Scientific Data Collection Protocols

Danda Ecological Monitoring Program (DEMP)

Siddharthanagar Municipality, Rupandehi, Nepal

(A Technical Document to Accompany DEMP Initiative & Proposal)

An International Collaboration to Improve Urban Resiliency in Health, Sanitation, and Environment using Citizen Science

**

Pratiman-Neema Memorial Foundation (PNMF)
(http://pnfoundation.org.np/community/)

&

Sustainable Development Lab Team
Nepal Study Center, University of New Mexico
(https://nepalstudycenter.unm.edu/SustainableResearchLab/Econ451FALL2016.html)

December 12, 2016

Summary

**

The main objective of this draft is to serve as a technical data collection protocol manual for the initiative and proposal related to the development of the Danda River Ecological Monitoring Program (DEMP) in Siddharthanagar Municipality (Bhairahawa) (see Section 2 and Appendix A). This is an international collaborative project between the PNMF, a non-profit organization in Siddharthanagar, and the NSC's Sustainable Development Lab team of the University of New Mexico (UNM). The proposed long-term environmental monitoring project aims to help close the knowledge gap (causes and consequences of water pollution, e.g.), and to help improve the urban ecosystem through the *evidence-based policymaking* exercises. In the process, the good science and data collection effort hope to generate positive impacts on health, wellbeing, knowledge, attitude and behavior, and ultimately the quality of life of the people, who live in and around the urban city of Siddharthanagar. The protocol and report are based on the analysis and work done by the Sustainable Development Lab team (faculty, graduate mentors, and undergraduates) as a part of the *Problem Based Learning using Data Analytics* concept class (Econ 451/551, Fall 2016: https://nepalstudycenter.unm.edu/SustainableResearchLab/Econ451FALL2016.html).

**

1. Introduction

Conservation efforts geared towards local ecosystems have been a critical priority among communities worldwide, as ecosystems remain central to the wellbeing of not only a region's specific flora and fauna, but to the surrounding populations. Economic, health, and sociopolitical implications are all intertwined in such a priority, and as such, approaching such goals through good science is key. Known as the Danda Ecological Monitoring Program (DEMP), this project uses an urban city of Siddharthanagar in Nepal and its Danda River system as a case study site and develops a set of scientific data collection protocols.

An important aspect of the DEMP initiative involves its eco-club students and citizen science volunteers collecting environmental data using the well-established protocols, followed by the data analysis, sharing and dissemination of the scientific data through e-portals, and, whenever appropriate, taking appropriate actions through special community projects and awareness campaigns. The ultimate goal of this project is to preserve an ecosystem that is becoming harmful not only to the communities around it but to the flora and fauna dependent on its health and conservation. (See Appendix D for background information about the city, its river system, and various background water and sanitation analysis.)

2. Data Collection Protocols: Preparations, Collection, & Dissemination

2.1. Creating a Network of Stakeholders

Schools

Pick a few schools (4-6) located near the river within a mile-range, each site adequately spaced from each other. Each school picks (adopts) a nearby river bank and a channel (if available) as its monitoring site. Talk to school principal and the science teacher and explain to them the benefit from a project like this (e.g., availability of good scientific data for student projects, introduction to community-engaged research, environmental awareness, building a good citizenry out of students, life-changing experiential learning, and exposure to international network.)

Eco-clubs

Form an eco-club in each of the schools involved in the DEMP initiative. For each club, start with a small dedicated student group and expand it gradually. Ask them to have a weekly meeting to discuss ideas for eco-activities (e.g., recycling, river bank clean-up, trash collection, building trails, photography, eco-cultural programs).

Coordination

PNMF foundation's college campus (PNMHI) and its DEMP and Citizen Lab office will act as a clearing house for the DEMP project. This central lab office gathers data from all of the sites and posts them on a website organizing the data.

International Collaboration

Collaboration effort will continue to evolve with the University of New Mexico's faculty, students, the Nepal Study Center's Sustainable Development Lab, and the New Mexico Bosque Ecological Monitoring Program (BEMP).

2.2 Site Selection and Management

- *Site Selection:* Maximum 4 locations per mile of sample site. Each school picks one near-by site.
- *Site Management:* Take great care not to disturb the surrounding habitats at each study site and use your GPS coordinates to easily find your pre-determined sample locations. Set a small pole with a flag and/or a set marker with a station number.

2.3 Types of Environmental Assessments

- *Chemical water quality testing:* (Nitrate, pH, Dissolved Oxygen, Biochemical Oxygen Demand (BOD), Ammonia, Turbidity, Phosphate, Temperature, Coliform, and E. Coli.)
- *Biological assessment:* Aquatic insects and their larvae (macroinvertebrates) will be trapped, captured, and identified using a Biotic Index (insect key containing the list of pollution sensitive organism).
- *Physical landscape assessment:* The riparian corridor will be examined for its physical condition (e.g., erosion, inadequate buffer, vegetation, and invasive species).
- *Geomorphic assessment:* Stream flow can affect the amount of dissolved oxygen, which in turn can impact the animal in the water. The flow (speed) and the volume of water in the river can reflect the changing environment (e.g., climate

change).

2.4 Data Sheets[1]

(See Appendix A)

- Data Sheet 1: Site, Weather & Investigator Information
- Data Sheet 2: Physical Assessment: Riparian Corridor Assessment
- Data Sheet 3: Geomorphology: Water Flow
- Data Sheet 4: Biological Assessment: Macroinvertebrate Survey"
- Data Sheet 5: Chemical Assessment: Water Quality Testing
- Data Sheet 6: Overall Stream Health Assessment

2.5 Guidelines and Manual[2]

- For chemical water quality testing, please refer to the manual provided in the La Motte Testing Kits and record values using the data sheet provided in the Data Sheet 5 (Appendix A)
- For biological, physical, and geomorphological assessments, please refer to the Data Sheets: 2, 3, 4, 6 and the instructions therein.

1. You should have removed large debris (e.g. leaves, rocks, sticks) from your sample and placed this material in a separate basin (after removing macroinvertebrates from it).
2. Check the basin with the debris to see if any aquatic macroinvertebrates crawled out. Add these animals to your prepared sample.
3. Fill the ice cube tray half-full with water.
4. Using plastic spoons or tweezers, (be careful not to kill the critters – ideally, you want to put them back in their habitat after you're finished) sort out the macroinvertebrates and place ones that look alike together in their own ice cube tray compartments. Sorting and placing similar looking macroinvertebrates together will help insure that you find all varieties of species in the sample.
5. Refer to the *Key to Macroinvertebrate Life in the River* and the *Citizen Monitoring Biotic Index* to identify the aquatic macroinvertebrates:

2.6 Equipment

[1] Maryland Department of Natural Resources (March 2016): http://dnr.maryland.gov/Education/Pages/streamed.aspx
[2] University of Wisconsin, Water Action Volunteers (2007): http://watermonitoring.uwex.edu/wav/

1. ***Chemical Assessment: Water Testing***	
La Motte Earth Force Low Quality Water Quality Monitoring Kit ○ **Coliform screening;** kit performs 3 tests ○ **Temperature;** kit performs unlimited number of tests ○ **Turbidity;** kit performs unlimited number of tests ○ **pH;** kit performs 10 tests ○ **Dissolved oxygen;** kit performs 10 tests ○ **Biochemical oxygen demand (BOD);** kit performs 10 tests ○ **Nitrate;** kit performs 10 tests ○ **Phosphate;** kit performs 10 tests	($47.95/unit)
Thermometer	($10.00/unit)
2. ***Biological Assessment: Macroinvertebrate Survey***	
Small net	($8.00/unit)
Forceps	($1.00/unit)
Ruler	($1.00/unit)
Pans	($5.00/unit)
Magnifier-plastic	($1.00/unit)
Sieve	($10.00/unit)
3. ***Physical Assessment: Riparian Corridor Assessment***	
Clipboard	($2.00/unit)
4. ***Geomorphology: Water Flow***	
La Motte Test Kit	($39.95/unit)
Hip boots	($75.00/unit)
Meter stick	($3.00/unit)
Stopwatch	($10.00/unit)
Measuring tape	($15.00/unit)
5. ***General Items***	
Clipboard	($2.00/unit)
Stake wire flags	(6.15/per pack of 100)
Calculator	($6.00/unit)
Safety goggles	($5.00/unit)
Gloves	($7.00/unit)
Plastic bin	($7.00/unit)
Estimated Total Cost per Observation Site	**~$350**

2.7 Data Preparation, Analysis, and Translation

After the data is collected by the eco-clubs and/or the citizen science groups, the technical team will begin to process the scientific data, as they arrive every month or in some cases a few times a year, using state-of-the art analytical methods and visualization tools. The data will be processed and converted into simple *quality indices*, if needed. The data will be plotted and displayed on the e-portal using charts, graphs, and GIS tools (e.g., over time and over the geographic locations). In the future, options could be explored to use smart phone apps to send public announcements, pollution information, and other environmental alerts.

3. Beyond Data Collection

3.1 Action Projects for Eco-clubs

Schools and corresponding eco-clubs can participate in the following action projects in order to foster greater awareness and involvement in environmental preservation and public health initiatives:

- *School fundraisers:* Have the general school body organize a school fundraiser, either with game nights or a school fair. Bake sales and earth day/clean environment drives are also a great way to garner student support and involvement. Proceeds will go to support data collection efforts of DEMP and participating school eco-clubs.
- *Community walk-a-thons:* Organize a walk-a-thon for students from each school and their families to raise awareness on the importance of environmental health issues and the effectiveness of community unity.
- *Science fairs:* Have schools hold science fairs for each grade level, with a focus on environmental health and conservation methods.

3.2 End-of-the-Year Reflection: Workshop, Assessment, & Poster Presentation

Have each group of students in the eco-club and in each participating school conduct an end-of-the-year discussion workshop using the following reflection guideline. Students can use collected data and participate in a research poster presentation workshop. (See Appendix C for some tips and guidelines.)

3.3 Expected Impacts

Several critical areas support such a project, namely in the following areas

- ❖ Ecological

From an ecological perspective, preserving such an integral part of an ecosystem as a body of water is critical to the supply of nutrients, habitat structure, and chemical cycles (Calvin cycle, nitrogen cycle, etc.) essential to the flora and fauna of all ecosystems. Simple elements of a water's health status such as its pH level and turbidity, for example, greatly affect the ability of certain fish species and macroinvertebrate from surviving, resulting in the reduction of their populations and possible extinctions. Other concerns can be seen in higher rates of intrusive species within an unhealthy ecosystem, and possible negative consequences of bio-amplification of toxic chemicals.

- ❖ Public Health

Public health efforts around the world have established the importance of improving not only access to healthcare services but in disseminating effective educational resources on a variety of public health initiatives and programs. Leading among these topics is the importance of clean water sources and the corresponding proper sanitation techniques to keep sources of water used by a community clean and safe. Among the top leading causes of preventable illness and illness-related death are waterborne diseases stemming from unclean water sources and unsafe sanitation techniques (WHO, 2015).

- ❖ Citizen Science

Citizen Science is a critical method of incorporating a sense of social responsibility and collective unity in environmental preservation and public health initiatives. Involvement of local community centers, schools, universities, and residential communities in helping collect a variety of essential data in the ecological monitoring of the Danda River and its surrounding ecosystem.

- ❖ Public Policy

The most important aspect of this project is to promote an evidence-based decision making process. To that end, we believe that the sound scientific data collection program as proposed here – DEMP-- will be extremely valuable. In fact, the proposal outlined in this exercise offers a big picture which attempts to bring all the parties together – scientists, the public, and policy makers.

- Environmental Conservation & Eco-system Services

Good scientific data and well-informed public and policymakers can all come together to improve the riparian health of its vital river system. Healthy bird population and clean river can promote its recreation value through the development of bio-galley, bio-park, and boating activities. A healthy river system will positively impact the eco-tourism and the image of the world heritage site of Lumbini, the birthplace of Buddha.

- Cultural Unity

"Rivers run through our history and folklore, and link us as a people. They nourish and refresh us and provide a home for dazzling varieties of fish and wildlife and trees and plants of every sort. We are a nation rich in rivers."[3]

[3] (Charles Kuralt, *On the Road With Charles Kuralt*)

Appendix A

Data Sheet 1: Site, Weather & Investigator Information

"Explore and Restore Maryland Streams"

MARYLAND DEPARTMENT OF NATURAL RESOURCES

Stream Health Data Sheet

Record information on this sheet as you conduct assessments to determine the overall health of your stream. There are three stream assessments for this investigation: (1) **physical**, rating the condition of the stream habitat based on observed characteristics; (2) **biological**, using living animals present to indicate stream health; and (3) **chemical**, testing the water quality based on the chemical content of the stream. Use all three to get a more thorough rating of your stream's health. You may share your findings and compare your data with others on maryland.fieldscope.org.

Stream Site and Stream Investigator(s) Information		
Name (Teacher or Observer)	**Date**	**Time of Day**
School or Organization Name	**Group Members**	
Stream Study Site Name (used for stream study permit, example: ERMS15 East HS ScienceTeam)		
Name of Stream	**River or body of water into which this stream flows**	
Latitude__________________ degrees NORTH	**Longitude**__________________ degrees WEST	

Weather	
Today's Air Temperature ________ ° C or ° F	**Today's Humidity** ______________________
Today's Cloud Cover clear____ partly cloudy ____ cloudy ____	**Yesterday's Precipitation (amount)** ______________________
How could yesterday's weather affect today's field study?	
PREDICTION: Do you think this stream is healthy? Explain why you think so.	

Stream Health Assessment: Instructions

Next, use the three stream assessments in this data sheet to guide your investigations. At the end of each section, you will use your tests and observations to give your stream a rating for that individual assessment. Then, at the end, use the results from all three assessments to determine an overall stream health rating. How does this rating compare with the prediction you made above?

2016

<u>Data Sheet 2:</u> Physical Assessment: Riparian Corridor Assessment
<u>Data Sheet 3:</u> Geomorphology: Water Flow

Physical Assessment: Stream Corridor Assessment

Based on Stream Corridor Assessment protocols developed by Kenneth Yetman, adapted by Amanda Sullivan and Alison Armocida, Maryland Department of Natural Resources.

Instructions: Observe the stream habitat in and around the water, and use the accompanying Stream Corridor Assessment photographs to rank each characteristic. Based on your findings, you will give your stream habitat a rating.

Characteristic	Good (4)	Fair (3)	Marginal (2)	Poor (1)	Score
Floodplain Vegetation	Lots of plants, bushes, and trees along banks and floodplain.	Some plants, bushes and trees along banks and floodplain.	Most trees and bushes are gone.	Very little plant life at all along banks and floodplain.	
Channel alteration	Channel formed by natural processes and allowed to bend often around rocks and wood.	Channel straightened in some places but some natural bends still present.	Channel mostly straightened but vegetation still present and no cement.	Channel straightened and flowing along a paved channel.	
Embeddedness – Are there rocks on the bottom and are they covered by silt?	Rocks and cobbles cover almost all of the stream bed. Very little sand or silt between rocks.	Rocks and cobbles cover most of stream bed. Some sand/silt between and on rocks.	Rocks and cobbles more than halfway buried (embedded) into sand/silt.	Rocks and cobbles entirely buried by sand and silt.	
Erosion	Banks only slightly above the level of the water.	Banks somewhat higher above the level of the water.	Banks significantly above the level of the water.	Banks extremely high compared to water level.	
Attachment sites for Macroinvertebrates	Lots of different sized rocks, wood, and plenty of leaf litter.	Only small, gravel sized rocks, some wood and leaf litter present.	No rocks or wood but some leaf litter present.	No rocks, wood, or leaf litter present.	
Shelter for Fish	Lots of pools, wood, and undercut banks present in the water.	Some pools, wood, and undercut banks present in the water.	Few pools, wood, and undercut banks present in the water.	No pools, wood, and undercut banks present in the water.	
Riparian Buffer Width (estimation)	More than 50 feet of trees and brushy vegetation extending out from EACH bank of the stream.	20 - 50 feet of trees and brushy vegetation extending out from EACH bank of the stream.	5 - 20 feet of trees and brushy vegetation extending out from EACH bank of stream.	0 - 5 feet of trees and brushy vegetation extending out from EACH bank of the stream.	

[continued, next page]

Characteristic	Good (4)	Fair (3)	Marginal (2)	Poor (1)	Score
Bank stability – Are the banks of the stream eroding, or could they erode easily?	Lots of roots and vegetation or large rocks on the vertical portion of the bank all the way down to the level of the water.	Roots and vegetation or large rocks covering the vertical part of the bank 2/3 of the way down to the level of the water.	Roots, vegetation and/or large rocks going only 1/3 of the way down the vertical part of bank towards the level of the water.	Steep banks of bare soil with no plants or roots or large rocks.	
Velocity and Depth combinations - Within 30 feet upstream and 30 feet downstream from where you are standing *There are no pictures for this category.*	Stream has areas of (1) fast/ deep water, (2) fast/shallow water, (3) slow/ shallow areas, and (4) slow/ deep areas.	Stream has 3 of the four types of speed and depth combinations.	Stream has 2 of the four types of speed and depth combinations.	Stream has only one type of velocity and depth combination.	

Add all scores to get a total.

Total Score for Stream ______

Analysis:

<u>If the total score is</u>: <u>then the Overall Stream Rating is</u>:

30 – 36 Good

This stream has excellent habitat with a wide variety of traits. If the water quality is good, this stream can support many different species of insects and fish, including those sensitive to pollution and habitat changes. The stream is stable; habitat quality will not get worse unless people make changes to the area.

23 – 29 Fair

This stream has good habitat for many different species of insects and fish, including some sensitive to pollution and habitat changes. The stream is most likely stable. Minor changes can increase the habitat quality, such as stabilizing erosion or planting vegetation.

16 – 22 Marginal

This stream can support some species of insects and fish that are tolerant to pollution. The stream is not stable, and will get worse without restoration. Habitat can be improved by planting vegetation near the stream, stabilizing erosion, or reducing water from paved areas.

9 – 15 Poor

This stream may only support a few species of insects that are very tolerant of pollution. The stream is not stable, and will get worse without restoration. Habitat can be improved by planting vegetation near the stream, stabilizing erosion, or reducing water from paved areas.

Stream Corridor Habitat Rating ______________

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<u>Data Sheet 4:</u> Biological Assessment: Macroinvertebrate Survey

Biological Assessment: Macroinvertebrate Survey

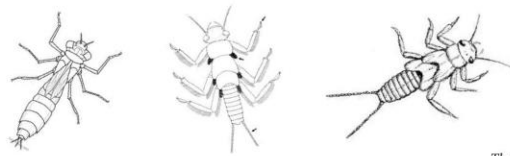
Collection method:

Kick-Seine or D-Net (circle method used).

If using a kick-seine, collect samples 3 times.

If using a D-net, collect 20 scoops and record the number of scoops taken from each of the habitat areas in the table →

Benthic Habitat Sampled	
Habitat	**# scoops**
Riffle	
Rootwads/ woody debris/ leaf pack	
Submerged Vegetation	
Undercut Banks	
Other (specify):	
TOTAL	**20**



Thank you to Howard County Public Schools System biology students for their contribution to the development of this tool.

Howard County Conservancy
connecting people to nature

Check all of the macroinvertebrates that you find in your stream and calculate the stream's water quality rating *[you may also record the number of each captured, but to calculate the rating at the bottom, only count each <u>kind</u> of animal once, regardless of the quantity found].*

✓	**Sensitive** to pollution	✓	**Less Sensitive** to pollution	✓	**Somewhat Tolerant** to pollution	✓	**Tolerant** to pollution
	Casemaker caddisflies		Net spinning caddisflies		Clams		Aquatic sowbugs
	Mayflies		Crane flies		Mussels		Black flies
	Stoneflies		Dragonflies		Planaria		Midge flies
	Water pennies		Riffle beetles		Gilled snails		Leeches
	Hellgrammites				Crayfish		Lunged snails
					Scuds		Damselflies
							Aquatic worms
# of check marks ________		# of check marks ________		# of check marks ________		# of check marks ________	
# above x 3 = ____		# above x 2 = ____		# above x 1 = ____		# above x 0 = ____	

Biological Water Quality Rating:

Add up the numbers you calculated for all three categories, above. Write the total # here: ________

Circle the rating that corresponds to the total of your columns.

Good: > 22 **Fair: 17 - 22** **Marginal: 11 – 16** **Poor: < 11**

Explore and Restore Maryland Stream ratings correspond with the Maryland Biological Stream Survey and Maryland Stream Waders ratings of streams found on the Stream Health website. Stream sites rated **Good** are shown there in green, **Fair** sites are yellow, and **Marginal/Poor** sites are red.

Maryland Department of Natural Resources

Sizes shown are for mature larvae/nymphs or adult animals, but individuals in earlier stages of development may be significantly smaller

Explore & Restore Maryland Streams
Key to Stream Macroinvertebrates

Companion to the Explore & Restore Stream Health Data Sheet

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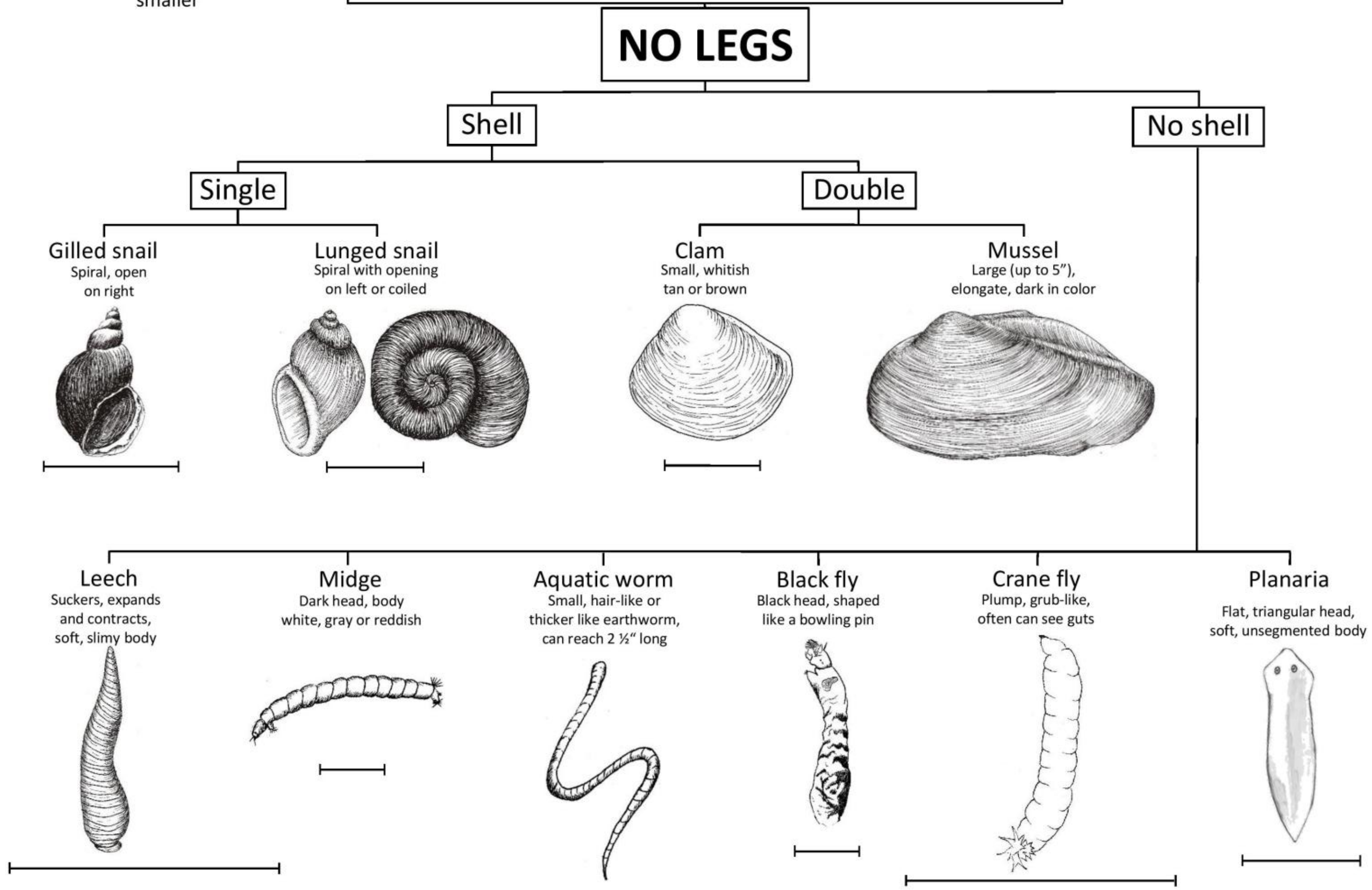

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Maryland Department of Natural Resources; Resource Assessment Service and Chesapeake & Coastal Services
580 Taylor Avenue; Annapolis, Maryland 21401; http://dnr2.maryland.gov/education/Pages/Biological_Assessment.aspx

Explore & Restore Maryland Streams
Key to Stream Macroinvertebrates

Companion to the Explore & Restore Stream Health Data Sheet

Sizes shown are for mature larvae/nymphs or adult animals, but individuals in earlier stages of development may be significantly smaller

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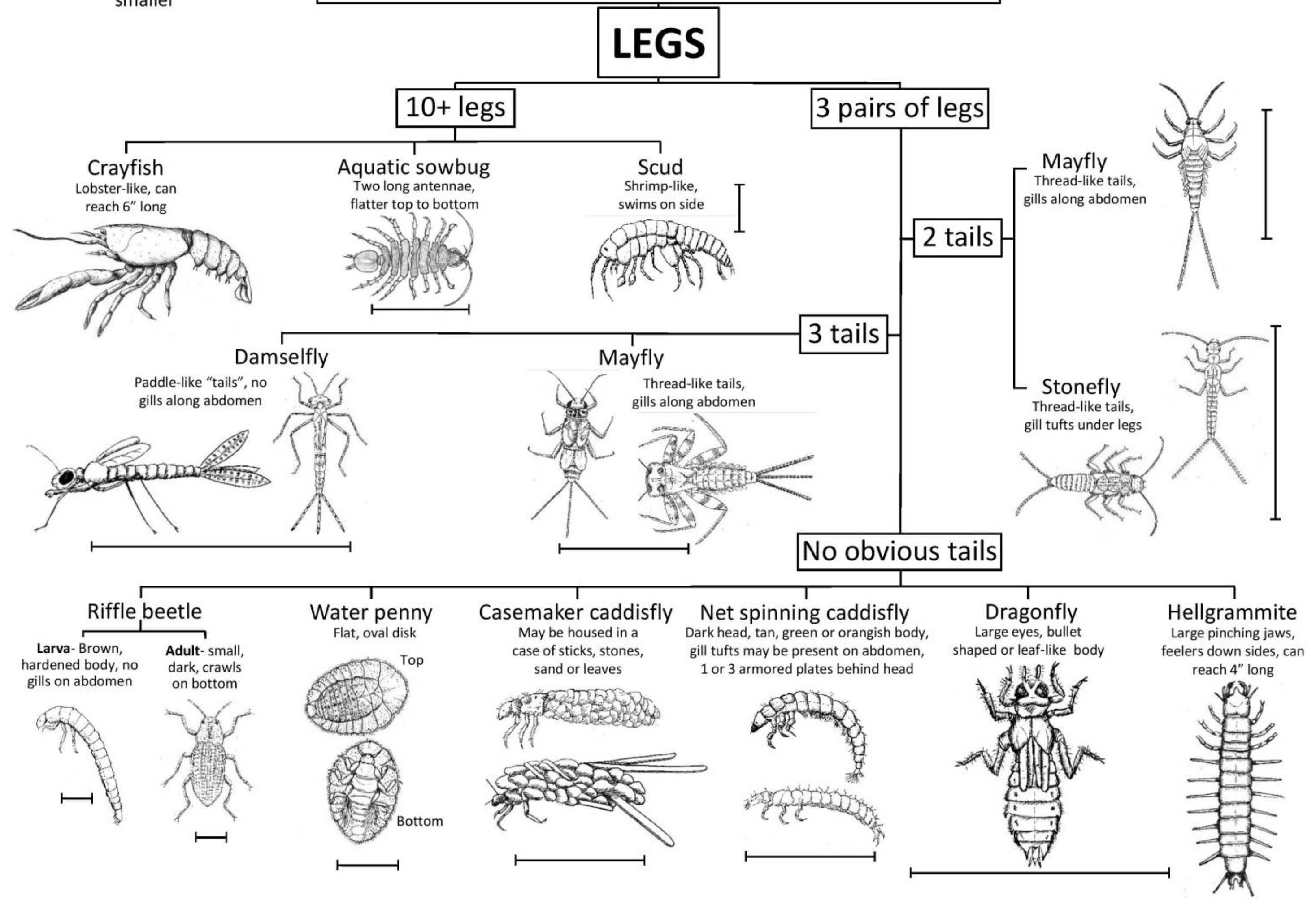


Data Sheet 5: Chemical Assessment: Water Quality Testing

Chemical Assessment: Water Quality Testing

(1) Follow instructions provided with each test kit to test different parameters.

(2) Record your data here:

DATA	**Water Temperature** (°C)	**Dissolved Oxygen (DO)** (mg/L)	**Dissolved Oxygen (DO) % Saturation** *See conversion chart*	**pH**	**Phosphate** (mg/L)	**Nitrate** (mg/L)	**Transparency** (cm)	**Turbidity** (JTU ~= NTU)	**Chloride** (mg/L)	**Conductivity** (µs/cm)	**Total Dissolved Solids (TDS)** (ppm = mg/L)
Trial 1											
Trial 2											
Trial 3											

(3) Circle the corresponding value here:

Water Quality Summation for Chemical Tests

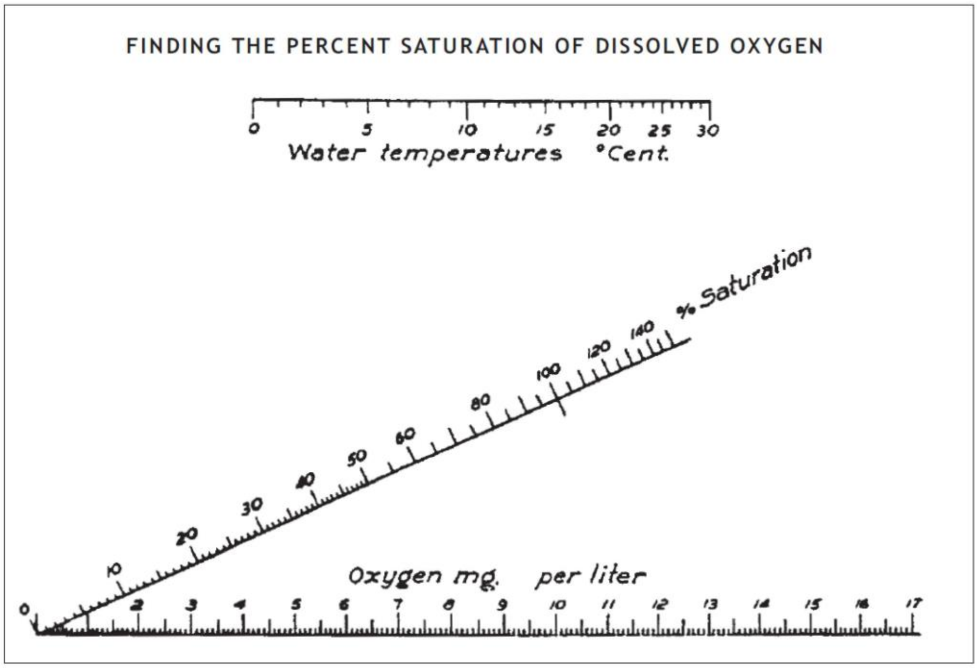
	GOOD	**FAIR**	**MARGINAL**	**POOR**
Dissolved Oxygen (DO) % Saturation *(see conversion chart)*	80 – 120	70 – 80 120 – 140	50 – 70 > 140	< 50
pH (units)	7.0 – 7.5	6.5 – 7.0 7.5 – 8.5	5.5 – 6.5 8.5 – 9.0	< 5.5 > 9.0
Reactive Phosphate (PO_4X^3) (mg/L)	0 – 0.2	0.2 – 0.5	0.5 – 2.0	> 2.0
Nitrate (NO^3) (mg/L)	0 – 3	3 – 5	5 – 10	> 10
Chloride (Cl) (mg/L)	0 – 20	20 – 50	50 – 250	> 250
Transparency (cm)	> 65.0	65.0 – 35.0	35.0 – 15.5	< 15.5
Turbidity (JTU ~= NTU)	0 – 10	10 – 20	20 – 30	> 30
Total Dissolved Solids (ppm = mg/L)	0 – 150	150 – 250	250 – 350	> 350
Conductivity (µs/cm)	0 – 171	172 – 247	248 – 500	> 500

Based on your tests and observations, how would you rate water quality overall? For example, if you had some excellent, some fair, mostly good, you might give an overall of good. Circle your answer:

Chemical Water Quality Rating: Good Fair Marginal Poor

[continued, next page]

Data Sheet 6: Overall Stream Health Assessment



To read this chart, use a straight edge. Place the straight edge on the mg/L of oxygen you have determined for your site, then place the other end of the straight edge on the water temperature you have measured. The point where the straight line passes through the line labeled "% Saturation" is your percent saturation.

Diagram reprinted from M.K. Mitchell and W.B. Stapp, *Field Manual for Water Quality Monitoring*

Overall Stream Health Assessment

Write your ratings from all three of the above tests, here:

Based on your tests and observations, how would you rate the health of your stream overall?

	Good	**Fair**	**Marginal**	**Poor**
Stream Corridor Assessment				
Macroinvertebrate Survey				
Water Quality Tests				

Overall Stream Health:

This publication was developed under Assistance Agreement No. CB96336601 awarded by the U.S. Environmental Protection Agency. It has not been formally reviewed by EPA. The views expressed are solely those of the Maryland Department of Natural Resources and EPA does not endorse any products or commercial services mentioned.

Appendix B

Equipment

1. Chemical Assessment: Water Testing	
La Motte Earth Force Low Quality Water Quality Monitoring Kit ○ **Coliform screening;** kit performs 3 tests ○ **Temperature;** kit performs unlimited number of tests ○ **Turbidity;** kit performs unlimited number of tests ○ **pH;** kit performs 10 tests ○ **Dissolved oxygen;** kit performs 10 tests ○ **Biochemical oxygen demand (BOD);** kit performs 10 tests ○ **Nitrate;** kit performs 10 tests ○ **Phosphate;** kit performs 10 tests	($47.95/unit)
Thermometer	($10.00/unit)
2. Biological Assessment: Macroinvertebrate Survey	
Small net	($8.00/unit)
Forceps	($1.00/unit)
Ruler	($1.00/unit)
Pans	($5.00/unit)
Magnifier-plastic	($1.00/unit)
Sieve	($10.00/unit)
3. Physical Assessment: Riparian Corridor Assessment	
Clipboard	($2.00/unit)
4. Geomorphology: Water Flow	
La Motte Test Kit	($39.95/unit)
Hip boots	($75.00/unit)
Meter stick	($3.00/unit)
Stopwatch	($10.00/unit)
Measuring tape	($15.00/unit)
5. General Items	
Clipboard	($2.00/unit)
Stake wire flags	(6.15/per pack of 100)
Calculator	($6.00/unit)
Safety goggles	($5.00/unit)
Gloves	($7.00/unit)
Plastic bin	($7.00/unit)

Estimated Total Cost per Observation Site	**~$350**

Appendix C

End-of-the-Year Reflection: Workshop, Assessment, & Research Poster

Have each group of students in the eco-club and in each participating school conduct an end-of-the-year discussion workshop using the following reflection guideline. Students can use collected data and participate in a research poster presentation workshop.

1. Identify local communities near your water source and their respective components (i.e., factories, farms, businesses, homes, roads):

____
____
____
____
____

2. Identify the relationships between these components and the adjoining water source (how is the river used, what does it provide these communities):

____
____
____
____
____

3. Are any of the relationships that you mentioned above a possible source of pollution for your water source? If so, how? Are there any possible unknown sources of pollution other than the relationships you have determined?

____
____
____
____
____

4. What recommendations, or changes, could you help with in reducing the negative relationship between any of the above components and your water source? What changes can you bring about? Your school? Local organizations or clubs? At home?

____
____
____

5. Identify local communities near your water source and their respective components (i.e., factories, farms, businesses, homes, roads):

6. Identify the relationships between these components and the adjoining water source (how is the river used, what does it provide these communities):

7. Are any of the relationships that you mentioned above a possible source of pollution for your water source? If so, how? Are there any possible unknown sources of pollution other than the relationships you have determined?

8. What recommendations, or changes, could you help with in reducing the negative relationship between any of the above components and your water source? What changes can you bring about? Your school? Local organizations or clubs? At home?

Appendix D

Background of Sddharthanagar and its River System

The city of Siddharthanagar is on the Danda River, which flows through the farmlands, open space, and urban settlements, and goes through one municipality and three or more rural counties. The river starts in the north-east corners of Rupandehi and Nawalparasi districts and runs toward the southwest direction, and going through several rural counties and the city of Bhiarahawa, it ends at the Indian-Nepal border. The Danda River is a unique “river system.” This groundwater-fed river system may be considered as a natural lake rather than a source-fed river. Some segments of the river are pristine and harbor numerous species of birds, reptiles, insects and a healthy riparian ecosystem. Several spots along the river are regularly clogged by the uncontrollable growth of algae (eutrophication), caused by the waste and discharges carried by the side channels that flow into the river as well as upstream agricultural and domestic sources. There are urban neighborhoods, farmlands, and factories within the city limits that have impaired the riparian sites along the river.

A recent study conducted by the University of New Mexico’s Nepal Study Center research team found numerous contaminants in these water bodies with detrimental health implications (See various water quality and sanitation analysis on the Sustainable Development Lab website: https://nepalstudycenter.unm.edu/SustainableResearchLab/Econ451FALL2016.html)