NATIONAL WATER AND SOIL CONSERVATION ORGANISATION

A PRACTICAL GUIDE TO THE PREPARATION OF WATER ALLOCATION PLANS

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PREAMBLE

The purpose of this document is two-fold:-

1. As an aide-memoire in conducting water resources studies;
2. More importantly, as an aid in progressing from water resources studies to the preparation of water allocation plans. It does not aim to promote a series of stereotyped plans, rather it is a guide to the preparation of a plan for a particular catchment which must be treated on its own merits.

The rationale behind its production is as follows:

Demand for water is rising, especially with substantial increases in the use of water for irrigation planned, and the resulting increases in abstractions are being drawn - and will probably continue to be drawn - from the same sources. Hence, given the time-variant nature of water flows, there will be periods when the available water in a catchment will be inadequate to meet all demands in full. The only exception to this is the case of a small demand being met from a large and reliable resource, when the total peak demand is somewhat less than the lowest known water flow. (Throughout this document, the term "demands" includes the demands of recreation, fish and wildlife).

There are two basic approaches in dealing with this situation. The simplest is to do nothing except to take emergency action in the form of the imposition of restrictions, whenever necessary, under Section 24E of the Water and Soil Conservation

Act 1967. The possibility of taking this approach as a matter of policy should not be forgotten, in some cases it would be the most suitable approach. An example is where a serious shortage of water occurs infrequently and, when it does occur, is of short duration. Under more severe conditions, however, when the resource is already inadequate for protracted periods or at some time during most years, a more sophisticated approach would be preferable. In the latter case, a plan should be prepared in advance to enable a fair and rational division of the catchment water amongst the competing demands - in short, a water allocation plan. This is more fully defined and discussed in Chapter 4.

It should be noted that development and augmentation of the resource is complementary to, not an alternative course of action to, the production of a water allocation plan, for two reasons. Firstly, a water allocation plan can be prepared and put into action more quickly than a resource can be developed or augmented. In any case, the data and information needed to assess how far to develop the resource can be used in the formulation of the water allocation plan. Secondly, it is not an economic proposition to develop a resource sufficiently to meet the very severe drought of infrequent occurrence. Therefore, although development of the resource may reduce the frequency of occurrence of water shortages and their severity, it will not eliminate them: a water allocation plan will therefore still be necessary after development. In any event a water allocation plan will form the basis of an economic study of the desirability of resource development and augmentation.

The structure of this document follows the four steps necessary to produce a water allocation plan for a catchment, one chapter being devoted to each step. These steps are:

1. . Collection and presentation of water resources data.
   This may include both surface and underground water resources in the catchment.
2. Determination of existing use. The demands represented by recreation, fish and wildlife aspects should be included. Using the data gathered in step 1, the frequency of occasions when the resource cannot meet existing demands can be calculated and stated.
3. Assessment of future use. Again, using the data gathered in step 1, the frequency of failure of the resource to meet the estimated level of demand at any specified time in the future can be stated.
4. Formuation of a water allocation plan. Based on the results of the previous steps, a water allocation plan may be formulated. A worked example is given to indicate one possible way of preparing and presenting a water allocation plan.

In all these four steps, contact with groups and individuals with an interest on the allocation and use of water should be encouraged. Also it is desirable to obtain public discussion and comment on a preliminary allocation plan to enable all interests to make representations as is done with the water classification procedure. In this respect it would be desirable to have the results of step 1, and possibly step 2, in a published form to provide a basis for discussion in the planning stage. The objective is to arrive at an allocation plan which is publicly acceptable. From the plan intending users should be ablé to gauge the impact of the degree and frequency of restrictions on their proposed developments. The plan should clearly state what these restrictions will be for new users.

An appendix has been included to include future developments and flood studies in water allocation planning.

It should be constantly borne in mind that each resource will need to be dealt with on its merits. Thus, some resources will require very detailed and sophisticated water allocation plans; in other cases, a simpler approach will suffice. There is usually enough prior knowledge regarding the extent and reliability of the resource and the extent of the demands upon it to indicate how extensive and detailed the necessary investigations will need to be.

A list of references on water allocation planning is available from the Director of Water and Soil Conservation. These references are held in the Water and Soil Division and the Ministry of Works and Development Central Library and are available on request.

CHAPTER 1

COLLECTION AND PRESENTATION OF WATER RESOURCES DATA

This chapter comments on the collection of water resources data and outlines some ways in which the data might be presented in a water resources report. It does not purport to be more than a "memory-jog" for those responsible for water resources studies. Consultation with agencies other than the Ministry of Works and Development will be required (e.g. Meterological Office, Ministry of Agriculture and Fisheries, etc.)

1.1 Collection of data

The techniques of collection of water resources data have been expounded in numerous texts and further elaboration is not required here. The /object is to acquire sufficient accurate, consistent and unbiased (i.e., statistically acceptable) data to enable the total water resources to be determined and documented, and hence to enable the production of a water allocation plan. An important section of this part of the report should deal critically with the identification of gaps in the network of data-gathering stations. The establishment of any short-term stations needed to remedy such deficiences should be carefully considered at an early stage. Water resources reports may, nonetheless, have to be prepared without the data from such short-term stations. At this point correlation and statistical models could be employed to generate synthetic records where long-term data is not available. This may require the use of computer techniques.

1.2 Presentation of data

The following suggestions of ways of presenting data in a report do not claim to be an exhaustive list. For an initial study and report, only a few of them will be needed. Conversely for a complete and wide-ranging study, data not mentioned here may well be required.

1.2.1 General

Map showing catchment and sub-catchment boundaries.

Map showing topography.

Hypsometric curve(s).

Land use (present time) - map

- summary tables, by sub-catchments.

Land use capability - map.

Map showing existing water use - i.e., present-day abstractions and additions.

1.2.2 Rainfall

Map showing location of rain-gauges.

Map showing isohyets - annual rainfall, average year.

Map showing isohyets - annual rainfall, dry year of 1 in 10, chance of occurring in any one year.

Map showing isohyets - annual rainfall, dry year of 1 in 5, chance of occurring in any one year.

Map showing isohyets - irrigation season rainfall, average year.

Map showing isohyets - irrigation season rainfall, dry year of 1 in 10 chance of occurring in any one year.

Map showing isohyets - irrigation season rainfall, dry year of 1 in 5 chance of occurring in any one year.

Map showing isohyets, monthly means as % of annual means, for each month of the year.

Table of average rainfall over catchment for each month of record.

Table of lowest summer rainfalls (ranked in order).

Table of lowest winter rainfalls (ranked in order).

Graphs showing cumulative departure from irrigation season mean rainfall.

1.2.3 Evaporation

Tables of Potential Evaporation - winter (monthly figures).

Tables of Potential Evaporation - summer (monthly figures).

Open tank evaporation (month by month).

1.2.4 River flow data

Mean monthly flow - maximum.

Mean monthly flow - average.

Mean monthly flow - minimum.

Annual hydrographs for 3 driest years of record.

Unsmoothed flow duration curves - annual.

Unsmoothed flow duration curves - irrigation season.

Smoothed flow duration curves - annual.

Smoothed flow duration curves - irrigation season.

Frequency curves - lowest mean discharges for periods of 7, 15, 30 and 60 consecutive days.

Graph of durations of flows less than or equal to specified values, the recurrence intervals being stated.

Mean monthly flow, separated into surface runoff and groundwater flow.

Table of mean daily flow, for period of record.

Table of estimated groundwater component of flow.

1.2.5 Geology, hydrogeology and groundwater

Geological map.

Table of areas of outcrops of geological formations.

Maps showing aquifers and groundwater contours.

Table of aquifers and their properties.

Map showing location of wells, water supply boreholes, abstraction points on rivers and streams.

Groundwater hydrographs - selected years at selected wells.

Groundwater hydrographs - mean for year.

Table - estimated potential replenishment of each aquifer - average.

Table - estimated potential replenishment of each aquifer - year by year.

Map - areas of possible groundwater development.

1.2.6 Effluent discharges

Map showing location of any significantly large discharges, including any disposed of on to the land.

Table of quality criteria at maximum, mean and minimum flows: BOD, suspended solids, pH, and other relevant parameters.

Table: summary of conditions of water rights.

Flow rates of effluents: tables, hydrographs.

1.2.7 Existing water quality

This is required at critical points, such as at existing and possible future intake sites and just downstream of effluent discharges, but existing data should also be included.

(i) Surface waters:

Tables of B.O.D. and suspended solids at average and low flows.

Tables of dissolved oxygen at average and low flows.

Coliform counts.

Map showing water classification (final or provisional), if available.

Temperature - mean daily, maximum and minimum daily.

pH at low and average flows.

Concentrations of particular ions - e.g., Na, Fe, Cl, NO_3

A survey of bed fauna may give a good indication of the general overall health of the river.

(ii) Groundwaters:

As above, plus: chloride and any other ions of interest or importance - alkalinity, nitrate nitrogen, ammoniacal nitrogen, albuminoid nitrogen, oxygen absorbed, hardness, iron and manganese.

1.2.8 Net resources

Rainfall, runoff and losses - year by year.

Rainfall, runoff and losses - extreme values and averages.

Soil water deficiences - month by month for average year, dry year (10% probability of return) and dry year (20% probability of return).

CHAPTER 2

DETERMINATION OF EXISTING USE

Each catchment will have distinctive modes of use. Examples of some of the usually important modes are given.

2.1 Non-consumptive use

Industrial: table of users and quantities involved	Extracted from both surface water and ground water
Cooling water table of users and quantities involved	

Recreation: fishing, boating, etc.

Hydro-electric power generation:

Hydrographs, derived from records of power generated, of:

Daily use, i.e., throughout the day on an hourly basis	Maximum; typical day, no. of days to be stated.
Use throughout the year, on a daily basis	
Use throughout the irrigation season on a daily basis	

2.2 Consumptive use

Tables of:

Stock water	Monthly means, Maxima, Minima.
Industrial water not returned to surface water	
Public water supply	

Graphs of present-day irrigation demand: average year

: dry year, 10% probability of return

: dry year, 20% probability of return.

CHAPTER 3

ASSESSMENT OF FUTURE USE

The choice of how far into the future to take the study is to some extent arbitrary. However, for the purpose of a water allocation plan, the time-period should be no further ahead than can reasonably be foreseen - probably not more than 10 years.

A longer time-period should be used for the purpose of getting some idea of the ultimate future demand, and hence of the extent to which the resource will need to be developed or augmented. At some stage in the study, economics will be involved, and the approximate average life of certain hydraulic structures is given by Linsley and Franzini, "Water Resources Engineering", Second Edition, Wiley (1972) as:

Canals and ditches		75 years
Public water supply	- intakes	say 75 years
	- treatment works,	say 40 years
	- pipelines 50-100 years, depending on size.	
Power generation	- penstocks	50 years
	- buildings	say 75 years
	- turbines	35 years

The economic life, for the purposes of economic studies, is somewhat less than that above, so a reasonable length of time to look ahead, and which is also commonly taken to be the economic life of many engineering works would be 40 years.

The exact magnitude of the future demands will depend to some extent on the availability of water; the availability will be affected by the demands made on it. A trial calculation must, therefore, be made to start with, using some reasonable initial assumption - for example, that water is freely available without restrictions. If a shortfall is predicted as a result of sufficient seriousness to affect the growth of demand, another calculation can then be made taking this into account. A reasonably accurate forecast of the growth of demand should be the end result.

3.1 Public Water Study

Estimates of future demand for domestic purposes can be obtained from the water supply authorities.

Expected population increase can be obtained from Town and Country Planning population estimates.

3.2 Industrial Demand

3.2.1 General

Consultations with local and national Town and Country Planning authorities will identify probable and possible areas of industrial growth. The estimation of future industrial demand will necessarily be approximate; nonetheless, an estimate will have to be made.

3.2.2 Presentation of data

Table showing: type of industry, usage of water, estimated expansion, estimated future demand.

Graph showing growth of demand vs time.

Table of river flows necessary for the dilution of wastes.

Graph showing growth of demand versus time. Again, as in chapter 2, it will be necessary to distinguish between consumptive and non-consumptive uses.

The needs of mining industries and problems caused by their activities (turbidity, for example) may need special consideration, especially if considerable future expansion seems possible.

3.3 Hydro-electric generation requirements

The Electricity Department can give a forecast of future demand from this source of generating capacity. In general, water used for hydro generation can be re-used. The effect of withdrawals from storage for electricity generation on the availability of water to other users later in the dry season should be carefully considered.

Data: future growth in demand (graph) - kWh
future growth in demand (graph) - volume of water/year.
(each present and projected station)
future growth in demand (graph) - volume of water/irrigation season (ditto)

The implications of possible future operating systems (such as development of pumped storage schemes) need to be considered as far as information and estimation permit.

3.4 Forestry and agriculture

3.4.1 Forestry

Although irrigated forests are unlikely in New Zealand in the foreseeable future, the possible effect of afforestation or deforestation on the quantity and quality of the water resources of the catchment may be important.

Areas of possible afforestation and likely afforestation to be shown on land use maps.

3.4.2 Agriculture

This term includes rural water-supply and irrigation water. A procedure for estimating future agricultural growth is:

(i) Determine area of farmland as at present day.

(ii) Determine area of farmland in the future - if it seems likely to be very different from (i).

(iii) Assess the area under crops, the area of pasture, and the animal population - as at present day.

(iv) Assess the area under crops, the area of pasture and the animal population - future.

Present day requirements have been discussed in Section 2.2. Future water requirements can now be assessed, taking into account climatic factors already dealt with in Section 1.

(v) Stock water requirements.

(vi) Domestic requirements.

(vii) Irrigation, water requirements for pastures
- average year
- dry year, 10% probability of return
- dry year, 20% probability of return

(viii) Irrigation water requirements for crops
- average year
- dry year, 10% return probability of return
- dry year, 20% return probability of return

(ix) Irrigation as in (vii) but assuming only high-value crops are irrigated. Steps (vi) - (viii) should initially be calculated assuming that the requisite water will be available.

The effect of peak demand of rostered irrigation as opposed to "on demand" irrigation should be examined; results could be presented as in (v) - (viii).

In such a procedure it will be necessary to consult with the Ministry of Agriculture and Fisheries and general farming interests.

3.5 Recreation and ecology

A river or lake that supports a large, healthy and diverse fish population is usually very satisfactory for all other purposes (water supply and bathing, for example) including preservation of scenic beauty. Sufficient flow should therefore be maintained in the river to prevent it becoming a series of stagnant pools, and to prevent irreparable damage to its ecology. This does not preclude the possibility of reducing the river flow to zero on occasions, under extreme conditions. Variable lake levels pose problems of their own which must be examined on an individual basis.

There is some guidance in the literature on minimum desirable flows, but each case must be considered in the light of local conditions.

Substantial public interest will exist in this area and there is a need to consult with all bodies and organisations who have an expressed interest in recreation and ecological aspects.

CHAPTER 4

FORMULATION OF A WATER ALLOCATION PLAN

4.1 Definition and purpose

A water allocation plan for any given resource is a published and publicly acceptable document that:

1 specifies clearly how the water available in the resource shall be allocated amongst the competing demands (including recreation, fish and wildlife) whenever the resource cannot meet the demands in full. The purpose of this is to allocate the available water in a rational and fair manner amongst those who wish to take and use water, taking into account the requirements and interests of both present and future users, including recreation, fish and wildlife.

2 indicates clearly the estimated frequency and severity of restrictions to be imposed pursuant to paragraph (1) upon different users in times of water shortage. Such restrictions would commonly be in the form of a roster which may reduce the allowed inflow rate or the time of abstraction or both. This is for the information of existing right-holders and prospective applicants for water rights

3 serves as a guide to the Regional Water Board when issuing new water rights and when varying existing water rights so that at no time does the amount of water allocated exceed the amount available. It enables the Board to write into these rights and variations such conditions as are necessary to enable the Board to implement the water allocation plan pursuant to paragraph (1).

4 serves as a guide to intending users of the resource who will wish to assess the economic impact on their proposals of the degree and frequency of restrictions they would have to face.

5 bears an expiry date. This is necessary because

(a) development and/or augmentation of the resource will change the availability of water on which the allocations considered in paragraph (1) were based; and

(b) the plan will need to be up-dated from time to time.

4.2 The necessity for producing water allocation plans

The urgency of a water allocation plan will vary from one catchment to another depending on the adequacy and reliability of the water resources to meet the existing and expected future demands. Thus, a catchment with immediate and pressing problems of water shortage will require a water allocation plan quickly, using whatever data is available. It is not necessary to delay the inception of a water allocation plan on the grounds of lack of enough data to produce very accurate results: any plan produced can be given a suitably short life-span and replaced on expiry by a more confident, up-dated one. On the other hand, if the water resources of the catchment are ample and will continue to be adequate for a few years, the preparation of a water allocation plan may be delayed until the results of the studies outlined in Chapters 1-3 start coming in.

Even when a resource has been developed, a water allocation plan will still be necessary: it is not economic to develop a resource far enough to meet the very severe drought of infrequent occurrence.

4.3 Principles and requirements

4.3.1 The relation between water use restrictions and flow duration:

This section is concerned with security of supply and frequency of restrictions. When the resource is adequate to meet all demands, including recreation and wildlife, there are no problems: all users may take up to the maximum their water rights allow. As the resource diminishes (for example, the flow in the river decreases) there comes a point where further reduction in the resource will have adverse effects on some users, and some form of rationing or allocation is necessary.

This point is not an unknown quantity: by adding up all present-day demands, including a residual flow in the river for recreation, fisheries and wildlife, the stage where demand begins to exceed the capacity of the resource is known. Further, in the case where the resource is a river, the total demand as calculated will correspond to a certain percentage flow duration (where the X % flow duration is a flow rate, and is defined as being the rate of flow which is exceeded or equalled for X % of the time). Therefore, the resource will not be able to satisfy the demands for the remainder of the time (i.e., for (100 - X) % of the time). As total demand increases it will be seen from the flow-duration curve that the X% of the time that the demand can be satisfied will decrease. Hence, it is possible to estimate in advance the effects that increased demand could have on the frequency and severity of restrictions on abstractions of water.

Thus, if, for example, it is proposed as part of the water allocation plan to suspend the rights of new irrigators whenever the river flow falls below a certain value, then the higher that value is, the more frequently those irrigators will have their rights suspended and the longer the restrictions will last. However, as an objective of the water allocation plan, prospective irrigators would be told in advance how often, on average, they could expect restrictions and how long they could be expected to last. They could thus decide whether it would be worthwhile setting up for irrigation.

The same argument would hold true for all other prospective abstractors.

4.3.2 Considerations of priorities

One method of allocating the available water is by the prior appropriation doctrine ("first in time is first in right") as practised in many states of the U.S.A. Under this system, as the resource decreases and becomes a progressively smaller proportion of the total demand, right-holders are compelled to suspend abstractions one by one, in the reverse order to the order in time in which the rights were originally granted. So, holders of more recently-granted rights may have to go without water completely to enable holders of longer-established rights to continue to take the maximum that their rights allow.

This system would probably not be acceptable to the majority of New Zealanders. However, it must be recognised that existing users (often with substantial investment dependent on the availability of water) should be given sufficient security of supply for them to be able to accept the allocation plan that is proposed. The mode of restriction between existing and new users must be clearly described in the water allocation plan together with estimates of the severity of proposed restrictions so that existing and prospective users can gauge the impact of the plan on their interests.