

# Contents

## STUDENT EDITION

FIGURES AND TABLES IN THE <i>STUDENT EDITION</i> .....	viii
PREFACE .....	xi
SciLinks .....	xiii

### SECTION 1: UNDERSTANDING WATERSHED DYNAMICS

<b>CHAPTER 1. INTRODUCTION TO WATERSHED DYNAMICS .....</b>	<b>3</b>
What Is a Watershed? .....	4
The Water Cycle .....	6
Competing Needs for Water .....	8
<b>CHAPTER 2. WHAT'S IN A WATERSHED? .....</b>	<b>11</b>
Classifying Land Uses .....	11
Effects of Land Use on Runoff Quantity .....	12
Effects of Land Use on Water Quality .....	13
Effects of Land Use on Habitat .....	13
<i>Riparian Zones</i> .....	13
<b>CHAPTER 3. BIOLOGICAL COMMUNITIES IN STREAMS .....</b>	<b>15</b>
Food Chains and Webs .....	15
Stream Invertebrates .....	17
Using Invertebrates to Assess Stream Quality .....	18
<b>CHAPTER 4. PHYSICAL CHARACTERISTICS OF STREAMS .....</b>	<b>21</b>
Temperature .....	21
Turbidity .....	21
Stream Order .....	22
Rates of Flow .....	23
<i>Streamflow Changes over Time</i> .....	23
<i>Impact of Impervious Surfaces</i> .....	24
<b>CHAPTER 5. STREAM CHEMISTRY .....</b>	<b>27</b>
Dissolved Oxygen .....	28
<i>Effect of Turbulence on Oxygen</i> .....	28
<i>Effect of Temperature on Oxygen</i> .....	29
<i>Effects of Living Things on Oxygen</i> .....	30
<i>Effects of Organic Pollution on Oxygen</i> .....	30
pH .....	31
Alkalinity .....	34
Phosphorus .....	34
<i>The Phosphorus Cycle</i> .....	34

<i>Effects of Excess Phosphate</i> .....	35
Nitrogen.....	36
<i>The Nitrogen Cycle</i> .....	36
<i>Effects of Excess Nitrate</i> .....	38
Chloride .....	39
<b>CHAPTER 6. MODELING AND MANAGEMENT .....</b>	<b>41</b>
Scientific Models .....	41
Using Models to Evaluate Management Options .....	43
A Case Study: Managing New York City’s Water Supply .....	44
Community Action: Making a Difference in Your Own Watershed .....	45

## SECTION 2. PROTOCOLS: INTRODUCTION TO RESEARCH

<b>OVERVIEW .....</b>	<b>49</b>
Protocols .....	49
Protocol 1 – Watershed Field Survey.....	51
Protocol 2 – Object Recognition Using Maps and Airphotos .....	54
Protocol 3 – Delineating a Watershed .....	57
Protocol 4 – Analyzing Stream Integrity Using Remote Sensing Data .....	62
Protocol 5 – Collecting Aquatic Invertebrates .....	78
Protocol 6 – Simplified Stream Biota Test (SSBT).....	85
Protocol 7 – Index of Biotic Integrity (IBI) Using Aquatic Invertebrates .....	87
Protocol 8 – Measuring Stream Discharge .....	92
Protocol 9 – Aquatic Chemistry.....	98
Protocol 10 – Computer Modeling with STELLA .....	106
<b>WORKSHEETS FOR PLANNING PROTOCOLS .....</b>	<b>130</b>
Protocol Planning Form .....	130
Data Analysis Peer Review Form.....	132

## SECTION 3. INTERACTIVE RESEARCH: FIELD STUDIES AND EXPERIMENTS

<b>IDEAS FOR WATERSHED DYNAMICS RESEARCH .....</b>	<b>135</b>
Watershed Surveys .....	136
<i>Land use</i> .....	136
<i>WHEBIP</i> .....	136
<i>Invasive Species</i> .....	136
Stream Assessment with Aquatic Macroinvertebrates .....	137
<i>Comparing Assessment Protocols</i> .....	137
<i>Effects of Land Use by People</i> .....	137
<i>Aquatic Invertebrate Ecology</i> .....	138

Flow .....	138
<i>Precipitation and Impervious Surfaces</i> .....	138
<i>Snowmelt</i> .....	139
<i>Invertebrates</i> .....	139
<i>Online Flow Data</i> .....	139
Stream Chemistry .....	139
<i>Point and Non-point Sources</i> .....	139
<i>Nutrient Load</i> .....	140
<i>Dissolved Oxygen</i> .....	140
Modeling .....	140
Online Resources and Long-Term Data .....	141
<b>FORMS FOR INTERACTIVE RESEARCH .....</b>	<b>143</b>
Planning Research .....	144
<i>Choosing a Research Topic</i> .....	144
<i>Interactive Research Planning Form 1</i> .....	147
<i>Interactive Research Planning Form 2</i> .....	149
Presenting Research Results .....	154
<i>Research Report Form</i> .....	154
<i>Poster Guidelines</i> .....	157
Peer Review Forms .....	158
<i>Experimental Design Peer Review Form</i> .....	158
<i>Research Report Peer Review Form</i> .....	159
<i>Poster Peer Review Form</i> .....	160

## SECTION 4. INTERACTIVE RESEARCH: STORMWATER TREATMENT DESIGN CHALLENGE

<b>STORMWATER TREATMENT DESIGN CHALLENGE .....</b>	<b>163</b>
<i>Materials</i> .....	163
<i>Setting the Scene</i> .....	163
<i>Background</i> .....	164
<i>The Challenge</i> .....	164
<i>Design Criteria and Constraints</i> .....	164
<i>The Design Process</i> .....	166
<b>FORMS FOR STORMWATER TREATMENT DESIGN CHALLENGE .....</b>	<b>169</b>
<i>Parts List and Cost Analysis Worksheet</i> .....	170
<i>Design Selection Matrix</i> .....	171
<i>Design Proposal Form</i> .....	172
<i>Team Questions</i> .....	173
<i>Presentation Assessment Form</i> .....	174

# FIGURES AND TABLES IN THE *STUDENT EDITION*

## FIGURES

### SECTION 1

- 1.1. The Mississippi River watershed is made up of many smaller sub-watersheds.
- 1.2. Water cycles between land, water, and the atmosphere.
- 1.3. The impervious surfaces in cities create more surface runoff than in suburbs or forests and allow less water to percolate into the ground.
- 1.4. Food webs combine food chains into complex networks of feeding relationships.
- 1.5. Complete metamorphosis includes a pupal stage.
- 1.6. Incomplete metamorphosis has no pupal stage.
- 1.7. Stream order classification system.
- 1.8. A hydrograph shows changes in streamflow following a heavy rainstorm.
- 1.9. Increase in impervious surface in a watershed causes increased surface runoff and decreased percolation of water into the ground.
- 1.10. Streamflows following storms rise more quickly and reach higher peaks in urban areas than in forested watersheds.
- 1.11. Cold water can hold more dissolved oxygen than warm water.
- 1.12. Through photosynthesis, green plants create organic matter and release oxygen.
- 1.13. Some types of aquatic life are more sensitive than others to acidic conditions.
- 1.14. Nitrogen undergoes chemical changes as it cycles between land, water, air, and living things.
- 1.15. Simple models of a water molecule illustrate bonds between hydrogen and oxygen atoms.

### SECTION 2

- 2.1. Example airphoto
- 2.2. Example watershed delineation.
- 2.3. Technicians enter the stream.
- 2.4. Cross section of stream.
- 2.5. Example line graph.
- 2.6. Example bar graph.

- 2.7. Dissolved oxygen nomograph.
- 2.8. Physical model.
- 2.9. Navigation arrow.
- 2.10. Stock icon.
- 2.11. Unnamed stock.
- 2.12. Dynamite tool.
- 2.13. Flow icon.
- 2.14. Flow from bucket.
- 2.15. Toggle icon.
- 2.16. Graph tool.
- 2.17. Flows in and out.
- 2.18. Scale arrow.
- 2.19. Connector tool.
- 2.20. Leak connector.
- 2.21. Slider tool.
- 2.22. Blank slider control.
- 2.23. Flow in slider control.
- 2.24. Converter tool.
- 2.25. Leak factor converter.
- 2.26. A watershed landscape.

## **T A B L E S**

### **SECTION 1**

- 1.1. Distribution of fresh water on Earth.
- 1.2. Typical water use in American homes.
- 1.3. Relationship between pH, acidity, and  $H^+$  concentration.

### **SECTION 2**

- 2.1. Example uses of watershed protocols.
- 2.2. Field survey observation data.
- 2.3. Qualitative interpretation of watershed airphotos.
- 2.4. WHEBIP categories and subscores.
- 2.5. Simplified land use code descriptions.
- 2.6. Land use in our watershed.
- 2.7. WHEBIP subscore totals.
- 2.8. Stream integrity rating.
- 2.9. Simplified stream biota test (SSBT).
- 2.10. Aquatic invertebrate tally.
- 2.11. Species richness subscore.

- 2.12. Dominance index subscore.
- 2.13. Indicator species.
- 2.14. Index of biotic integrity and water quality.
- 2.15. Downstream chemistry data.
- 2.16. Upstream chemistry data.
- 2.17. Chemical measurements.
- 2.18. Model stream flow.

## **SECTION 3**

- 3.1. Potential research questions.