CMSC 150

PROJECT SPECIFICATIONS

Outline

- Motivation
- River Quality Monitoring
- Improving River Quality on the Field
- Your Project

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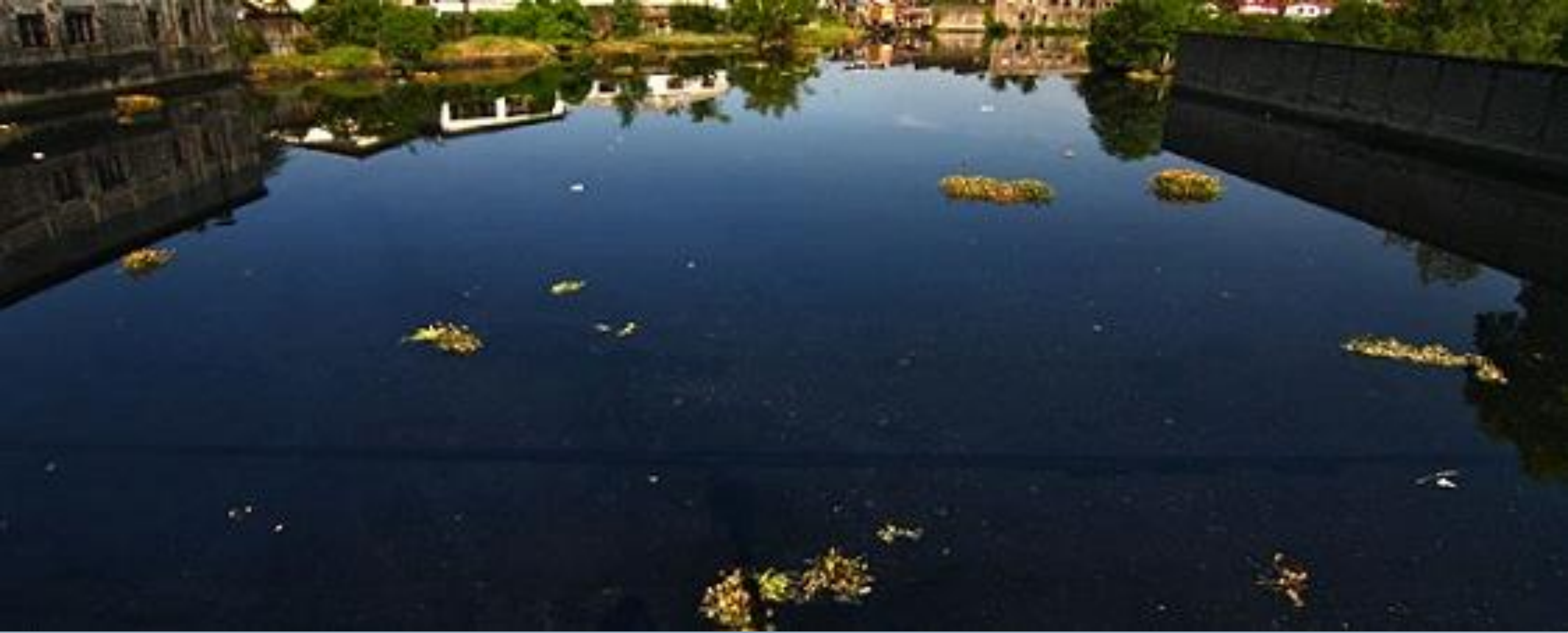

River Pollution

Marilao River.

Photo by Vincent Go, VERA Files.

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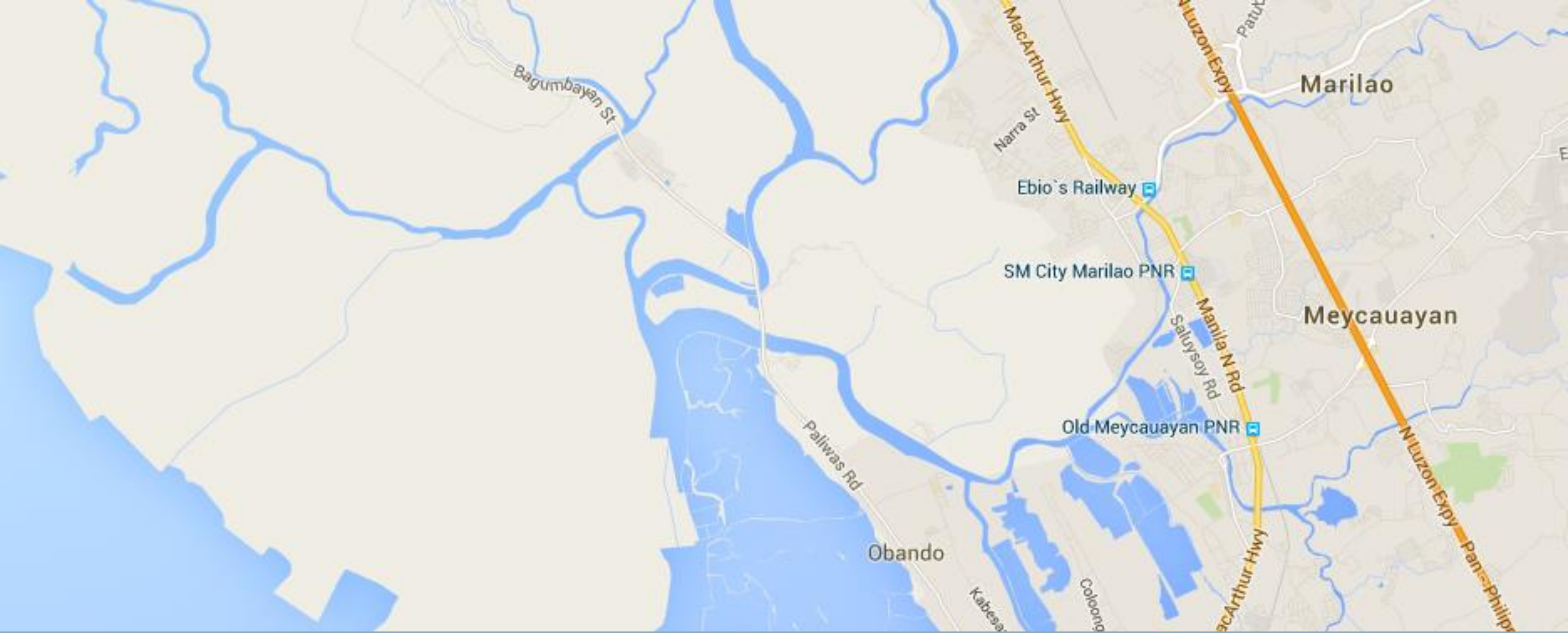
Our focus is on the MMORS or the Meycauayan – Marilao – Obando River System.

It is tagged as one of the Dirty Thirty rivers of the world by the Blacksmith Institute in 2007.

It is currently a dead river, mostly caused by industries surrounding the river system – piggeries, tanneries and smelters.

It has a river mouth directly connected to the Manila Bay.



Screencap of Google Maps on the MMORS

Obtained 4 November 2015.

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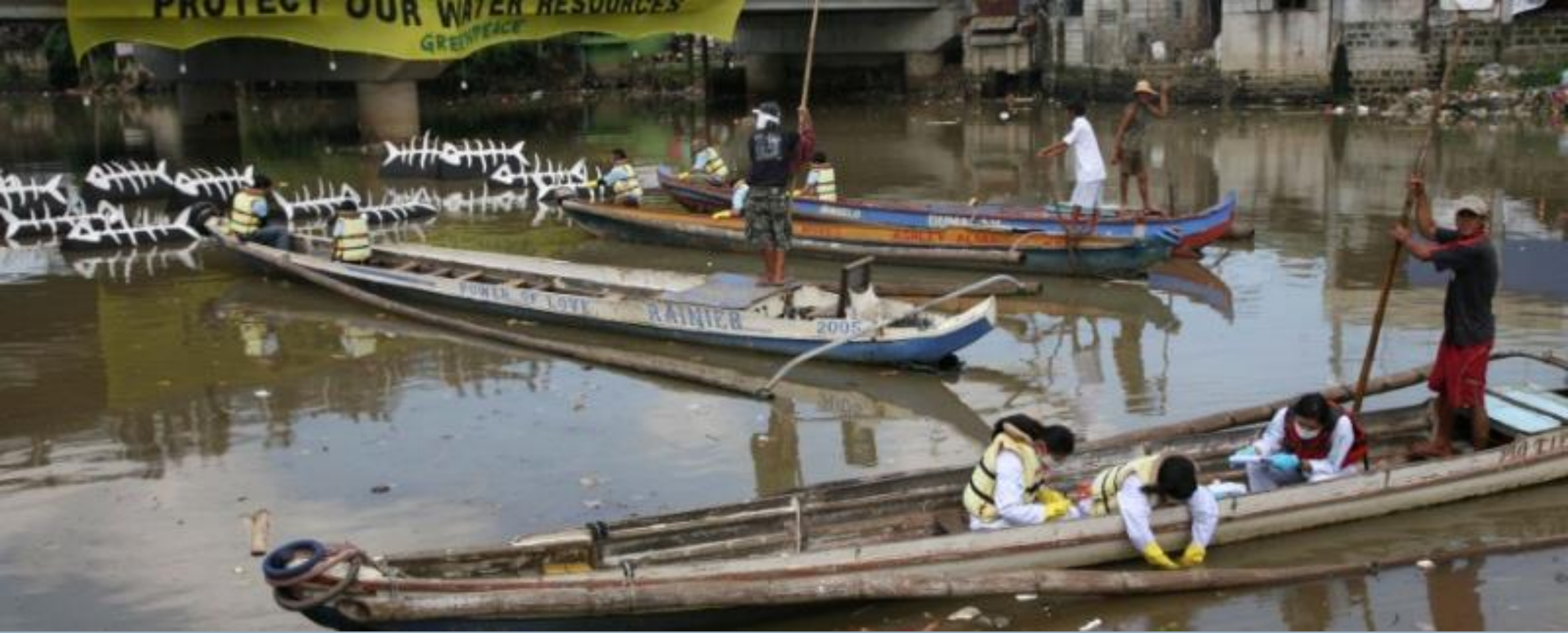
River Quality Monitoring

This activity seeks to identify the current content of toxic materials in river systems.

In the context of the MMORS, water and sediment samples are collected in river monitoring stations across the river system.

The amount of toxic materials are being identified by research and government agencies such as the UPLB BioTech and the Bulacan State University, and non-government organizations such as Greenpeace and Blacksmith Institute.



River Quality Monitoring Activities

Marilao River.

Photo by John Novis, Greenpeace.

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Improving River Quality

The following are the river quality components that we need to control and consider:

1. Arsenic (As)
2. Cadmium (Cd)
3. Chromium (Cr 6+)
4. Copper (Cu)
5. Lead (Pb)
6. Mercury (Hg)

Each river quality component has a minimum and maximum amount on a liter of water.

Each river quality component also has a cost for reducing it into a certain amount from a liter of water.

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Your Project

- Goal
- Given
- Linear Programming Optimization Problem
- Specifications

Your Project

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We wish to minimize the cost of cleaning the water in the river monitoring stations spread out across MMORS, subject to the constraints available.

Your Project

- Goal
- Given
- Linear Programming Optimization Problem
- Specifications

Given

- River Quality Components (RQC)
- River Monitoring Stations (RMS)
- Cost of Lowering RQC
- Amount of RQC Lowered
- Amount of RQC in RMS
- Minimum and Maximum RQC
- Volume at RMS

Given

- River Quality Components (RQC)
- River Monitoring Stations (RMS)
- Cost of Lowering RQC
- Amount of RQC Lowered
- Amount of RQC in RMS
- Minimum and Maximum RQC
- Volume at RMS

A set $R = \{r_1, r_2, \ldots, r_m\}$ containing m river quality components.

In our case:

1. Arsenic (As)
2. Cadmium (Cd)
3. Chromium (Cr 6+)
4. Copper (Cu)
5. Lead (Pb)
6. Mercury (Hg)

All elements should be considered.

Data is found in the `costing` sheet of the data set.

Given

- River Quality Components (RQC)
- River Monitoring Stations (RMS)
- Cost of Lowering RQC
- Amount of RQC Lowered
- Amount of RQC in RMS
- Minimum and Maximum RQC
- Volume at RMS

A set $S = \{s_1, s_2, \dots, s_n\}$ containing n river monitoring stations.

In our case:

1. 500m to MeyMZ
2. Caingin Bridge
3. Expressway Bridge
4. Mc Arthur Bridge II
5. McArthur Bridge
6. Meyc-Mar Mixing Zone
7. Meymart Bridge
8. Perez Bridge
9. Polo Bridge
10. Tawiran Bridge
11. Viente Reales Bridge

Not all river stations may be selected.

Data is found in the `Elements` data set.

Given

- River Quality Components (RQC)
- River Monitoring Stations (RMS)
- Cost of Lowering RQC
- Amount of RQC Lowered
- Amount of RQC in RMS
- Minimum and Maximum RQC
- Volume at RMS

Each river quality component can be lowered, by using a chemical procedure, which is priced per liter of water.

a_i = amount of RQC i that can be lowered in a liter of water

c_i = cost of lowering RQC i by a_i

Example:

- i = Arsenic, $a_i = 0.04$, $c_i = 0.06$
- You need PhP 0.06 to lower 0.04 mg of arsenic in a liter of water.

Data is found in the `costing` sheet of the data set.

Given

- River Quality Components (RQC)
- River Monitoring Stations (RMS)
- Cost of Lowering RQC
- Amount of RQC Lowered
- Amount of RQC in RMS
- Minimum and Maximum RQC
- Volume at RMS

For all river monitoring stations, each river quality component has been computed in a monthly basis.

C_{ijk} = amount of RQC i in RMS j in time k

Example:

- i = Arsenic, j = Meymart Bridge
- For the following months, these are the computed arsenic values in the Meymart Bridge (i.e. $\forall k$):
  - March: 12.47 mg/L
  - April: 8.99 mg/L
  - June: 0 mg/L
  - July: 8.99 mg/L
  - October: 8.99 mg/L

Data is found in the `Elements` data set.

Given

- River Quality Components (RQC)
- River Monitoring Stations (RMS)
- Cost of Lowering RQC
- Amount of RQC Lowered
- Amount of RQC in RMS
- Minimum and Maximum RQC
- Volume at RMS

For all river quality components, there is a minimum and maximum amount that is allowed in a liter of water that is allowed, according to a national standard set by the DENR.

$minC_i$ = minimum value of RQC i over a liter of water

$maxC_i$ = maximum value of RQC i over a liter of water

Example:

- i = Chromium
- The amount of chromium should be between 0 and 0.05 mg/L, inclusive.

Data is found in the `costing` sheet of the data set.

Given

- River Quality Components (RQC)
- River Monitoring Stations (RMS)
- Cost of Lowering RQC
- Amount of RQC Lowered
- Amount of RQC in RMS
- Minimum and Maximum RQC
- Volume at RMS

For all river quality stations, there is an amount of volume in which it maintains.

V_j = current volume of river station j in liters

Example:

- j = McArthur Bridge
- The amount of water in the McArthur Bridge is 46 000 000 liters.

Data is found in the `volumes` sheet of the data set.

Your Project

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Linear Programming Optimization Problem

- Minimal Standard Case
- Maximal Standard Case
- Summary

Linear Programming Optimization Problem

- Minimal Standard Case
- Maximal Standard Case
- Summary

Our objective is to **minimize the total cost** of remediating the waters of the river to accommodate the minimum and maximum amount of river quality components.

min_{x_i} = minimum value of RQC i over a liter of water

Minimize total cost

$$TC = \sum_{i=1}^{m}(c_i \times min_{x_i})$$

Subject to

$$a_i \times min_{x_i} \geq \left(\sum_{j=1}^{n} C_{ij}\right) + (minC_i \times n), \forall i \in R$$

Linear Programming Optimization Problem

- Minimal Standard Case
- Maximal Standard Case
- Summary

Our objective is to **minimize the total cost** of remediating the waters of the river to accommodate the minimum and maximum amount of river quality components.

max_{x_i} = maximum value of RQC i over a liter of water

Minimize total cost

$$TC = \sum_{i=1}^{m}(c_i \times max_{x_i})$$

Subject to

$$a_i \times max_{x_i} \geq \left(\sum_{j=1}^{n} C_{ij}\right) + (maxC_i \times n), \forall i \in R$$

Linear Programming Optimization Problem

- Minimal Standard Case
- Maximal Standard Case
- Summary

You will find **how many times to clean** the river stations to achieve the minimum and maximum standards for each river quality component with the **minimum cost**.

Questions?

Your Project

- Goal
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Specifications

- Ultimate Optimizer
- River Quality Monitoring

Specifications

- Ultimate Optimizer
- River Quality Monitoring

Provide an interface where the user can specify the
- Goal (minimize or maximize);
- Objective function; and
- Constraints.

You need to specify in your project the necessary syntax for your inputs.

The user will instruct the system (most likely, RStudio) to start solving (by pressing run source).

Specifications

- Ultimate Optimizer
- River Quality Monitoring

Implement a program that solves the optimization problem using the **simplex method**.

The tableau and the basic solution for each iteration must be placed in **comma separated value (`csv`)** files in a folder named **`iterations`**.

Each iteration has its own filename: **`iteration_<number>.csv`**.

The final solution and the resulting value of the objective function must be identified.

You should only use R as the programming language.

Questions?

Specifications

- Ultimate Optimizer
- River Quality Monitoring

Provide an interface where the user can select any or all of the river monitoring stations.

Make sure that changing the input is an easy task for the user. Please refer to the specification on what data should be changed.

Specifications

- Ultimate Optimizer
- River Quality Monitoring

The final output shall be a table which contains:

- The corresponding costs for treating $r, \forall r \in R$ over the set S (i.e. min_{x_i} and max_{x_i}); and
- The minimum and maximum amount of river quality components that can be treated (i.e. $\sum_{j=1}^{n} V_j min_{x_i}$ and $\sum_{j=1}^{n} V_j max_{x_i}$).

Please refer to the test case for more information.

Specifications

- Ultimate Optimizer
- River Quality Monitoring

The values of the output are exceedingly large. Please convert the final outputs into kilograms instead.

You shall use your Ultimate Optimizer in doing this task, and you shall use any programming language as your interface. You should therefore know how to integrate R over your language of choice.

Questions?

Incentive

- Time Component

Incentive

- Time Component

As you observe, in your data set, there are columns for corresponding months.

Your objective is to do the same for the other months.

You are entitled to your own methods on how to do this task.

Questions?

If there are questions not raised here, you may also contact your lab instructors. ☺