

COMPETING DEMANDS FOR WATER -

THE DEVELOPMENT OF A MANAGEMENT PLAN FOR
EQUITABLE SHARING OF WATER BETWEEN TOWN AND
AGRICULTURAL USERS

A Thesis submitted for the Degree of Master of
Natural Resources at the University of New England

by

ROBERT GEORGE FULCHER B.Sc., B.E. (HONS.).

(University of Sydney)

- 1983

PREFACE

The study presented in this thesis is original and was completed by the author as an internal, part-time, post-graduate student in the Resource Engineering Department of the Faculty of Resource Management, at the University of New England, under the supervision of Professor J.R.Burton and Dr.S.J.Perrens. Assistance with computing was given by Dr.I.H.Fisher and with economic analysis by Mr.A.D.MacDonald.

I certify that the substance of this thesis has not already been submitted for any other degree and is not currently being submitted for any other degree.

I certify that all sources of data, all help received in preparing this thesis and all sources used, have been acknowledged in this thesis.

ACKNOWLEDGEMENTS

I wish to express my gratitude to my supervisors, Professor J.R.Burton and Dr. S.J.Perrens, of the University of New England, for their valuable assistance in the preparation of this thesis.

I also wish to thank Uralla Shire Council for the use of its information, records and resources used in this study.

All part-time students need the encouragement, support and patience of their family. My wife Jennifer, and my children were wonderful supports to me and I gratefully acknowledge their contribution.

I also wish to express my gratitude to Dr. M. Jones of the University of New England for his valuable assistance and advice in the drafting of this thesis.

LIST OF FIGURES

<u>Figure Number</u>	<u>Description</u>	<u>Page</u>
1	The Location of Bundarra on the Gwydir River in N.S.W.	5
2	Population Characteristics of Bundarra during the 20th Century	8
3	Sketch Plan showing the Relative Location of the Gwydir River, the Village of Bundarra and the Irrigation Sites	9
4	Effect of Evaporation on Draft-Storage Capacity Relationships	18
5	Contours of Maximum Possible Streamflow Regulations at 95% Reliability, expressed as a Percentage of Mean Annual Flow	19
6	The Great Dividing Range in New South Wales	23
7	The Extent of the Upper Gwydir Valley Catchment	44
8	The Principal Geological Formations of the Upper Valley	47
9	Land Use in the Upper Gwydir Valley, as at 1980.	52
10	The Daily Water Supply and Demand Situation in the Gwydir River at Bundarra	56
11	Simplified Flow Chart of the Programme	58
12	The Relationship between Soil Moisture Level and Time During Successive Irrigation Applications, as affected by Rainfall	64
13	The Effect of Varying the Water Level at which Irrigation is Required to Cease, in Taylor's Pond, on interruptions to water use	82

14	The Effect of Varying the Water Level at which Irrigation is required to cease, in Taylor's Pond, on the occasions of interruptions to Irrigation	83
15	The Effect of the Level at which restrictions on town supply are Imposed, with varying values of the Level at which Irrigation must cease	85
16	The Effect of Increasing the Storage Capacity of Taylor's Pond on the Reliability of Town Supply	87
17	The Effect of Increasing the Storage Capacity of Taylor's Pond on the Reliability of Irrigation Supply	88
18	The Effect of the Level at which water use is Restricted on the Value to Irrigation Reliability of Increasing the Storage Capacity of Taylor's Pond.	90
19	The Effect of the Level at which Irrigation Must Cease on the Value to Town Users of Increasing the Storage Capacity of Taylor's Pond	91
20	The Effect of Increasing the Capacity of Taylor's Pond on extreme Periods of Interruption to Water Usage	93
21	A Typical Demand Curve	106
22	The Demand Curve - The Concept of Utility	108
23	Marginal Value In Use of Irrigation Water Foregone with Varying Irrigation Control Levels in Taylor's Pond	115
24	Demand Curve for Water in the Township of Bundarra, Based on the Results of the Bundarra Water Questionnaire	120

Marginal Value in Use of Town
Water Foregone with Varying
Irrigation Control Levels in
Taylor's Pond

LIST OF TABLES

<u>Table Number</u>	<u>Description</u>	<u>Page</u>
1	Potential for Stream Regulation Expressed as a Percentage of Mean Annual Flow	21
2	Water Quality Limits	22
3	Water Resources and Estimated Usage in New South Wales - 1976	25
4	Amounts of Water Supplied to Cities and Towns in Australia	28
5	Reported Values of Water in Alternative Uses	38
6	Average Maximum and Minimum Temperatures for Uralla and Bundarra	46
7	Average Monthly Evaporation for the Headwaters of the Gwydir Valley	47
8	Comparison of Actual Periods in which Irrigation was not permitted from Taylor's Pond, During the Summer of 1981/82 and those Predicted by the Simulation Programme	77
9	The Effect of Raising the Level at which Restrictions on Water Usage Apply from 40Ml to 60Ml	94
10	The Influence of the Area of Irrigation on Reliability of Supply	96
11	The Effect of Increased Irrigation Application per Hectare on the Reliability of Supply	98
12	Calculation of the Marginal Value in Use of Irrigation Water	112
13	Results of Bundarra Water Use Survey	117

14	Table of Assumed Marginal Values in Use of Water Foregone by Residents of Bundarra	123
15	The Effect of Raising the Irrigation Control Level on the Reliability of Town and Irrigation Supply	131

TABLE OF CONTENTS

<u>CHAPTER 1</u>	<u>INTRODUCTION</u>	<u>PAGE</u>
1.1	Aims of the Study	2
1.2	Aspects of Water Usage Considered in the Study	2
<u>CHAPTER 2</u>	<u>THE CONFLICT</u>	4
2.1	The Location	5
2.2	The Village of Bundarra	6
2.3	The Irrigators	7
2.4	Uralla Shire Council	10
2.5	The Choice	10
2.6	Liaison with the Parties Involved	13
<u>CHAPTER 3</u>	<u>WATER USE IN AUSTRALIA</u>	15
3.1	The Driest Continent	16
3.2	New South Wales - Water Resources	23
3.3	Water and the Future Develop- ment of Australia	26
3.4	Urban Water Usage	27
3.5	Irrigation Water Usage	29
3.6	Drought	31
3.7	Control of Water Usage	32
3.8	The Value of Water and the Price of Water	34
3.9	Land Use and Water in Australia	40
<u>CHAPTER 4</u>	<u>THE UPPER GWYDIR VALLEY</u>	43
4.1	Source of Information	44
4.2	Topography and Climate	44
4.3	Geology and Groundwater	47
4.4	Streamflows, Floods and Droughts	48
4.5	Land Use in the Upper Valley	51
<u>CHAPTER 5</u>	<u>THE SIMULATION MODEL</u>	54
5.1	The Use of Computer Simulation in Decision Making	55
5.2	The Structure of the Simulation Programme	55
5.3	Simulation of the Irrigation Demand - The Subroutine Irrigate	60
5.4	Simulation of the Urban Water Demand - The Subroutine TOWN	66

5.5	The Main Programme	68
5.6	Groundwater Flow	69
<u>CHAPTER 6</u>	<u>MODEL DATA AND VALIDATION OF THE PROGRAMME</u>	71
6.1	Model Data	72
6.2	River Inflow Data	72
6.3	Rainfall Data	74
6.4	Data Concerning the Physical Situation being Simulated	75
6.5	Data Concerning the Management Plans to be Tested	75
6.6	Validation of the Model	76
<u>CHAPTER 7</u>	<u>GENERAL DISCUSSION OF THE RESULTS OF THE PROGRAMME</u>	79
7.1	Trends in the Results of Various Management Control Options	80
7.2	Sensitivity of the Results to Area of Irrigation	95
7.3	Sensitivity of the Results to Variations in the Volume of Water Applied to a Specified Irrigation Crop	97
7.4	Summary of Trends in Results and Discussion of Management Plans Indicated to Justify Further Assessment	99
<u>CHAPTER 8</u>	<u>ECONOMIC ANALYSIS</u>	102
8.1	Project Economics - The Role of Price	103
8.2	The Principle of Equi-Marginal Value In Use	105
8.3	Price Theory and Resource Allocat- ion	106
8.4	The Value of Irrigation Water	109
8.5	The Value of Town Water	116
8.6	Deficiencies in the Economic Analysis	126
<u>CHAPTER 9</u>	<u>STRATEGIES PROPOSED FROM THE ECONOMIC ANALYSIS</u>	129
9.1	Conclusions from the Results of the Economic Analysis	130
9.2	Technical Considerations and Practical Limitations	131
9.3	Selection of a Proposed Management Plan	132
9.4	Summary of Conclusions of the Analysis	134
<u>CHAPTER 10</u>	<u>CONCLUSIONS AND RECOMMENDATIONS</u>	136
10.1	Summary	137
10.2	Conclusions and Recommendations	137

<u>REFERENCES</u>		145
<u>APPENDIX A</u>	DOMESTIC HOUSEHOLD DAILY WATER ALLOWANCES	149
<u>APPENDIX B</u>	THE EXTENT OF THE GWYDIR RIVER CATCHMENT UPSTREAM OF BUNDARRA	150
<u>APPENDIX C</u>	FLOW-DURATION CURVE FOR GWYDIR RIVER AT BUNDARRA	152
<u>APPENDIX D</u>	DURATION OF NO-FLOW VERSUS PERCENT OF TIME DURATIONS IN A YEAR ARE EQUAL TO THE GIVEN VALUE	153
<u>APPENDIX E</u>	FORTRAN PROGRAMME "GRISB.FOR"	154
<u>APPENDIX F</u>	DETAILED FLOW CHART AND SIMULATION PROGRAMME "GRISB.FOR".	167
<u>APPENDIX G</u>	RESULT SHEET OF THE ANALYSIS OF THE EFFECTS OF A PARTICULAR MANAGEMENT PLAN BY THE SIMULATION PROGRAMME "GRISB.FOR".	190
<u>APPENDIX H</u>	ADOPTED VALUES FOR PARAMETERS TO DESCRIBE THE IRRIGATION PROCESS AT BUNDARRA	197
<u>APPENDIX I</u>	ADOPTED VALUES FOR PARAMETERS TO DESCRIBE THE TOWN WATER DEMAND AT BUNDARRA	199
<u>APPENDIX J</u>	POND CAPACITY CURVES	200
<u>APPENDIX K</u>	DOCUMENTATION USED IN THE SURVEY OF WATER USERS AT BUNDARRA	203