a water allocation plan to maximize financial BENEFITS Of Available water in a river

Prepared by Joshua Ward for the Regional Water Manager (Client)

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Utah State University

CEE 5410/6410 | Dr. David Rosenberg, PhD

# Introduction

Water is a valuable, but often limited, resource; water system managers must optimize their distribution of water to meet many demands and constraints while maximizing community benefits. The author was asked to recommend a plan for allocating some 320 additional acre-ft of available water from a local river between a large urban area and a neighboring wetland area to maximize financial benefits to the client, the water manager of the region. This report outlines the application of a Lagrangian method used to suggest allocated water volumes the urban and wetland areas that maximize financial benefits to the client using 320 acre-ft of available water. The analysis also includes a recommendation for allocating an additional 10 acre-ft of water above the 320 acre-ft currently available (Rosenberg 2020).

# Methods

Finding an optimum allocation plan using a Lagrangian method involved the following:

* Exploring relationships between the allocated volumes of water to both regions and their resultant financial benefits shown in *Appendix A: Calculations*.
* Defining the constraining conditions governing the system behavior, including a maximum combined allocation of 320 acre-ft between the two areas and
* Combining benefit and constraint equations, differentiating the new equation, and solving for the conditions that give maximum benefits.

The same procedures were used to analyze the potential scenario with an additional 10 acre-ft of water available in the river for a total of 330 acre-ft and make a recommendation for allocating the additional water (see *Appendix A: Calculations*).

# Results

The optimization model yielded several key insights:

* Financial benefits are maximized when 268.5 acre-ft of water is diverted to the urban development and 51.5 acre-ft of water is diverted to the wetlands.
* The client can expect $266,300 in financial benefits from this management plan.
* The model predicts a maximum volume of 51.5 acre-ft for which diverting water to the wetlands is beneficial. If 10 more acre-ft of water were available in the river, the client should divert the additional water to the urban developments for an $8,000 increase in total benefits.
* Beyond this threshold, all additional available water should be diverted to the urban developments; below this threshold, all available water should be diverted to the wetlands to maximize financial benefits.

# Conclusion

To maximize financial benefits using the available 320 acre-ft of water in the river, the client should divert about 268.5 acre-ft (about 84%) to the urban development and 51.5 acre-ft (about 16%) to the wetlands. The client can expect $266,300 in financial benefits from this management plan. Should an additional 10 acre-ft of water come available, the client should allocate the 10 acre-ft to the urban development for an $8,000 increase in financial benefits. The client should also divert available water above the 51.5 acre-ft threshold to the urban development.

# References

Rosenberg, David E. 2020. "Analystical Solution to an Optimization Problem." *CEE 5/6410 Lecture Notes.* Logan, UT: Utah State University, September 1.

# Appendix A: Calculations

A screenshot of a cell phone

Description automatically generated

Benefit information was provided by the client.

A screenshot of a cell phone

Description automatically generated

**CEE 6410, HW-Grading Rubric** **HW-1 Date: 09/08/2020 Student: Joshua Ward (A02081581)**

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| **Category (Max. Score)** | **No Evidence** | **Doesn’t Meet Standard** | **Nearly Meets Standard** | | | **Meets Standard** | | | **Exceeds Standard** | | | | | **Self-**  **Score** | **Instructor Score** |
| **Title**  **(1)** | Absent      0 | Evidence of two  or less    0 | Evidence of three      0 | | | Evidence of four      1 | | | Title – can assess main point from title alone; Name, Instructors’ Names, Course, | | | | | 1 |  |
| Date, Neatly finished | | | 1 |  |
| **Introduction**  **(3)** | Absent, no  evidence      0 | There is no clear introduction or main topic.      1 | Introduction states the main topic but either:   1. Does not give a full overview, Or: 2. Too detailed, leading to annoying repetition later. 2 | | | The introduction states the main topic and previews the structure of the report.    2 | | | The introduction states the main topic and previews the structure of the report. Good overview of the problem and solution approach. Gives enough detail to motivate the reader to continue reading.  3 | | | | | 3 |  |
| **Organization and structural**  **development of the idea**  **(10)** | No content provided.              0 | Paragraphs fail to develop the main idea. No section headers or guide to help the reader understand how material is organized. 1 – 5 | Organization of ideas not fully developed. Paragraphs lack supporting detail sentences. No transitions and/or ineffective section headers.  6 - 7 | | | Paragraph development present but not perfected. Each paragraph has sufficient supporting detail sentences. Few transitions. 8 | | | Writer demonstrates logic and sequencing of intro, procedure, results, and conclusions through well-developed section headers, paragraphs, and transitions. The first sentence of each paragraph is the summary sentence. 9 - 10 | | | | | 8 |  |
| **Technical**  **Correctness**  **(70)** | Questions not addressed.    3 – 42% | The writer has no clue what they are talking about.  45 – 58% | Sketchy: left out required design points. Did not work on this as much as you should have, and it shows. Many important answers are incorrect. | | | Discussion lacks adequate detail, but all the necessary points are covered and nearly all answers are correct. | | | Provides what was explicitly asked for. The function of each piece is demonstrated to the reader in adequate, but not overwhelming, detail. Answers are correct and reasonable. | | | | |  |  |
|  | 61 – 79% |  |  | 82 – 88% |  |  | 91 – 100% |  | | |
| a) Description of solution method (25) | | | | | | | |  | | | | | 25 |  |
| b) Recommended allocations to urban users and the wetlands (20) | | | | | | | |  | | | | | 20 |  |
| c) Total benefits generated (15) | | | | | | | |  | | | | | 15 |  |
| d) Additional benefits generated with more water available (10) | | | | | | | |  | | | | | 10 |  |

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| **Category (Max. Score)** | **No Evidence** | **Doesn’t Meet Standard** | **Nearly Meets Standard** | | | | **Meets Standard** | | | | **Exceeds Standard** | | | | | **Self-**  **Score** | **Instructor Score** |
| **Word Usage and Format**  **(10)** | Not applicable | Numerous and  distracting errors in punctuation, capitalization, spelling, sentence structure, word usage, significant figures, tables, and figures. Data vomited onto page(s). Unacceptable / unprofessional at the graduate level. 1 – 5 | Misspelled words, poor English grammar and word choice. Main body of report is either longer or significantly less than one page. Figures are too small and/or underlabeled, although they are usually of acceptable quality and focus. Tables incoherent or not cohesive. Bad font sizes. Too much or too little data in appendices. Could be improved by being more meticulous. 6 - 7 | | | | Almost no errors in punctuation, capitalization, spelling, sentence structure, word usage, significant figures, and presentation of figures, tables, and appendices. Main body of report is one page or less      8 | | | | Punctuation, capitalization, spelling, sentence structure, word usage, and significant figures all correct. Main body of report is one page or less. Clear, consistent fonts. Good word processing skills. Figures have adequate contrast. Informative figure and table titles and legends. Figures have appropriate axis tick spacing, labels, units, and legends. Table columns cohesive, labeled, and specify units. Document is stapled. Appendices, if provided, are separated by topic, and each have a title, discussion, and proper formatting and display of   |  | | --- | | 9 - 10 |   information | | | | | 10 |  |
| **Conclusion**  **(4)** | Absent    0 | Incomplete and/or not focused. 1 | The conclusion does not adequately restate the | | | | The conclusion restates the main | | | | The conclusion restates the main results, and is an effective | | | | | 4 |  |
| main results. | | 2 |  | results. | 3 |  | | summary. | 4 |  | | |
| **References**  **(0)** | Absent    0 | Numerous errors, off-the-wall sources used. 0 | Some errors in citing format; more sources should be cited. | | | | Prior work cited with few errors. | | | | All prior work and data sources are cited in the correct format with no errors. | | | | | NA | NA |
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| **TOTAL** (98) |  |  |  | | | |  | | | |  | | | | | 96 |  |

Instructor Feedback:

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