected concentrations of the metals from a review of the literature on mine waste leachates. Samples of the biomass at the end of the period showed no accumulation of the metals. The cyanide degradation rate was also not affected by the metals. All metals except iron were accounted for in the effluent of the reactor. It was believed that iron oxidized in the aerobic environment and precipitated, remaining in the reactor.

Task 2.3: Determine the effect of influent cyanide concentration on the cyanide removal rate.

Some concentrations of cyanide are toxic to microorganisms. This study demonstrated the maximum cyanide concentration that could be treated by the biofilm system. Influent cyanide concentrations were gradually increased from 10 and 100 mg/L. As with most toxic substrates, the rate of cyanide removal increased with concentration to the point of toxicity, after which point increases in cyanide concentration resulted in a decreased in removal rate. The rate of cyanide destruction was greatest at approximately 40 mg/L but decreased markedly by 100 mg/L.

Task 2.4: Determine the relationship between the biomass concentration in the reactor and the cyanide removal rate.

In general, the more organisms present in a reactor, the faster a contaminant will be removed. Ten batch tests were conducted to relate the cyanide removal rate to biomass concentration. Comparing the ten tests, no correlation was observed between biomass concentration and cyanide removal rate for the biomass concentrations tested (160 mg/L to 240 mg/L). It was hypothesized that no correlation was observed because cyanide was not used directly as a food source by the microorganisms but was destroyed as a defense mechanism. In this scenario, cyanide destruction could be achieved at the same rate by a small population as a large population.

Conclusion

The four tasks established for the project were successfully completed. The most important data was reported in the publications listed in the references.

Descriptors

Gold Mine Reclamation
Biological Detoxification
Cyanide
Sequencing Batch Biofilm Reactor

Articles in Refereed Scientific Journals

White, Daniel M. and William Schnabel, 1998, Treatment of Cyanide Waste in a Sequencing Batch Biofilm Reactor, Water Research, Vol. 32, No. 1, pp.254-257.

White, D.M., T. Pilon and C.R. Woolard, (1999), Biological treatment of cyanide containing wastewater, Water Research, Vol. 34, No. 7, pp. 2105-2109.

White, D.M. and W. Schnabel, (1998), "Treatment of Cyanide Waste in a Sequencing Batch Biofilm Reactor," Water Research, Vol. 32, No. 1, pp. 254-257.

Book Chapters

None to report.

Dissertations

None to report to date.

Water Resources Research Institute Reports

None to report to date.

Conference Proceedings

Pilon, Tim and Daniel M. White, 1998, Cyanide Treatment in a Pilot Scale SBBR "in" Proceedings: 9th International Cold Regions Engineering Specialty Conference, ASCE, pp. 235-242.

White, D.M., H. Zhang and C.R. Woolard, (2000), Reclamation at Northern Gold Mines, to be published in the Proceedings of the 6th International Symposium on Cold Regions Development, February 1-6, 2000, Hobart, Tasmania. Accepted.

White, D.M., H.-Y. Zhang (2000), Temperature effect on cyanide degradation by bacteria in mine leachate, to be published in the Proceedings of the 2000 AWRA Spring Specialty Conference, May 1-4, 2000, Anchorage, Alaska.

Other Publications

None to report to date.

Basic Project Information

Basic Project Information	
Category	Data
Title	In Situ Gibbs Free Energies of Hydrogen-Oxidizing Terminal Electron-Accepting Processes in Contaminated Subarctic Groundwater
Project Number	B-03
Start Date	03/01/1999
End Date	03/01/2001
Research Category	Water Quality
Focus Category #1	Hydrogeochemistry
Focus Category #2	Toxic Substances
Focus	---

Category #3	Treatment
Lead Institution	University of Alaska-Fairbanks

Principal Investigators

Principal Investigators			
Name	Title During Project Period	Affiliated Organization	Order
Joan F. Braddock	Associate Professor	University of Alaska-Fairbanks	01
Sharon Richmond	Student	University of Alaska-Fairbanks	01

Problem and Research Objectives

Identifying the predominant terminal electron-accepting process (TEAP) is important when determining redox conditions in contaminated ground water. Degradation of environmental contaminants is largely due to microbial activity, and the products and rates of those reactions are highly dependent upon the predominant TEAP.

Current methods for determining the distribution of TEAPs in ground water couple measurement of available electron donors and acceptors with concentrations of dissolved hydrogen (Chapelle *et al.*, 1995). Empirically derived ranges of hydrogen correspond to particular TEAPs and assume steady-state conditions and competitive exclusion of other microbially mediated redox processes. However, temperature may significantly affect hydrogen concentrations (Westerman, 1994; Schulz and Conrad, 1996; Jakobsen *et al.*, 1998; Hoehler *et al.*, 1998). Because these reactions are also functions of pH, hydrogen concentrations should also vary with reservoir pH (Hoehler *et al.*, 1998). In addition, various TEAPs may not always be competitively exclusive (Jakobsen *et al.*, 1998; Jakobsen *et al.*, 1999). In these studies, evidence suggesting concomitant Fe(III) and sulfate reduction in cold (2-10°C) ground water was reported with hydrogen concentrations within or below the range predictive of Fe(III) reduction. In such systems where it may not be possible to assign a predominant TEAP, hydrogen data alone may not accurately reflect all TEAPs and, therefore, may not allow investigators to accurately predict the fate of some environmental contaminants.

To address this problem, Jakobson *et al.* (1998) proposed that calculated *in situ* Gibbs free energies of hydrogen-oxidizing TEAPs (ΔG_r) might be useful when determining the distribution of TEAPs in ground water. This approach was based upon previous laboratory studies, which suggested that in steady-state systems, a threshold ΔG_r for a given TEAP corresponds to the minimum energy necessary for bacteria to be able store the energy gained in the reaction (Westermann, 1994; Hoehler *et al.*, 1994; Conrad, 1999). This integrated approach may be more useful when determining TEAPs in highly dynamic or very cold ground-water systems.

In a previous study, geochemical data were collected from TCE-contaminated ground water within the Chena Alluvium (Hinzman *et al.*, 2000). This particular system experiences periodic influx of surface water, which was expected to alter redox chemistry, and therefore affect microbial degradation of contaminants. The data collected from this hydrologically dynamic site suggested active sulfate reduction and methanogenesis, although in most cases hydrogen concentrations were within or below the range expected for iron reduction. Because preliminary geochemical data did not allow us to assign a predominant TEAP, it was hoped that calculating Gibbs free energies would provide more insight

into the energetics of microbial metabolism in cold ground water and systems at disequilibrium. For comparison, geochemical data was collected at two additional contaminated sites (Eielson Air Force Base and Six Mile Village). By calculating ΔG_r of TEAPs for these more hydrologically stable sites, we hoped to determine what effect permanently cold temperatures sites had on TEAP distribution and contaminant degradation.

Methodology

Three TCE-contaminated sites near Fairbanks, Alaska were chosen for this study. At one site, Ft. Wainwright, data had been previously collected. Groundwater samples were collected and analyzed with currently accepted methods (Hinzman *et al.*, 2000). Geochemical and physical parameters measured included dissolved and total iron, sulfate, sulfide, carbonate, methane, hydrogen, temperature and pH. Most analyses were performed on site at the time of collection using spectrophotometry and gas chromatography. Groundwater samples from Eielson Air Force Base and Six Mile Village were collected and analyzed using similar methods. Gibbs free energies were calculated using these data and the equations in Table 1.

Table 1. Equations and thermodynamic values used for calculating in situ Gibbs free energies (ΔG_r) for hydrogen-oxidizing terminal-electron accepting processes (TEAPs)^a

TEAP	Equation used to calculate <i>in situ</i> ΔG_r	ΔG° (kJ/mol)	ΔH°
$1/2\text{H}_{2(aq)} + \text{Fe}(\text{OH})_{2(am)} + 2\text{H}^+ \rightleftharpoons \text{Fe}^{2+} + 3\text{H}_2\text{O}$	$\Delta G_r = \Delta G^{\circ T2} + RT \ln \frac{[\text{Fe}^{2+}]}{[\text{H}_2]^{1/2}[\text{H}^+]^2}$	-102.2	-121.1
$4\text{H}_{2(aq)} + \text{SO}_4^{2-} + \text{H}^+ \rightleftharpoons \text{HS}^- + 4\text{H}_2\text{O}$	$\Delta G_r = \Delta G^{\circ T2} + RT \ln \frac{[\text{HS}^-]}{[\text{H}_2]^4[\text{SO}_4^{2-}][\text{H}^+]}$	-264.1	-235.0
$4\text{H}_{2(aq)} + \text{HCO}_3^- + \text{H}^+ \rightleftharpoons \text{CH}_4(aq) + 3\text{H}_2\text{O}$	$\Delta G_r = \Delta G^{\circ T2} + RT \ln \frac{[\text{CH}_4]}{[\text{H}_2]^4[\text{HCO}_3^-][\text{H}^+]}$	-229.3	-237.8

^a R is the gas constant, T is the absolute temperature in K, [] indicate species molarity. At low concentrations, activity is near equal the molar concentration. Thermodynamic data for solutes from Langmuir, 1997, Stumm and Morgan, 1982, and Kraushopf, 1994. Table adapted from Jakobsen *et al.*, 1998.

Principal Findings and Significance

At the time of this writing, we have completed analyzing data from two sites in the Chena Alluvium, near Fairbanks, AK (Ft. Wainwright and Eielson Air Force Base; see Table 2). Hydrogen concentrations ranged between < 0.10-0.9 nM, with most wells having dissolved hydrogen concentrations of ca. 0.15nM, suggesting that Mn(IV)- or Fe(III)- reduction were the predominant TEAPS. However, the presence of sulfide (< 0.001-0.085 mg/L) is strong evidence for active sulfate reduction. Methane concentrations at some wells were above saturation (ca. 2.0- > 100mg/L), although it is not clear whether elevated methane is indicative of active methanogenesis in groundwaters tested or the result of diffusion from other sources, perhaps deep, underlying peat layers.

Table 2. Concentrations of redox-sensitive TEAP indicators used for calculating Gibbs free energies.

	Temp (K)	O ₂ (mg/L)	Fe(II) (M)	Fe(III) ^b (mg/L)	SO ₄ ⁻² (M)	HS ⁻ (M)	CH ₄ (M)	HCO ₃ ⁻ (M)	pH	H ⁺ (M)	H ₂ (M)
FWM6389	278.97	0.20*	1.95E-04	1.5	1.77E-04	1.23E-06	2.25E-06	5.55E-03	6.86	1.38E-07	2.10E-10
FWM6390	280.37	0.44*	1.47E-04	1.0	1.77E-04	5.87E-08	5.86E-07	5.26E-03	6.93	1.17E-07	2.10E-10
FWM6885	278.74	0.20*	4.80E-05	0.14	2.39E-04	2.94E-08	5.91E-07	4.33E-03	6.94	1.15E-07	9.00E-10
FWM7073	278.88	0.22*	5.01E-05	0.1	2.50E-04	9.10E-07	2.09E-07	3.88E-03	7.22	6.03E-07	1.90E-10
FWM7075	278.32	0.42*	5.55E-05	0.1	2.19E-04	8.51E-07	1.99E-08	3.52E-03	7.05	8.91E-08	2.10E-10
MW01	276.92	< 0.01	2.83E-05	0.21	5.21E-04	2.03E-06	1.00E-05	3.46E-03	6.91	1.23E-07	1.00E-10
MW07	276.50	0.20	1.36E-04	1.9	5.52E-04	2.60E-07	3.80E-05	4.07E-03	6.98	1.05E-07	8.00E-11
MW08	277.99	< 0.01	1.45E-04	5.42	1.46E-04	8.50E-07	6.10E-06	4.53E-03	6.49	3.24E-07	1.50E-10
MW09	277.40	< 0.01	7.16E-05	1.2	2.60E-04	3.80E-07	5.80E-06	3.84E-03	6.80	1.58E-07	1.00E-10

*Reported dissolved oxygen concentrations were measured with a probe and therefore, are likely greater than actual values. Other dissolved oxygen measurements at this site using the more sensitive titration method of analysis have consistently been near the lower detection limit of 0.01 mg/L (Hinzman *et al.*, in press).

^bFerric iron present as suspended or colloidal material in unfiltered samples.

Collectively, these results suggest concomitant Fe(III) and sulfate reduction at most wells examined and calculated Gibbs free energies for various TEAPs supported this interpretation (Table 3). For the sake of brevity, some data are not presented. However, the presence of appreciable quantities of manganese in conjunction with low hydrogen concentrations implies that manganese reduction may also occur at these sites.

Table 3. Calculated *in situ* ΔG_r for H₂-oxidizing terminal-electron accepting processes (TEAPs). Values are reported as kJ/mol.

	Iron reduction	Sulfate reduction	Methanogenesis
FWM6389	-24.2	-30.5	-4.5
FWM6390	-23.7	-36.1	-6
FWM6885	-28.4	-53.2	-20.3
FWM7073	-34.1	-34.6	-11.8
FWM7075	-25.3	-31.4	-13.9
MW01	-27.8	-26.5	5.3
MW07	-23.3	-29.3	10.2
MW08	-28.7	-30.6	-1.4
MW09	-26.7	-28.9	3.8

Methane concentrations were high in most wells tested (Table 2). Generally, its presence is indicative of active methanogenesis; however, this interpretation may not apply at these two sites. Peat lenses and discontinuous permafrost are present throughout the area and their presence may result in elevated methane concentrations (Kvenvolden and Lorenson, 1993). Presence of methane in these wells may simply represent diffusion from other underlying sources. This interpretation is supported by thermodynamic calculations (Table 3). Methanogenesis is reported to occur at or below a threshold of $\Delta G_r \sim -23$ kJ/mol and by this criterion, was not energetically favorable in any waters examined. Because sulfate concentrations are not limiting and hydrogen concentrations are very low, it is likely that

methanogenesis at these two sites could only occur in stagnant pore water with increased hydrogen concentrations or via interspecies hydrogen transfer.

At this time, data have been collected from the third site, Six Mile Village, located near Fairbanks, Alaska, and analysis is ongoing. Hydrogen concentrations were generally within iron reducing range and again, sulfide and methane were present.

Results of this study suggest that hydrogen concentrations alone may not reflect all TEAPs occurring in highly dynamic or very cold groundwater and, therefore, may not allow investigators to accurately predict the fate of some environmental contaminants. An integrated, thermodynamic approach appears to be more useful when describing TEAPs in highly dynamic systems or very cold ground water characteristic of subarctic aquifers. It appears that under these conditions, multiple TEAPs may co-occur.

LITERATURE CITED

Chapelle, F.H., P.B. McMahon, N.M. Dubrovsky, R.F. Fujii, E.T. Oaksford, and D.A. Vroblesky. 1995. Deducing the distribution of terminal electron-accepting processes in hydrologically diverse groundwater systems. *Water Resour. Res.* 31:359-371.

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Schulz, S., and R. Conrad. 1996. Influence of temperature on pathways to methane production in the permanently cold profundal sediment of Lake Constance. *FEMS Microbiol. Ecol.* 20:1-14.

Westermann, P. 1994. The effect of incubation temperature on steady-state concentrations of hydrogen and volatile fatty acids during anaerobic degradation in slurries from wetland sediments. FEMS Microbiol. Ecol. 13:295-302.

Descriptors

biodegradation, biogeochemistry, groundwater quality

Articles in Refereed Scientific Journals

None to report yet.

Book Chapters

None to report yet.

Dissertations

None to report yet.

Water Resources Research Institute Reports

None to report yet.

Conference Proceedings

None to report yet.

Other Publications

None to report yet.

Basic Project Information

Basic Project Information	
Category	Data
Title	Geomorphological Controls on Hydrological Processes in the Alaskan Arctic
Project Number	B-04
Start Date	06/01/1999
End Date	05/30/2001
Research Category	Climate and Hydrologic Processes
Focus Category #1	Climatological Processes
Focus Category #2	Hydrology
Focus Category #3	Geomorphological and Geochemical Processes
Lead Institution	University of Alaska-Fairbanks

Principal Investigators

Principal Investigators			
Name	Title During Project Period	Affiliated Organization	Order
Larry D. Hinzman	Professor	University of Alaska-Fairbanks	01

Problem and Research Objectives

The objective of this research is to develop a better understanding of watershed morphology dynamics and to elucidate how a basin structure may evolve with the onset of climatic warming. Over the past several years, river morphology studies performed in the Kuparuk River have documented some of the changes that have occurred as a result of bedload transfer. This study will provide insight into the nature of the bedload transportation process. The study is being conducted simultaneously at two different locations on the river. One location is near the intersection of the Kuparuk River and the Dalton Highway. The second site is located near the headwaters of the river.

Objective

There are three primary goals for the proposed study:

1. Determine the amount and size of bedload movement versus volumetric flow rate for a specific location of the Kuparuk River.
2. Establish a relationship between particle distance traveled and the flow distribution curve for the same portion of river.
3. Compare the bedload material movement that occurs during the spring snowmelt to that which occurs in response to significant rainfall events during the summer.

Methodology

There are two types of tracer rocks that have been used to perform this type of study: passive tracers and active tracers.

Passive tracers can be either painted rocks, which may remain visible as long as they remain on the surface of the riverbed, or rocks with a ferrous metal implant that can be traced with a metal detector even when they are buried below the riverbed surface, or rocks that have both a ferrous metal implant and a coat of highly visible paint.

Active tracers are rocks which have a radio signal transmitter implanted in them. These transmitters allow for continuous monitoring of the particle position. Transmitters are available with a motion sensor that will emit a different signal when the rock is in motion than when it is stationary.

This study uses a combination of active and passive tracer rocks. A Telonics Radio Tracking System will be used for the active tracers. This system has been chosen because it has been successfully used for this type of study in the past. Due to the cost associated with active tracers, they will be used in relatively low numbers (approximately 20 transmitters). These tracers will be used to provide specific

and accurate particle movement data.

The bulk of the tracer rocks will be passive. Both painted and ferrous implants will be used in sufficient quantities to provide a statistically significant body of data to correspond with the smaller set of active tracer data.

The process outlined above should provide enough data to meet each of the three primary objectives stated earlier. In addition to measurements described above, an automated suspended sediment sampler may be installed at the test site to completely capture the sediment transportation spectrum.

Principal Findings and Significance

Progress has been limited to date due to the difficulty in finding a graduate student to participate in this research. All of the funding associated with this project has been allocated to directly support the student salary or supplies with no funding allocated for faculty support. An ambitious M.S. student named Jeff Oatley has been hired and he has initiated a rigorous project. One set of passive tracer (high visibility paint only) was installed in the lower research site on June 23, 2000. There was no measurable movement of these rocks during the past three months. They will be left in place over the winter and should provide some data during the break-up period in the spring of 2001.

The set contains a total of 201 tracer rocks of various sizes. The rocks were intended to represent the normal size distribution of that stretch of the river. This set is probably biased slightly toward the large end of the spectrum. In the spring of 2001 this bias will be corrected.

The focus for the winter of 2000 will be on preparing for the spring season, acquiring materials, and becoming familiar with the Telonics tracking system.

Descriptors

Geomorphology
Hydrogeology
Hydrologic models

Articles in Refereed Scientific Journals

None at this time.

Book Chapters

None at this time.

Dissertations

None at this time.

Water Resources Research Institute Reports

None at this time.

Conference Proceedings

None at this time.

Other Publications

None at this time.

Information Transfer Program

USGS Internship Program

Student Support

Student Support					
Category	Section 104 Base Grant	Section 104 RCGP Award	NIWR-USGS Internship	Supplemental Awards	Total
Undergraduate	N/A	N/A	N/A	N/A	N/A
Masters	1	N/A	N/A	N/A	1
Ph.D.	N/A	N/A	N/A	N/A	N/A
Post-Doc.	N/A	N/A	N/A	N/A	N/A
Total	N/A	N/A	N/A	N/A	N/A

Awards & Achievements

Publications from Prior Projects

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications