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THE EFFECTS OF HUMAN ACTIVITY AND URBANIZATION ON THE FLINT RIVER: A COMPARATIVE STUDY

By

Debra K. Bassett

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ABSTRACT

THE EFFECTS OF URBANIZATION AND HUMAN ACTIVITY ON THE FLINT RIVER: A COMPARATIVE STUDY

By

Debra K. Bassett

In the fall of 2004, two classes of inner-city biology students conducted a study of the effects that human activity had on their local river. In the past, students at the school had shown very little interest in the ecology of the local river and its watershed. It was believed, however, that if the students were allowed to participate in the study of a real local issue and were given the opportunity to educate the citizens of Flint about what they had learned, the attitudes and opinions of the students, as well as their understanding of the river ecology, would drastically change.

The students were taken to two sections of the Flint River to assess the water quality and surrounding habitat - first to a rural area, then to a site in the city. They discovered the difference in water quality, determined the reasons for the difference and concluded what citizens might do to slow river degradation.

In the beginning the students were apathetic and disinterested. After their study, however, they developed an active interest in the river. They were able to succinctly state (in brochures that they developed and radio-broadcast public service announcements that they wrote) how they, as well as others, could make a difference in the health of the river. The students also demonstrated an awareness and understanding of the ecology concepts with increased scores on a post-unit test as compared to a pre-unit assessment.

DEDICATION

I dedicate this thesis to the memory of my dad, Carroll (Bud) Bassett, for instilling in me a love of and respect for nature and the environment, thereby setting me on this journey

and

My brother, Gary Bassett, whose advice, even though he's gone, carried me through this program:
"Don't try to eat the whole elephant at once; take it one bite at a time."

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If there is one thing I know for certain, it is that we never arrive at a place without some help along the way. I have many people to thank for their love, support and encouragement as I traveled this journey. Many people helped me, each in their own way, many unaware that they had made a difference for me. It is important that I name a few, for they made all the difference.

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"Good science programs require access to the world beyond the classroom"

--National Science Education Standards, 1996

The field of education, and in particular science education, abounds with ideas and theories about what is the best way to teach science. It is generally agreed, however, that science can best be learned through hands-on learning. It has been demonstrated that students who are involved in the hands-on process of learning science are more motivated to learn (Yeany, 1989). Just as there are many learning styles among students, teachers must use a number of teaching strategies to reach as many students as possible. One popular theory is that of inquiry-based learning, which became prominent in science education classes during the late 1950's and early 1960's (Chiappetta, 1997). Although there is no true single definition of "inquiry-based learning" (Short and Burke, 1996), the National Science Education Standards (1996) refers to it as "a set of interrelated processes by which scientists and students pose questions about the natural world and investigate phenomena". They go on to state that "in doing so, students acquire knowledge and develop a rich understanding of concepts, principles, models and theories".

In 1996 the National Research Council set forth the National Science Education Standards in which they stressed the use of inquiry as a "critical component of a science program at all grade levels and in every domain of science". The U.S. Department of Education and the National Science Foundation endorse the use of inquiry-based learning and problem solving, as well, agreeing that it is a method that will motivate students to learn (Haury, 1993). Further, Haury (1993) states that there is evidence that inquiry-based learning "fosters science literacy and understanding of science, conceptual understanding, critical thinking and positive attitudes toward science". Martin-Hansen (2002) describes inquiry as "activities of students mirroring what scientists do" and states further that of the types of inquiry that exist (open or full inquiry, guided inquiry, coupled inquiry [open with guidance], and structured inquiry), the type of inquiry chosen for the individual science classroom should reflect the specific needs of the learners in the class.

In keeping with this thought, it is sometimes desirable to utilize a type of structured inquiry in which the inquiry is directed by the teacher and the students are directed to collect particular data, then guided through the process of formulating an answer to their inquiry (Martin-Hansen, 2002; Goodman and Bernston, 2000). In this way, the teacher can pique the students' curiosity, and then by example help the students understand the nature of inquiry and the processes that are utilized in answering scientific questions. Goodman and Bernston (2000) suggest that it is important to consider the academic level of one's students, the environment from which they come (rural, suburban, inner-city) and the previous knowledge that they bring to the class when developing activities. They propose that the students need to have a basic understanding of the concepts being studied before they can pose a meaningful question for inquiry. This is in keeping with the belief held by Duschl (1986) that inquiry-related teaching "does not preclude textbooks and other materials, rather it should accompany and support them". The concept of a teacher-directed inquiry can also overcome some inherent problems such as the lack of background knowledge, or students who are hesitant to think for themselves, because they are used to being "fed correct answers and regurgitating them on tests and quizzes" (Lawson, 2000). Indeed, Edwards (1997) states that the "present education system promotes providing answers for students to memorize then spit out on a test". Windschitl and Buttemer (2000) concur with this and assert that many students are "too comfortable assimilating knowledge produced by others via text, direct instruction and overly structured classroom lab exercises". They see structured inquiry, then, as being valuable to learners who "have little or no experience in developing questions themselves".

Windschitl and Buttemer (2000) also believe that inquiry can build confidence, while giving the students the experience of being "scientists". It is a way to for the student to "connect" with science in a personal way. They assert that "a first hand experience with scientific inquiry can be more important for developing scientific literacy than all the well-designed discussions or inspiring lectures". Uyeda et al (2002) agree, maintaining that too often a "disconnect" takes place between "real science" and "school science". They add that inquiry-based science can combine the two, connecting students to science, as well as helping them to comprehend the connection between science and society. Further, students will learn that "doing science" is far more than simply following a few rote and inflexible steps that we teach as the scientific method. Instead, they will find that science is not just a collection of cookbook laboratory experiments but a reiterative learning process.

In keeping with this thinking, the American Association for the Advancement of Science (AAAS), in their *Science for All Americans Summary*, asserts that "teaching related to science literacy needs to be consistent with the spirit and character of scientific inquiry and with scientific values. This includes starting with questions about phenomena rather than answers." They go on to say that science should be "learned by engaging students actively in the collection and use of evidence…providing students with hands-on experience" (AAAS, 1995).

Another benefit of scientific inquiry by students is that they have more control over their own learning. When the students are focused on their inquiry, they will learn the content as well (Uyeda, et al 2002). AAAS makes the assertion that "myths and stereotypes that young people have about science are not dispelled when science teaching focuses narrowly on the laws, concepts, and theories of science" (1993). Thus, science should be taught as a way of knowing by students gaining experience in actual scientific investigation and being able to explain their findings, rather than being told what others have found. The National Research Council agrees. In their National Science Education Standards (NSES), the council maintains that among the strategies for teaching science, teachers must "reflect the acquisition of scientific understanding through inquiry (so that) students will learn science in a way that reflects how science actually works" (1996) In having the opportunity to test their own ideas, investigate a question for themselves, derive their own data, and reach their own conclusions, students will see that science is truly an ongoing, active process. The way for students to achieve these skills is by actively participating in authentic scientific investigations. Students who simply observe teachers demonstrating science or who passively listen to a lecture are less motivated to solve problems independently than those who are allowed to experience "hands-on" science inquiry (Glasson, 1989).

According to many researchers, in order for students to derive meaning from the inquiry-based experiences that they do have, they must be able to adapt their new experiences and knowledge to their pre-existing knowledge and views of the world. This school of thought is known as the constructivist theory, which is one of the most prominent theories in education (Bencze, 2004). Piaget, a leading proponent of constructivism, wrote that children's minds were not empty – rather they "actively process material presented and assimilate it into their own schema or adapt their ideas to accommodate new ideas" (Atherton, 2003).

Constructivists believe that students construct their own understanding of the world and their own knowledge. In other words, students learn based on their own experiences and preconceived ideas (Ishii, 2003). According to Suping (2003), students may have preconceptions that can easily be revised or altered by receiving instruction, or they may hold misconceptions that are more resistant to change. Chi and Roscoe (2002) believe that students can be taught conceptual change in order to repair those misconceptions by helping them to see the new thought as rational. Authentic investigation conducted by the student is one way to do so.

In either case, it is generally agreed upon by most constructivists that students must either assimilate the new knowledge into their existing concepts or accommodate the new experience or knowledge into their existing view. Posner, et al (1982) suggests that the new knowledge must be rational and plausible to the student, and must create dissatisfaction with the ideas that they already have regarding the concepts.

Students will approach the study of science with preconceived notions that they may be hesitant to give up. In addition, because learning new ideas is dependent on adapting the new knowledge to what is already known or conceived, the pre-existing notions may affect the way that a student observes, hypothesizes, analyzes and concludes ideas (Bencze, 2004). Lorsbach and Tobin (1997) propose that students should be given the opportunity to make sense of their new knowledge by comparing it to what they already know and believe, then reconciling any conflict between them. To encourage this, students should, instead of sitting at desks, be given opportunities to *experience* science, then work out its meaning and relevance to their lives and views. One way to accomplish this is through inquiry-based investigations by the students.

Bencze (2004) suggests that before we try to teach new ideas and concepts to students we should first have students express their existing conceptions. He states that because students will "see what they want to see" it is not enough to give the students new ideas and experiences and expect them to make the same discoveries or reach the conclusions that we are trying to get them to reach. They will "discover what is apparent to *them*" unless they are given the skills and experiences that will assist them in their learning. He goes on to say that telling or showing students abstract ideas is inadequate in leading them to knowledge. Instead, they should have "concrete" experiences to combine with those ideas in order to change their thinking. "Education should be about enlightening others, not convincing them. We need to help them understand. *They* decide whether or not to accept" (Bencze, 2004). Conducting scientific investigations has the potential to be those experiences.

Paul Ernest (1996) recommends that teachers maintain a sensitivity to the students' previous knowledge, as well as an awareness of the contrast between the teacher's goals and the students' goals. Brooks & Brooks (1999) suggest that lessons should be structured around the pre-existing concepts to minimize the amount of accommodation necessary to assimilate the new concepts. (The students' pre-existing knowledge and conceptions can be ascertained by conducting pre-unit assessments prior to the teaching of a unit.) It is important to consider the experiences that students bring to the classroom. These experiences may be affected by lifestyle differences such as culture or socioeconomic level, and the students' exposure, experiences and preconceptions may be completely different than those of students from a different culture or higher socioeconomic level. Bencze (2004) declares that those who are the least likely to "discover" the important ideas from inquiry are those who are disadvantaged, which is often tied to socioeconomic level. The concepts of the world held by students will affect the way they approach science as well as functioning as "filters" for their accommodation of new concepts and knowledge (NSES, 1996), "modifying its subsequent meaning" (Stahl, 1991).

Lorsbach and Tobin (1997) stress that knowledge "resides in individuals; it cannot be transferred intact from the head of teacher to the heads of students". Students, then, try to make sense of what is being taught by attempting to fit it in and around his/her prior experience.

Inquiry-based learning fits well into the constructivist theory in that it provides students with the type of experience that allows the student to establish the connection between the knowledge and concepts that they presently hold with the new scientific knowledge found in inquiry (NSES, 1996). Glasson (1989) concurs when he writes that the practice of hands-on inquiry "promotes peer interaction where students are free to argue, make mistakes and challenge each other – these stimulate conceptual conflicts in students, who are then motivated to resolve discrepancies between what they already know and what they have seen in the hands-on lab". This in turn, according to Glasson, will lead to the accommodation of new concepts. Chiappetta (1997) also expresses agreement when he writes that "inquiry-based instruction will help students construct fundamental science concepts that will help them better understand themselves and the world around them". Haury (1993) upholds this tenet, as well, by stating that inquiry-based teaching "engages students in investigations to satisfy curiosities, with curiosities being satisfied when individuals have constructed mental frameworks that adequately explain their experiences".

How to stimulate the students' curiosity is another challenge. However, if the concept that they are being taught has been made meaningful and relevant to their lives, and if they perceive it to be an authentic investigation, students will be more engaged in the investigation. The National Science Teachers' Association (NSTA), in its *Standards for Science Teacher Preparation* (2003) points out that teachers must be "creative decision-makers who adapt and create meaningful activities".

The National Research Council, in the *National Science Education Standards* states that "an important purpose of science education is to give students a means to understand and act on personal and social issues (as well as) give students a foundation on which to base decisions they will face as citizens" such as community health, natural resources, environmental quality, natural and human-induced hazards and the interdependence of organisms (NSES, 1996). They go on to say that one of the biggest challenges of science teachers today is to make scientific investigations meaningful to the students. Windschitl and Buttemer (2000) agree, stating that meaningfulness is tied to the personal interest of the students and must connect to their own world of experience. Students need to feel that their inquiry and study is in response to a legitimate problem or question.

AAAS (1993), in their *Benchmarks for Science Literacy,* maintains that it is necessary that students know that scientists contribute information to the public about areas of concern. They should understand, as well, that scientists can help the public understand the cause and effects of natural and man-made events. In addition, students should learn subject matter in the context of inquiry into science that has a personal and social perspective (NSES, 1996). Students must be motivated to become interested and then guided in making observations. Newman, Wehlage and Lamborin (1992) believe that disengagement, not low achievement, is the "most immediate and persisting issue" for students today. They go on to state that students who are engaged in their learning make a psychological investment in their education. Wigfield and Eccles (1992) assert that since tasks in education are often just rituals that students perceive as meaningless and unrelated to them personally, lessons should be developed that students will see as meaningful, valuable and significant to their lives beyond school i.e. "connected to the real world". In agreement with that principle, the National Research Council (1996) advises that "teachers should remember that some experiences begin with little meaning for students but develop meaning through active involvement, continued exposure and growing skill and understanding". Students should be motivated to become interested, and can then be guided in their learning. Bringle and Hatcher (1999) propose that students are "more satisfied with the learning experience and the educational outcomes are enriched and deepened when learning is more relevant".

One school of thought on the best way to get students engaged is to allow them to work in "learning teams"; in other words, engage in cooperative learning. Cooperative learning has been highly promoted by many educational theorists (Hillkirk, 1991). Babbage (1998) believes that students are eager to learn and like to be involved in their own learning. It is his belief that interaction with other students causes learning. Yager (1991) maintains that even academically talented students, in order to retain new information, need to participate in discussion with their peers. Lord (1998) explains that the use of cooperative learning groups promotes constructivist learning by allowing students to test their newly attained knowledge through discussing the information with other students. He continues by saying that with rote memorization, students don't really have the chance to apply the new knowledge that they have obtained, but the discussion with others allows them to "manipulate and fit the material" with what they already know. He cites a study by Tinto (1987) that found that many students cannot apply the new knowledge they have learned in class to everyday situations. However, Lord (1994) found that knowledge, comprehension and critical thinking skills increased significantly in cooperative learning groups, with the knowledge being retained longer when applying it in that setting. In addition, most of the students who worked in cooperative learning groups during the research said they enjoyed learning from each other and enjoyed class more when working in their groups. Lord cites additional research in enumerating the other proven benefits of cooperative learning. Students have shown higher achievement, increased motivation, more positive attitudes toward the subject being taught, less disruptive behavior and increased on-task behavior. He concludes by stating that students do not learn by being "passive bystanders" in their learning process. Rather, they need lessons that will cause them to think about, discuss and use what they are being taught.

Others advocate cooperative learning, as well. Niaz, et al (2002) determined that when students are given the opportunity to argue and discuss their new knowledge, their "understanding can go beyond simple regurgitation of detail". In addition, when students are part of a cooperative learning group, they have to organize their new knowledge and make connections as they explain and question. Further, students learn through interactions with peers who are more academically capable (INTIME, 2005). Windschitl and Buttemer (2000) believe that students should be allowed to argue the validity of a concept in order to reconstruct their thinking. It ends in the cognitive conflict that can lead a student to question his/her understanding and investigate new ideas.

In addition to communicating ideas to other classmates in a cooperative learning setting, NSES (1996) suggests that students apply new knowledge in context by communicating their scientific investigations and explanations to the public. This can take place in the form of service learning projects in which students conduct a scientific inquiry into an issue that is relevant to both the students and the community and share that knowledge with the citizens of the community. Service learning is a teaching/learning method that connects meaningful service with academic learning and civic responsibility. According to the National Youth Leadership Council (1991), service learning helps students transfer the experiences and knowledge they have attained to their everyday lives by applying their learning to help solve a real concern in the community. Lindberg (1990) states: "When students are involved in hands-on science, when they actually do science, they understand science. But when they teach what they have learned, it becomes part of them, stored safely in their memory banks". Greenwald (2000) also believes this is the case. He writes that an important part of inquiry-based education is the communication of ideas in which students present what they have learned to their peers, teachers and others.

John Dewey stated: "Exposure itself does not necessarily result in learning. It becomes educative when there is communication with others. Further communication leads to social development" (In Bringle & Hatcher, 1999). Turner (2003) concurs and states that the practical application of newly acquired knowledge can bring learning to life. She goes on to add that recent pre- and post-survey research indicates that students who were involved in service learning projects maintained a higher grade point average than their counterparts who participated in typical classroom learning.

Research has shown that students who experience the practical application of their new knowledge either by practicing the concept or teaching others have a much higher retention rate than students taught by other methods. (see figure 1 – next page)

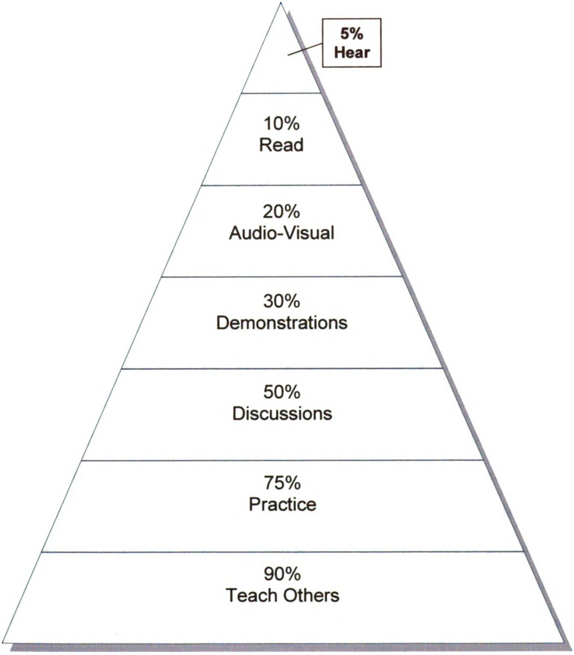

Figure 1. Average Retention Rates for Different Teaching Methodologies California Department of Education (1999)

The Alliance for Service-Learning in Education Reform (1995) states that in today's society youth are not seen as contributing members of society. They strongly suggest that in order to be given credit for their work, achievements and newly acquired skills, students should be given the opportunity to be publicly recognized for their contributions, either through work with the school or the community.

Finally, service-learning projects fulfill several of the Content Standards and Benchmarks of the State of Michigan (see appendix A) by giving the students the knowledge and skills to apply their new knowledge to the real world.

As mentioned earlier in this paper, one would be remiss by not considering the "audience" when developing lesson plans. Whatever the students' backgrounds might be it is not unusual for students to have been "turned off" to science. They may, in fact, resent science due to a lack of understanding and success during earlier science experiences. Hoots (1999) writes: "Scientific papers and science texts do not reflect the spirit of science itself with its imagination, errors, tenacity, emotions and, most of all, its artistic passion….all the features associated with scientific creativity have been purged from it." She goes on to say that "knowledge without meaning or understanding is nothing more than empty rhetoric". Hoots suggests that this has resulted in a widely accepted "social aversion and phobia to science" and says that science needs to be humanized and made meaningful to students. In other words, teachers need to put "life back into biology". Krupa (2000) asserts that one way to do that is to involve students in field trips that will develop an appreciation of nature and the environment. He suggests that in the face of declining funds, field trips have been put aside and the price for that will be fewer opportunities for young people to learn about the natural world, thus creating a lack of new naturalists (an area where inner-city youth are under-represented). Krupa strongly urges biology teachers to use nature as a classroom, stressing that there is nothing that can replace direct contact with the environment to learn what it is about.

Bicak (1997) believes this as well. He maintains that in order to establish an "environmental ethic", there must be an *acquired* insight into nature. The problem, as he sees it, is that most people spend the majority of their time in an urban setting and very little time in a rural environment. Thus, he says, students must be directly exposed to nature and the environment in order to establish an environmental ethic and, hopefully, a "passion for the environment". NSTA (2003) speaks to this issue: "science teachers should give explicit attention to the study of socially important issues related to science and technology such as species preservation, land use and chemical pollution." NSTA adds that teachers must contribute to helping students become informed citizens who are prepared to "make decisions and take action on contemporary issues of interest to general society".

O'Neal (1995), while acknowledging that field trips are not a new idea, says that due to the current environmental crisis, science education should play a vital role in promoting "environmental literacy" and awareness. He points out that although ecology taught from textbooks and videos might have some advantages, there is nothing that can compare to the experience of being in the environment and having a first-hand encounter with nature. He goes on to remind us that many students have never been in a natural environment and that visiting a local habitat could provide the motivation necessary for students to learn. He adds that "to see, smell, hear, and touch the environment leaves an indelible mark on the minds of students".

Klepper (1990) agrees. She states that there is no substitute for a hands-on experience with the environment that students take for granted and that a field trip can be an enormous help towards shaping adults who are aware of the importance of preserving our environment. She argues that one afternoon of allowing nature to be the teacher is more worthwhile than a *series* of lectures!

Finally, the NSTA (2003) recommends that teachers should utilize resources outside of the school in their teaching so the students can relate science to the local community and its important issues. This, they say, should be in the form of guest speakers, field trips, service learning and in the study of local problems.

HYPOTHESIS

Taking these ideas into consideration, the goal of this unit was to increase the students' knowledge about the river ecosystem and the interdependency of the river's organisms and the humans that inhabit the area around it. This would include observing/studying the effects of daily human activity on the river. By employing a combination of teaching strategies that would provide the students with an inquiry-based, hands-on investigation and the opportunity to share their new knowledge with others, the students would construct and retain a new knowledge base about the ecology of the Flint River. In addition, by comparing two sites of the same river, the students would be able to see the effects that human activity and urbanization have had on the Flint River. It was a goal, as well, that the opinions and attitudes of the students toward the river and their responsibility to it would change as a result of having a personal experience with the river. My final goal was to develop a unit that met the majority of the benchmarks and standards set forth by the State of Michigan for a secondary school biology class studying the topic of Ecology. (See appendix A)

RATIONALE FOR STUDY

The students who participated in this study attend Flint Northern High School, an inner-city secondary school that is part of the Flint Community School District. It is a district that is in great transition and is in serious financial trouble. In the past two years, a dozen schools have been closed and nearly 300 employees have been laid off due to declining enrollment. The yearly classroom budget allotted for supplies for science classrooms has dropped to $375.00, many of the textbooks are outdated and the classes are usually overcrowded.

The majority of our 1,392 Northern students are minorities (98% African-American, 0.3% Hispanic), mostly from low-income families (69% of Flint students are eligible for government-funded free lunch), with 12% of Northern students living with someone other than a parent. For the students who do live with their parent(s), there is very little parental involvement in their academic life. At the last parent-teacher conference, I had a visit from the parents of 28 of my

165 students. At the present time, there are three students in the school carrying a 4.0 GPA, while 55% of the students carry a GPA below a 2.0. Reading tests conducted with the incoming 9th graders two years ago revealed the average reading level to be at 5th grade. The retention/graduation rate is 29%, and special education students make up 27% of the student body.

The Flint Community Schools created a program (Magnet Program) for students who are considered to be "college-bound" that endeavors to give the students a more challenging classroom experience, while grouped with other students with similar goals. This program gives students from the other schools in the district the opportunity to attend classes across town in schools providing a somewhat higher level of instruction and increased expectations of the students. The schools each have their individual "specialty" areas, with Northern being the Science/Math Magnet School. The students attend the Magnet school for one or two hours, then return to their "home" school for the remainder of the day.

I teach the Magnet Biology class referred to as Specialty Biology 1&2. The class is intentionally limited in number, typically15-18 students, and the majority of the students are in the 9th grade. After the students successfully complete this class, they have the option of moving into the Specialty Biology 3&4 class. With this sequence, the students are provided a more in-depth look at various topics in biology rather than a general overview of all of the chapters of the book. Until last year, neither Specialty Biology class included any instruction in Ecology. I requested, and was granted, permission to add Ecology to the

Specialty Biology curriculum; I taught Ecology in that class for the first time in the spring of 2004.

While teaching the new unit on Ecology to my Specialty Biology class, we began a discussion of the Flint River, which runs through the heart of Flint. I discovered that the majority of my students had no idea that the run-off from the street sewer drains empties directly into the river. Not only did they not realize that the sewer drains empty directly into the river, most thought the run-off went to the water treatment plant or to a huge holding tank under the street. Upon further query, I discovered that the students had no knowledge about watersheds, river ecology or the impact of human activity on the health of the river. Most disturbing was their total lack of interest in the Flint River and their impact on it. None of them knew that the Flint River eventually empties into Lake Huron's Saginaw Bay where it joins the source of Flint's drinking water at Port Huron. It became my desire to increase their knowledge and awareness of the river, and to change their attitude of apathy as well. It was with this in mind that I developed this unit on the impact of urbanization and human activity on the Flint River.

In the process of the study, the students would develop research skills by conducting a scientific inquiry. They would learn to gather, record and analyze data, conduct on-site water quality tests, collect and identify indicator organisms, and conduct fieldwork. As part of that fieldwork, they would be exposed to the field ethics of caution and respect for the environment and the living organisms that reside there. By conducting this inquiry themselves, the students would also acquire the skills of observation and interpretation, working and cooperating in teams, problem solving and decision-making. It was my goal that by performing water quality tests, habitat assessment, and macroinvertebrate surveys on the river in both areas and comparing the findings, the students would discover the links between land use, human activity and water quality. In addition, the students would develop communication skills by being required to share what they had learned with other students and the community at large as a service-learning project in order to reinforce the knowledge they gained during the course of their study. It was also my intention to make it relevant to their life by giving them a personal, hands-on experience with an ecosystem that they see every day and feel no ownership or interest in – were, in fact, repelled by.

While many secondary school Ecology units include a trip to the river for water quality testing, I couldn't find the value in one-time testing without something with which to compare the data. I was convinced that the lesson for the students was in what the river quality should and could be; indeed, what the river quality *is* in areas where there is less damaging human activity and less urbanization. I believed that the only way to personalize this lesson for the students was to let them make this discovery for themselves, then share that new knowledge with others.

Prior to this unit, the students were taught the fundamentals of Ecology beginning with the study of biomes, habitats, populations/communities, and interactions of organisms with their environment. We discussed, at length, the use of resources and the students were asked to keep track of the water usage in their home for one week to raise their awareness of how much water they consumed weekly. As the study of ecology narrowed down to different ecosystems, our focus turned to the river ecosystem, and finally to the Flint River and the Flint River Watershed as the developed unit began.

TIMELINE FOR RIVER STUDY

This table will outline the five-week unit in which the Specialty Biology 1 & 2 students will study the effects of urbanization and human activity on the Flint River. The tests, worksheets, labs, field guide, etc. can be found in Appendices C-P at the end of this thesis.

Table 1

WEEK ONE	• Flint River History – homework assignment • Pre-assessment of knowledge of river ecology, pollution, Flint River/Opinion paper to determine attitudes towards the role the students play in the health of the river/Begin discussion of Flint River quality status • LECTURE: What is a watershed? Use model to demonstrate • Darren Bagley from MSU Extension to speak to class about Flint River Watershed and groundwater issues • Watershed Worksheet Packet to assess understanding of concept • Pass It On Activity followed by discussion: What's in a river and what is its value? Where does the Flint River start and where does it end? How does it affect me? How does pollution get passed down the river? • Minamata article, analysis questions and class discussion	App. C-G
WEEK TWO	• What do we mean by urbanization? Tox-town computer lab • What is storm water? Where does it come from? Where does it go? (Use drain blueprints) – how does urbanization affect this? • Demonstration of storm sewer model vs. percolation into ground • Use handouts and brochures to reinforce ideas about stormwater, groundwater, watersheds and solutions to problem • Stoichiometry for calculating runoff from impermeable surfaces to be used during the measuring lab tomorrow • Conduct Measuring Impermeable Surfaces lab	App. H
WEEK THREE	• Polluted or Not Polluted Lab – two or three days in preparation for the field study – students should be able to demonstrate understanding of tests • Identifying critters from the river to prepare for field trip collection • Stream flow practice • DISCUSS FIELD TRIP – rules and guidelines, tasks, safety • South Branch of Flint River – Metamora FIELD TRIP	App. I - L
WEEK FOUR	• Kearsley Park – Flint River/Gilkey Creek FIELD TRIP • Round Robin discussion on what we have seen so far and what the student impressions are (rural, "natural" area vs. urban river; effects of human activity; effects of urbanization • Journal assignment to assess understanding of concepts that we have studied through field trips and testing • Appoint teams for service-learning projects and begin work on brochures, posters, public service announcements for radio broadcast	

WEEK FIVE	• Finish public service announcements and fax for approval • Take brochure to printer • Hang posters in school • Post-assessment test • Final opinion journal entry to assess understanding of unit concepts as well as detect any changes in attitudes/opinions • Student evaluation of unit	App. M-P

IMPLEMENTATION

The students involved in the study of this unit included both sections of Specialty Biology 1&2. The classes were somewhat larger this year than normal (a typical Magnet class has around eighteen students), one section having twenty-five students, the other having twenty-four. Due to counselor errors, several of the students enrolled in the class did not qualify academically for Magnet classes but were forced to stay due to a lack of room in other General Biology classes. The forty-nine students were comprised of thirty-one girls and eighteen boys; thirty-nine were 9^{th} graders, ten were 10^{th} graders. Forty-four students/parents consented to have their data used for this study. (Consent form – appendix B)

Week One

In order to meet the goals established for this unit, five weeks were set aside for the study of the Flint River. The unit began with an assignment in which the students were asked to write about the history of the Flint River, starting in the 1700's. This was intended to demonstrate to the students that the river was once a vital, healthy river that was literally the lifeblood of the community. They were also asked to write an opinion paper entitled, "What Does the Flint River Have To Do With Me?" to assess the attitudes and opinions of the students prior to this study.

In addition to the opinion papers, the students' prior knowledge about watersheds, the Flint River, and river pollution was assessed by conducting a pretest (see appendix C). After the test was completed, the students were instructed to keep a daily journal regarding their impressions, new information learned, labs, activities, assigned writings and field trips (see appendix-D for journal rubric).

In the opening lecture of the unit, the students were introduced to the concept of watersheds, runoff, groundwater and pollution. The students learned that a river can be healthy or unhealthy, depending on what is in it, and we discussed what effect the surrounding habitat has on the river. We discussed where runoff comes from, where it goes, and we looked at the flow of groundwater as well. A watershed model that I developed was used to demonstrate how the water flows over the land and to the river from the area of the watershed. Overhead transparencies were used which illustrated and outlined the Flint River watershed and its boundaries, showing that seven counties are included in the watershed. A several-page watershed exercise was given to the students to assess their understanding of the ideas presented. (See appendix E).

A speaker from the Michigan State University Cooperative Extension spoke to the students about watersheds, the Flint River, groundwater and the impact that humans have on the river when they pollute. The speaker is the president of the Flint River Watershed Coalition who brought a functioning groundwater model to demonstrate how both run off and groundwater enter the river, carrying with them pollution that is in or on the ground.

"Pass It On" is a simple activity that was used to stress the impact of human activity on the river (see details in appendix F). It is through this activity that the students see that whatever they do with their land will be carried downstream to the other parts of the river.

An article, *The Tragedy and Triumph of Minamata,* about the mercury poisoning, and subsequent cover up, of the town of Minamata, Japan, was given to the students at the end of the first week to read along with analysis questions to answer regarding the article (see appendix G). A class discussion was held about the article the following day.

WEEK TWO

Week two was dedicated to studying the effects of urbanization and daily human activity on the river. Handouts obtained from the Department of Environmental Quality, the U.S. Environmental Protection Agency, University of Wisconsin Extension Environmental Resource Center, and the Michigan Sea Grant College Program were given to the students to read and a class discussion was held regarding the content of the brochures. The handouts were intended to help the students visualize some of the concepts (such as watersheds, storm water, human activity and the preventions of river pollution) that we had talked about up to that point.

During a computer lab, students accessed a website called "Tox-Town", (http://toxtown.nlm.nih.gov/town/main.html) an interactive site in which they visited different sites (including homes, schools and businesses) in a typical town to see what types of pollution are routinely released into the water supply from each site.

At this point in the unit, the goal was to pull together the idea of urbanization's effect on the river due to creation of impervious surfaces, increased human activity and the resulting runoff into the river. The lecture focused on the storm water that drains into the river via storm sewers, the pollution that is carried along with it to the river, and the vast increase in runoff to the drains due to the impermeable surfaces that result from urbanization. A model of the street drain system alongside a grass-covered soil plot was used to demonstrate the difference in the amount of runoff from an impervious surface compared to the amount of runoff from a grass-covered soil area. Blueprints of the drains in the neighborhood of the school were shown to the students to help them visualize how the drains in their own streets reach the river.

The students conducted a "Measuring Impermeable Surfaces" lab to reinforce the idea of the increased amount of runoff to the river from impervious surfaces (see appendix H). The students were divided into groups and given an impervious area of the school campus to measure (parking lots, school roof, sidewalks, track, etc.). Once the measurements were taken, the students returned to the classroom where, based on the inches of rainfall that month and the square feet of impervious surface on the school campus, they converted the measurements to gallons of runoff. This led to a discussion of the amount and types of waste that could be carried into the river as a result of the stormwater running over the land before it reaches the storm drains that empty into the river. A journal entry was assigned to evaluate the students' understanding of these ideas.

WEEK THREE

The students were prepared for the trips to the two sections of the river where they would be testing water quality. Lecture and discussion focused on the types of tests, test parameters, what the results indicate and the reasons they were being done. The students were broken into teams, each team was assigned a specific test or assessment. They practiced the tests/assessments that they would perform at the river sites during a lab exercise entitled "Polluted or Not Polluted" (see appendix K). During this lab, teams were to determine if water samples that were given to them were contaminated. The samples included distilled water, river water from town and river water that contained fertilizer (to represent phosphates and/or nitrates). This allowed the 'water-test' teams to become familiar with the tests, see what positive and negative tests would yield, and master the skill of collecting samples.

The 'stream flow' team practiced in the hall using the hall as the river and tennis balls to determine the velocity of the "river". They practiced using stopwatches to time the "flow" of the river by rolling the balls in the hallway, then practiced calculating the velocity of the "river". They also measured the hall with meter tapes to determine the width and depth (given to them), and then used all of the data to determine the stream flow of their "river" (see appendix I).

The 'habitat assessment' team studied the assessment sheet and discussed the types of things that they would be looking for at the river site. The 'macroinvertebrate' team spent their time in the lab learning to recognize/identify macroinvertebrates that I had collected during the summer from the sites we would visit (see appendix J).

On Friday of that week, the classes visited the first testing site, the South Branch of the Flint River near the headwaters in Metamora, Michigan. The site was by the home of a family who lives in Metamora, and we were allowed to enter the river from their property. Some of the students from the teams were given waders and went into the river to collect water for testing, collect macroinvertebrates for identification and to conduct the stream flow study. The other members of the teams set up stations for conducting tests for phosphates, dissolved oxygen, turbidity, temperature, pH, nitrates, and E. coli. Macroinvertebrates were collected, identified and released, habitat assessment was performed and recorded, and the stream flow study was conducted. (See appendix L for Field Manual)

WEEK FOUR

Week four began with a discussion of the trip on the previous Friday and the students entered their impressions into their journals. The water quality data was shared among the students, the Q-test for determining water quality was applied and the macroinvertebrates were surveyed for water quality indicators (see tables in field manual – appendix L).

The second site on the Flint River was visited on Wednesday of week four. The site was a section of river in a park in the heart of the Flint city limits. The teams conducted the same tests and assessments as done at Metamora. The students also spent a good deal of time pulling trash and waste out of the river which included a stereo, a tire, a real estate sign, shoes, a steering wheel, etc. Back in the classroom, the students shared data from the river and compared the findings to the findings from Metamora.

The rest of the week was spent on discussion and review of the material we had covered over the past four weeks, impressions from the two field trips and a round-robin discussion on what the students felt should and could be done to help the river. As we went around the room, the students were expected to be able to verbalize what their findings were and what those findings meant. In addition, the students were expected to be able to explain how human activity and urbanization had impacted the river, and to be able to explain how we can change our daily activities/habits to decrease our negative impact on the river in our city.

The week ended with students working in teams to develop ways to reach out to other students and the Flint community. The goal was to educate them about how they impact the river by their daily activities at home and away from home. The students from each of the two class sections were given one of three tasks: make posters to hang around the school regarding what Northern students could do to make a difference in the river, develop a brochure to be published and distributed to the schools and various places within the city, and write public service announcements to be broadcast on the radio. The students were expected to be able to develop these projects from the knowledge they had gained, with little formal guidance or input from me until they were done. They were instructed to turn in a rough draft for proofing with all of the pertinent information included.

WEEK FIVE

At the end of the fifth week, the posters were hung in the school halls, the brochures were taken to the printer for copying and the public service announcements were faxed to the radio stations for approval (see appendix N for PSAs and appendix O for brochures). The students were given a post-unit test over the material from this unit (see appendix M). Imbedded in the test were questions from the pre-test to determine if they had improved on the scores of the pre-test as well as expanded their knowledge of all of the material covered. Finally, students were asked to evaluate the unit, and instructed to again write an opinion paper on "What Does the Flint River Have To Do With Me?" This opinion paper, as well as assigned writings in the student journals about what they had learned served as additional assessments of the knowledge the students had gained over the course of the unit.

On December 4, 2004, twelve students went to Regency Broadcasting and recorded six public service announcements to be aired on two of the main radio stations (WCRZ and WKLB) in Flint and the surrounding area. This summer, WDZZ will be airing the PSAs, as well. In addition, 4,000 copies of the students' brochures were distributed throughout Greater Flint, encouraging others to take care of the river that they had decided was worth saving.

RESULTS

The assessment of student learning, understanding and attitude change was carried out in a variety of ways. Marshall Sundberg, (2002) writing in *Cell Biology Education* suggests that while exams are useful in assigning grades, other tools might be used to provide a "rich understanding" of learning outcomes. Thus, assessment was performed by pre- and post-unit testing, pre- and post-unit opinion papers, journal writing, and unit-end projects in the form of brochures and radio-broadcast public service announcements. In this way, the assessments would be more in the context of the class rather than simply a means at the end for students to "regurgitate" facts. In addition, it was expected that in doing these types of assessments, the students would learn from them while taking part in the evaluation.

The post-test was an expanded version of the pre-test, with the pre-test questions comprising 60% of the questions. The students demonstrated an overall average improvement in test scores of 43% in the pre-test vs. post-test. Average score on the pre-test was 44% with the average score on the post-test (pre-test items only) was 87%. The high test-item improvement was 82% while the low test-item improvement was 7%. (see Appendix Q for table of scores) Paired t-test for the reliability of the pre- and post-test data was applied to the fifteen test items on forty-four tests. In twelve of the fifteen test items, the null hypothesis was rejected with a probability of less than 0.05 (see Appendix Q for t-test results table) indicating that there was a significant difference in the pre-and post-unit test scores. The questions that showed the greatest difference between pre- and post-test scores pertained to watersheds, storm water, the source of our local water supply and where runoff goes from our yards and streets. This reflected knowledge gained in areas where the students had little pre-existing knowledge. Areas that showed the least improvement were those with relatively high pre-test scores. Two were questions regarding pollution in general and groundwater which the students had little problem answering. This indicated that there was existing knowledge regarding those two areas. Test item scores for the pre- and post-unit tests are presented in graph form in *figure 2*.

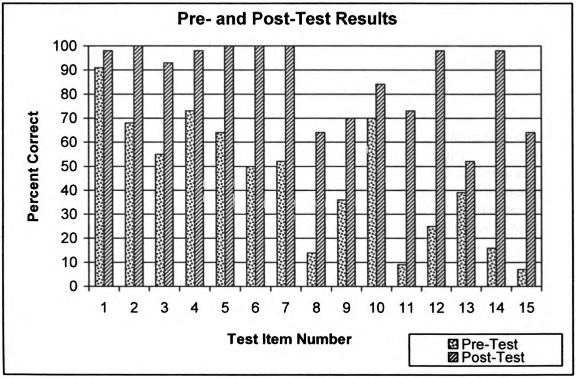

Figure 2. Pre- and post-unit test item scores by students in Specialty Biology 1 & 2 classes.

The questions on the pre- and post-tests were not multiple-choice. Instead, open-ended questions were asked to ascertain previous knowledge the students brought to this unit. Because of the subjective nature of short essay answers, excerpts from both the pre- and post-tests are given below to illustrate what was considered both unacceptable (pre-test) and acceptable (post-test) answers to the questions. When a pre-test answer is given, the post-test answer that accompanies it is a quote from the same student.

QUESTION: *How does it (river pollution) become pollution?*

Pre-test:	*"Because once this happens, it's no longer good of use."* (unacceptable)
Post-test:	*"It's pollution when it's not supposed to be there. It's pollution when ever it changes or effects the the way organisms live with things that aren't supposed to be there."* (acceptable)

Pre-test:	*"When it affects the given area it is classified as pollution."* (unacceptable – too vague)
Post-test:	*"It becomes pollution when it hits the water and things start taking a turn for the worst. For example, putting down lawn fertilizer isn't bad, but when it goes down that drain it turns into pollution in the river."* (acceptable)

QUESTION: *Where does the water go that flows into your street drains?*

Pre-test:	*"It flows to either an ocean or lake, or goes to a plant."* (unacceptable)
Post-test:	*"The Flint River."* (acceptable)

Pre-test:	*"Somewhere to be cleaned so it will be able to drink."* (unacceptable)
Post-test:	*"It goes straight into the Flint River."* (acceptable)

Pre-test: *"In the storward (storage) under ground."* (unacceptable)
Post-test: *"To Flint River."* (acceptable)

QUESTION: *Where does your drinking water come from?*

Pre-test: *No answer – left blank* (unacceptable)
Post-test: *"Lake Huron. The Flint River flows into the Shiawassee River that goes to the Saginaw Bay that eventually pours into Lake Huron."* (acceptable)

Pre-test: *"My drinking water comes from the treatment plant in Detroit which comes from their water sources."* (unacceptable)
Post-test: *"My drinking water comes the flow of water from the Flint River to the Shiawassee which then connects to the Saginaw. The Saginaw then flows to the Saginaw Bay where it's carried out into Lake Huron. From there the water's treated and sent to Flint and to my home."* (acceptable)

In addition to the pre- and post-unit tests, written assignments and journal entries were utilized to establish the knowledge, as well as opinions, with which the students were approaching this unit. The students were asked the open-ended question, "What does the Flint River have to do with me?" Journal answers varied, but the majority (77%) of the students indicated that they felt the river has nothing to do with them, 18% stated they were unsure and 5% could state how they might affect the river or how it affects them. After the unit was completed, the students were asked once again, "What does the Flint River have to do with me?" Examples of some of the entries before and after the completion of the unit are presented as follows:

STUDENT A:
Pre-unit: "The Flint River has nothing to do with me because it's so polluted that it's not even healthy to go near it…I wouldn't want anything like that to have to do with me."

Post-unit: "Well, before we did the river water tests, I felt that the Flint River had nothing to do with me. Now I think that the Flint River has everything to do with me and that I may actually be able to help stop polluting the river…I could tell other people about what's going on."

STUDENT B:
Pre-unit: "I believe the Flint River has nothing to do with me. I say this because I don't use the water and I don't eat or drink from it.

Post-Unit: "I now know that the Flint River does have something to do with me. I've learned that the Flint River drains into Lake Huron which is the main source of our drinking water. I also learned that we are the reason our river is the way it is and the little things we do (that can be prevented) are polluting the river. This came as a shock to me. An even bigger shock was learning that the only water that goes to the water treatment plant is the water that comes directly from your house. I thought and probably would have thought all the water went to the water treatment plant!"

STUDENT C:
Pre-unit: "I really have no ideal (sic) what the Flint River has to do with me. It might be a part of my water system. But I don't think so."

Post-unit: "The Flint River has everything to do with me. It is a source of water for me. I can control what goes into it like what makes it more polluted…I found out the Flint River doesn't affect us as much as we affect it….we are destroying the Flint River."

STUDENT D:
Pre-unit: "Personally I do not feel the Flint River has much to do with me…..it doesn't really affect me drastically."

Post-unit: "In this unit we basically study (sic) all the things included and that affects our watershed. I learned an awful lot! I had no idea that me, such a small person to this world, had such a tremendous affect on the Flint River. Neither did I know that the Flint River ends up being in our drinking water. Now I can say the Flint River has a lot to do with me and in return I have a lot to do with it. I affect the river's quality. I determine how it looks and smells. I alter my drinking water. I do this by every thing I put on the ground, including litter, pet waste, fertilizers and patches of dirt. I play a big role in my environment & so do you."

STUDENT E:
Pre-unit: "I wouldn't want to drink it and if I already do, I'm off fountain water forever!"

Post-unit: "I have found out over the course of this marking period that because we pollute the river, it is the way it is. I have done just about everything wrong, and for years people just like me have been doing the same thing. The pollution just reflects poorly on us. The pollution we put in the river is the same thing in our drinking water and water we shower in. I have found that the river has everything to do with me."

STUDENT F:
Pre-unit: "The Flint River pollutes the air around me. The Flint River could be a source of water but isn't because it is not clean."

Post-unit: "Throughout this unit we have learned a lot about the Flint river. The Flint River is very important to people around it. Run-off makes the river dirty and we can prevent this!! The Flint River has a lot to do with me since the Flint River is part of my water supply. Run-off goes to the Flint River, I drink this water. Now I must try to keep it clean."

STUDENT G:
Pre-unit: "The Flint River has not much to do with me. I don't use it as my water source and that isn't where I get my food. I really don't think a lot about it. The water is nasty anyway so I really don't want anything to do with the Flint River."

Post-unit: "This unit was great. I learned so much more about how our water system works and the watershed. I understand how important the river is to me. I see that I need to be careful with what I do, and that the littlest thing you do can affect our watershed in a big way. I think that from this unit I can tell other people how important the Flint River is in our daily lives. The Flint River is a beautiful area that we need to be proud of and start taking care of it more and more."

The change in the students' opinions after they had visited and compared the two river sites was clear. Numerous classroom discussions that were held over the course of the unit also reflected a turn-around in the students' understanding of the material as well as their attitudes and opinions.

Journals were also kept by students in order to track their learning as well as their attitudes/opinions regarding the river and the causes of its pollution.

The journal entries by the students after the field trips to the two river sites indicate that the difference was as apparent to them as I hoped it would be. Below are journal entries from three students from both field trips:

STUDENT A:
Metamora: "Today we went to Metamora to test the water in the Flint River. I was very surprised when I got out there. The water was so clean and nice. I was expecting a very dirty and disgusting river. I think this was a great experience and I learned so many new things."

Kearsley Park (in Flint): "Oh my. My biology class went to Kearsley Park today. We again tested the water of the Flint River and there was quite a difference in the results. The water was so gross. The water was slimy and very smelly. We found many critters that "like" polluted water."

STUDENT B:
Metamora: "At Metamora Township the river was flooded with nature. From the results of my dissolved oxygen test, I found that the area of the river could be flooded with living organisms. Not to mention the fact that the water temperature was cold locks in more oxygen. The smell of the river was refreshing, especially since the section of the river I'm close to in town smells like sewage. It just showed that nature takes care of itself and humans only disrupt this cycle when we interfere."

Kearsley Park: "The river was filthy; it made no sense at all. Stop signs, a stereo system and all kinds of cans and litter were pulled from under the surface. I hated to even step in with waders on. My dissolved oxygen test was much lower than Metamora's water!"

STUDENT C:
Metamora: "It was easy to see the distinction between leaving the city and coming to the country. It was breathtaking. The water looked as crystal

as holy water. It was a drastic difference between this part of the river and the river back home."

Kearsley Park: "Today we went to Kearsley Park to test the water there. Instantly there was a drastic difference. The stream had litter on its banks. It was along side a paved road. The stream last week looked natural, something out of a portrait. It looked pure, it looked healthy. This week's stream wasn't so clean; you could see that from the manufactured goods floating in it."

In addition to the journal entries from the field trips, entries were made in regard to other activities that were conducted in class. The entries reflect learning and understanding and three examples are shown here:

IMPERVIOUS SURFACE LAB:

STUDENT A: "I learned that just in the small amount of area there is SO much soil that is covered up and so much concrete prevents the water from absorbing."

STUDENT B: "It was a big surprise to me to find out how much water runs off our campus. Thinking of all the stuff it took with it makes me sick, too."

STUDENT C: "Today we calculated in class how many gallons of run-off runs off from Northern. I was amazed to see the huge numbers because that's only the numbers from Northern, not all of Flint. I can just imagine how much run-off goes into the Flint River. When we first started this project I kind of brushed it off because I didn't realize what was going on with the Flint River. Now I have a better understanding."

STREET SEWER VS. GRASS MODEL: IMPERVIOUS SURFACE RUNOFF

STUDENT A: The street and grass representation of rainwater was awesome. Doing the concrete vs. grass model made me realize how pavement affects everything.

STUDENT B: Today we had a "live" demonstration of run-off. It was the difference between rain soaking into the ground and becoming groundwater and rain hitting pavement and just running off quickly and a lot. It was a good demonstration that will help me remember about it in the future.

HANDOUTS

> **STUDENT A**: "When I read through the handouts I learned quite a few things about what not to do. I understand now stormwater runoff is what runs off of streets, lawns, any surface. I also see that even the littlest polluting you do can turn into a huge problem. I learned a lot about what to do and what not to do."
>
> **STUDENT B**: "After reading the handouts, I have found out some surprising things. For example, the rainbows that you see in the puddles after it rains in your driveway or the street or parking lots are signs of leaking fluids from someone's car. These puddles may seem harmless, but if these materials get into the groundwater, runoff or stormwater, it can contaminate the river."
>
> **STUDENT C**: "I realized out of all the pamphlets and brochures, it highly emphasizes runoff and pollution. I can tell human activity the main cause for aquatic pollution. I'm glad I got to read this information. I never thought about how everything we do to our Earth is affecting something else. I really think we should aware the community. I'm positive there's someone else who is just like me, uneducated about water pollution."

At the end of the unit the students were anxious to share their new knowledge, and the final evaluation of what they had learned was the application of that knowledge as a teaching tool.

The students, in groups, were given the task of putting the new knowledge they had gained into a brochure, a public service announcement or several posters. They were instructed to share the information that had the most impact on them, prepare the brochures, posters or announcements and turn them in completed and ready to publish. The information that the students included in those projects reflected a level of understanding and knowledge that the students did not exhibit before they took part in this unit (see Appendix O for copies of the two brochures and Appendix N for the text of the public service announcements).

At the end of the unit, an anonymous survey/evaluation was given to the students to ascertain whether the unit had made an impact on the students, and to find if the students considered the unit to be helpful in their learning. The results of the survey indicate that the majority of the students found the unit and what they learned to be of value.

Table 2 below lists several of the survey questions with results:

SURVEY QUESTION	% Yes	% No	% Maybe
Did you learn things about the Flint River that you never knew?	98%	2%	
Can you name three things that you learned during this study? (List them)	98%	2%	
Did your opinion of the river change during this study?	88%	12%	
Do you think that humans have an impact on the river?	100%	0%	
Do you think we could make a difference in the quality of the river?	94%	4%	2%
Do you think your new knowledge will make a difference in how you do things?	65%	9%	26%
Do you feel that any of the activities in (this unit) helped you learn the material?	86%	14%	
Do you find the knowledge that you gained to be personally valuable?	96%	4%	

Table 2. Results of Post-Unit Student Survey/Evaluation

Although apathy still existed in a small percentage of the students and some did not invest themselves in the study, both the objective data and the subjective observations/evaluations demonstrate that the river unit was effective in facilitating the students' learning as well as changing attitudes and opinions.

DISCUSSION

Teaching in an inner-city high school can be an extremely challenging experience; Flint Northern High School is no exception. A small budget, outdated textbooks, large classes, lack of parent involvement, lack of experience and a high rate of students who are reading at a level far below their grade leaves one having to rely on imagination and resourcefulness to find meaningful ways to engage and teach the students. This unit was developed to provide the students with an experience that most of them have never had, while presenting the material that must be taught. It has been my experience during my 7-year tenure at Northern that if the students are fully engaged, given an opportunity to experience something new, and are invested in the project, the learning curve rises. In the past, this has been solely based on instinct and observation. However, the river study unit was an intentional attempt to provide all of those things to students who have received very little in the way of instruction that isn't just bookwork and a paper trail. All but three of my students had never been *in* a river before, and only two of the fifty eight students had seen a "clean" river, so I hoped that the stark differences in the two sites of the river would have the desired impact on the students. I was not disappointed.

After developing the unit at MSU during the summer of 2004, my next big challenge was to obtain the supplies that I would need to carry out this study. I needed at least a dozen pair of waders, nets for collecting macroinvertebrates, water testing equipment, measuring tapes, supplies to assemble field guides, and copies of the field guide. Weeks were spent scouring the community for donations, with great results. Seven pairs of waders were donated from local stores, and Central Michigan University's GEAR-UP Program provided five more pairs. A local hardware store provided a measuring wheel, a local printer provided 25 sets of copies of the field guide, an office supply store donated three-ring binders and sheet protectors for the field guides and the Department of Environmental Science at UM-Flint provided dip nets, collection jars, and three more pair of waders to borrow. In addition, two undergraduate students from the Environmental Honor Society at UM-Flint agreed to assist during the field trips.

The Magnet Program typically guarantees the student a smaller than usual class for more individualized attention, as well as the opportunity to take part in the type of activities that a larger class would prohibit. This unit was designed with that in mind. However, at the beginning of the year, my Magnet Biology classes had 58 students between the two sections. This presented one of my biggest challenges, as there should only have been around 30 students total (including both sections) in the classroom and on the field trips. The large classes yielded larger lab groups than is optimal. As a result, the labs seemed a little less organized than I would have liked, and left some of the students with the opportunity to get distracted while others were genuinely involved with the testing procedures. Although I am used to making adjustments for this type of situation, it isn't often necessary in a Magnet class of more focused students doing somewhat complicated labs.

Certainly working with smaller groups on the field trips would have been less hectic, as well. Due to the large number of students, it seemed that I was spread a little thin at the river and didn't have as much opportunity as I felt necessary to monitor the students while they were conducting the tests. It did help, however, having the two UM students along to help guide the students through the tests, as they had conducted them in their own studies.

Additionally, because of the size of these Magnet Biology classes, administration opted to open another section of Magnet Biology and put some of the students from each of my two sections into the third section three weeks into the study. The students had already started the study with me, had been pre-tested, had done some of the labs, and were counting on going to the river. It was agreed that they would participate in the rest of the labs and the field trips, but the transition to the other class would be started prior to the river visits. After the field trips to the river, the students were immediately transferred to the other teacher, who agreed to administer the post-test to those students. The post-test was given and returned to me for grading. The end of the unit felt somewhat disjointed to me, with the students who had moved still taking part in the radio broadcasts but not actually being in my classroom during that time. However, under the circumstances, I felt it went well overall.

At the beginning of the unit, the students seemed bored and disinterested. The average grade on the watershed assessment packet was lower than I had expected. However, the scores were in keeping with my belief that lecture simply isn't enough for students to "internalize" science concepts. Surprisingly, the street-drain model seemed to pique their interest more than anything else in the beginning. They made comments in their journals and showed excitement during the demonstration. I had hoped it would be successful, but was pleasantly surprised that it had such an impact. They also enjoyed the speaker that came from the MSU Cooperative Extension and started showing an even greater interest during his visit. The *Measuring Impervious Surfaces Lab* went well, although the students did a lot of complaining about being cold, not having proper shoes to walk around campus, etc. After calculating the amount of runoff, the students were shocked that so much water would drain from our campus into the river. It sparked the beginning of a genuine discussion among the students about how much harmful material can be carried by so much water, as well as what types of things might be carried. I explained again how each of those things might impact the river, and it was then that the students began to show a true understanding of what I had been talking about. From that point, I saw a drastic increase in the level of interest shown by the majority of the students. Several of the parents that I spoke with related to me that their children were talking about our project at home…a good sign.

One of the indicators of interest among high school students is when you can draw them into a true discussion about a topic. It is not very often that one can engage the students in conversation/discussion about a topic that you are trying to *teach* them. This wasn't the case after the students realized that what we were talking about applied to *them*, to *their* activity and to *their* drinking water. We had a good level of discussion about some aspect of this study daily, with the students demonstrating an increased knowledge and understanding of the issue of river pollution due to human activity. Although this is not something that can be measured quantitatively, it was apparent in their discussion that the material was taking hold.

Although I will definitely be adding this unit to my curriculum, there were some difficulties that I believe could be alleviated by making a few changes. The unit was run in the fall due to time constraints of data collection and the completion of this thesis. However, in an ordinary school year, I would teach this unit in the spring for several reasons. Because we needed to get to the river before the weather got too cold, the general ecology material wasn't covered to my satisfaction prior to the unit. I believe if it had been, the interdependency of organisms would have been better established in the students' minds. Further, I would dedicate at least two more days to the preparation for the field trip, having the students repeat the tests until they were truly competent at running them and could explain them to me. We ran into a couple of problems with the tests. The *E. coli* group used the wrong test kit and misplaced the instructions for reading the results; it had to be repeated using a different test kit. Upon returning to the classroom, the student responsible for the *E. coli* test dropped the tubes in the classroom and broke them before we had a chance to read the results. We encountered problems with our conductivity monitor so the test was not conducted. The dissolved oxygen group had difficulty at Metamora, as well, so stopped working and had to conduct the test again while the others waited on the bus to leave. Although our data clearly showed that the river was healthier at Metamora, I believe it would have gone smoother with a little more classroom time dedicated to preparation and practice and with smaller groups. Overall the field trip went amazingly well. The majority of students were extremely enthusiastic, and the trip to the second site indicated that they had learned from the practice at Metamora.

The students were greatly impacted by the beauty and condition of the river at Metamora, and this gave rise to a meaningful classroom discussion among the students regarding what should be done by citizens in our town to try to return the river to the state of the site we just visited.

After seeing the river at Metamora, the river at Kearsley Park had the exact effect that I had anticipated. The students were upset about the trash that they pulled from the river, the smell of the river, and the "scum" that was found on all of the macroinvertebrates that we pulled from the river. It was the natural flow due to the frame of mind in the classroom to make comparisons between the two sites without my having to lead the discussion in that direction; they were emphatic about how human activity had affected the river and about what needed to be done. That WAS the lesson! The students had made the discovery for themselves and it was the *EUREKA* moment.

When the time came for the students to share their new knowledge (as the "service" part of the service learning), they were enthusiastic about doing so. It was important that they be able to pull their new knowledge together and express it in a coherent and meaningful way. As mentioned in the implementation section of this paper, some of the students were on a team to develop a brochure for distribution to the public, some made posters to display around the school and the rest were on writing teams to develop public service announcements for radio broadcast. I had already contacted several radio stations in the area who had agreed to review the PSAs once they were written.

The only direction that was given to the students regarding the assigned projects was to put into their work what they had learned that they wanted others to know. The projects were to be brought to me "ready to go". As the students worked on their projects, they would consult with me regarding questions or conflicts that they were having, but I allowed them to demonstrate what they had learned without interjecting much. I was extremely pleased to find that they were able to express themselves succinctly, indicating to me that there was an understanding of the material they had just studied.

Per instruction from the radio stations, the PSAs had to be limited to thirty seconds each, so the students had to struggle to be able to include the information that they wanted to share in such a small time frame. It was a good exercise in decision making about what they considered the most important.

All of the projects were a great experience in teamwork and cooperative learning. Just as working on the river water quality tests together taught them to cooperate in teams, sharing what they had learned in the environment of a whole new team was a learning experience in cooperation, as well. Finally, when it was time to go to the radio station, teams had to be formed once more. It was decided, by the students, who would actually read the announcements, who would be on the teams for each announcement (most required two or three voices) and when a couple of people were unable to make it, how they were going to compensate and regroup.

At the radio station, the students were interviewed on the air and briefly discussed what they had done at the river. They were well-spoken and knowledgeable, and it was obvious that they were very proud of the new knowledge they had gained.

A significant goal of this unit was to inspire the students to become involved in river projects or at least develop an awareness and sensitivity to these issues. It is my desire that there will be a far-reaching impact by helping the students become informed and responsible voters and stewards of the Flint River or the rivers where they live in the future, as well as practicing responsible habits in their daily lives that will have a positive impact on the river. While it is acknowledged that this is not something I will be able to measure or assess, it is a goal, nevertheless.

As a result of an invitation by the MSU speaker that came to our class, one of my students took part in the hazardous waste collection that took place in Flint last October, and three of my students accompanied me on a water-testing venture at the home of a gentleman who lives on Kearsley Creek (a tributary of the Flint River) who was interested in the study that the students had undertaken. On the way home, we passed the river that flows through the old Buick City factory. One of the students commented that now every time he sees water, he wants to test it. This same student, who had chosen to pursue a career in Engineering, has decided to pursue Environmental Engineering as a result of what he experienced and learned during our study. In the spring he asked me to take him back out to another part of the river to do more water quality testing, which I agreed to do. In addition, two of my students assisted me in conducting a river-testing workshop for Genesee County students enrolled in a summer science program at the U of M-Flint.

Test scores before and after the unit clearly showed that combining the constructivist theory with inquiry and service-learning can improve both learning as well as understanding of the concept of ecology as applied to solving a real problem in a local environment. While I am pleased with the results of the pre- vs. post-unit tests, in retrospect I think I would have made the test more specific and more inclusive. Although fifteen questions seemed sufficient, I would like to have shown more about the students' gain in knowledge with regards to the specific tests, etc. I know from working with the students that they knew next to nothing coming into the unit, but I would like to have been able to document the gains that they made. The paired t-test revealed that there was confirmed significance in the difference between the pre- and post-unit test scores on twelve of the fifteen questions. Question one (what is pollution?) didn't show a significant difference but had a high *pre*-test score (91%), not leaving a lot of room for improvement. Question ten only showed a 14% (70% → 84%) improvement in correct answers. The question asked "What is groundwater?" and that was a concept that some of the students still had a problem grasping, even though the speaker brought a very nice groundwater model and demonstrated it for the students. My intention is to try to discover a better way to get this across to the students, but as of now I have been unable to think of anything that is better than a model that demonstrates the concept for the students.

Question thirteen regarding household waste water only reflected a 13% (39% → 52%) improvement. This question asked "What happens to the water that you pour into your sink?" and although a majority of the students could tell me that it goes to the water treatment plant, nearly half could not answer correctly. Many of them had switched to thinking that it, too, went directly to the river. The next time this unit is covered, I will need to make sure that the students are clear about household vs. storm sewer drainage. I am fairly certain that a trip to the wastewater treatment plant by our school would help the students to clarify this issue. I had considered taking them there as part of this unit but didn't feel that I had the time or resources to do it. I will try to make it happen with the next class.

The results of the survey (Appendix P) were helpful in showing some of the weaknesses of the unit with the inquiry about what the students liked the most about the unit, liked the least about the unit, and what suggestions they had for the next time I conduct this unit. The biggest complaint the students had was that they needed more practice with the tests, critter collection needed to be more thorough, the groups were too big and the weather was too cold. These suggestions were in keeping with the weaknesses that I, too, had identified and will correct before the unit is undertaken next spring. In addition, I didn't have the opportunity to become acquainted with the students so early in the school year.

If the unit is undertaken in the spring, I will know each student better and will be better able to determine who would be best suited for each team.

I believe that this unit had an impact on most of the students in my class. The students with whom I work just don't come to me with any experience or interest in environmental issues, and this class was no exception. They started the unit apathetic and disinterested, but many became enthusiastic and involved as the unit progressed. Most importantly, it is clear that this approach for teaching ecology proved to be effective and increased the rate of student success in learning the material as well as changing the apathy of many of the students.

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APPENDICES A – R

APPENDIX A

STATE OF MICHIGAN
CONTENT STANDARDS AND BENCHMARKS
SATISFIED BY UNIT

MICHIGAN CONTENT STANDARDS AND BENCHMARKS SATISFIED BY THIS UNIT OF STUDY

Content Standard I

- Construct new scientific and personal knowledge and reconstruct previously learned knowledge
- Reflect on the nature, adequacy and connections across scientific knowledge
- Show how common themes apply in a real-world context
- Communicate their findings

Content Standard II

- Describe how human activities affect the quality of water in the hydrosphere

Benchmarks:

I.1.H.1 Ask questions that can be investigated empirically
I.1.H.4 Gather & synthesize information from books and other sources
I.1.H.2 Conduct scientific investigations
I.1.H.7 Identify and use safe procedures in science activities

<u>ECOLOGY</u>

II.1.H.6
- Develop an awareness of and sensitivity to the natural world

III.5.H.1
- Identify abiotic factors that impact the river; predict and analyze how changing factors affect the ecosystem of the river

III.5.H.3
- Predict how specific changes with the environment may increase/decrease a population's size
- Analyze how specific human activities may affect population sizes.
- Identify the environmental (biotic or abiotic) factors that may affect the carrying capacity of a population.

III.5.H.4
- Explain the relationship between the stability of an ecosystem and its biodiversity (organisms adapt, migrate or die)

III.5.H.6
- Identify the specific impacts of manufacturing, recreation and human activities on urban rivers.
- Discuss how natural resources can be protected and at the same time used.

APPENDIX B

PARENT CONSENT FORM

The Effects of Urbanization and Human Activity on the Flint River:
A Comparative Study
(Parent/Student Consent Form)

Dear Parents/Guardians and Students:

For the past three summers I have been working on my Master's Degree at Michigan State University. This past summer I developed an ecology unit that I believe will be an exciting and interesting way for the students to learn ecology, based on our own Flint River. As a requirement for my Master's Degree, I will be utilizing this unit at Northern as part of the Specialty Biology Class (1SE & 2SE). Another requirement will be for me to collect/analyze data to determine the effectiveness of this unit in improving the students' learning and motivation and report the results in my thesis.

I will be collecting this data from pre- and post-tests, lab questions, projects, reflection/opinion papers and a final project put together by the students. As part of the unit, I will be taking the students to two river sites where we will conduct habitat assessment, water quality testing and specimen collection/identification. I will be taking pictures of the students working, as well. It is the goal of this unit to teach the students about the effects of urbanization and human activity on the Flint River and to explore the possible ways that we, as individuals, can make a difference in the health of the river. The unit will be part of the normal ecology unit that starts in September and the time that the students will be involved in the study will be 4-5 weeks (the approximate duration of the study). They will be participating during normal class hours with the inclusion of two *field trips* which will involve most of the school day.

With your permission, I would like to use your student's data and/or photograph in my Master's thesis. **At no time will the student's name be used in my thesis; identity of the student will remain confidential. Your privacy will be protected to the maximum extent allowable by law.** The required work for the course will be the same for all students whether the data related to this work is used in my thesis or not. However, *permission for the use of your student's class work is voluntary, and there will be no penalty for not giving your consent.* Should you decide to give your consent, you do have the right to disengage your child from this study at any time without penalty.

If you have any questions about this study, please be certain to contact me at any time at Northern High School (810)760-1740 (or by e-mail at biogeek53@aol.com. If you have questions or concern about your rights as a study participant, you may contact Peter Vasilenko, PhD, Chair of the University Committee on Research Involving Human Subjects (UCRIHS) at (517) 432-4503, by e-mail at ucrihs@msu.edu , or by mail at 202 Olds Hall, East Lansing, MI 48824.

Please sign and return the attached permission form by Monday, September 13, 2004. Thank you for your time.

Sincerely,

Debra Bassett
Biology Teacher
Flint Northern High School

STUDENT

I voluntarily agree to participate in this study and have my **data and photograph** used as part of this thesis. My name will remain confidential and will not appear anywhere in the thesis.

____
Print name

______________________________ ____________
Student Signature Date

I voluntarily agree to participate in this study and have my **data only** used as part of this thesis. My name will remain confidential and will not appear anywhere in the thesis.

____
Print name

______________________________ ____________
Student Signature Date

PARENT/GUARDIAN

I voluntarily agree to have my child participate in this study and have his/her **data and photograph** used as part of this thesis. The student's name will remain confidential and will not appear in any way in this thesis.

______________________________ ____________
Parent/Guardian Signature Date

I voluntarily agree to have my child participate in this study and have his/her **data only** used as part of this thesis. The student's name will remain confidential and will not appear in any way in this thesis.

______________________________ ____________
Parent/Guardian Signature Date

APPENDIX C

PRE-UNIT TEST

Test Your Water Knowledge!!

Please remember that this is a tool for you and me to use to learn how much knowledge you have about water and the river. The answers that you put down should come from your own pre-existing knowledge. You won't be penalized for what you don't know. Rather, it will help us to know where we need to go with our study! **You will receive a grade based on the completion of this test.**

1. Describe pollution and use examples. ____________________
2. Where does river pollution come from?
3. How does it become pollution?
4. Name a polluted site:
5. What affect does pollution have?
6. Does it affect you? ________ How? ____________________
7. Do you pollute? ________ How? ____________________
8. What is a watershed?
9. Is there one near you? ____________
10. What is groundwater?
11. What is stormwater?
12. Where does the water go that flows into your street drains?
13. What happens to the water that you pour into your sink?
14. What happens to the water that you wash your car with outside?
15. Where does your drinking water come from? ____________________

APPENDIX D

JOURNAL RUBRIC

KEEPING A JOURNAL

We often see, feel or experience things that we are certain we will never forget. However, as time goes by, the recollection of those things changes a little or fades away. The human memory is not like a photograph...it has a tendency to change over time. Because this is so, I will ask you to keep a written journal in which you will reflect your thoughts, responses and impressions as we journey through this ecology unit together. You will also be keeping a written record of any labs that we do.

LABORATORY REPORTS

Laboratory reports in your journal will have the following requirements:

1. Lab reports should be in the back section of your journal.
2. Actual lab information should be written in ink on the right-hand page ONLY.
3. If you make a mistake, do not erase!! Simply draw a single line through the error and rewrite the correct information.
4. Notes to yourself, calculations, etc. may go on the left-hand page. This could include unexpected things that you saw, problems that you experienced during a lab, equations that you used that you will need to remember, etc.
5. Reports should include the following:
    a. Name of lab
    b. Date performed and location
    c. Lab partner's names
    d. Purpose of lab – what are we trying to discover?
    e. Hypothesis
    f. Materials used
    g. Procedure
    h. Results
    i. What did you learn?

FIELD ENTRIES

If you are in the field, you should record

a. Date
b. Location
c. Weather conditions
d. Team that you were on
e. What test you did and the results
f. Other significant observations that you made while out

OTHER GOOD STUFF

Your journal should include other things besides data and observations! Also record your personal experiences during this unit; what did you like and what didn't you like? Did you discover anything that you thought was exciting? Did your feelings or attitudes change about anything? Did you do anything you never thought you could? Did you learn anything about yourself through this? As you go through this unit and do class projects and field work, make notes and entries DAILY regarding what happened that day. You will be surprised when you go back to read it just how much you experienced!!

Journals will be collected at the end and will be part of your grade.
They will be scored according to the following rubric:

Journal has consistent entries

Journaling was done on a daily basis or every other day and include all projects, labs & field trips and many impressions	Journaling was done on a weekly basis. Includes most projects, labs and field trips as well as some personal impressions	Journaling is inconsistent; most labs missing; information from labs and field trips missing; no personal impressions entered	
5	3	1	x 10 =

Journaling was done following requirements as described above

Journal has been done according to requirements as described above	Journal has been done following most of the requirements as described above	Journal was not done following requirements as described above	
5	3	1	x 5 =

Journal is neatly done and readable

Journal is neat, in order, and easy to read.	Journal is fairly neat, somewhat in order and fairly easy to read	Journal is messy, not in order, and is difficult to read	
5	3	1	x 5 =

Total points possible = 100

APPENDIX E

UNDERSTANDING WATERSHEDS WORKSHEET ACTIVITY

UNDERSTANDING WATERSHEDS

What Is A Watershed?

A watershed is an area of land that drains water from precipitation and underground springs to a body of water such as a stream, river, pond or lake. The land is typically higher than the water that it drains into and can be mountains, forests, fields, or cities. Watersheds can be very large (covering several counties) or relatively small. But all land, no matter where it is located, is part of some watershed.

If you think about land at a higher elevation, you can imagine that water will run off to a lower level. This is exactly what happens in a watershed. The original site where the water flow begins is called the headwaters of the river. Water flow typically begins in smaller creeks and streams called tributaries that flow into a larger stream that joins with other streams to make an even larger stream, and so on. Many tributaries, then, join together to eventually form a large river that will eventually flow into a large lake or the ocean. Our watershed is the Flint River Watershed...in other words, all of the creeks and small streams in our watershed eventually flow into the Flint River. The smallest streams in the watershed (at the beginning) are called first-order streams. Two or more first order streams join together to create a larger second-order stream, two second order streams join to form a third-order stream, and so on. But it isn't just the creeks and streams that run into the river. Any water flowing over the land will potentially end up in the Flint River, either as runoff or through the ground as groundwater. (See fig. 1)

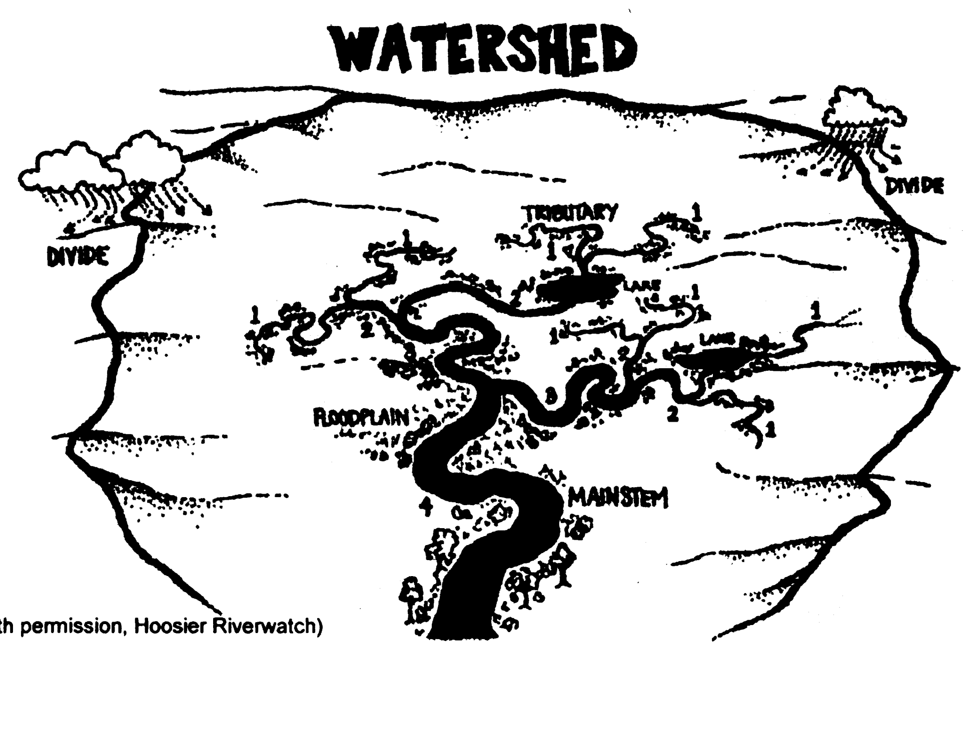

Fig.1

(Used with permission, Hoosier Riverwatch)

Referring to figure one, follow the directions below:

- The source of the river is where is begins. Find the sources of the river and put an 'S' by each site.
- Find the 8 first-order tributaries and mark them in red
- Find where they join to form 4 second-order tributaries and mark them in green
- The boundary of a watershed is called the watershed divide. Locate the divide and mark it blue.
- Find where the second-order tributaries join to form 2 third-order tributaries and mark them in orange
- Find where the third-order tributaries join to form a fourth-order mainstream and mark it in yellow
- Downstream is the direction of flow of a river from its highest point to its mouth (where it drains into a large body of water). Draw an arrow pointing downstream on your watershed map.
- The mouth of the river is where the river flows into a large body of water such as the Great Lakes or the ocean. Locate the mouth of the river and label it 'M'

Where does the water end up?

If you give it some thought, it makes sense that the water must go SOMEWHERE! Have you ever wondered where? The Flint River flows west until it meets and flows into the Shiawassee River, which turns and flows east into the Saginaw River. Finally, the Saginaw River drains into Lake Huron at the Saginaw Bay.

Is that the end of the story?

Of course not! Lake Huron is where your drinking water comes from!!! Now think about whether or not you have ever put anything into the river that you wouldn't want to drink???

More than likely you have never walked to the river and dropped something in it. However, have you ever thrown gum, paper or bottles down on the ground? Have you ever dumped anything into a street sewer drain? Do you have a pet that uses the bathroom outside? Do you (or someone in your home) ever put fertilizer on your lawn? If the answer is yes to any of those questions, chances are you have contributed those things to the river because rain will wash all of the above into a street sewer. And the street sewers lead directly to the Flint River!! (See fig. 2)

Water pollution is usually placed in two categories: point source pollution which is straight out of a sewer/drain pipe and non-point source pollution which is a result of run-off from the land and it is harder to locate the source. Either way, the water is a powerful force that picks up whatever is along the way. Unfortunately, this can include potentially harmful chemicals, trash, animal feces and dirt/debris that all too quickly become part of the river.

Referring to figure 2, name as many sources of pollution as you can and identify them as point source or non-point source pollution.

Identify which sources of pollution in figure 2 would be a result of some kind of human activity:

Fig. 2

(Used with permission, Hoosier Riverwatch)

UNDERSTANDING THE WATER CYCLE

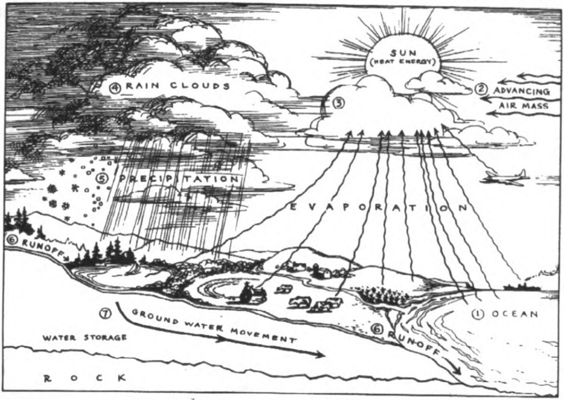

Fig. 3 From *Geography Curriculum Activities Curriculum Activities Kit*: Ready-to-Use Lessons and Skillsheets for Grades 5-12 by James F. Silver (2000) by The Center for Applied Research. Used by permission.

The diagram in figure 3 reviews the water cycle and illustrates how water falls to Earth and is recycled into the atmosphere, to fall back to Earth once more. Referring to fig. 3, name the 8 sources of moisture that is being evaporated into the atmosphere.

1. ______________________ 5. ______________________
2. ______________________ 6. ______________________
3. ______________________ 7. ______________________
4. ______________________ 8. ______________________

- What is the process that is taking place at location 3?

  ____

- What are the forms of precipitation that are falling?
  1. ______________________
  2. ______________________
  3. ______________________

- What two things are happening to the precipitation that is falling?
  1. ______________________________
  2. ______________________________

- What are some things that might be carried along with the run-off?
  1. ______________________________
  2. ______________________________
  3. ______________________________
  4. ______________________________
- Where is the run-off going?
  1. ______________________________
  2. ______________________________

o Using small circles, indicate where the water is stored underground
o Using diagonal lines, indicate where the rock layer is.

- Where does the ground water appear to be going?
  ____
- What might be carried along with the ground water?
  ____
  ____

In your own words, explain why it pays to be mindful of the things that we put on or in the ground and explain what effect urbanization might have on the watershed:

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APPENDIX F

PASS IT ON CLASSROOM ACTIVITY

PASS IT ON

(Teacher-directed Activity)

This is a fun activity that will impress upon the students that all parts of the river are related. At the end of the activity, the students will be able to explain how human activity in one part of the river can be carried downriver and affect its health. It is intended to instill in the students the idea that human activity can indeed impact the quality of a river ecosystem.

Materials

1 piece of plain white art paper for each student
Pencil
Colored pencils or crayons
An assortment of many items from around the room (your choice)

Procedure

1. Give each student a piece of art paper and make available colored pencils or crayons.
2. Instruct the students that they have just inherited 100 acres on a local river and have them illustrate what they would do with the river if they had the choice.
3. After the students have had a chance to decide what they will do, as they are illustrating their ideas, walk around the room and hand each student one, two or several items. There doesn't necessarily have to be a theme to the items, but if you see a land use that lends itself to certain items you could do so.
4. Based on what land use each student has chosen (without telling the students what you are doing) have the students come to the front of the room, one by one, and tell what land use they chose. (If a student has chosen to leave his/her land "natural", put that student at the end of the line.
5. When the students have lined up, have the student at the beginning of the line hand their given items to the student next to them. The second student will then hand those items, as well as the items received from you, to the third student and so on. This will continue until the student at the end of the line has accumulated all items from "up river".
6. Explain to the students that this is what happens when activity upstream pollutes the river and its effects are carried down river.
7. Have the students discuss what activities are carried on around your local river that might affect the rest of the river ecosystem.

JOURNAL ENTRY: Explain, in your own words, what you learned from this activity. Be specific and tell how your own river is affected by human activity.

APPENDIX G

THE TRAGEDY AND TRIUMPH OF MINAMATA
ARTICLE/QUESTIONS

The Tragedy & Triumph of Minamata

A Paradigm for Understanding Ecological, Human-Environment & Culture-Technology Interactions

Douglas Allchin

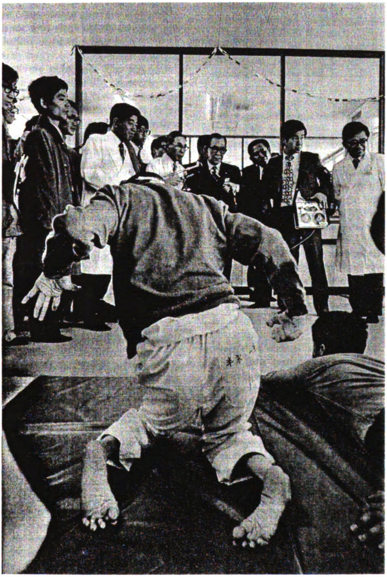


Figure 1. As mercury destroyed their nerve cells, patients lost sensation and motor control, and their limbs become contorted. In the 1960s President Shimada of Chisso, with journalists in tow, visited the Minamata Rehabilitation Center to examine the problem and express sympathies, though officially he denied Chisso's responsibility. Photo by Aileen M. Smith.

IT STARTED out quite simply, with the strangeness of cats "dancing" in the street—and sometimes collapsing and dying. Who would have known, in a modest Japanese fishing village in the 1950s, that when friends or family members occasionally shouted uncontrollably, slurred their speech, or dropped their chopsticks at dinner, that one was witnessing the subtle early symptoms of a debilitating nervous condition caused by ingesting mercury? Yet when such scattered, apparently unconnected, and mildly mysterious events began to haunt the town of Minamata, Japan, they were the first signs of one of the most dramatic and emotionally moving cases of industrial pollution in history.

The outcome was tragic: a whole town was both literally and figuratively poisoned. The residents of Minamata learned, all too painfully, how elements can concentrate in food chains, how humans and their environment are interconnected in sometimes unexpected ways, and how biology and culture interact. Yet their story is also one of healing and eventual triumph, as they have come to embrace the lessons of their history and share them with others. Even for those of us more distant, the episode is conceptually clear and emotionally powerful—a paradigm for teaching ecology and science-society issues.

The case of Minamata and the mercury poisoning (originally called Minamata disease) that took place there appeared briefly in news headlines in the 1970s and then receded from public attention—at least in the U.S. The episode was fully and richly documented by former *Life* photographer, Eugene Smith, and his wife, Aileen, who lived in Minamata for several years; much of what follows draws on their book (Smith & Smith 1975, see also Smith 1972, Kuriki 1990, Ishimure 1990; Mishima et al. 1992). The striking photos here and on the cover are theirs (along with others, available on CD-ROM: Smith & Smith 1996).

The Episode

Minamata is located on the Western coast of Kyushu, Japan's southernmost island (see Figure 2). Its disturbing story begins in the 1930s as the town was continuing to shed its heritage as a poor fishing and farming village. In 1932 the Chisso Corporation, an integral part of the local economy since 1907, began to manufacture acetaldehyde, which was used to produce plastics. As we know now, mercury from the production process began to be discharged into the bay. Though no one knew until decades later, the heavy metal became incorporated into methyl mercury chloride: an organic form that, when ingested, could be incorporated into organisms and then passed through the food chain. At the time, Minamata residents relied almost exclusively on fish and shellfish from the bay as a source of protein. The threat of pollution seems immediately evident to many students today. One ought not fail to underscore the historical context in which neither scientific experience nor a pervasive environmental awareness could offer such an explicit warning.

After World War II (around 1952), the production of acetaldehyde boomed. So, too, did the local economy—and most residents welcomed their improved lifestyles. About the same time, fish began to float in Minamata Bay. Chisso, as it had since 1925, continued to pay indemnity to local fishermen for possible damage to their fishing waters. Also at that time, cats began to exhibit bizarre behaviors that sometimes resulted in their falling into the sea and dying, in what residents referred to as "cat suicides."

In the early 1950s, similar behaviors began to appear—sporadically and without much notice—in humans. People would stumble while walking, not be able to write or button their buttons, have trouble hearing or swallowing, or tremble uncontrollably. In 1956 an apparent epidemic broke out and one can imagine the confusion—and fear—that was prevalent because no one knew the cause. Was it a viral inflammation of the brain? Was it syphilis? Was it hereditary ataxia? Or alcoholism? Was it infectious? The popular names of "cat's-dancing disease" and the "strange disease" convey some of both the mystery and its alienating quality.

The physiological effects, including successive loss of motor control, were devastating, and resulted in sometimes partly paralyzed and contorted bodies. Here, the photos of Eugene and Aileen Smith speak more fully and sensitively than any words one can imagine. One resident, Tsuginori Hamamoto, described the plight of his father, a fisherman. Virtually overnight, Sohachi lost his ability to keep his balance, or to stay afloat in the water once he had fallen off the boat. He could not put on his sandals, walk properly, or understand what others were saying to him. His son recalled how Sohachi had once been hardy and strongly self-willed. Now his condition degenerated quickly. He was hosptialized on the fourth day. There, even tied to his bed with bandages, he "craze-danced," said words that were not words. He salivated. He convulsed. Later, he tore at his own skin with his fingernails until his body bled. "Mother would look at Dad," Tsuginori recalled, "and just stand there—tears dropping from her eyes—looking dazed. Then we realized that the same symptoms were developing in Mother." The father died within seven weeks, the mother nine years later.

Douglas Allchin is in the Department of Biological Sciences, The University of Texas at El Paso, El Paso, TX 79968-0519; e-mail: allchin@utep.edu.

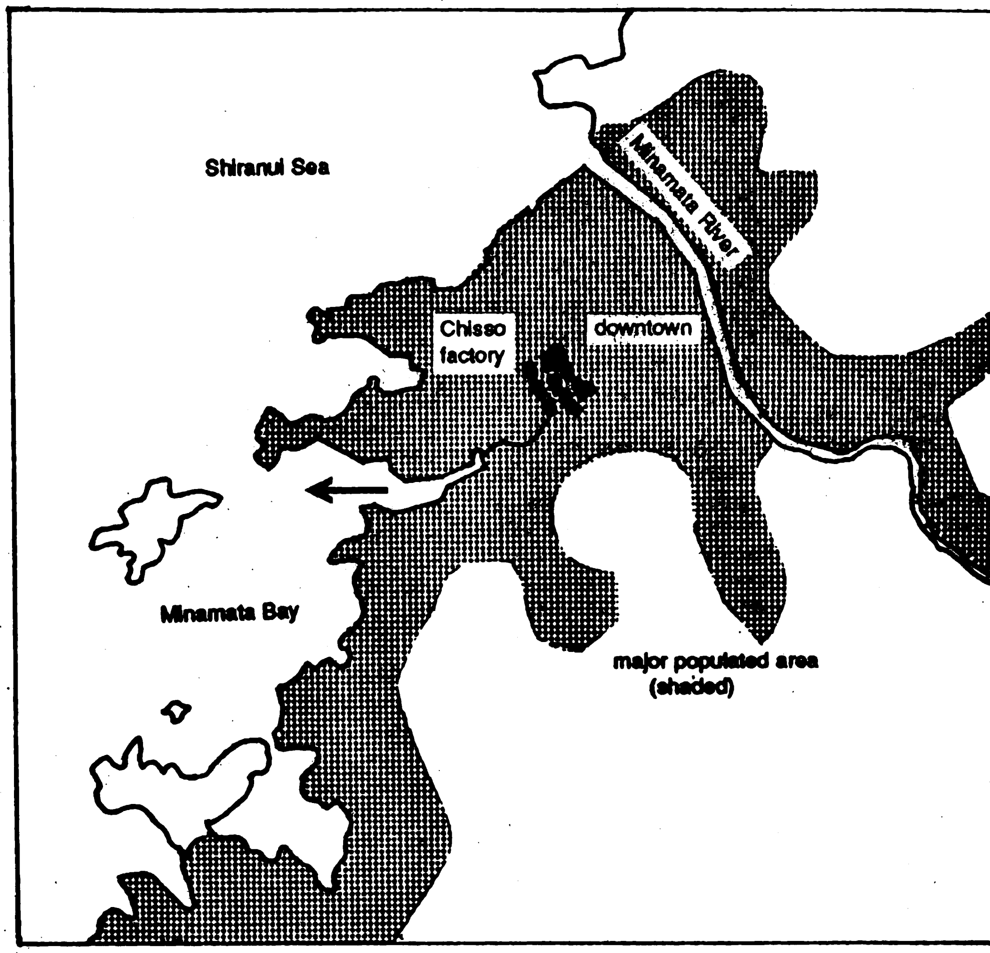


Figure 2. The city of Minamata, Japan, and the adjacent bay form a relatively closed ecosystem. The bay's fish were the primary source of protein until the mid-1950s. The effects of mercury pollution from the Chisso factory discharge (arrow) quickly cascaded through the food chain, back to the city's residents.

By the end of 1956, epidemiological and medical researchers identified the disease as heavy-metal poisoning caused by eating the fish and shellfish of Minamata Bay. Direct evidence that mercury from the Chisso plant was responsible, however, did not emerge until 1959. Dr. Hajimé Hosokawa, in private tests with cats at the Chisso Company Hospital, showed that the plant's acetaldehyde waste water caused the disease symptoms (though the results were not made public). Chisso installed a "cyclator" designed to control the emissions, offered *mimai* (consolation payments) to the patients, and the matter seemed resolved. Nearly 100 patients had been identified, of whom more than 20 had died.

Still, more patients emerged. Children were also born with the "disease." The geographical distribution of cases widened. In 1963, Public Health Service researchers traced the disease to mercury from Chisso. Controversy soon erupted over who was responsible for compensating the victims and supporting their families. It was not until 1970 that a district court ruled that Chisso make payments totalling $3.2 million to the original group of patients; others soon received payment by negotiating directly with Chisso.

Chisso still operates in Minamata and now produces liquid crystals, preservatives, anti-dessicants, fertilizers, and other chemical products. The city has diminished in size, now almost 70% of its peak population in the 1960s. From 1977 to 1990, 1.5 million cubic meters of contaminated sludge was dredged from the bay at a cost of half a billion dollars. Fifty-eight hectares of land were reclaimed over the main dumping site and now house a park, museum, bamboo garden, study center, and contemplative memorial for the victims. In 1997, the bay was declared safe again for fishing and swimming. The city, once devastated by the disease, has renewed itself recently through commitments to environmental education.

The Social & Cultural Consequences

The case of Minamata is surely engaging because the relationship between the causal agent and the effect is so unambiguous (at least today). Yet a full account also includes the more "human" dimension—those elements that contributed to the figurative poisoning of the city, and that make the case both more striking and more valuable for teaching.

For example, because the disease was related to the unexplainable behavior of wildly acting cats, the disease became stigmatized, often in the victim's own eyes. In the Japanese view of medicine, the condition of the body reflects how the individual has maintained his or her balance with the external world—and sickness can be viewed as something "deserved." The victims were thus often implicitly "blamed" for their own condition. Also, wary of contagion, residents ostracized diseased patients. Neighbor turned against neighbor. One tatami mat-maker, Yahei Ikeda, disparaged those who had the disease—until one day he, too, ironically, showed the symptoms. Neighbors with whom he had earlier shared his isolationist sentiments regarding the victims now turned those same feelings against him.

Fishermen and their families were the earliest and most severely afflicted, having consumed the most contaminated fish. It was also the fishermen who fully embodied the traditional Japanese appreciation of nature (familiar to many through classical haiku poetry and ink painting). For the fishermen, the sea was life-giving. It was hard for the villagers to comprehend that the sea could also take life away. One fisherman expressed his love of the sea:

When I thought I was dying
and my hands were numb
and wouldn't work—
and my father was dying too—when
the villagers turned against us—
it was to the sea
I would go to cry.

...

No one can understand
why I love the sea so much.
The sea
has never abandoned me.
The sea
is the blood of my veins.

Indeed, it was the poison in the food from the sea that also flowed in his blood, generating the numbness in his hands and prompting his fears of dying. Here, not only his food was polluted, but also the fundamental view of nature in his culture.

The most disturbing social overtones in Minamata may have involved the employees of Chisso. In the 1950s and 60s, Chisso employed about 60% of the town's workforce. Having essentially inherited the role of patriarchal lord from feudal Japan, Chisso was both provider and protector. The employees depended on Chisso for their livelihood and, in turn, honored this with their loyalty. So deep was this loyalty that Dr. Hosokawa, who had uncovered his company's role in causing Minamata disease, felt he could not divulge the results of his research publicly (though he did so later on his deathbed). Even today, Chisso enjoys a favorable image among many residents. When fishermen began to demonstrate against Chisso for damages, for example, company employees held counter-demonstrations. To have admitted Chisso's "guilt" would have been to acknowledge that the corporation had abandoned its filial responsibility and that the relationship could no longer be trusted. Though members of Chisso's Workers' Union could sympathize with those in Minamata's Fishermen's Union, there was no question where their loyalty would lie. The whole town of Minamata became splintered. The mercury had poisoned the community's social relations as much as the individuals' physiologies.

Causation & Responsibility

In a narrow, epidemiological sense, Chisso's effluent was the "cause" of the problems in Minamata. Yet the case here is also valuable by allowing one to see the broader economic and cultural contexts that linked Chisso and its effluent with the community around it (as noted above). Causes occur at many levels or in many contexts simultaneously: physiological, ecological, economic and political. The lessons that emerge here about the conditions that promote pollution (even if unwanted) are correspondingly clearer. They can help students move beyond the simple black-and-white view that pollution is blatantly "evil" and can be easily avoided.

There is no question, now, that Chisso withheld critical information in 1959 and continued to dump waste. The corporation was held legally liable for its negligence in 1972. Yet this does not solve the deeper problems of responsibility. One must look at how the pollution first started, and later continued. Blaming victims is unwarranted. Yet there is a sense in which the entire episode resulted from communal values and social decisions. The town as a whole welcomed Chisso's arrival and later growth, and the town as a whole prospered. And the town as a whole also suffered the unfortunate consequences. In this sense, the case of Minamata follows the classical form of tragedy taught since Aristotle: there was a tragic choice, followed by unforseen tragic consequences. The difference is that, here, events occurred on a social rather than individual level. Who, ultimately, is responsible?

One lesson may be that all the members of a society must accept the undesirable, even unanticipated, consequences of their collective judgments. Even if we do not "choose" individually to endorse nuclear energy or manufacturing with toxic byproducts, for instance, we cannot personally abdicate social responsibilty for the consequences of their waste. The problem is epitomized in current efforts to situate new landfills and hazardous waste sites. "Anywhere but in my neighborhood (or state)," is the common reply. The events in Minamata challenge whether attitudes, exemplified by the "not-in-my-backyard" syndrome, can be maintained effectively or ethically.

Political Action

Finally, Minamata can teach us about politics and the environment. Due to their economic status and the social dimensions of the disease, the victims of Minamata disease were as politically handicapped as they were physically handicapped. They—and the fishermen whose livelihoods had been destroyed—did not initially command the power or the resources to obtain proper compensation from Chisso. The story of their struggle is equally informative.

In the late 1950s, the diseased patients organized a "Mutual Help Society." Through continued petitioning, recruiting of grassroots support across Japan, months of sit-ins at Chisso headquarters, and an unsightly tent settlement on their front sidewalk in Tokyo, they focused unfavorable public attention on Chisso. Eventually Chisso management agreed to negotiate directly with the patients, rather than appeal to the government's authority (which supported Chisso). Another group of patients brought suit, wherein Dr. Hosokawa's testimony was made public and became instrumental in demonstrating Chisso's particular negligence. The court ruled in favor of the patients, and the demands of the separate negotiations group were met soon thereafter. The political campaign succeeded only through an investment of considerable effort and time.

Some teachers may feel that such political lessons are inappropriate in a biology classroom. However, students today are increasingly exposed to acts of violence intended to "resolve" conflicts. Even in environmentalism, we find tree-spiking and other forms of "monkeywrenching" or ecological sabotage (e.g. Davis 1991). Minamata exemplifies how bearing witness, patience and persistence can be effective and offer a significant alternative for action.

Epilogue

Headline disasters such as the Valdez oil spill certainly focus our attention on the adverse human effects and environmental risks of some industries. Yet such "incidents" like those at Chernobyl or Three Mile Island can also be easily dismissed as "accidents" or exceptions—not as symptoms of the status of human ecology. One can forget the often larger threats posed by low-level, more sustained release of chemicals. And one can equally overlook the more difficult, yet far more fundamental tensions involving attitudes, lifestyles, and economic and social forces (Brower & Leon 1999)—issues that are so keenly profiled by the history of Minamata. One Minamata city pamphlet frames the lesson:

> *Mass production, mass consumption, and mass waste make our lives more convenient and prosperous. Yet, our environment and health are suffering, surrounded by exhaust fumes, agricultural chemicals, food preservatives, and various toxic substances. We can not think about our rich materialistic lives without referring to the relationships we have with other countries. Minamata disease tells us that we are the perpetrators as well as the victims. ("Ten things. . ." 1997).*

The culture's traditional theme of unity with nature, evident in the poem above, now has adopted a distinctly environmental tone.

In hindsight, it is easy to prescribe what ought to have been done in Minamata—and to assign blame accordingly. But such an interpretation fails to appreciate what a historical perspective can teach us. Who could have guessed earlier this century when autos first started rolling off the assembly line that decades later we would be concerned about carbon monoxide, smog, leaded gas, drunk drivers, and global warming? Minamata is an excellent example for suggesting an environmentally informed ethos of treading lightly. Even so, no one can foretell the long-term and sometimes undesirable consequences of an action, and we must cope with them as they emerge.

Chisso finally stopped production of acetaldehyde in 1968, when an alternative technology for producing plastics emerged. Still, during the 1970s and 80s, new patients continued to surface. In some cases, the symptoms were partial: numbness or tingling in the extremities, frequent headaches, or the inability to concentrate. Determining the exact extent of the mercury's effects is difficult. Wary of the potential scope of the problem, the government was at first reluctant to verify patients. Now, more than 12,000 victims have been verified. More than $2 billion in compensation has been paid, though the costs can surely not be measured in economic terms alone.

As described to me by one Japanese native, the story of Minamata looms over the country as an example of the dark side of Japan's post-World War II industrialization. But similar incidents of mercury poisoning also occurred in Canada, China, Brazil and Indonesia (Pearce 1999). Parallel cases in the U.S.—Love Canal, Times Beach, and other less highly profiled Superfund sites—also suggest resonances well beyond Japan. Yet in Minamata, a spirit has endured. The city now sponsors several environmental awards and strives to share the hard-earned lessons of Minamata disease with the rest of the world. From tragedy they have ultimately triumphed—and that, too, is a powerful lesson.

Much like the dropping of nuclear bombs on nearby Hiroshima and Nagasaki, the poisoning of Minamata has left a profound legacy. The long-term biological effects in each case have placed a medical and social burden on society, measured both in terms of yen and our collective conscience. They also serve as poignant reminders of the consequences when man disregards the environmental effects of his actions—a lesson we often hope to convey as we teach the many meanings of biology.

THE TRAGEDY AND TRIUMPH OF MINAMATA
The Environmental Effects of Human Activity

Answer the following questions on a separate sheet of paper and return this to me with the answers. PLEASE DO NOT WRITE ON THIS PAPER! Thanks!

1. What was this article about?
2. How did the water become polluted?
3. What was the first sign that there was a problem?
4. What was the disease?
5. What are the symptoms of the disease?
6. How did the humans end up with the disease?
7. Did the Chisso Corporation know who was responsible?
8. Did they do something right away?
9. Why didn't the employees of the corporation want to help stop the problem?
10. Why didn't the government do something right away?
11. What do you think the citizens could have done sooner than they did?
12. Were the people of Minamata closely connected with nature?
    If so, how could this have happened?
13. How did the environmental issues of mercury in the water conflict with the Japanese culture?
14. Do you think the same thing could happen in the United States? In Flint, Michigan?
15. What would *you* do if the situation happened here in Flint through pollution from one of our big factories?

THOUGHT QUESTION: Does pollution just come from factories/industry?

APPENDIX H

MEASURING IMPERVIOUS SURFACES
LAB ACTIVITY

MEASURING IMPERVIOUS SURFACES

IN OTHER WORDS, HOW MUCH IS RUNNING OFF INTO THE RIVER??

As we discussed earlier, most rainwater soaks into the ground and will eventually become what we call groundwater. However, if the ground is surfaced and the rain can't soak in, it is what we refer to as an impervious surface. Some impervious surfaces that are the result of urbanization or human activity are roads, sidewalks, driveways, rooftops, etc. But just how much rain or snow will run off of impervious surfaces?

Today we will determine how much runoff comes from the impervious surfaces on our school campus. This will involve taking some measurements and doing some calculations so let's get started!

MATERIALS:

Tape measure
Pencil or pen
Paper for writing measurements
Clipboard
Calculator

PROCEDURE:

1. You will be working in groups of three. Each member of the group will play a role in this investigation. Decide who will be the recorder and which two will take the measurements using the tape measure.
2. Report to your teacher who will assign the area that you are to measure.
3. Once outside, set quickly to work, measuring and recording the area that you have been assigned. If the site has areas that are not uniform, you may have to measure it in sections then add the area together. Remember: the area of a space is the length x width.
4. Record the measurements in the space provided on the bottom of this page.
5. After you are done measuring, report to your teacher or lab tech and wait for others to finish. DON'T WANDER AROUND CAMPUS!
6. When we are back in the classroom, report your findings to the class recorder for use in calculating the total runoff for our campus.

MEASUREMENTS:

Area measured: ____

Measurements: Length ________________ Width ______________________

Calculations:

Total area: ______________________________

When you have returned to the classroom, report your findings on the data chart on the board and copy all data into the chart below.

Surface Measured	***Area***
School Roof	
Storage Building	
Mackin Rd.Lot	
Dayton St. Lot	
Mackin Rd. Driveway	
Dayton St. Driveway	
Track	
Driveway Between Lots	
Sidewalk to Mackin Rd.	
Sidewalk to Dayton St.	
Auto Shop Area	
Dock Area and Lot	
Sidewalk Around School	
Sidewalks Leading to School Mackin Lot to School	
Sidewalks Leading to School Dayton Lot to School	
Sidewalks Leading to School Side Driveway to School	
Tennis Courts	

Inches of rain this month: ____________________

Using the known area of impervious surfaces on our campus and the inches of rain this month, calculate the amount of storm water run-off that went into the sewer and out to the Flint River. Use the equation shown here:

rain" x 1 ft/12" x ft^2 impervious surface x 1 gallon/.13368 ft^3

DO YOU SUPPOSE THAT WATER CARRIED ANY SUBSTANCES WE WOULDN'T WANT IN OUR RIVER?

APPENDIX I

STREAM FLOW PRACTICE

STREAM FLOW PRACTICE

Before going out to the river, it is recommended that you practice your technique. This can be done in the hallway at school (remember that there are classes in session so try not to be disruptive!). Tennis balls are a good substitute for the oranges that we will be using in the river.

Materials:
Three students
Three tennis balls
Stopwatch
Measuring tape or metric sticks
Chalk

1. Using the measuring tape, measure the width of the hall or a designated "river" area outside. Take three measurements and then average them for the average width of the "river". Record the width for later calculations
2. Your teacher will assign a predetermined random measurement to use as the depth of the "river".
3. Measure the velocity of the "river" using a tennis ball.
   a. Determine an area 25 meters in length & mark in chalk.
   b. One of you (student #1) will stand at one end of the 25 meters while two students stand at the other end of the 25 meters. (students #2 & 3)
   c. Student #3 will be the timer (using a stopwatch)
   d. When ready, student #3 will give the signal for student #1 to roll the ball. When student #1 rolls the ball, student #3 will start the stopwatch.
   e. When the ball reaches 25 meters, the timer will stop the stopwatch and record how long it took for the ball to travel 25 meters.
   f. Repeat this process three times and calculate the average velocity.
   g. Using the determined velocity, calculate the stream flow as follows:

width x depth x velocity x n = stream flow

***n** is a factor assigned according to the type of substrate in the river. For this exercise, we will use n = **0.8**.

APPENDIX J

LEARNING TO IDENTIFY BENTHIC MACROINVERTEBRATES

LEARNING TO IDENTIFY BENTHIC MACROINVERTEBRATES

Benthic macroinvertebrates are animals without a backbone (invertebrates) that can be seen with the bare eye (macro) and live on or near the bottom of the river (benthos). These animals are an excellent indicator of the health of the river because many cannot live in a polluted environment, while others can live in almost any quality of water. It stands to reason, then, that one could collect these invertebrates to observe what populations are present to determine the quality of water in the river.

Some invertebrates spend their entire life in the water while others only spend their larval stages in the water and emerge later as adult insects. These animals are generally easy to collect and fairly easy to identify. When we are out in the field, we will be collecting and identifying invertebrates to determine the composition of the communities at each site.

Today you will be identifying some macroinvertebrates that have been collected from a site on a Flint River tributary. Your job will be two-fold: 1) Identify the animals that are preserved in the bottles and 2) using the data that you have, make a general determination about the quality of the water in the area where the animals were collected.

MATERIALS:

Taxonomic Key to Benthic Macroinvertebrates
Macroinvertebrate specimens
Pencil

PROCEDURE:

1. There are 7 bottles/tubes containing macroinvertebrates. You will need to share/exchange these with your classmates as you finish.
2. Using your macroinvertebrate key, identify each of the specimens in the containers. Note that there may be more than one type of specimen if they are tiny.
3. Enter your data into the data chart on page two.
4. Based on your data analysis, draw general conclusion about the quality of water that these animals may have come from.

DATA SHEET

BENTHIC MACROINVERTEBRATES

Species Identified:

1. ______________________
2. ______________________
3. ______________________
4. ______________________
5. ______________________
6. ______________________
7. ______________________
8. ______________________

CONCLUSION

____
____
____
____

EXPLAIN

____
____
____
____
____

POLLUTANT INTOLERANT

Stonefly Nymph
Mayfly Nymph
Dobsonfly Nymph
Caddisfly Larva
Right-hand Snail
Riffle Beetle
Water Penny

MODERATELY TOLERANT
(lives in wide range)

Dragonfly Nymph
Cranefly Larva
Clams
Scud
Crayfish
Damselfly Nymph
Sowbug
Beetle Larva

POLLUTION TOLERANT

Leeches
Aquatic Worms
Midge Larva
Left-hand Snails
Black Fly Larva
Rat-tailed Maggots
Planaria

A STEP FURTHER:

Using the Invertebrate Key, draw pictures of four of the invertebrates that you DID NOT see in this collection today. This will help you to be more familiar with some of these animals when we are in the field should you come across them in your collecting!

Identify ______________________________

Identify ______________________________

Identify ______________________________

Identify ______________________________

A NOTE TO THE TEACHER:

This exercise is intended to give the students a chance to become familiarized with some of the invertebrates they will encounter in the field. This will get them used to being "close up" with the specimens, as well as giving them a sense of knowing when they reach the river site. I have found that the students show a greater interest if they can recognize something they are already familiar with. Further, it is helpful if they only have to learn how to collect the specimens at the site and not how to ID them, as well.

If you already have preserved specimens, these could be used. However, you might want to choose a site and collect specimens for this lab. I chose a site that is historically known to have poor water quality and collected specimens for use in this lab. On the other hand, you may want to find a river site with better water quality and make your collection there.

Specimens were preserved in 70% isopropyl alcohol. They were left in the alcohol for 24 hours, then alcohol was poured out and new alcohol put in the bottles due to the dilution of the alcohol from the specimen fluid. This should give you a longer period of preservation.

APPENDIX K

POLLUTED OR NOT POLLUTED
LAB ACTIVITY

POLLUTED OR NOT POLLUTED? THAT IS THE QUESTION!

We have discussed, at length, the history and use of the Flint River. We have learned that there are many things that influence the water quality of a river, including industry, transportation, run-off from storm sewers and pavement, as well as human activities both at home and out in the environment. In some cases, natural processes can serve to keep water pure. However, when pollutants enter the water in large enough quantities, nature cannot keep up.

You are scientists at an Environmental Research Laboratory in our area and you have received a sample of water from a concerned citizens' group for analysis. Your job is to determine whether the sample of water has come from a polluted site or if the water is "healthy". While there are many ways that one would determine the health of the river, we are limited in the lab to chemical testing of the water itself.

Remember that you should always have a control when conducting research. Therefore, you will be testing an unpolluted sample to establish a baseline for your test.

OBJECTIVE: The series of tests that you will conduct today will help to familiarize you with some of the tests that we will be conducting in the field when we visit several locations within the Flint River Watershed. This will be a lab in which you will also learn how various factors affect the quality of water in the river as well as the health of organisms that must live in that water. Further, you will learn how we, personally, affect the well-being of the river and its residents.

MATERIALS:

- 10 test tubes and a test tube rack
- two capped bottles
- 250 ml distilled water
- 250 ml unknown water (this will be assigned by your teacher)
- 2 pipettes
- stirring rods
- rubber (latex) gloves
- goggles
- thermometer
- water quality tests for:

  pH
  nitrates
  phosphates
  dissolved oxygen
  conductivity

GETTING STARTED:

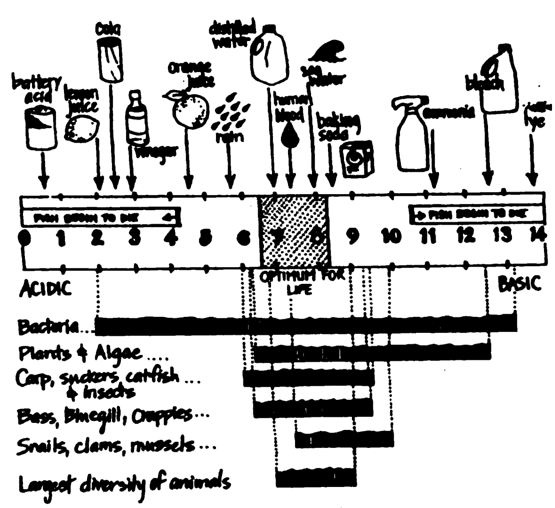
1. Collect the materials that you will need to conduct your lab and take them to your lab station.
2. Obtain 250 ml of unknown water from your teacher. Your control is number _______. Be certain to wear gloves and goggles when handling your unknown!
3. Obtain 250 ml of distilled water (this will be your control)
4. Label 5 test tubes "control: (name of test)"
5. Label 5 test tubes "unknown: (name of test)"
6. Label one capped bottle "control: do"
7. Label one capped bottle "unknown: do"
8. Put 25 ml of control water in your control test tubes
9. Put 25 ml of unknown water in your unknown test tubes
10. Set aside the capped bottles until it is time for the dissolved oxygen test, then consult your teacher for assistance in filling your bottles
11. Now let's conduct some tests!!!!

PROCEDURE:

1. Observe the appearance of your control and your unknown. (Take note if there is any type of film on the top of your water. Record your observations in your Water Quality Table.

2. **pH** **Recall that pH is a measure of how acidic or basic a substance is.** pH will affect how soluble some nutrients and some metals are in water. pH outside of the normal range renders water unsafe for human consumption and can be fatal to water plants and animals. pH can be affected by the natural presence of carbon dioxide and the erosion of limestone rocks (which are carbonate rocks), but human activity can contribute to the change in pH, as well. Acid rain or snow as a result of the burning of fossil fuels (e.g. gasoline), chemical spills, runoff from city streets and lawns, sewage, and agricultural activity all contribute to abnormal changes in the pH of water. The temperature of the water will also directly affect the water's pH. Using the test strips in your kit, measure the pH of both samples of water and record the results in your Water Quality Table.

Most aquatic organisms live in pH 6-9. Species diversity will decrease outside of this range. A pH above 9 can dissolve Organic substances including animal skin and scales. (American Chemical Society, 2002)



(With permission, Hoosier Riverwatch)

3. **NITRATES** - As you may or may not know, nitrogen makes up ~79% of the air we breathe and is found in the cells of all living things. Plants are able to "fix" nitrogen by bonding it to hydrogen or oxygen, thus making compounds (e.g. ammonia and nitrates) which render it useable to them. Plants consume the nitrogen and, in turn, humans and other animals consume the plants, using the nitrogen-containing compounds (i.e. nutrients) for growth, metabolism and reproduction. However, when too much nitrogen enters the river, a chain reaction can take place that can be deadly to living organisms. Too much nitrate in a waterway can result in the excessive growth of surface algae and aquatic weeds. This overabundance of plants in a waterway is known as eutrophicaton (EWE-TRO-FE-KAY-SHUN). Deeper plants cannot get light and die, thus wiping out a food source for bottom-dwelling organisms. In addition, as these plants die and decay, the decomposer bacteria use valuable oxygen, thus the other organisms suffocate.
A human consequence is the development of methemoglobinema, a condition caused by high nitrates in drinking water. This condition, which mainly affects infants and the elderly, prohibits oxygen from properly binding to hemoglobin (the oxygen-carrying molecule in the blood) so cells do not receive enough oxygen. This results in a bluish appearance to the skin, giving rise to the name "Blue Baby Syndrome".
The biggest contributor of nitrogen to our waterways is lawn (and crop) fertilizer. While some fertilizer is absorbed by plants (& grass), some is washed off by rain and enters rivers as runoff and through groundwater. Other sources include human sewage and animal waste runoff.
Using your nitrate test kit and following the directions in your field manual, determine the nitrate level of your samples and enter the results in your Water Quality Table.

4. **PHOSPHATES** – As with nitrogen, phosphorus is essential for plant growth and development. And, as with nitrogen, too much phosphorus in a waterway can promote an overabundance of algae (such as seaweed and pond "scum"). Recall that when this occurs, sunlight is blocked from the bottom-dwelling plants and they die. The bacteria that decomposes them will use up oxygen that is needed by living organisms in the water and they will eventually die, as well. This can lead to the thriving of anaerobic bacteria (bacteria that does not need oxygen), resulting in a foul smell and the filling-in of the waterway with decaying organic matter.
Once again, human activity can greatly increase the amount of phosphates in our water systems. Fertilizers and detergents are the two main sources of human-induced phosphate over-loading. Phosphates in fertilizers can enter rivers in runoff or groundwater and detergents are often released when they are poured down sewers or sent down drains to the water-treatment plant and then released into the river. Further, erosion from human activity such as construction or even areas where the grass has been worn off can also release phosphorus-containing soil into the river.
Using your phosphate test kit and following the directions in your field manual, determine the phosphate level of your samples and enter the results in your Water Quality Table.

5. **DISSOLVED OXYGEN** – Dissolved oxygen is literally oxygen gas that has dissolved in the water of the river; this oxygen is used by fish and other aquatic organisms just like you use oxygen from the atmosphere. Different species require different amounts of oxygen, thus some species can live in a river that would kill others. However, there must be enough dissolved oxygen in the water for the organisms, and as we saw in our discussion on nitrates/phosphates, a river with too many of these nutrients will become dangerously low in dissolved oxygen. Typically, dissolved oxygen levels less than ~ 2 mg/l cannot support fish and many other aquatic organisms, and more than 5 mg/l is required in order to maintain a healthy community of organisms. The presence of oxygen in water, then, is a positive sign and the absence of oxygen is a red flag that there is probably pollution.

   Oxygen in the water generally comes from two sources: atmospheric oxygen that is mixed in by waves and water tumbling over rocks, and especially by algae and rooted aquatic plants that release oxygen as they conduct photosynthesis.

   Oxygen is more easily dissolved in cooler water than in warmer water, so temperature can have an effect on how much dissolved oxygen is in a river. In addition, human activity contributing to the collection of organic waste (such as urban runoff from factories, neighborhood yards, sidewalks, and street sewers—remember the effects of nitrates and phosphates!)

   It is important to note that the dissolved oxygen levels will change depending the temperature and time of day so it is important to record the testing conditions on your Water Quality Table (date, location, time, air temperature, and weather conditions) proceeding with the test.

   CAREFULLY FOLLOW THE DIRECTIONS BELOW. IT IS VITAL THAT YOU DO NOT HAVE BUBBLES IN THE COLLECTION BOTTLE SO TAKE YOUR TIME AND PRACTICE COLLECTING THE WATER IN SUCH A WAY THAT NO BUBBLES ARE TRAPPED.

   a. Thoroughly rinse the water sample bottle before you collect your sample.

   b. Gently fill the collection bottle until it is overflowing with water (this can be more efficiently done if you collect the water under the surface). If you have air bubbles in your bottle, you can often get them out by tapping the side of the bottle or dropping a small glass bead to the bottom of the bottle.

   c. Taking care not to introduce air into your water sample, immediately add 8 drops of Manganous Sulfate Solution and 8 drops of Alkaline Potassium Iodide Azide Solution to the sample. (GENTLEY drop the reagents onto the surface of your water sample as you add them.) Cap the bottle and mix the solution gently by tipping the bottle several times. You will see a precipitate (a solid material) form which you should allow to settle some, then tip the bottle to mix again. Now let the precipitate settle again.

   d. Use the 1 gram measuring spoon to add one level spoon of Sulfamic Acid Powder to the water sample. Recap the bottle and gently shake it until the acid and the precipitate have dissolved. Now the sample will be clear-yellow to brown-orange in color (depending on the oxygen present in the sample). Now the oxygen is "fixed" and the sample cannot be affected by atmospheric oxygen.

   e. Fill the titration vial to the 20 mL line with your "fixed" sample and cap the vial. Add 8 drops of starch indicator to the fixed sample and gently swirl to evenly mix the starch. Your sample should now be a purple color.

f. Fill the Titrator Syringe with Sodium Thiosulfate Solution by inserting the syringe into the plastic fitting of the bottle of Sodium Thiosulfate Solution and turning the bottle up. Slowly withdraw the plunger MAKING CERTAIN YOU DON'T GET ANY AIR BUBBLES IN THE SYRINGE. Stop withdrawing when the bottom of the plunger reaches the zero mark. Now carefully insert the Titrator syringe into the center hole of the titration vial cap. While you gently swirl the vial, SLOWLY press the plunger to inject the Sodium Thiosulfate Solution into the vial ONE DROP AT A TIME just until the purple color disappears. Make a note the total of units of Sodium Thiosulfate that were required to make the color disappear. This is your measurement of dissolved oxygen. Record this measurement on your Water Quality Table. Then use this measurement on the DO Concentration Conversion chart, as well as the temperature of the water to determine the percent saturation of the water with dissolved oxygen. Record this figure, as well, on your Water Quality Table.

6. **CONDUCTIVITY** – Conductivity is the measure of how well a substance conducts electricity. This is true of water conductivity, as well. When an atom gains or loses an electron, it becomes a charged ion: if it gains an electron, it becomes negatively charged; if it loses an electron, it becomes positively charged. As with other qualities of water, too many or too few ions can be harmful to plants, humans and aquatic animals.

Natural ions found in water may include those such as calcium, magnesium, chloride, nitrates, sodium, etc. If these are present, the conductivity will increase. And while many of these ions are useful and necessary for plant and animal growth and development, too many or too few ions can be an indication of water quality problems. Too much salt (high conductivity), for example may be deadly to plants, while water with low ions can be corrosive and pull lead and copper out of pipes carrying it to drinking water.

Human-caused ions in the water may include factory and sewage discharge (chloride, nitrates and phosphates), as well as urban runoff of road salt, other chemical deicers and various fluids from cars. Too few ions can be caused by the discharge of oils into the water.

Conductivity is measured with a special meter called a conductivity meter which has two probes that are immersed in the water sample that can use a small amount of voltage to measure the conductivity of the water. Because ions move more rapidly in warmer water (thereby being better conductors of electricity), it is Important to always measure and record the temperature of the water when measuring the conductivity.

Using the conductivity meter, measure and record the conductivity of both water samples and record them on your Water Quality Table.

7. **TEMPERATURE** – Just as the temperature in your body must remain within normal limits for you to stay healthy, water temperature of a river must remain consistent, too. Temperature affects many of the functions of the river, both biological and chemical. Remember, the amount of dissolved oxygen in the water depends on the temperature: if the temperature of water rises, there is less oxygen available. Cooler water holds more oxygen because oxygen dissolves easier in cool water. Remember, too, that conductivity increases as the temperature goes up. But what other things are affected by temperature?

   Aquatic organisms are more sensitive to disease at higher temperatures, the rate of metabolism of organisms increases (requiring more oxygen), photosynthesis and growth increases in algae and plants (as more plants die, more oxygen is required for decomposition) and aerobic bacteria cannot live (due to low levels of oxygen).

   How do humans (especially in the city) affect the temperature of the river? Stripping of vegetation along the river bank for parks or construction removes the cooling shade as well as increasing erosion. Impervious surfaces such as roads, parking lots, roofs, etc. absorb heat that in turn heats water that runs over them. That heated runoff drains into the river, increasing the temperature of the river water. Erosion from construction, worn spots in grass, etc. also produce sediment in the river that absorbs sunlight and increases temperature.

   What was the temperature of your water samples?

   Control __________
   Unknown __________

8. There are other tests that can be run to help discover the overall quality of water in a river. We will be doing the tests you have just completed, as well as a few of the others when we visit our river. But, as you probably noticed, the measurements are not all in the same units. To find the overall quality of water in a river, we must convert our data into a **Q-value**. Using the graphs on the following pages, determine the Q-values of your data (this will give you a percentage) and enter them in your Water Quality Table.

   As with any assessment, some tests have more weight than others. This is true of water quality testing, as well. To give the data the value in the overall picture that it should have, the tests have been assigned a **weighting factor**. These weighting factors are on your Water Quality Table. You will **multiply** your Q-values x weighting factor for each test performed, giving you a total % for each test. Finally, add all of the percentages in your last column to give you the **Overall Water Quality Index.** This figure will give you the figure that you need to determine the quality of your water! Now compare your figure to the chart on your Water Quality Table to determine the overall water quality of your unknown water sample.

- Our unknown # ________ had a water quality rating of ____________________.

Signatures:

____

____

Journal Entries: Following the journaling guidelines, enter this lab into your journal, including an *explanation* of what we did in this lab exercise.

Journal Questions:

1. Explain why it is important to do water quality testing.
2. Explain several ways that humans have an impact on our river based on the tests that you conducted in this lab.
3. Tell if your unknown sample was polluted or not and explain how you came to this conclusion.

POST-LAB QUESTIONS

1. What can cause the temperature of river water to change?
2. What problems can be caused by the change of water temperature?
3. What is pH?
4. What can cause a change in the pH of river water? *Be specific.*
5. What problems can be caused by the change in water pH?
6. What are phosphates?
7. What outside factors cause the presence of phosphates in the river water?
8. What is the problem with a high phosphate level in the river?
9. What are nitrates?
10. What outside factors cause the presence of high nitrate levels in the river?
11. What is the problem with a high phosphate level in the river?
12. What is meant by "dissolved oxygen"?
13. Why is dissolved oxygen important in the river?
14. What might cause a low level of dissolved oxygen in river water?
15. What is conductivity?
16. What human activity may affect the conductivity of the water?
17. What is E. Coli (Fecal Coliform)?
18. How does it get into the water?
19. What can we tell from a BOD test?
20. Why is it necessary to find a Q-value?

CONTROL SAMPLE

Test Performed	Measurement	Q-Value (%)	Weighting Factor	Total (%)
Ph			**0.11**	
Nitrate	mg/L		**0.10**	
Phosphate	mg/L		**0.10**	
Dissolved oxygen	% Sat		**0.17**	
Conductivity				
Temperature	°C		**0.10**	

Observations:

____

____

UNKNOWN SAMPLE

Test Performed	Measurement	Q-Value (%)	Weighting Factor	Total (%)
Ph			**0.11**	
Nitrate	mg/L		**0.10**	
Phosphate	mg/L		**0.10**	
Dissolved oxygen	% Sat		**0.17**	
Conductivity				
Temperature	°C		**0.10**	

Observations:

____

____

OBJECTIVES

Students will:

- Master the skills of water quality testing in the classroom before going into the field.
- Be able to explain what the individual tests mean
- Be able to describe what effect each factor has on the water and on living organisms, as well as humans
- Learn how to calculate the Q-value for each parameter using the Q-value graphs provided
- Understand the weighting factor and be able to use it to obtain the total percentage for each parameter.
- Use the data obtained to determine the overall water quality of their sample of water (taking into consideration that some tests were not performed that will be undertaken at the river site)

Teacher notes:

- This lab will take two or three lab periods, depending on the speed with which the students are able to work. It will be helpful to stop at points along the way to discuss the students' findings and discuss any difficulty that they may be having with the tests.

- Journaling with this lab will help to reinforce the concepts that we are trying to get across. Each student will be expected to keep a journal of their data, along with personal impressions, even when they are working in groups.

- A preceding pH lab will give the students the skills they need to use the dipstick/color chart method of reading test results so that they won't have difficulty mastering these water quality tests.

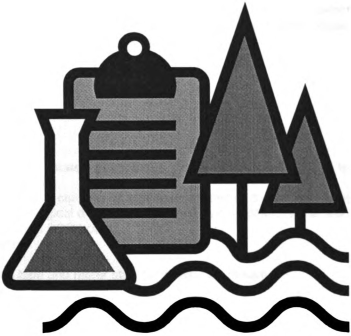
- Practice with the dissolved oxygen bottles will be helpful before students actually try to run the test. Clean water can be put in a bucket and the students can practice the skill of collecting water samples with no bubbles.

- Students will probably need help with the math so the actual overall water quality index may require one lab period of its own. (It is important to stress to the students that some tests were not performed today that will be conducted at the river site)

APPENDIX L

FIELD MANUAL FOR WATER QUALITY TESTING

Field Manual For Water Quality Testing



Written and compiled by:

Debra Bassett

(July, 2004)

THE RIVER CHALLENGE – OFF WE GO!

You will now have the opportunity to experience the wonder of the river! When we visit our various sites at the river, please keep in mind that everything we do will affect the river and its inhabitants in some way. We must be mindful of where we step, what we throw down, and be certain that when we leave, it doesn't look as though we have been there at all!

While at the river, we will be doing several things: assessing the habitat surrounding the river, testing the quality of the water in the river and collecting and identifying the critters that live there! By analyzing the data that you have collected, you will be able to assess the health of the river at the site where we do our study. And by comparing the different sites on the river, you will be able to make a comparison between different areas, the urban setting where there is much human activity and the rural setting where there is a minimum of human activity.

OBJECTIVES

This will be an opportunity for you to learn about field work as you use your powers of observation, as well as your skills at water testing, data collection and analyzing water quality. You will also learn how to collect invertebrates, use your new skill of identifying those critters and use that data as an indicator to help determine the health of the water. It is a chance to actually be in the river and experience what it is all about!

MATERIALS

Waders
Goggles
Rubber Gloves
Water quality tests for nitrates, phosphates, pH, dissolved oxygen (DO), turbidity
Thermometer with guard
Sterilized bottle for fecal coliform (E. coli) test (will be conducted in the classroom)
Capped bottle for biological oxygen demand test (will be conducted in the classroom)
Electrical tape to wrap BOD bottle
Conductivity meter
Distilled water
Metric measuring tape and meter stick for measuring stream
3 Oranges
Stopwatch for timing flow
Collection nets for benthics collection
2 Pan for invertebrates
2 Sorting trays for invertebrates
Invertebrate key
Forceps
Clipboard
Monitor sheets
Writing utensil (pencil recommended)
Cooler for transporting water samples back to classroom

FIELD STUDY TIPS

WATER SAMPLING:

Samples should not be collected from the bank of the river. Rather, you should take samples from the middle of the river in the current flow and sample at least 6 inches to one foot below the water if it is deep enough. (If the water is not wadeable, you should collect from a bridge by lowering a collection container or from the shore with a long handle attached to the container.) Be sure to collect samples upstream from where you are standing and be careful not to stir up the sediment in the bottom of the stream. Rinse the bottle two or three times with the river water before you collect the sample you will keep. You can keep the cap on the bottle until it is at the point where you want to collect, then remove the cap and allow the water to fill the bottle naturally. Cap the bottle while still under water. **REMEMBER!!! When collecting for the dissolved oxygen test, there should not be ANY bubbles in bottle.**

TESTING TEMPERATURE CHANGE

When testing the **temperature** of the water, lower the thermometer by its string until its bulb is approximately 6 inches to one foot below the water's surface in the main stream flow. Hold it in place for 2-3 minutes. If it is possible, read the thermometer without taking it out of the water. Otherwise, remove it from the water and read it immediately before the air temperature has an effect on your reading. Remember, you will need another reading at a site approximately one mile upstream with pretty much the same shade and water depth &velocity for your second reading. Once you have your second reading, subtract the two figures to calculate any temperature change. Temperature change of over 2° C indicates that there may be thermal pollution.

HABITAT ASSESSMENT

A habitat assessment will consist of many aspects of the total river habitat. You will be looking at the land use around the river, the stream's riffles, runs and pools, any dams present (natural or man-made), obvious pollution/polluting factors, areas of erosion, substrate (bottom) type, vegetation, stream shape, alterations from human activity, width, depth and velocity. It is helpful to sketch a map of the river and its surrounding area. A habitat evaluation survey form will help to guide you through the assessment.

BENTHIC ASSESSMENT (WHAT'S LIVING THERE?)

When collecting invertebrates, you will be in groups of three. One person will be the "netter", one person will be the "shuffler" and one person will be the "collector" (this person will hold and keep track of the collection pan. It will probably be necessary to collect several nets full before returning to shore to sort your specimens. When collecting, you should sample several areas in the river. You will want to collect in the middle of the river, along the edge, underneath undercut areas, along root masses and at riffles where many important invertebrates live attached to rocks in the rapidly moving water.

The netter will stand downstream from the shuffler against the current and force the net against the bottom of the stream while the shuffler disturbs the stream bottom by shuffling his/her feet, stirring up the bottom. If rocks are present, scrub your feet on the rocks or turn them over to stir up any organisms that are attached to the rocks. Ideally, if the stream is shallow enough, you can pick up the rocks and collect the attached animals. Each net can be emptied into the pan and later sorted on shore in the shade.

Remember, we do not want to harm these animals; we just want to count/identify them!!

STEPS TO TAKE AFTER ARRIVING AT THE SITE:

1. Assemble with your team after getting off the bus. For safety purposes, each of you should be aware of the whereabouts of each member of your team at ALL TIMES!
2. Gather any equipment that your team will be using during the field study at the site.
3. Check to make sure that you have your monitor sheets and a writing utensil, as well as your own field journal.
4. If you are going to be in the water, take a pair of waders.
5. Each person should have a pair of goggles and a pair of rubber gloves.
6. When all teams are assembled, your teacher will guide you to the spot where you will either enter the river or where you will start the assessment that you will be conducting at the site.
7. If you are on private property with permission, be sure to respect the property and the property owners at all times. Remember that you are representing not only yourself but your school district, as well.
8. These assessments are time-consuming so when instructed to begin, you will want to work steadily and efficiently in order to get all of the work done before it is time to leave.
9. If you are working in the river, take small steps and check your footing each step to assure that there are no sudden deep spots.
10. If you are assessing the invertebrates in the river, you may want to compare notes with another team that is conducting the same survey. Compare the actual invertebrates and check to insure that you are identifying them as the same animal! Once you have identified them, double check with your teacher to make certain that you have assigned the proper identification to each organism.
11. If you have questions or problems with any of your tests, don't go any further until you ask your teacher or intern for help.
12. If you finish your assigned assessment before the others, you may sit quietly on the bank of the river and begin your journal entries.
13. Be absolutely certain that you do not litter or leave anything in or around the river.
14. Dispose of chemicals in the container that has been assigned for "waste".
15. When you leave the site, take an inventory of all items that you took to the site to make certain that you are leaving with all of the equipment checked out to you.
16. LEAVE ONLY FOOTPRINTS when you go back to the bus!
17. **HAVE FUN!!!!!!!**

MACROINVERTEBRATE ASSESSMENT

EQUIPMENT:

Waders

Dip net

Collecting pans and sorting trays

Forceps

1. All three of you should enter the water together, being careful to test the footing as you go. Be sure to keep track of the others' whereabouts.
2. *NETTER*: You will be downstream from the others. Facing your partner upstream, force the net to the bottom of the stream, holding the handle perpendicular to the water.
3. *SHUFFLER*: Facing the netter who is downstream from you, shuffle your feet in a side-to-side motion, stirring up the bottom so that any organisms that are there will be swept by the river current into the dip net.
4. After a couple of minutes of shuffling and netting, you will want to check the net for invertebrates. You can do this by emptying the contents of your net into the pan held by the *COLLECTOR*. (If your net is full of mud, you can dip it UP AND DOWN in the water a few times to rinse out excess mud. Don't throw out the weeds, though. It is almost guaranteed that there are critters in them!!)
5. Move to another area and repeat the [net, shuffle, collect] procedure many times to make certain that you are collecting the maximum number of invertebrates as possible. The more you have the more accurate picture you will have of the water quality from which you are collecting.
6. Be sure to collect specimens from the middle, sides, shallow and deep areas of the stream. Don't neglect undercut banks, tree root areas and areas of vegetative growth.
7. If you are in a riffle (an area with a shallow, rocky bottom), disturb the rocks with your feet or turn them over with your hands and use the forceps to remove any insects that you find. As you disturb the rocks, collect with a dip net the same way you did in the other areas.
8. SORTING AND IDENTIFYING is an important part of the macroinvertebrate assessment. When you have a good amount of invertebrates, take them to the sorting/identifying team on shore and get a new pan. Go back and continue to collect some more specimens while the other team works on your collection.
9. Remember to keep about an inch of water in the pan so the animals won't die from lack of oxygen. It is a good idea to add some fresh water periodically if it takes a while to identify the organisms.
10. When sorting, you may have to wait a few minutes to watch for movement. You can gently pick up the animals with the forceps or capture them in a small container to move them to the sorting tray. You will undoubtedly have to pull any weeds apart and stir around in them to expose critters hiding in there.
11. To help you identify the collected specimens, observe their body structure, legs, any tails on the back, antennae, etc. Observe, as well, how they move. Movement can sometimes be a great clue as to what they are. Use your key to help identify your specimens, and then compare notes with another team. Confirm your identifications with your teacher, and then gently return the animals to the water!
Don't forget to enter your data on your monitoring sheet.

BENTHIC MACROINVERTEBRATE DATA SHEET

Date ______________________ Site ________________________________

Collectors Names ____

____

____

Parts of River Sampled:

_____ Riffles _____ Sediment _____ Other

_____ Undercut Banks _____ Roots/Vegetation (explain:_____________)

Macroinvertebrates Collected:

CHECK	***Pollution-Sensitive*** Require high dissolved oxygen level – presence of these invertebrates indicates generally good quality water	CHECK	***Fairly Tolerant*** Can survive with somewhat moderate levels of dissolved oxygen – can live in fair quality water	CHECK	Pollution Tolerant Can survive in low levels of dissolved oxygen –can live in just about any water quality
	Gilled Snail (Rt. Opening)		Fingernail Clam		Pouch Snail (Left opening)
	Riffle Beetle		Freshwater Clam		Orb Snail
	Water Scavenger Beetle		Cranefly Larva		Midge Larva
	Predaceous Diving Beetle		Blackfly Larva		Leech
	Whirligig Beetle		Crayfish		Planaria
	Crawling Water Beetle		Amphipod or Scud		Threadworm
	Caddisfly Larva		Isopod		Tubiflex Worm (reddish-brown)
	Water Penny		Water Mite		Limpet
	Dobsonfly Larva		Dragonfly Nymph		Rat-tailed Maggot
	Stonefly Nymph		Alderfly Nymph		Mosquito
	Mayfly Nymph		Damselfly Nymph		

Other invertebrates found today: ________________________________

Based on your findings, how would you rate the water quality of this stream?

____

Explain your conclusion:____

Did the water quality testing conducted at this site agree with your conclusion? __________

Signatures of team: ________________________ ________________________

________________________ ________________________

STREAM FLOW CALCULATIONS

Stream flow is a useful characteristic to measure as it can use this information to determine its effect on physical, chemical and biological aspects of the river. It is a good tool when making comparative studies such as different sampling dates to determine the effect of land uses, precipitation, etc. Remember, paved surfaces increase runoff into the river and large amounts of runoff carry sediment and potential pollutants into the water!

Using the Stream Flow Calculation Worksheet, determine the stream flow of this part of the river. Remember that stream flow is simply the volume of water flowing past a certain mark over a period of time. Today we will be calculating the stream flow for THIS day. After a heavy rain, one might find that the stream flow has increased significantly! Stream flow is typically measured in metric units of cubic meters/second (m^3/s).

MATERIALS

Measuring tape (metric)
Meter stick
3 oranges
2 stopwatches
Clipboard with Stream Flow Calculation Worksheet
Calculator
Pencil

PROCEDURE:

1. Using the measuring tape, measure the width of the stream at an area that appears to be representative of the stream. The width of the stream is the actual water at the point where it touches the bank. It is best to take three width measurements then average them for your average width. ENTER THIS DATA INTO YOUR STREAM FLOW CALCULATION WORKSHEET.
2. At each area that you measure the width, take three depth measurements using the meter stick. Take these three measurements at regular intervals across the stream. (i.e. divide the width into 3 segments of equal width and measure the depth at each point). ENTER THIS DATA INTO YOUR STREAM FLOW CALCULATION WORKSHEET and calculate the average depth for each segment.
3. Measure the velocity of the stream (how fast the water is moving). This will involve all three of the people on your team as follows:
   a. Determine an area 50 meters in length in a straight section of the river.
   b. Team member 1 will stand at one end of the measured area and team member 3 will stand at the other end of the measured area with a stopwatch. Team member 2 will stand on shore with a stopwatch in a spot where he/she can see both team members in the water.
   c. #2 will signal #1 to release the orange into the water as he/she starts the stopwatch. When the orange reaches #3, stop the stopwatch and record how long it took the orange to reach the end. # 2 will record the data on your worksheet. (TRY NOT TO LET THE ORANGE GET AWAY! However, if it does, it is biodegradable – that is why we use oranges!!!)
   d. Repeat this process three times and calculate average velocity.
   e. Calculate stream flow as follows: W x D X V x n = Flow (use averages) [Use the constant 'n' indicating the roughness of the substrate – if the bottom is sandy or muddy, use 0.9; if the bottom is gravely or rocky, use 0.8]

STREAM FLOW CALCULATION WORKSHEET

RIVER WIDTH (w)

(take three measurements)

1._______________
2. _______________
3. _______________

Avg. Width ____________meters

SURFACE VELOCITY (V) = Length/Time

Trial	Length (m)	Time (sec)	Velocity (m/s)
1.	________	________	________
2.	________	________	________
3.	________	________	________

Avg. Velocity____________________m/s

RIVER DEPTH (D)

(take three measurements at each section)

Section One	Section Two	Section Three
1.	1.	1.
2.	2.	2.
3.	3.	3.
Avg.	Avg.	Avg.

Avg. Depth ______________________ meters

STREAM FLOW (discharge) (S.F.)

Multiply: W x D x V X n = S.F.*

___________ X ___________ X ___________ X ___________ = _____________ m^3/s
(cubic meters per second)

* Remember that 'n' is a constant indicating the roughness of the substrate (bottom) of the river –
If the riverbed is sandy or muddy, use 0.9 for 'n'
If the riverbed is gravel or rocky, use 0.8 for 'n'

Signatures of Stream Flow Team ____
____
____

Has there been recent rainfall? ________ How much? __________ When? __________________

(Adapted with permission from Hoosier Riverwatch Volunteer Training Manual, 2004)

HABITAT ASSESSMENT WORKSHEET

The river habitat assessment surveys the land in and around the stream. The condition of the land surrounding the river, including land use and human activity (including land and river alteration) can have an effect on the health of the river.

Use the area below to sketch a map of the river site including any grass, trees, shrubs, logs, etc. Be certain to show direction of flow, bends in the river, shallow spots (riffles), pools, bridges, dams, crops, etc. You should make a key to show what each is.

HABITAT SURVEY

Stream name ______________________________ **Date** ____________________
Surveyors ____

____

Weather Conditions: ________________**Temperature:** ______________________
Water Temperature: ________________ **Stream Velocity:** ___________________
Avg. Stream Width: ________________ **Avg. Stream Depth**:__________________
Estimated Stream Flow: ________________ **Substrate:** ____________________

Stream Shape: (has the stream been artificially channelized?)

_____ very straight _____ mostly straight _____ few bends ______ many bends

Riparian Vegetation: (check all that apply)

_____Trees _____Shrubs _____Plants _____Grass _____Crops _____Bare
_____Paved

Man-made Structures:

_____ Bridges _____ Dams _____ Streets/roads _____Buildings _____ Parking
Lot

Stream Bottom:

_____ Silt/mucky (does gentle kicking of the bottom cloud the water for a couple of minutes?)
_____ Large rocks (As big as a fist or bigger)
_____ Medium rocks (Smaller than a fist but bigger than your fingernail)
_____ Small rocks (Smaller than a pea)

Stream Shading:

_____ 75-100% _____ 50-74% _____25-49% ______0-24%

Bank Erosion:

_____ Extensive _____ Moderate _____ Little or None

Surrounding Land Use: (If more than one, indicate 1= most 2= less 3= least, etc.)

______ Forest _____Wetland/Marsh _____Open Field ______Farmland

______ Residential ______Industrial ______ Paved/Commercial _____ Park

Water Coloration: **Water Odor:**

______ Muddy ______ Clear Describe: ____________________________

Trash/Debris Present: (indicate in water or on bank)

Describe: ____

____

Drains or Storm Sewers Emptying into Stream? _______ **(# of drains)** ____________
Describe where they are coming from

____

CHEMICAL ASSESSMENT OF THE WATER QUALITY OF THE RIVER

Today you will have the opportunity to use the new water testing skills that you have acquired in a real-life setting. You will also be conducting a couple of tests that we did not do in class. By conducting this group of chemical tests and combining them with the benthics assessment, you should be able to make a judgment about the quality of water at the site of collection. Remember that in order to get a complete picture of what's going on with this river, it is helpful to visit the site a couple of times a year on a yearly basis to compare what the data looks like over a period of time.

MATERIALS

Waders for collectors
Bottles for collecting water
Test kits for nitrates, phosphates, pH, dissolved oxygen (DO), and turbidity
Sterile bottle for fecal coliform test
Fecal coliform test
3 sterile petri dishes
Capped bottle for phosphate test sample (to be taken back to school)
Capped bottle for Biological Oxygen Demand test (to be taken back to school)
Electrical tape for wrapping BOD bottle
Conductivity Meter
Distilled water
Graduated cylinder (25 ml)
Goggles and rubber gloves
Monitor sheet and clipboard
Cooler for transporting water samples

PROCEDURE

Collecting water samples

3. Students going into the water should have waders if water is over knee high.
4. Collect several samples of water from the middle of the stream current to use for pH, nitrates and turbidity. The sample should be taken from at least 6 inches to one foot below the surface if river is deep enough.
5. Rinse the bottle two or three times with river water before collecting the sample you will test. It is helpful to keep the cap on the bottle until you are at the level that you want to sample, then pull cap off and let bottle fill from the current run.
6. To collect for the **fecal coliform** test, use the sterile bottle provided. Put the lid on the bottle right away to be certain that nothing else contaminates the contents of the bottle.
7. Collect water for the **dissolved oxygen** test, using the capped bottle provided.
    a. To avoid contamination of the sample, rinse the water-sampling bottle with river water to be sampled.
    b. Lower the bottle with the cap on until you are ~ 6 inches-1 foot below the surface of the water, then remove the cap and carefully fill the sample bottle to overflowing, taking care that there are NO AIR BUBBLES trapped inside. If there are air bubbles inside, repeat the procedure.
    c. Gently cap the bottle under water without allowing air in to be trapped.
8. Repeat step #5 to take a sample for the Biological Oxygen Demand test that will be conducted in five days in the classroom.

PROTOCOL FOR DISSOLVED OXYGEN TEST

CAUTION: *THIS ACTIVITY REQUIRES THE USE OF HAZARDOUS MATERIALS THAT CAN BE CORROSIVE TO THE SKIN AND EYES. YOU MUST WEAR GOGGLES AND RUBBER GLOVES FOR THIS ENTIRE TEST!*

1. Gently uncap the sample bottle, taking care not to shake the bottle.

2. Carefully, without introducing air into the sample, add 6 drops of Winkler solution #1 (manganous sulfate solution) directly to the sample, holding the bottle tip as close to the sample surface as possible. Now add 6 drops of Winkler solution #2 (alkaline-iodide solution) following the same procedure.

3. Cap the bottle and invert gently several times. This step "fixes" the dissolved oxygen in the sample and you will see a solid precipitate forming in the bottle.

4. Allow the formed precipitate to settle to the bottom half of the bottle (this could take a few minutes)

5. CAREFULLY add 6-7 drops of concentrated sulfuric acid to the bottle, cap the bottle and gently invert several times to mix solution. The acid will make the precipitate soluble, forming a clear, gold-yellow solution.

6. Using a graduated cylinder, transfer 20 ml of the sample into a 125 ml Erlenmeyer flask. DO NOT USE THE BOTTOM PRECIPITATE!

7. Fill the 12 ml syringe with the sodium thiosulfate solution. Make a note of the starting volume on your monitor sheet and in your lab report in your journal.

8. Titrate the sample in the flask one drop at a time with the sodium thiosulfate solution in the syringe until the sample solution fades to a pale straw color.

9. Add 6 drops of starch solution to the flask and swirl gently to mix. The sample will turn dark purple. This indicator is used to provide a very obvious endpoint to your titration.

10. Return to the sodium thiosulfate titration until the solution is colorless (swirl as you titrate to mix).

11. Record the total number of milliliters of sodium thiosulfate that was required to turn the solution colorless. This number is directly proportional to the amount of dissolved oxygen that was in the original sample.

Sodium thiosulfate used = dissolved oxygen in mg/L OR ppm

FECAL COLIFORM PROTOCOL

CAUTION: Fecal coliform is a bacterium. You must wear goggles and gloves when conducting this test.

1. Obtain sterile bottle with water sample to be tested.

2. On the bottom of three petri dishes, mark
   a. Date
   b. Location sample was taken from
   c. Mark one dish 1ml, one dish 3 ml and one dish 5 ml
   d. Place the petri dishes on a flat surface where they are level and will not be disturbed.

3. Check to make certain that three bottles of Redigel Colichrome 2 medium are thawed.

4. Using a small, sterile graduated cylinder, measure 1 ml of sample water and pour it into a bottle of Redigel. Cap the bottle and gently invert to mix.

5. Pour the Redigel/water mixture into the petri dish marked 1 ml and cover.

6. Again using the graduated cylinder, measure 3 ml of sample water and pour into another bottle of Redigel. Cap the bottle and gently invert to mix.

7. Pour the Redigel/water mixture into the petri dish marked 3 ml and cover.

8. Once more using the graduated cylinder, measure 5 ml of sample water and pour into the last bottle of Redigel. Cap the bottle and gently invert to mix.

9. Pour the Redigel/water mixture into the petri dish marked 5 ml and cover.

10. DO NOT DISTURB THE DISHES FOR 30 MINUTES WHILE YOU ALLOW THE MEDIUM TO BECOME FIRM.

11. After the gel is firm, tape the lids to the petri dish and return them to the school to be read after incubation.

12. The petri dishes should be incubated at 44.5°C for 24 hours (a couple of hours more or less is acceptable). If an incubator is not available, you may use a warm water bath by putting the petri dishes in a waterproof bag and placing them in the bath. You may want to invert the petri dishes to avoid condensation on the inside of the lid. Per the manufacturer, if no incubator is available, petri dishes may be left out at room temperature for 48 hours to establish growth.

PROTOCOL FOR NITRATE TEST

You will be using glassware that has been cleaned with dilute HCl and rinsed with de-ionized water. Be certain that you are using the glassware that has been set aside for this purpose.

CAUTION: THIS TEST INVOLVES THE USE OF CADMIUM, WHICH IS A HAZARDOUS CHEMICAL. DO NOT, UNDER ANY CIRCUMSTANCES POUR IT ON THE GROUND OR IN THE WATER. IT MUST BE DISPOSED OF AFTER WE RETURN TO THE SCHOOL. BE CERTAIN TO PLACE IT IN THE CONTAINER MARKED "NITRATE TEST" WHEN YOU ARE FINISHED.
<u>YOU MUST WEAR RUBBER GLOVES AND GOGGLES AT ALL TIMES WHILE CONDUCTING THIS TEST.</u>

1. Obtain the bottle of water collected for this test from the collectors

2. Put 2.5 ml of the water sample into the test tube provided for this test.

3. VERY CAREFULLY add the Mixed Acid Reagent to the line marked 5.0 ml using the dropper that has been provided.

4. Place the cap on the test tube and gently shake. Wait exactly two minutes before going on to step 5.

5. Add one level 0.1 g spoon of Nitrate Reducing Reagent. TAKE CARE NOT TO LET THIS GET ON YOUR SKIN!

6. Cap the tub once again and invert the tube gently 50-60 times in one minute.

7. Wait for ten minutes, and then gently invert the tube a few more times.

8. Insert the tube into the comparator and match the color with the standards to obtain a test result. This will be expressed in ppm (parts per million) Nitrate Nitrogen.

9. Multiply the test result by 4.4 to get the ppm Nitrate result.

10. Place the liquids in the waste jar; rinse out equipment and pour rinse water into waste jar, as well.

11. Record your results on the monitor sheet.

INTERPRETING THE RESULTS OF THE FECAL COLIFORM TEST USING REDIGEL

Caution: Fecal colonies are bacterial colonies; you should use caution when doing this test. Never touch your face, eyes or mouth once you have started your count. Be sure to wash your hands with soap and water when you are done with your colony count!

1. The fecal colonies should be counted within 20 minutes of taking the petri dishes out of the incubator. You will be using the dish with the largest sample if there are less than 200 colonies. (If a dish has more than 200 colonies, it should be discarded; the sample is too big). DO NOT AVERAGE COUNTS FROM SAMPLES!

2. All coliform bacteria will cause a chemical reaction resulting in a red dye color. These are not fecal coliforms.

3. Some bacteria will appear green. If there is any sign of a green color, do not count the colony.

4. True fecal coliform will produce a red color followed by a blue reaction. If the colony appears purple, you can count as a fecal coliform. Each bluish spot should be counted as one fecal colony.

5. Multiply the number of colonies by a factor number that will equal a 100 ml sample.

6. Using the Q-value graph for fecal coliform, determine the Q-value of the sample and enter into the chart.

7. BE CERTAIN TO WASH YOUR HANDS WITH SOAP WHEN YOU ARE DONE.

8. Don't throw the petri dishes away. Give them to me to dispose of later.

PROTOCOL FOR TURBIDITY TEST

Remember that turbidity is a measure of how much material is suspended in the river water. This could be soil from erosion, sewage, garbage, microorganisms, etc. The more material that is suspended in the water, the less clear it is. If you looked into water that is not turbid, you would be able to see down into it, sometimes to the bottom. However, if the water is turbid, you might only be able to see a short distance.

1. Obtain the sample of water indicated for turbidity testing.

2. Fill one turbidity tube from the test kit to the 50 ml line with sample water. If the black dot on the bottom of the tube is not visible when you look down through the water, pour out enough of the water to that the tube is filled to the 25 ml line.

3. Fill the other turbidity tube with the same amount of distilled water as you have sample water in the first tube.

4. Set the tubes side by side and compare the clarity.

5. Shake the bottle of Standard Turbidity Reagent vigorously and add 0.5 ml to the clear water tube. **It is extremely important to shake the Standard Turbidity Reagent to thoroughly mix it. If you don't do so, it will affect your test and any other test that is done with the reagent later!**

6. Stir the contents of both tubes with a stirring rod to mix. Make sure that you wipe off the stirring rod before you stir the second tube!

7. Check to see if the river water sample is still greater than the distilled water by looking down into both tubes. If the turbidity of the river water is still more turbid than the distilled water, keep adding Standard Turbidity Reagent by 0.5 ml increments to the distilled water (stirring each time) until the distilled water turbidity matches the river water.

8. Record the total amount of Standard Turbidity Reagent that was required to make them match.

9. Every 0.5 ml of STR added to the 50 ml size sample is equal to what is known as 5 Jackson Turbidity Units (JTUs). If a 25 ml is used, each 0.5 ml addition of STR is equal to 10 JTUs. Refer to the table on the following page and determine how many JTUs were measured.

TURBIDITY TEST RESULTS

Number of 0.5 Additions	Amount in ml	50 ml Graduations	25 ml Graduations
1	0.5	5 JTU	10 JTU
2	1.0	10 JTU	20 JTU
3	1.5	15 JTU	30 JTU
4	2.0	20 JTU	40 JTU
5	2.5	25 JTU	50 JTU
6	3.0	30 JTU	60 JTU
7	3.5	35 JTU	70 JTU
8	4.0	40 JTU	80 JTU
9	4.5	45 JTU	90 JTU
10	5.0	50 JTU	100 JTU
15	7.5	75 JTU	150 JTU
20	10.0	100 JTU	200 JTU

10. Record your results on the monitor sheet in JTUs!

11. Place all liquid in the non-hazardous waste jar. Rinse both cylinders and place that waste liquid in the non-hazardous jar, as well.

DO NOT POUR ANY LIQUID ON THE GROUND!!!

PROTOCOL FOR pH TEST

1. Obtain a bottle of sample water for the pH test.
2. Fill a sample tube to the mark with sample water.
3. Add 10 drops of pH indicator solution.
4. Put a cap on the tube and invert to mix.
5. Insert the tube into the comparator that most closely matches the color of your tube.
6. Remove the cap and hold the comparator up to the light.
7. Take your pH reading from the comparator.

What if the water is turbid (cloudy)?

1. Fill the other four tubes with sample water
2. Insert the tubes into the comparator in the row behind the sample. You will skip the hole behind your original sample.
3. Place the clear glass ampule of water that is included in the test into the hole behind your original sample. BE VERY CAREFUL WITH IT!
4. Once again hold up the comparator to the light and take a reading.
5. Record your reading on the monitor sheet.
6. Place all liquid into the non-hazardous waste jar, rinsing out the tubes and also pouring the rinse water into the waste jar.

PROTOCOL FOR FIVE-DAY BIOLOGICAL OXYGEN DEMAND (BOD)

This test will be conducted at the school five days from the day of collection. In order to get an accurate reading, the bottle must be kept in a dark environment at room temperature. To ensure that no light will get to the sample, **wrap the bottle completely with black tape** to block the light. Make sure there are no open areas where the light can get through. This is because if there is microscopic plant life in the bottle, the plants will conduct photosynthesis if there is light available. A byproduct of photosynthesis is oxygen, so the test results would be inaccurate!

1. After five days, conduct the dissolved oxygen test on the water sample. Again, take care that you do not introduce air into the test sample as you conduct the test!

2. You will determine the Biological Oxygen Demand (BOD) by subtracting the 5-day DO from the DO test that was conducted on the day it was collected at the river.

   DO at river - DO 5th day = Biological Oxygen Demand

3. Record your results on the monitor sheet.

- If there are living organisms in the water that use oxygen, it will cause the dissolved oxygen level to go down. This usually takes place in water that has too much organic matter, which causes other organisms to die and decay. A high BOD can indicate a pollution problem while a BOD of only 1-2 mg/L indicates higher quality water.

PROTOCOL FOR TOTAL PHOSPHORUS TEST

CAUTION! THE TESTS FOR PHOSPHORUS USE HAZARDOUS CHEMICALS. THEREFORE, YOU MUST WEAR RUBBER GLOVES AND GOGGLES WHILE CONDUCTING THIS TEST.

It is important that you use glassware that has not been washed with soap that contains phosphates. This could result in an inaccurate reading.

PART ONE

1. The water sample for this test must be filtered before conducting the test. Filter 75 ml of the sample water into a 125 ml Erlenmeyer flask, using a funnel and a folded piece of round filter paper. The filter paper will fit into the funnel if you will fold it in half twice, then tease it open at the top and slip into funnel.
2. Measure 50 ml of the *filtered* sample and pour it into another 125 ml Erlenmeyer flask.
3. Use a 1 ml dropper (marked "sulfuric acid" to add 1 ml of sulfuric acid to the 2nd flask and *gently* swirl to mix the solution.
4. Add 0.5 g of Ammonium Persulfate to the flask and *gently* swirl again to mix and dissolve the Ammonium Persulfate.
5. Put the flask on a hot plate and boil GENTLY for 30 minutes. Add deionized water to the flask, as necessary, to keep the volume at 10 ml as the solution boils. NEVER ALLOW THE FLASK TO BOIL DRY OR SMOKE.
6. After 30 minutes, remove from the hot plate and allow to cool to room temperature.
7. After the solution cools, add one drop of Phenolphthalein.
8. Use a 1 ml dropper marked "Sodium Hydroxide" and add Sodium Hydroxide one drop at a time until the solution turns a pale shade of pink. (You will notice the change much easier if you place the flask on a piece of white paper)
9. Add one drop of sulfuric acid (this should make the solution colorless)
10. Pour the sample into a 50 ml graduated cylinder and add a small amount of deionized water to the flask. Swirl the solution around to try to rinse all of the water off the sides of the flask.
11. Pour that water into the graduated cylinder with the rest of the sample.
12. Keep slowly adding deionized water to the graduated cylinder until there is **exactly** 50 ml of solution in the cylinder.
13. Wrap aluminum foil over the top of the cylinder TIGHTLY and invert the cylinder a couple of times to mix the solution.

PHOSPHATE TEST PART TWO – There are two different tests you can do in part two and it is hard to know which one to do. It depends on what the ppm of phosphate is present and there's no way to know that ahead of time. Project Green suggests trying the test for 1.0 – 10.0 ppm first; if you end up having more, you can go back and do it again, this time for the 10 -100 ppm range.

For 1.0 to 10.0 ppm Phosphate

1. Fill a test tube from the kit to the mark with the sample.
2. With a 1 ml dropper, add 1.0 ml of VM Phosphate to the sample. Put a stopper into the test tube and mix by inverting the tube.
3. AFTER FIVE MINUTES use another dropper to add 3 drops of Reducing Reagent, stopper the tube, and mix by inverting the tube.
4. Watch for color, which should develop in about 10 seconds.
5. Put the sample tube into the VM-12 Comparator and take the reading.
6. Record your results on the monitor sheet.
7. All waste should be put in the non-hazardous waste jar, rinsing out all glassware and putting the rinse water in the waste jar as well.

For 10 to 100 ppm Phosphate – you will need to use this procedure if you find that you have more than 10 ppm Phosphate in your sample water.

1. Use a 0.5 ml dropper and add 0.5 ml of sample water to the test tube. Add distilled water until the tube is filled to the mark.
2. Use a 1.0 ml dropper and add 1.0 ml of VM Phosphate to the sample, stopper the tube and invert several times to mix the solution.
3. AFTER FIVE MINUTES use another dropper to add 3 drops of Reducing Reagent. Stopper the tube and mix by inverting the tube.
4. Watch for color, which should develop in about 10 seconds.
5. Put the sample tube into the VM-12 Comparator and take the reading.
6. Multiply the value of the reading by 10 to get the Phosphate level.
7. Record your results on the monitor sheet.
8. All waste should be put in the non-hazardous waste jar, rinsing out all glassware and putting the rinse water in the waste jar as well.

PROTOCOL FOR WATER TEMPERATURE CHANGE

Remember that water temperature is extremely important in a number of ways. There are many stream characteristics that are affected by the water temperature such as DO, photosynthesis rate, and the metabolic rate of the organisms that live there.

MATERIALS

Thermometer with guard
Rubber gloves
Waders, if necessary

PROCEDURE

1. Be certain that you are using a thermometer with a guard to avoid the risk of the thermometer breaking.

2. Lower the thermometer approximately 4 inches below the surface and keep in place for about two minutes or until a constant reading is reached.

3. Have a second student verify the reading and report findings on the monitor sheet.

4. Repeat steps 2 and 3 three times and calculate the average temperature reading for this site.

5. Move approximately one mile upstream and repeat the above procedure.

6. Subtract the upstream temperature from the downstream temperature using the following equation:

   Downstream temp. - Upstream temp. = Temperature change

7. Record the temperature change on your monitor sheet.

Chemical Assessment of Water Quality – Monitor Sheet

Date ____________________ Location: ____________________________________

Time: ____________________ Air Temperature: ______________________________

Weather Conditions: ____
Weather Conditions in past 24 hours: ____________________________________

Data Collector: ____

TEST CONDUCTED	UNITS OF MEASURE	AVERAGE READING
Dissolved Oxygen	mg/L - % Saturation	
Fecal Coliform	colonies/100 ml	
pH	Units	
Temperature Change	°C	
Total Phosphate	mg/L	
Nitrate	mg/L	
Turbidity	JTU	
BOD 5-day	mg/L	

Signature of data collector: ____

Date: ____

WEIGHTING FACTORS FOR WATER QUALITY TESTS

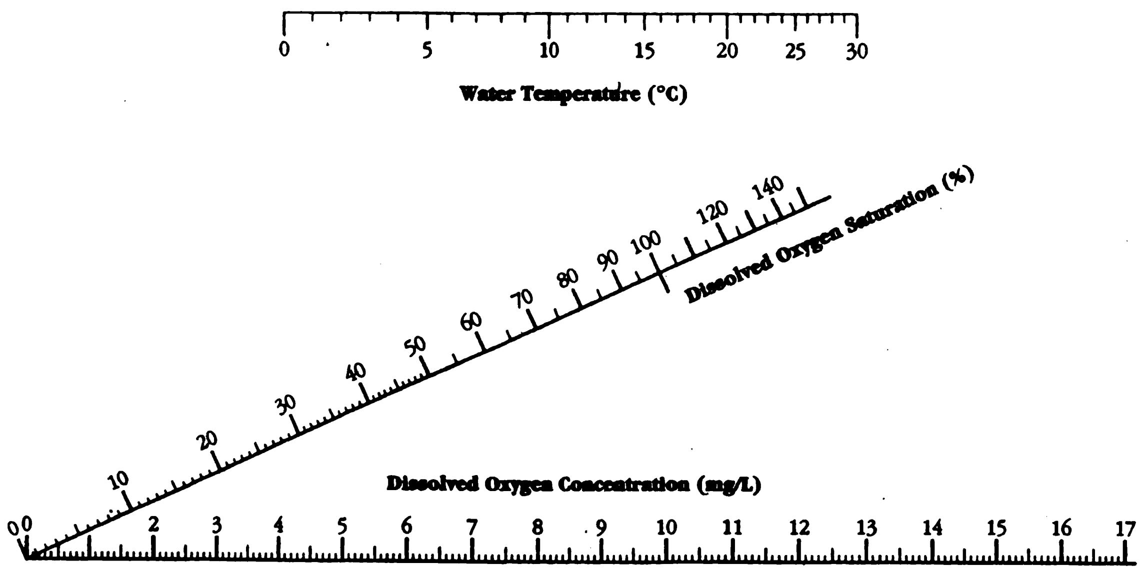
TEST	UNITS	Q-Value	WEIGHTING FACTOR	PERCENT	TOTAL (%)
Dissolved Oxygen	% Sat		0.17	= 17%	
Fecal Coliform	Colonies per 100 ml		0.16	= 16%	
pH	Units		0.11	= 11%	
BOD 5 day	mg/L		0.11	= 11%	
Temperature change	°C		0.10	= 10%	
Phosphate	mg/L		0.10	= 10%	
Nitrate	mg/L		0.10	= 10%	
Turbidity	JTU		0.08	= 08%	
Total Solids	mg/L		0.07	= 07%	

QUALITY OF WATER

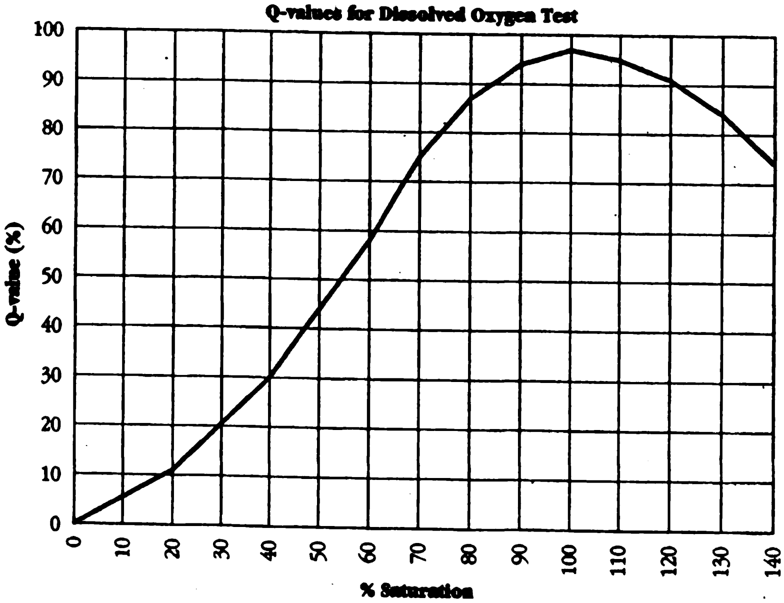
OVERALL WATER QUALITY INDEX	QUALITY OF WATER
90 – 100%	Excellent
70 – 89%	Good
50 – 69%	Medium
25 – 49%	Bad
0 – 24%	Very Bad

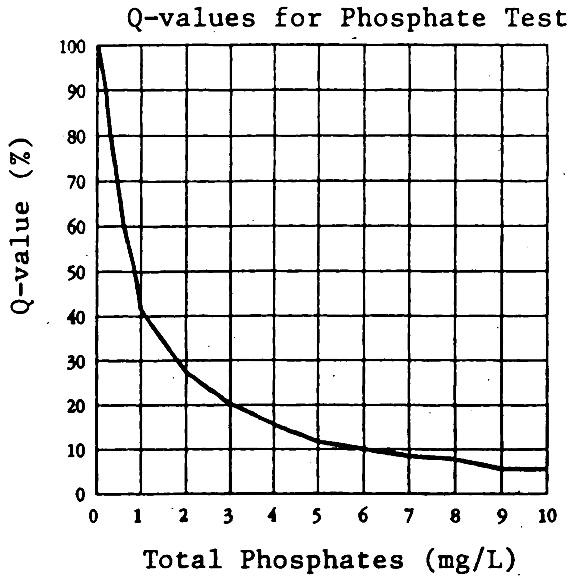
(Courtesy of Rivers Curriculum Guide, Bryan, et. al, 1995)

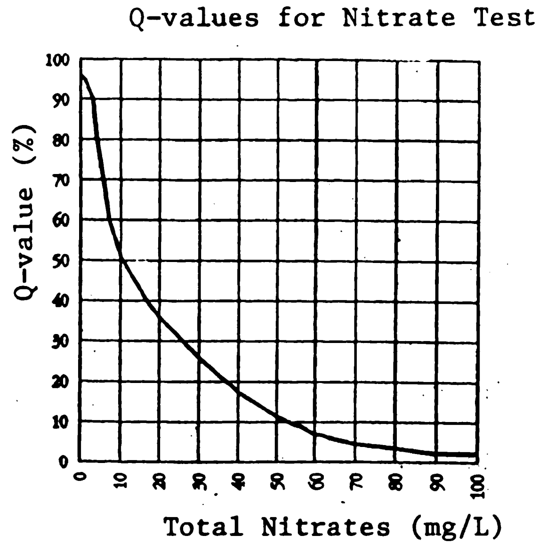
Chart for Converting Dissolved Oxygen Concentration at a Certain Temperature to Percent Saturation

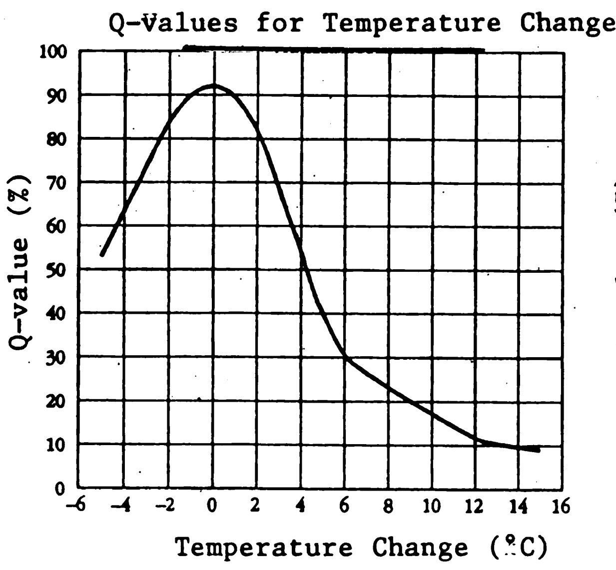


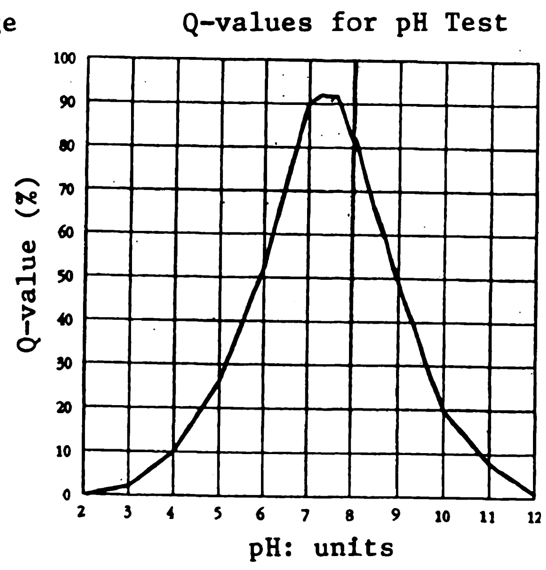
Q-values for Dissolved Oxygen Test



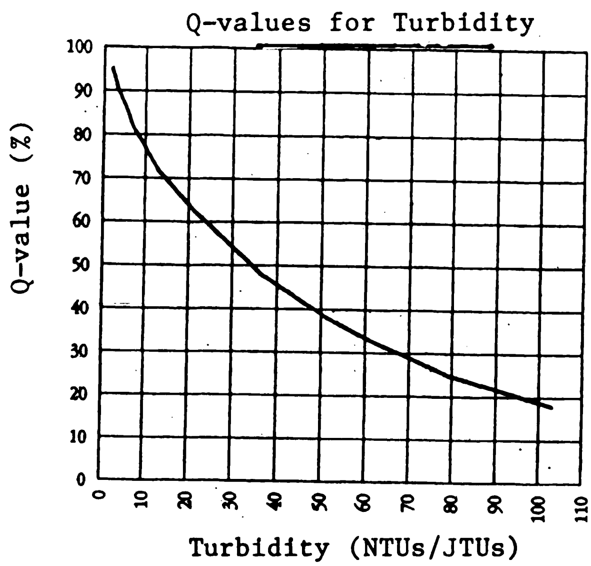


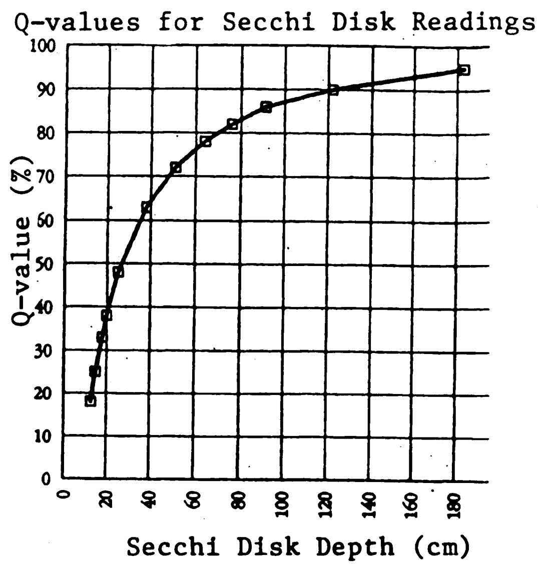


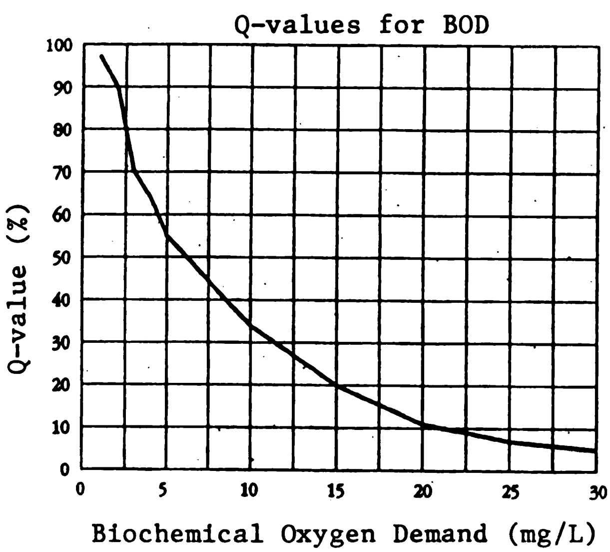


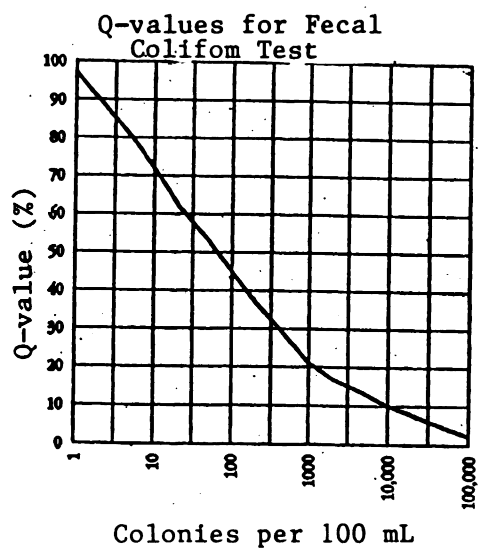


(Rivers Curriculum Guide, Bryan, 1995)









(Rivers Curriculum Guide, Bryan, 1995)

Interpreting Your Water Quality Data

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Alkalinity: measures the water's capacity to neutralize acids in (mg/l) or (mg/l $CaCO_3$)	Increase	Wastewater treatment plant effluent Surrounding geology	• Residues from food substances and cleaning agents • Weathering and erosion of limestone	Total alkalinity of seawater averages 116 mg/l Total alkalinity of freshwater is often between 30 and 90 mg/l
	Decrease	Acid precipitation Surrounding geology Industrial effluent	• Burning of fossil fuels • Weathering and erosion of granite or igneous rocks • Low pH water consumes alkalinity	
Bacteria: measures Fecal Coliform, E. coli, or Enterococci to indicate potential fecal contamination of water in Colony Forming Units (CFU) or cells /100 ml of water	Increase	Warmblooded animal or human feces Soil Pulp and paper mill wastes	• Leaking or failing septic and sewer systems • Sewer overflows, overloaded/malfunctioning waste water treatment plant • Runoff from areas containing pet and animal waste • Direct defecation of animals and birds/waterfowl in waterways • Many coliforms are naturally found in soil • The genus *Klebsiella* of the Fecal coliform group common (harmless)	EPA criteria for Bacteria in recreational waters Fresh water: E. coli levels shall not exceed... • 236 cells or CFU per 100 ml of a single water sample, or • 126 cells or CFU per 100 ml as a geometric mean from at least 4 water samples
	Decrease	Bacteria-free influent water	• Springs, tributary, runoff or other clean water source that reduces the total number of coliforms per unit volume of water	Marine water: Enterococci levels shall not exceed... • 35 cells or CFU per 100 ml as a geometric mean from at least 5 water samples equally spaced over a 30-day period
Biochemical Oxygen Demand (BOD): measures the amount of oxygen in the water consumed by aquatic organisms and chemical reactions in (mg/l)	Increase	Organic matter	• Microorganisms consume oxygen when decomposing animal/pet waste, leaves and woody debris, nutrients	
	Decrease	Aeration Waste water treatment plant effluent	• Increases the rate of decomposition of organic and inorganic material • Chlorine kills decomposers (microorganisms)	
Conductivity: measures the water's ability to conduct an electrical current in cont. next page	Increase	Urban runoff Surrounding geology Temperature	• Chemical de-icers, salts • Clay soils dissolve into ionic components • Conductivity is higher in warmer water	Conductivity of common waters in µmho/cm Deionized water: 0-1 Distilled water: 0.5-3

Interpreting Your Water Quality Data/Cont.

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
micromhos/cm or microsiemens/cm ($\mu S/cm$)	Increase	Wastewater treatment plant effluent	• Ions such as chloride, phosphate, and nitrate	Rivers in the US: 50-1500 Healthy streams: 150-500 Some industrial effluent: 10,000 Seawater: 50,000
		Mining operations	• Ions such as sulfate, copper, cadmium, or arsenic in mine drainage	
	Decrease	Agricultural runoff	• Ions such as nitrate, phosphate, and salts.	
		Surrounding geology	• Granite and igneous rocks often do not dissolve into ionic components	
		Industrial effluent	• Oils, alcohols, sugar, and many hazardous organic compounds reduce the number of charged ions per unit volume of water	
		Urban runoff	• Oils	
Dissolved oxygen (DO): measures the amount of oxygen dissolved in water in (mg/l)	Increase	Aeration	• Waterfalls, rapids, rocks, and turbines add oxygen to water	Dissolved oxygen levels required for aquatic organisms 0–2 Prolonged exposure lethal 3–5 Stressful to most aquatic organisms 6–10 Usually required for growth and activity
		Photosynthesis	• Plants give off oxygen	
		Temperature	• Colder water is able to dissolve more oxygen than warmer water	
	Decrease	Respiration, decomposition, and chemical reactions	• Plants, animals, and microorganisms consume oxygen during these processes	
		Turbidity	• Blocks sunlight from plants, decreasing photosynthesis and increasing decay and decomposition • Causes water temperature to rise by increasing absorption of solar radiation	
		Ground water influent	• Low in dissolved oxygen because it is not exposed to the atmosphere while underground	Note: DO levels can fluctuate greatly with depth, especially in lakes and reservoirs
		Elevation above sea level	• As atmospheric pressure decreases, less oxygen is dissolved in the water	
		Reservoir bottom-water influent	• Low in DO due to reservoir stratification	
		Nutrients	• Fuel overgrowth of algae, which die and decompose	
Hardness: measures the concentration of dissolved minerals by measuring polyvalent cations in (mg/l of $CaCO_3$)		Surrounding geology	• Weathering and erosion of limestone	Water hardness levels in mg/l of $CaCO_3$ 0-60 = soft water 61-120 = moderately hard 121-180 = hard water 181 and greater = very hard
		Waste water treatment plant effluent	• Residues from food substances and cleaning agents	
		Mining operations	• Expose rocks containing calcium and magnesium	
		Surrounding geology	• Weathering and erosion of granite or igneous rocks	

Interpreting Your Water Quality Data/Cont.

Parameter:	Your data indicate:	Which may come from:	Which may be caused by:	Additional Notes:
Nitrate: measures the organic or fertilizer matter in water in (mg/l)	Increase	Nutrients	• Runoff from agricultural land, residential lawns, and golf courses	The EPA suggest that unpolluted waters shall contain less than 1 mg/l of nutrients
		Human and animal wastes	• Wastewater treatment plant effluent, runoff from areas containing pet or animal waste • Direct defecation of animals and birds/waterfowl in waterways	
		Burning of fossil fuels	• Releases long-term store of nitrogen	
	Decrease	Nutrient-free influent water	• Springs, tributary, runoff or other clean water source that reduces the level of nutrients per unit volume of water	
		Plant use	• Nitrates are used by aquatic organisms for growth	
pH: measures the hydrogen ion concentration or activity on a logarithmic scale (no units)	Increase	Photosynthesis	• Plants use carbon dioxide, which reacts with water to form carbonic acid	acidic 0 1 Stomach acid 2 3 Soft drinks tolerable range 4 Acid rain 5 Natural rain 6 neutral 7 optimal range 8 Sea water 9 10 11 12 Bleach 13 basic 14 Drain cleaner
		Mining operations	• Acid mine drainage	
	Decrease	Respiration	• Plants give off carbon dioxide, which reacts with water to form carbonic acid	
		Surrounding vegetation	• Sphagnum moss and pine needles are slightly acidic (bogs, marshes, and pine forests) • Decaying vegetation produces organic acids	
		Burning fossil fuels	• Emissions react with the atmosphere to form acid precipitation	
Phosphate: Measures the organic or fertilizer matter in water	Increase	Surrounding geology	• The mineral apatite contains phosphates	The EPA suggest that greater than 0.1 mg/l of total phosphates stimulates plant growth to surpass natural eutrophication rates
		Human and animal wastes	• Waste water treatment plant effluent, runoff from areas containing pet or animal waste • Direct defecation of animals and birds/waterfowl in waterways	
		Nutrients	• Runoff from agricultural land, residential lawns, and golf courses	
	Decrease	Nutrient-free influent water	• Springs, tributary, runoff or other clean water source that reduces the level of nutrients per unit volume of water	
		Plant use	• Phosphates are used by aquatic organisms for growth	
	Increase	Weather/seasonal	• Water temperature varies with air temperature	
Temperature: measures the average amount of heat in the water in degrees Fahrenheit (°F) or degrees Celsius (°C)		Removal of vegetation	• Stream-bank vegetation provides shade and reduces runoff (turbidity)	Many plants, bass, crappie, bluegill, carp, sucker, caddisfly, larvae, many fish diseases at temperatures around 20°C (68°F)
		Impoundments	• Impoundments increase the surface area of the water that is exposed to	

Interpreting Your Water Quality Data/Cont.

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Temperature: cont.		Thermal pollution Urban runoff	solar radiation • Warm-water discharge from power plants and other cooling waters • Water is heated by asphalt and pavement	Some plant life, trout, walleye, northern pike, stonefly nymph, caddis fly larvae, water beetles, water striders, some fish diseases 14°C (57°F)
	Decrease	Cold water inflow Depth	• Groundwater, tributary, springs, and reservoir bottom water can be colder than the receiving water • Seasonal stratification, especially in lakes	Few plants, trout, caddisfly larvae, stonefly nymph, mayfly nymph, few fish diseases 7°C (7°F)
Total dissolved solids (TDS): measures ions and particles that will pass through a filter with pores of about 2-4 microns (0.002-0.004 cm) in size in (mg/l)	Increase	Seasonal/weather Erosion Waste water treatment plant effluent Surrounding geology Organic matter Urban runoff	• Runoff from rain an snowmelt carries dissolved constituents • Agricultural, road-building, construction, and logging all increase erosion rates. • Many dissolved constituents are not removed • Limestone or sedimentary rocks dissolve easily, releasing ions • Decaying plants and animals • Chemical de-icers, salts, fertilizers (nutrients), and chemicals	According to the World Health Organization, TDS of natural water sources varies greatly from less than 30 mg/l to as much as 6,000 mg/l
	Decrease	Surrounding Geology	• Granite and igneous rocks often do not dissolve easily	
Turbidity: measures either the clarity of water using a Secchi Disk, or the amount of light reflected by suspended particles using a Turbidimeter in either a Secchi Depth (meters) or a Turbidimeter reading in Nephelometric Turbidity Units (NTU)	Increase	Erosion Nutrients Weather/seasonal Urban runoff Forest fires/flooding Waste water treatment plant effluent	• Agriculture, road-building, construction, and logging all increase erosion rates • Increased algal growth • Runoff from snowmelt or rainfall • Salts, fertilizers (nutrients), chemicals, sediment • Increases stream-bank erosion since pavement prevents slowseepage of water into the ground • Temporarily increases erosion and therefore turbidity • Nutrients increase algal growth • Carries dissolved and suspended solids	Typical groundwater has a turbidity of less than 1 NTU
	Decrease	Erosion prevention measures	• Stream-bank vegetation; Best Management Practices for agriculture, road-building, construction and logging	

AQUATIC CHEMISTRY REFERENCE SHEET

pH		
0–4.0	Aquatic life is severely stressed	pH (measured in pH units) indicates the concentration of H^+ ions in a solution, measured on a logarithmic scale. A solution with a pH of 4 is ten times more acidic than one with a pH of 5. Most aquatic organisms favor relatively stable, neutral streams, though some tolerate or thrive in moderately acidic or variable streams. The median pH of US streams and rivers is about 8.
4–4.5	Few fish and invertebrates can survive	
4.5–6.5	Acid-tolerant invertebrates and fish can survive	
6.5–8.5	Suitable for most aquatic animals	
6.5–13.0	Suitable for most aquatic plants	
5.0–9.0	Suitable for human consumption	
Phosphate (ppm or mg/L)		
0.005–0.05	Typical of undisturbed forest streams	Phosphate typically limits plant growth in rivers and streams, and phosphate levels above 0.1 ppm can result in algal blooms. The presence and extent of blooms will vary according to other variables such as temperature and nitrate levels. Stream phosphate levels may be too low to detect. Consult your test kit or probe to determine appropriate range. Most US streams and rivers have 0.05 to 0.3 ppm phosphate.
<0.5	Suitable for human consumption	
0.05–0.1	May increase aquatic plant growth	
>0.1	Likely to cause algal blooms	
1.0	Approximate ideal upper limit for wastewater treatment plant effluent	
Nitrate (ppm or mg/L)		
0.1	Typical of undisturbed forest streams	Nitrogen is an important nutrient for plant growth, and nitrate levels above 0.1 ppm can result in algal blooms if sufficient phosphate and other nutrients are present. High nitrate concentrations indicate pollution from fertilizers or runoff from agricultural or urban sources. Most rivers and streams in the US have levels between 0.2 and 0.9 ppm.
0.1–1.0	May increase aquatic plant growth	
>1.0	May cause algal blooms	
<10	Suitable for human consumption	
<90	No *direct* effect on fish	
Dissolved oxygen (ppm or mg/L)		
0–3	Few organisms can survive	Because it is a gas, oxygen diffusion into water is limited by temperature. Colder water can hold more oxygen than warmer water. Using the nomograph in Figure 2.7, you can determine the percent saturation for each sample. Percent saturation levels lower than 80 percent may indicate presence of decomposing organic matter such as untreated sewage or manure. Most US streams have dissolved oxygen levels from 8.5 to 10.5 ppm.
3–4	Only a few fish and invertebrates can survive	
4–7	Most non-trout, warm-water fish species can survive	
5	EPA's suggested lower limit for maintenance of healthy aquatic biota	
> 7	Necessary for trout, salmon, and many invertebrates. Neither low nor high dissolved oxygen levels are *directly* harmful to humans	

Alkalinity (mg/L $CaCO_3$)		
20	EPA's suggested lower limit for maintenance of healthy aquatic biota	Alkalinity is typically expressed as mg/L $CaCO_3$. It is a measure of a stream's ability to buffer inputs of acidity, for example by acid precipitation. The higher the alkalinity, the higher the buffering capacity. Highly buffered streams are better able to support organisms sensitive to acidity. Most US streams range from 25 to 150 mg/L $CaCO_3$.
<25	Poorly buffered	
25–75	Moderately buffered	
>75	Highly buffered	
Chloride (ppm or mg/L)		
<12	Typical of undisturbed forest streams	Chloride is a component of salt (NaCl). Road salt runoff can raise streamwater chloride levels to over 10,000 ppm and harm stream organisms. Note that chloride is an ion (Cl^-), and should not be confused with the chlorine (Cl_2) that is found in bleach and used to disinfect swimming pools.
0–200	Suitable for most fish and invertebrates	
200–1000	Suitability varies by species	
<500	Suitability for human consumption	
>1000	Most aquatic invertebrates are negatively affected	
Temperature (°C)		
<13	Suitable for cold-water species such as trout, salmon, mayflies, caddisflies, and stoneflies	Temperature is important because aquatic organisms are adapted to life within certain temperature ranges, and also because it affects the concentrations of dissolved oxygen. Salmon and trout require high dissolved oxygen levels that can be found only in cold streams. As water gets warmer, concentrations of dissolved oxygen decrease at the same time that the need for oxygen goes up because of increases in metabolic rates of cold-blooded organisms.
13–20	Suitable for some salmon, mayflies, caddisflies, stoneflies, and beetles	
20–25	Suitable for most other fish, invertebrates, and warm-water species	
>25	Lethal to trout, salmon, many aquatic insects, and most cold-water species	

(Watershed Dynamics, Carlsen et.al, 2004)

Water Quality Standards

Per the Indiana Administrative Code (327 IAC 2), the following water quality standards exist for most of the state's rivers and streams; however, water quality standards may vary among waterways. Always check with the IDEM-Office of Water Management at (317) 232-8670 for official water quality information.

Dissolved Oxygen	=	average > 5, not < 4 mg/L; also > 7mg/L trout spawning
E. coli	=	< 235 colonies/100 ml for total body contact
pH	=	average between 6 and 9
Water Temp Change	=	< 5° F change downstream; also < 2° F trout stream
Total Phosphates	=	< 0.04 mg/L
Nitrate Nitrogen (N)	=	< 10 mg/L
Nitrates (NO_3)	=	< 44 mg/L
Total Solids	=	< 750 mg/L

Guide for Water Quality Ranges

Dissolved Oxygen (% Saturation)

91-110	Excellent
71-90, >110	Good
51-70	Fair
<50	Poor

***E.Coli* (colonies per 100ml)**

<50 colonies	Excellent
51-200 colonies	Good
201-1000 colonies	Fair
>1000 colonies	Poor
	>2.0

pH (Units)

6.5-7.5	Excellent
6.0-6.4, 7.6-8.0	Good
5.5-5.9, 8.1-8.5	Fair
<5.5, >8.6	Poor

BOD (mg/L or ppm)

<2	Excellent
2.0-4.0	Good
4.1-10	Fair
>10	Poor

Temperature Change (°C)

0-2	Excellent
2.2-5	Good
5.1-9.9	Fair
>10	Poor

Total Phosphate (mg/L)

<.10	Excellent
.11-.16	Good
.17-.58	Fair
.59-2.99	Poor
>3.0	Very Poor

***Nitrate Nitrogen (N) (mg/L)**

<0.3	Excellent
.4-.8	Good
.9-1.9	Fair
Poor	

* Not multiplied by 4.4

Turbidity (NTUs or ft/inches)

1-10 or >3'	Excellent
10.1-40 or 1-3'	Good
40.1-150 or 2"-1'	Fair
>150 or < 2"	Poor

Total Solids (mg/L)

<100	Excellent
100-250	Good
251-400	Fair
>400	Poor

www.HoosierRiverwatch.com

Pollution Indicators Table

Watershed Land Uses	Potential Pollutants	Primary Indicators	Secondary Indicators
Agricultural	erosion/sedimentation	turbidity total solids	benthics
	pesticide runoff	benthics	
	nutrient runoff	nitrates phosphates	phytoplankton macrophytes dissolved oxygen BOD
	animal waste	fecal coliform *E.* coli	nitrates phosphates BOD
Residential	nutrient runoff	nitrates phosphates	phytoplankton macrophytes dissolved oxygen BOD
	human/pet waste	fecal coliform *E.* coli	nitrates phosphates BOD
	stormwater runoff	temperature total solids turbidity	
Industrial	toxic discharges	benthics	
	thermal discharges	temperature	benthics phytoplankton dissolved oxygen
Mining	acid drainage	pH	benthics
	heavy metals	benthics	
	erosion/sedimentation	turbidity total solids	benthics

(With permission, Hoosier Riverwatch)

Water Contaminants Worksheet

Pollutant	Specific Contaminant	Possible Environmental and Human Health Impacts
Pet Waste	• Nitrate • Phosphate • Coliform bacteria	Algal blooms–dissolved oxygen depletion Algal blooms–dissolved oxygen depletion, *Pfiesteria* Human illness (watery diarrhea, fever, and dehydration)
Sediment	• Turbidity • Phosphate • Coliform bacteria	Blocks sunlight, kills submerged vegetation Algal blooms, dissolved oxygen depletion Human illness (watery diarrhea, fever, and dehydration)
Sewage	• Nitrate • Coliform bacteria	Algal blooms, dissolved oxygen depletion Human illness (watery diarrhea, fever, and dehydration)
Litter	• Coliform bacteria	Human illness (watery diarrhea, fever, and dehydration)
Parking Lot Runoff	• Petroleum products (benzene, toluene, organic lead compounds.)	Human illness (fever, chills, vomiting)
Fertilizers	• Nitrate • Phosphate	Algal blooms, dissolved oxygen depletion Algal blooms: human illness (respiratory illness)
Pesticides	• Chlorinated hydrocarbons, rhothane (DDD), lindane (HCH's), Atrazine	Human illness (headaches, dizziness, respiratory problems) Animal illness (muscle tremors, convulsions, tetanus)
Air Pollution	• Acid rain (sulfate aerosols, nitrogen oxides, copper, nickel, zinc) • Sulfur dioxide	Human illness (inherited heart defects, respiratory diseases, gastrointestinal disorders, skin and eye diseases, asthma, bronchitis, lung inflammation–asthma and emphysema) Acidifies waters (lakes, rivers, streams)
Boat Pollution	• Sewage waste (bacteria) • Nutrient loading • Litter • Oil spills	Human illness (watery diarrhea, fever, dehydration, dizziness, muscle aches, vomiting) *Pfiesteria piscicida* outbreaks; red-tide algal blooms Animal strangulation (can block digestive system when ingested) Human illness (cancer, sterility, brain dysfunction, fever, chills, ear discharge, vomiting)
Waterfowl	• Coliform bacteria	Human illness (watery diarrhea, fever, and dehydration)

*Habitat Parameters for Selected Macroinvertebrates**

pH Ranges for Selected Macroinvertebrates*

TAXA	1 2 3 4 5 6 7 8 9 10 11 12 13 14
mayfly	XXXX
stonefly	XXXX
caddisfly	XXXX
snails	XXXXXXXXX
clams	XXXXXXXXX
mussels	XXXXXXXXX

* pH ranges 1-6 and 10-14 are unsuitable for most organisms.

Temperature Ranges for Selected Macroinvertebrates

TAXA	Cold Range < 12.8°C	Middle Range 12.8 - 20°C	Warm Range > 20°C
caddisfly	X	X	X
stonefly	X	X	
mayfly	X		
water pennies	X		
water beetles		X	
water striders		X	
dragonfly		X	X

Minimum Dissolved Oxygen Levels for Selected Macroinvertebrates

TAXA	High Range 8-10 ppm	Medium Range 4-8 ppm	Low Range 0-4 ppm
stonefly	X		
water penny	X		
caddisfly	X	X	
some mayflies	X	X	
dragonfly		X	
true bugs		X	
damselfly		X	
mosquito			X
midges			X
pouch snail			X
rat-tailed maggot			X

* The values provided are preferred ranges for most species of these groups of organisms.

(With permission, Hoosier Riverwatch)

NOTES TO THE TEACHER

This can be a very rewarding experience for both you and your students. There are several things to be considered when undertaking this unit.

1. If you are taking your students into the river, it is imperative that they have waders or boots if they are in a stream that is potentially polluted. Waders are an expensive item (~$80/pr.). I called the local sporting goods stores and procured some donations, but not everyone was willing to give!
2. It is advisable to have several adults along to assist. I contacted the local college campus to recruit upcoming science teachers and members of the local biology club to come along on the field trips. This is helpful because they do have some biological background and are fairly knowledgeable about the process.
3. When taking students to the river, it is advised to take along safety equipment:
    a. Cell phone
    b. Rope
    c. Eyewash
    d. Blanket in case of a fall in the river! I also suggested that students bring along a complete dry change of clothing including shoes and socks
    e. Towels
    f. Safety goggles
    g. Rubber gloves
4. The test protocols that are in this Field Manual are written for LaMotte water test kits; different test kits may have different directions! Dipstick tests are available, but I found that they are not necessarily as accurate as the liquid chemical tests.
5. You may want to have students work in teams of three. It helps to give each student something meaningful during the field trip.
6. If students finish early, they can help other groups, work on their journal entries, or collect equipment.
7. Egg cartons can be used for sorting pans for the macroinvertebrates.
8. We chose not to take the animals back to the school; however, if you would like to preserve the animals for identification in the classroom, they can be placed in bottles with 70-90% isopropyl alcohol. It is helpful to change the alcohol in 24 hours due to dilution of the alcohol from the fluids in the animals. This should help preserve them for a longer period of time.
9. It is helpful to visit the site ahead of time. You will want to check depth of water, steepness of banks, accessibility of site, etc.
10. Arrange ahead of time which students will do which test at the site. It is fun to have them switch activities when they visit a second site.
11. Insect repellent is highly recommended!!
12. It is helpful to have each group collect and carry their own equipment to the water. You may want to assign one or two students to be responsible for checking out equipment to each team.
13. For the sake of time, it is easier to have the students determine the Q-values of their tests that next day in the classroom.
14. You will want at least two waste containers on site – one for hazardous waste and one for non-hazardous waste.
15. It is best to use an alcohol thermometer due to the risk of mercury contamination of the water if the thermometer breaks.
16. It is best to have a "practice day" ahead of time so the students are familiar with the tests that they will be performing on site. It is worthwhile, as well, to have the students become familiarized with the invertebrates before they go out (see preceding labs)

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Stapp, W. and Mitchell, M., (1990). Field Manual for Water Quality Monitoring. Dexter, MI: Thompson-Shore Printers, Dexter.

APPENDIX M

POST-UNIT TEST

Test Your Newly Acquired Water Knowledge!!

1. Describe water pollution and use examples.
2. Where does river pollution come from? ____
3. How does it become pollution? ____
4. Name a polluted site and tell me where some of the pollution came from (BE SPECIFIC):
5. What affect does pollution have (on things that live in the river, as well as humans)?
6. Does it affect you? ____ How? ____
7. Do you pollute (even unintentionally)? ____ How? ____
8. What is a watershed? ____
9. Is there one near you? ____ (tell me about it) ____
10. What is groundwater? ____
11. What is " stormwater" ? ____
12. Where does the water go that flows into your street drains?
13. What happens to the water that you pour into your sink?
14. What happens to the water that you wash your car with outside?
15. Where does your drinking water come from (describe its path to you)?

16. Where do phosphates come from? ____________________

17. What do phosphates in the river cause? ____________________

18. Why is dissolved oxygen in the river important? ____________________

19. Why is the temperature of the river important in terms of dissolved oxygen?

20. Why is it helpful to do a habitat assessment of the area around the river when trying to determine the health of the river?

21. Why must we be concerned about soil erosion (when considering the health of the river)?

22. How can you learn about the quality of water in a river by looking at the macroinvertebrates (critters) that live in the river?

23. Why do we check the pH of the river?

24. Make a comparison of the two rivers that we visited (be specific and give me some details).

25. Name five things that everyday citizens can do to improve the quality of our Flint River:
    1.
    2.
    3.
    4.
    5.

APPENDIX N

PUBLIC SERVICE ANNOUNCEMENTS WRITTEN BY STUDENTS

PSA One:

Person one: For over four years
Person two interjects: TRY FORTY!!
Person one continues: people have been polluting the Flint River, dumping trash and chemicals into the river and our street sewers, as well as wasting water!
All three people: but WE have a plan, "The Solution to Pollution!"
Person two: Our opponent, Pollution, is caused by improper disposal of chemicals, overfertilization, not picking up after our pets, and allowing bare spots on our lawns!
Person three: Our opponent can be overthrown! By properly disposing of oil, chemicals and household cleaners, fertilizing after it rains, and putting our trash in the proper place!
Person one: Make the right choice...the Flint River can't afford forty more years of pollution!
All three people: We are the Magnet Biology students from Flint Northern and Flint Central High Schools and we approve this message.

PSA Two: (a rap version)

Hi! The name is Fred T. Watershed
I'm here to put knowledge in your head.
Whatever you put on the ground
goes straight to the river in our town.
Storm sewer water goes to our river unseen
That's why our river looks unclean.
So throw your trash in the garbage can
Instead of throwing it on the land
Stop pouring waste in the sewer
and soon our river can look much newer.
Lake Huron picks up the Flint River
that soon becomes your drinking water at dinner!

This public service announcement is brought to you by the Magnet Biology students at Flint Northern High School.

PSA Three:

Neighbor A: Don't you know you have motor oil, antifreeze and car wax running down your driveway into the sewer?

Neighbor B: I'm gonna get that car fixed next month and I had to wash my car for my daughter's dance.

Neighbor A: What about the dog waste on your lawn?

Neighbor B: I haven't gotten around to throwing that in the sewer yet.

Announcer: Everyday trash, fertilizer, antifreeze, motor oil, carwash soap and other toxic waste are entering our street sewers and going straight to the Flint River! These things are affecting our river harshly, damaging the aquatic life living there. And remember, the Flint

River eventually drains into Lake Huron, so what you put on the ground can end up in YOUR drinking water!

This message is brought to you by the Magnet Biology students at Flint Northern High School.

PSA Four:

What's happening Flint-town? We're your girls coming from the Magnet Biology class at Flint Northern High School. We're here to talk to you about the Flint River. We've tested the water and our results show that the river is in trouble!

Here are some easy ways that you can help prevent the pollution of our river:

- Wash your car on the lawn so the phosphates won't run off into the river.
- Pick up after your pet or bury the waste.
- Put your trash in the garbage so it doesn't end up in the river
- Don't use heavy fertilizer and don't fertilize if rain is predicted
- Don't put anything in the street drains because everything goes straight to the river!!!

Do you like to drink water? Remember that the Flint River eventually drains into Lake Huron, the main source of our drinking water.

So help our river and our city by not polluting! The river can get better if we do our part!!

PSA Five:

Hello! We're from the Magnet Biology class at Flint Northern High School here to talk to you about the problem of Flint River water pollution. You may not know that the Flint River eventually runs into Lake Huron, the main source of our drinking water. If it wasn't for the water treatment plant, let us tell you what you would be drinking: fertilizer, toxic chemicals, animal waste and anything else that goes down our street drains straight to the river!

Take our advice: even if you don't care about the water critters, do it for YOUR health! Don't use fertilizer if rain is due, wash your car on the grass to keep phosphates out of the river, and don't dump chemicals or oil in the street drains. And remember! we have trash cans...use them!!

PSA Six:

Person one: Did you know that our Flint River eventually drains into Lake
Huron, the source of our drinking water?

Person two: Oh no, now that's nasty!

(music beat comes on here)

All: We're the Flint Northern High School water crew here to bring a message straight to you (echo, echo)

Person 3: Our clean water availability is getting lower and lower but there are a few simple things that you can do to keep our river up to par.

Person 4: Sweep your driveway off into the grass instead of hosing the dirt into the street where it will end up in the river.

Person 1: Be sure to buy and use environmentally friendly products

Person 2: Don't pour anything down the street sewer – these drain straight into our river!!

Person 3: Pick up after your pets!

ALL: We are the Flint Northern High School water crew and we approve this message!!

APPENDIX O
STUDENT BROCHURES

What can we do?

- Do not allow soil, leaves or grass clippings to accumulate on your driveway, sidewalk, or in the street.
- Do not use the storm sewers for disposing of motor oil, antifreeze, pesticides, paints, solvents, or other materials.
- Sweep (do not wash) fertilizer and soil off driveways and walkways on <u>to</u> <u>the</u> <u>lawn</u>.
- Minimize your use of salt on sidewalks and driveways.
- Dispose of pet wastes by flushing them down the toilet or burying them.
- Use a commercial car wash or wash your car on a lawn. The grass loves phosphates! Also check your car for fluid leaks.

Fig. 3a. Inside Flap of Brochure

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Figure 3. Student Brochure One: T
in Magnet Biology Section

Summary

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The River flows on
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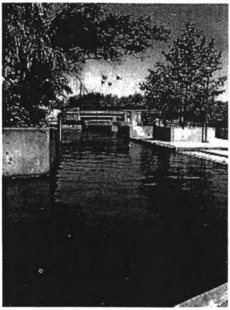
urn flow into Lake
ess what...that's our
ater!!!! Question:

you want to
oxic waste and
ypes of trash?

t was written and designed
t Biology Students at
orthern High School

Back of Brochure

fold brochure was written and designed by the students
who took part in this study



Did You Know:

- We are the reason the Flint River is the way it is.
- The Flint River drains into Lake Huron, which is the key source of our drink water.
- Everything on the ground eventually ends up in the river.

For more information
KEEP READING!

Fig. 3c. Front of Brochure

What is a Watershed?

You may wonder, "What is a watershed"? A watershed is an area of land that drains water from precipitation and ground water into a body of water, such as a lake, river, or stream.

Watersheds can differ in size. Our watershed is the Flint River Watershed, which covers 1,332 square miles of land that lie in Genesee, Lapeer, Oakland, Shiwasee, Saginaw, and small parts of Sanilac and Tuscola counties.

The main part of the river is about 142 miles long and is fed by many creeks including Gilkey, Kearsley, and Swartz Creeks in our city.

What is Run-off?

Run-off is the rain and melting snow that runs off streets, rooftops, and lawns into our street sewer drains. The flowing water carries salt, sand, soil, pesticides, fertilizers, leaves, and grass clippings, oil, litter, and many other pollutants into our river.

Since these pollutants are washed away off a wide area and cannot be traced to a single source, they are called non-point source or runoff pollutants. Point source pollutants would be those coming from the street sewers and pipes.

Runoff from the impervious (water can't soak in) surfaces at a typical high school, for example, could be thousands of gallons of water in a month that will end up in the river.

Imagine what goes with it!

What is Pollution?

Pollution is anything and everything we put on the ground that runs into lakes, rivers, streams, and eventually our drinking water. Things like:

- Sediments (soil particles eroded from yards, construction sites, and stream banks, can cloud the water and make it hard for fish, aquatic plants and animals to breathe, feed and see.)
- Sediments also increase flooding problems by making streams shallower.
- Nutrients such as nitrates and phosphates (when they come from manure, pet wastes, fertilizer, and detergents) in the water can make algae bloom. When the algae dies, it sinks to the bottom and uses a process that removes oxygen from the water. Without oxygen, living organisms will die and decompose.
- Debris, which is most common, can choke and kill the animals.

Pollution is something we do and can be fixed!

Fig. 3d. Inside of Opened Brochure

Figure 4. Student Brochure Two: This tri-fold brochure was designed and produced by the students in Magnet Biology section two who took part in this study.

Fig. 4a. Back of Brochure

Ways You Could Prevent Pollution

- Don't Litter
- Don't Put Anything Down Storm Drains
- Use Phosphate-free Soaps/Detergents
- Recycle
- Pick Up After Pets
- Wash Your Car on the Grass (grass loves phosphates, but rivers don't!)
- Don't Put Down Lawn Fertilizer if Rain is Predicted

SPECIAL THANKS TO:

-Fishing Tackle Grab Bag (waders)
-Hicks Archery and Tackle (waders)
-Meijers (waders)
-Mrs. Jean Williams (waders)
-GEAR-UP, CMU (waders & transportation)
-Beauchamp's Ace Hardware
-Lewis Driskell, Union Printing (printing)
-Schaefer's Complete Office Source
-Bart & Shelley Jones - Metamora (for generously allowing us to use their property for testing the river)
-Jarrett Trombley - UM-Flint (equipment, chaperone, and unending support)
-Anne Taylor - UM-Flint (chaperone)
-Jennie Farah - Parent Chaperone
-Karen Dutil - Parent Chaperone
-John Campbell - Parent Chaperone
-Mr. Clyde Bell - Principal, Northern High School

This pamphlet was written and designed by Magnet Biology Students at Flint Northern High School

?????????????????

WHY DRINK SEWAGE WHEN YOU CAN PREVENT IT FROM EVER BEING A PROBLEM?

?????????????????

Fig. 4b. Front of Brochure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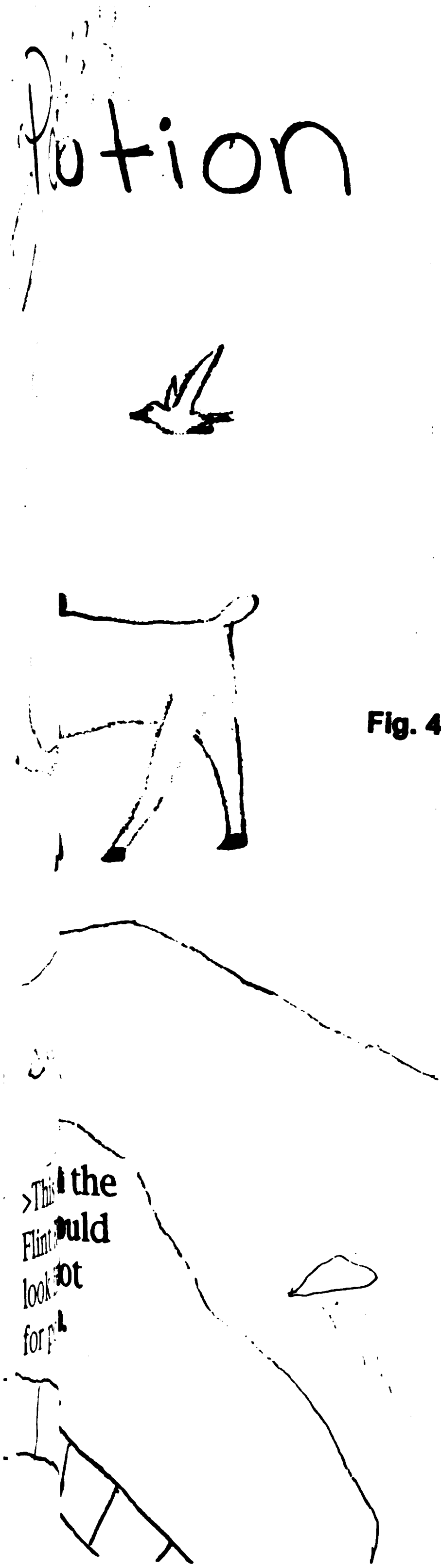
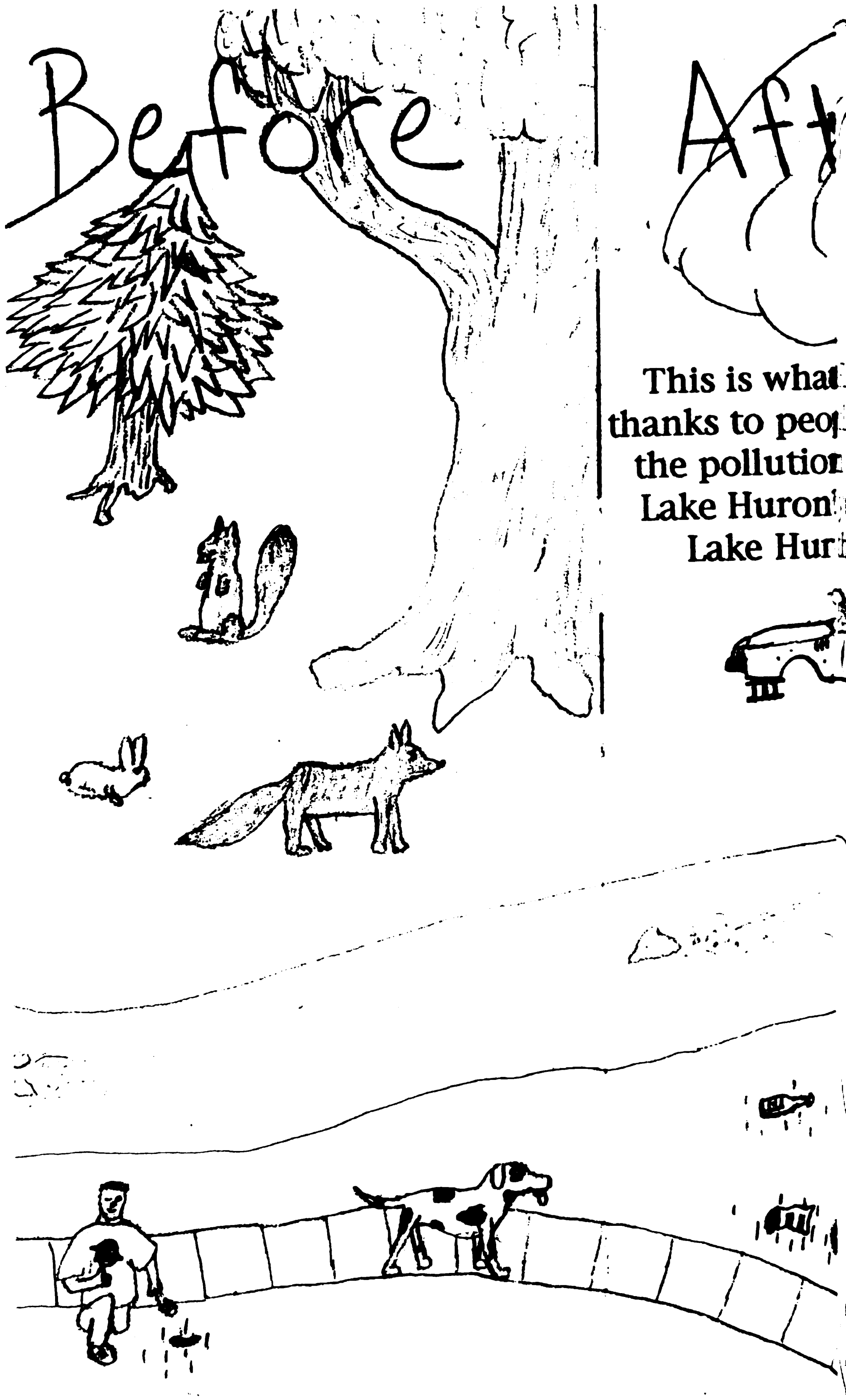


Fig. 4c. Inside of Brochure (folded in)


Before
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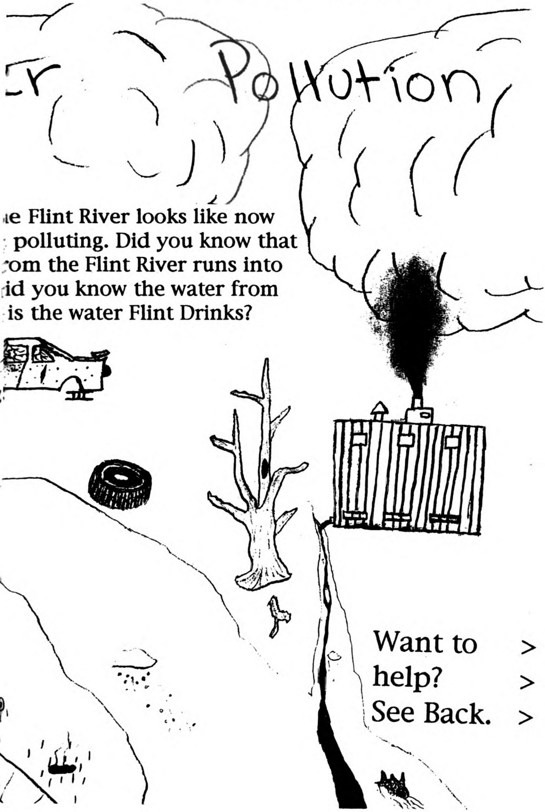
thanks to peo
the pollution
Lake Huron
Lake Hur

Fig. 4d. Inside of Opened Brochure



APPENDIX P

POST UNIT STUDENT SURVEY

THE EFFECTS OF HUMAN ACTIVITY AND URBANIZATION ON THE RIVER
POST-UNIT STUDENT SURVEY

Your opinion is important to me. I would like for you to take this survey to let me know if you feel that this unit of study was valuable to you. Please take a moment to reflect on your experiences during this study and tell me what you think. I've appreciated all of your hard work and hope that you have taken some important knowledge with you as well as having fun! It isn't necessary for you to put your name on this paper. Thanks!

1. Did you learn things about the Flint River that you never knew? ______
2. Please tell me THREE things that you learned during this study:
   1.

   2.

   3.

3. Did your opinion of the river in general change during this study? _____
   If you answered yes, how did it change?

4. Do you think that humans have an impact on the river? ______
   If you answered yes, please explain what kind of impact we have:

5. Do you think we could make a difference in the quality of the river?
   If you answered yes, please explain how:

6. Do you think your new knowledge will make a difference in how you do things? (Be honest!!!) _______ If you answered yes, please explain what you will do differently:

7. Do you feel that any of the activities (including in the classroom, outdoors on campus and at the river) helped you learn this material?

   If you answered yes, please tell me about it:

8. What did you like best about this unit and why?

9. What did you like least about this unit and why? Be honest – I value your opinion!

10. Do you find the knowledge that you gained to be personally valuable?

    Why or why not?

DO YOU HAVE ANY SUGGESTIONS FOR THE NEXT TIME THAT I CONDUCT THIS UNIT?

APPENDIX Q:

TABLE OF PRE- AND POST-UNIT TEST SCORES PER TEST ITEM

PRE- AND POST-UNIT TEST SCORES PER TEST ITEM

Test #	Question	% Correct Pre-Test	% Correct Post Test	% Gain In Score
1	Describe pollution and use examples	91	98	7
2	Where does river pollution come from?	68	100	32
3	How does it become pollution?	55	93	38
4	Name a polluted site	73	98	25
5	What affect does pollution have?	64	100	36
6	Does it affect you? How?	50	100	50
7	Do you pollute? How?	52	100	48
8	What is a watershed?	14	64	50
9	Is there one near you?	36	70	34
10	What is groundwater?	70	84	14
11	What is stormwater?	4	32	18
12	Where does the water go that flows into your street drain?	11	43	73
13	What happens to the water that you pour into your sink?	17	23	13
14	What happens to the water that you wash your car with outside?	7	43	82
15	Where does your drinking water come from?	3	28	57

Table 3. Pre- and Post-Test Unit Scores per Test Item

APPENDIX R

PAIRED T-TEST RESULTS OF PRE- AND POST-UNIT TEST

PAIRED T-TEST RESULTS OF PRE- AND POST-UNIT TEST

Table shows the results of the paired t-test that was applied to the scores of the pre- and post-unit test given to students conducting the river study. All but three of the questions had a probability of less than 0.05, indicating that the null hypothesis could be rejected for 12 of the 15 questions, as well as for the overall test scores.

n = *44*
degrees of freedom = *43*
critical value = *2.021*

TEST QUESTION NUMBER	t - VALUE	PROBABILITY (p)	REJECT H_O
1	1.77	0.083	No
2	4.25	0.000	Yes
3	4.77	0.000	Yes
4	3.40	0.001	Yes
5	4.96	0.000	Yes
6	6.56	0.000	Yes
7	6.27	0.000	Yes
8	5.62	0.000	Yes
9	3.98	0.000	Yes
10	1.96	0.057	No
11	8.67	0.000	Yes
12	10.7	0.000	Yes
13	1.43	0.160	No
14	13.9	0.000	Yes
15	7.52	0.000	Yes
OVERALL TOTAL (d.f. = 14) (c.v. = 2.145)	7.34	0.000	Yes

Table 4. Paired T-test results of pre- and post-unit assessment.

APPENDIX S

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ONE LAKE STREET
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Bound date:	**Summer 2005**
Pages to be copied:	**Q-Values graphs on pgs. 44, 57, 75, 107, 117, 129, 140, and 156**

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Jamie Cook 6/20/2005(revised)
Jamie Cook
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(201) 236-6716

Date: 6-25-05

ISBN: 0201493675

Subj:	**RE: Riverwatch Training Manual**
Date:	**7/6/2004 12:21:37 PM Eastern Standard Time**
From:	jhosier@dnr.in.gov
To:	Biogeek53@aol.com

Hi, Debra!

You have our permission to use those materials with appropriate credit given! Thank you for asking and good luck with your thesis! Let us know how everything turns out!

Jan Hosier
~~~~~~

Hoosier Riverwatch
Volunteer/Outreach Coordinator
Natural Resources Education Center
Fort Harrison State Park
5785 Glenn Rd
Indianapolis, IN 46216-1066
317-541-0617
riverwatch.in.gov

-----Original Message-----
From: Biogeek53@aol.com [mailto:Biogeek53@aol.com]
Sent: Tuesday, July 06, 2004 7:48 AM
To: riverinfo@dnr.state.in.us
Subject: Riverwatch Training Manual

Hello-
I am a high school biology teacher and I am currently creating a unit for my classes on rivers. I would like to use some of the training manual in my class and am requesting your permission to reprint them. Specifically,

1. Taxonomic Key to Benthic Macroinvertebrates
2. Ch. 2 Identifying your watershed illustrations fig.2 & 3
3. Citizens Qualitatie Habitat Evaluation Index
4. Guide for Water Quality Ranges
5. Habitat Parameters for Selected Macroinvertebrates
6. Q-Value graphs
7. Fig. 10 on page 48 (pH scale)
8. Fig. 12 on page 55 (Eutrophication)
9. Biological Monitoring Data Sheet
10. Page 78-88 Detail on macroinvertebrates by pollution tolerance

Obviously if you are kind enough to let me use these great materials, I will give complete credit to Hoosier Riverwatch.
I am presently working on my master's degree and this unit will be part of my master's work. Because of this, I will be expected to include the above in the appendix of my thesis (as part of my classroom unit) and would like permission to do that, as well. Again, full credit will be given to your
~~~~~~

Subj:	**Copyright Permission**
Date:	**7/15/2004 11:11:51 AM Eastern Standard Time**
From:	lhveem@montana.edu
To:	blogeek53@aol.com

Good morning...you have been granted permission to use the material from the Healthy Water, Healthy People Educators Guide for your masters thesis. All copyright provisions apply. WET must be cited at each use site and addresses provided for contact. Please don't hesitate to contact me if you have questions or desire additional information. Good luck!!

Linda Hveem
Assistant to the Executive Director
The Watercourse/International Project WET
201 Culbertson Hall
Montana State University
Bozeman, MT 59717-0575
406-994-1916

Subj:	**Permission request**
Date:	6/23/2005 1:51:28 P.M. Eastern Daylight Time
From:	rallan@nsta.org
To:	biogeek53@aol.com

Hi, Debbie—
Thank you for your permission request.

NSTA Press grants you permission to reprint in its entirety pages 102-103 (Aquatic Chemistry Reference Sheet) from Watershed Dynamics published by NSTA Press copyrighted 2004 in your master's thesis.

Please let me know if you have any questions.

Cordially,
Robin

Robin Allen
Book Acquisitions Coordinator, NSTA Press
National Science Teachers Association
1840 Wilson Boulevard
Arlington, VA 22201
Telephone: 703-312-9238
Fax: 703-526-9754
Email: rallen@nsta.org
www.nsta.org

Subj: **Re: Reprint Permission**
Date: 6/13/2005 3:30:35 P.M. Eastern Daylight Time
From: cmerrill@nabt.org
To: Biogeek53@aol.com

on 6/13/05 11:42 AM, Biogeek53@aol.com at Biogeek53@aol.com wrote:

> Hello!
> I just spoke with you regarding permission to reprint an article in my master's thesis which I will be submitting this month. The article is entitled "The Tragedy & Triumph of Minamata" (Douglas Allchin) published in the June 1999 issue of *The American Biology Teacher* (Volume 61, No. 6). I used the article in a river study unit in my high school biology class and would like to include a copy as an appendix to my thesis. I appreciate your help!
> Thanks so much!
>
> Deb Bassett
> Flint Northern High School
> Flint, Michigan
>
> My home address is:
> 7135 Granada Lane
> Flint, MI 48532
> Phone: (810) 630-0044

Hi Deb,
NABT is happy to grant you permission to reprint "The Tragedy & Triumph of Minamata" by Douglas Allchin (published in the June 1999 issue of The American Biology Teacher) in your master's thesis. Please be sure to list the article and author as you have above and give credit to NABT as the publisher.

Also, I wanted you to know that I spoke to our Executive Director, Dr. Wayne Carley. If you would be able to volunteer 4 hours of your time to help us at the Milwaukee Convention, NABT will waive your registration fee.

Best of luck with your thesis.

Sincerely,

Cheryl S. Merrill
Director of Publications
NABT

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(201) 236-5471
(201) 236-5455 FAX

July 7, 2005

Deb Bassett
7135 Granada Lane
Flint, MI 48532

VIA EMAIL: biogeek53@aol.com

Re: Your email of June 22, 2005 to use material from:

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0-13-042591-5; 0-13-016119-5

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________Comments:____

Please supply any requested information within 60 days; otherwise, we must consider the request withdrawn.

Sincerely,

Beth Attig
Permissions Editor

APPENDIX T:

UCRIHS APPROVAL FOR STUDY

MICHIGAN STATE
UNIVERSITY

August 5, 2004

TO: Merle HEIDEMANN
118 North Kedzie Hall
MSU

RE: **IRB# 04-586** CATEGORY: EXEMPT 1-1, 2-6

APPROVAL DATE: August 5, 2004
EXPIRATION DATE August 5, 2005

TITLE: The Effects of Urbanization and Human Activity on the Flint River: A Comparative Study

The University Committee on Research Involving Human Subjects' (UCRIHS) review of this project is complete and I am pleased to advise that the rights and welfare of the human subjects appear to be adequately protected and methods to obtain informed consent are appropriate. Therefore, the UCRIHS approved this project.

RENEWALS: UCRIHS approval is valid until the expiration date listed above. Projects continuing beyond this date must be renewed with the renewal form. A maximum of four such expedited renewals are possible. Investigators wishing to continue a project beyond that time need to submit a 5-year application for a complete review.
REVISIONS: UCRIHS must review any changes in procedures involving human subjects, prior to initiation of the change. If this is done at the time of renewal, please include a revision form with the renewal. To revise an approved protocol at any other time during the year, send your written request with an attached revision cover sheet to the UCRIHS Chair, requesting revised approval and referencing the project's IRB# and title. Include in your request a description of the change and any revised instruments, consent forms or advertisements that are applicable.
PROBLEMS/CHANGES: Should either of the following arise during the course of the work, notify UCRIHS promptly: 1) problems (unexpected side effects, complaints, etc.) involving human subjects or 2) changes in the research environment or new information indicating greater risk to the human subjects than existed when the protocol was previously reviewed and approved.

If we can be of further assistance, please contact us at (517) 355-2180 or via email: UCRIHS@msu.edu. Please note that all UCRIHS forms are located on the web: http://www.humanresearch.msu.edu

Sincerely,

Peter Vasilenko, Ph.D.
UCRIHS Chair

PV: jm
cc: Debra Bassett
7135 Granada Lane
Flint, MI 48532

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University Committee on Research Involving Human Subjects
Michigan State University
202 Olds Hall
East Lansing, MI
48824
517/355-2180
FAX: 517/432-4503
Web: www.msu.edu/user/ucrihs
E-Mail: ucrihs@msu.edu

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