

No. 6 Daily extraction management in unregulated rivers (2002 version)

Development of this policy

This policy advice was initially released in late 2001, and guided water sharing committees in the development of the initial round of Water Sharing Plans in 2001/02. However, the design and analysis of daily extraction limits for these plans raised a number of issues regarding the appropriateness and practicality of adopting full daily extraction management in some rivers. In particular:

- the high cost of monitoring and administration means that moving to full daily flow shares cannot be justified in some rivers with relatively few users and low water use demand,
- the high variability in flows across some water sources means that the water source must be subdivided to ensure that daily extraction limits reasonably reflect local water availability,
- inadequate flow data, particularly when the water source is subdivided, means that the daily extraction limits cannot be reliably determined.

This indicated that in some water sources or parts of the water sources, it might be more appropriate to introduce an interim management option over the term of the first Water Sharing Plan. This option, while seeking to protect at least the very low flows and move toward daily extraction management, will recognise the limitations and risks identified above.

The policy advice was revised in mid-2002 to reflect a more flexible approach to the introduction of daily extraction management. It also clarifies some of the ambiguities in the earlier version.

Why daily extraction management is needed

During 2000, most irrigation licences on unregulated rivers were converted from an area basis to a yearly volume known as a share entitlement. All other river licences are also being converted to a yearly volume entitlement. This began the process of more clearly defining users' rights to access water.

The volumetric conversion provides water users with greater business flexibility and establishes a better basis for managing river flows. However, the share entitlement does not, on its own, fully define users' access to water. Nor is there in place sufficient protection of the river flow needed to maintain the environmental health of our rivers.

Under the *Water Management Act 2000*, water must be specifically allocated for environmental needs. So while the establishment of share entitlements is a critical first step, it will be necessary in many unregulated rivers to progressively move to provide greater protection for river health. This will involve establishing river flow levels below which licensed water users must cease to pump, and defining access to water according to the share of the actual flow which is available.

In Australia our rivers are naturally variable, changing frequently from flood to drought conditions and our native flora and fauna are uniquely adapted to these conditions.

However, in most unregulated rivers, it is during drier periods when flows are naturally low to moderate, that there is generally greatest concern for the health of the river. This is when pools contract, water quality deteriorates rapidly, algae

blooms, oxygen levels decline and fauna compete for the reducing food supplies. This is also when demand for water for human uses is often at its highest.

If river extraction is allowed to proceed unrestricted, upstream pumpers could potentially remove all the water. This would not only leave insufficient water to provide drought refuge or relief for native aquatic plants and animals but also affect the water users downstream. In some systems, particularly where there is a large amount of storage relative to flow, water extraction can also threaten high flows and freshes that are important for river and estuary ecosystems.

We need a way of establishing the amounts of flow that should stay in the river and the volumes that can be extracted, through all of these flow levels.

River flow objectives

The Government has agreed to broad river flow objectives (see below) aimed at safeguarding river

flows for environmental health. Not all of these flow objectives are relevant to all rivers - many of these relate to rivers that are controlled by major dams.

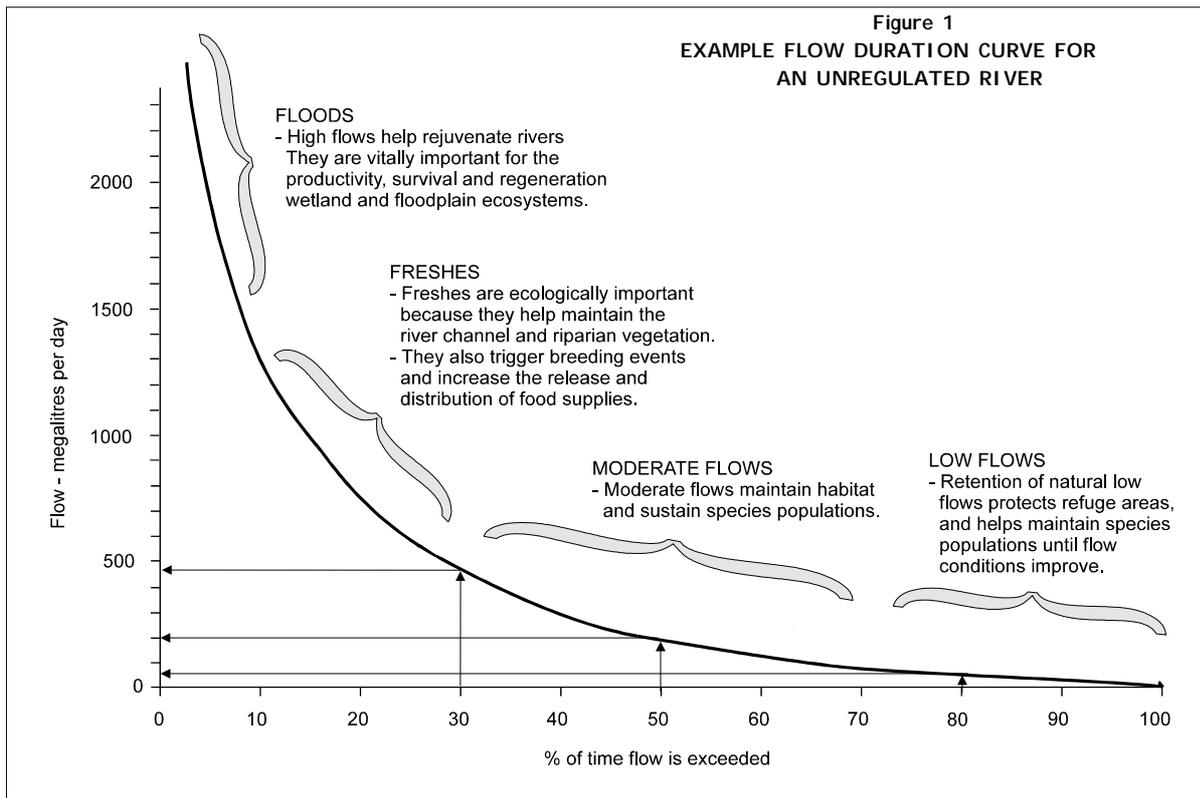
The river flow objectives are based on the principle of mimicking the key characteristics of the natural flow regime.

River flow regimes can be characterised by the size and duration of various flow levels. How often a flow of a particular size is likely to occur is best illustrated by a flow duration curve. A flow duration curve plots the volumes of flow (megalitres per day) against the percentage of days that such a flow will be equalled or exceeded.

Figure 1 shows a typical flow duration curve.

If our rivers are to be sustainable to meet current and future water needs, we must retain certain proportions of river flow to maintain the biodiversity and health of our rivers.

River Flow Objectives	
Objective 1	protect natural water levels in pools of creeks and rivers and wetlands during periods of no flow
Objective 2	protect natural low flows
Objective 3	protect or restore a proportion of moderate flows, "freshes" and high flows
Objective 4	maintain or restore the natural inundation patterns and distribution of floodwaters supporting natural wetland and floodplain ecosystems
Objective 5	mimic the natural frequency, duration and seasonal nature of drying periods in naturally temporary waterways
Objective 6	maintain or mimic natural flow variability in all rivers
Objective 7	maintain rates of rise and fall of river heights within natural bounds
Objective 8	maintain groundwaters within natural levels, and variability, critical to surface flows or ecosystems
Objective 9	minimise the impact of in-stream structures
Objective 10	minimise downstream water quality impacts of storage releases
Objective 11	ensure river flow management provides for contingencies
Objective 12	maintain or rehabilitate estuarine processes and habitats



What are daily extraction limits?

Establishing cease to pump (CTP) flow levels on the unregulated rivers will protect the very low flows. Establishing daily extraction limits are a means for both protecting river health and for sharing available flows above the CTP between competing water users. These extraction volumes will ultimately enable a portion of the natural river flows to be protected for environmental needs.

The daily extraction limits will enable licence holders' extractive rights to be specified and protected to a greater degree than currently exists - that is, when and what amount can be extracted from a river will be clearly specified.

These extraction volumes may be converted into licence conditions advising individual water users of the minimum river flow level at which they can pump, and the maximum rates at which they can extract water (in litres per second or megalitres per day) depending on flow. This is referred to as the daily extraction entitlement. Water users can convert these rates into the equivalent number of pumping hours a day relevant to their pumps and irrigation set ups. This will allow them to better plan their extraction patterns and/or watering

schedules to fit in with the likely volumes of water available to them at critical times.

Daily extraction limits will not overcome local water supply constraints (eg small creeks which frequently cease to flow) or the competition for water that occurs when available flows are less than the daily extraction limit.

However, they will ensure that when there is a moderate flow through the catchment, then all licence-holders have the right to a fair share of it.

Equitable sharing of available flows that are less than the daily extraction limit should aim to be achieved by way of rostering.

The Department may choose to announce a percentage of daily extraction entitlement access during these competition periods if rostering fails to equitably share these flows.

Where will daily extraction management be applied?

Ultimately all unregulated rivers should move to a daily extraction management to ensure that:

- environmental flows are protected across the whole flow regime

- property rights to water are established which makes transparent and protects the share of the flow available to individual licence holders
- licence holders are better able to assess their supply reliability in terms of frequency of access and thus make informed investment and trading decisions
- water transfer rules are consistent and objective
- a market in individual daily extraction entitlements can operate so that individuals can adjust their supply reliability to suit their enterprises and infrastructure
- rostering can occur between any number of individuals based on the sum of their pooled daily extraction entitlements.

However, establishing and implementing daily extraction management will require additional infrastructure and management effort including:

- actual or simulated streamflow data,
- operational gauges providing daily flow information,
- announcements to all users of daily flow class,
- daily pumping/metering information,
- improved data storage and management,
- audit and compliance.

This will impose significant additional costs for water resource management and administration that may not be justifiable in some systems during the term of the current Water Sharing Plan.

It is likely that at least some of these costs will be passed on to water users so implementation needs to be set at realistic levels for each system.

Therefore in the shorter term, daily extraction management should only be established and reflected in Water Sharing Plans for those rivers which have some or all of the following characteristics:

- stressed (high level of current extractive demand relative to low to median flows)
- extractive demand is likely to threaten identified conservation values, in particular threatened species
- likely to have high levels of competition for access to water in the short to medium term
- likely to have high demand for water transfers

- likely to have high potential for development of inactive entitlement
- having reasonable historic flow record
- having a suitable operational gauging station(s).

Even where daily extraction management is established, it may take several years to fully implement the necessary management and compliance arrangements such as:

- installation or upgrade of gauging station(s)
- installation of meters and/or pump diaries
- establishment of a data storage and management system
- automated flow class announcements.

For other rivers, an interim management strategy may be adopted. The choice of management strategy will depend on what flow information is available, the degree of environmental water and property rights required, and the potential cost of management relative to the water use demand.

All options should aim to improve the current flow regime resulting from the visible flow pumping conditions that exist on the majority of unregulated licenses.

Selecting the appropriate management strategy

Where it is determined that daily extraction management is not appropriate for a water source (i.e. does not meet the characteristics listed above), one of the following alternate types of management may be considered:

Cease and/or commence to pump thresholds only.

In this case there is no daily limit on extraction once the commence to pump threshold has been exceeded. It has the benefit of requiring a lower level of management in that:

- i) it can be implemented in a shorter time frame
- ii) it can be managed using a low flow staff gauge only
- iii) cease to pump (CTP) levels can be established with or without a historic flow record. However, no flow record will also mean that the impact of the CTP on water users' will be difficult to assess.

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- iv) compliance considerations are limited to determining whether or not there are any pumps operating illegally during cease to pump periods.

Its disadvantages, however, are that:

- i) it can only protect very low flows and potentially does not protect flow variability.
- ii) it establishes a property right to a lesser degree than the daily extraction management option.
- iii) the reliability of the water resource is more unclear when it comes to making decisions in relation to investment and trade.
- iv) there is no quantitative limit, which when reached, would trigger refusal of any further transfers into a water management zone
- v) depending upon the level that it is set at, it may only achieve a small improvement in the protection of environmental flows and the implementation of the river flow objectives.

Cease and/or commence to pump thresholds, plus daily extraction limits.

In this case daily extraction limits are established for flows above the CTP, but are not distributed to individual licence holders as a daily extraction entitlement.

The daily extraction limit can be specified in the Water Sharing Plan and used as solely a basis for management of trade with no on ground implementation. Alternatively all extractions can be monitored by the Department and collectively managed by the users to ensure that usage stays within the amount specified by the daily extraction limits.

The approach has the advantages that:

- i) it does formalise environmental rights to water throughout the flow range.
- ii) it ensures that any water transfers are consistent with the daily extraction limits.
- iii) if daily extraction limits are implemented the audit requirements are that all water extractions stay within the daily extraction limit.

For many rivers, the low level of active use should keep current extraction within the daily limits. On others, water users may need to roster and be audited in critical periods if there is any risk they may jointly exceed the daily limit. Failure to comply would require resolution at the local level.

If this can't be achieved the introduction of individual daily extraction entitlements may be necessary.

Its disadvantages are:

- i) it does require a reliable and representative historic flow record to enable the daily extraction limits to be determined and their impacts assessed
- ii) where the extractions are managed to the daily extraction limit a fully operational gauging station(s) is required to inform the water users of the access class
- iii) in addition, it will require compliance audits on the daily extraction but these can be done at the group level (sum of metered extractions during any audit period) to ensure that environmental flows are protected.

The methodology for establishing CTP levels and daily extraction limits is outlined in detail in the Attachment.

Management Options

Six management options based on the strategies of the previous sections can be established. These are:

- 1a Common cease and commence to pump thresholds only based on field verification.
- 1b Common cease and commence to pump thresholds only, based on analysis of historic flow data, and field verification.
- 2a CTP thresholds set based on streamflow record and field verification. Daily extraction limits set but not distributed to individuals as a daily extraction entitlement with compliance on CTP only.
- 2b CTP thresholds set based on streamflow record and field verification. Daily extraction limits set but not distributed to individuals as a daily extraction entitlement with compliance on CTP and daily extraction limits.
- 3a CTP thresholds set based on streamflow record and field verification. Daily extraction limits set and distributed to individuals as daily extraction entitlements for some or all flow classes. Compliance on CTP, and daily extraction limits. (partial implementation of daily extraction management)
- 3b CTP thresholds set based on streamflow record and field verification. Daily extraction limits set and distributed to individuals as daily extraction entitlements. Compliance at individual levels according

- A decision to move from option 1a to 1b may be based on obtaining streamflow information which indicates that the frequency of exceedence of the CTP is unacceptable in terms of either impact on the environment or extractive use.
- A decision to move from 1b to 2a may be prompted by large amounts of trade moving into the catchment or large amounts of unused share entitlement activating. This would create the need formally establish the environmental rights to water in terms of daily extraction limits.
- Movement from option 2a to 2b could be as a result of daily extractions exceeding the daily extraction limits set in 2a.
- Movement from 2b to 3a could be prompted by users desiring to know what their individual daily extraction entitlement will be in order to prepare their businesses to operate under a full daily extraction regime. Alternatively it could be prompted by the need to establish a daily extraction trading market.

Note: Option 2b and 3a are similar the only difference being that in option 3a users are notified of their individual daily extraction entitlement for some or all classes. Management of daily flow access remains identical to that of option 2b.

- Movement from either option 3a to 3b or for that matter option 2b to 3b would be prompted by usage failing to remain within the daily extraction limit. This would result the issuing of individual daily extraction entitlements for all classes and compliance to either individual entitlement or group registers.

Establishing management zones

Most unregulated river catchments have been divided into subcatchments based on consideration of hydrology, location of gauging stations, and water user associations. These subcatchments formed the basis for the 1998 Stressed Rivers Assessment and have more recently defined the water source areas of Water Sharing Plans. However in some cases these subcatchments are large and the flow characteristics across the subcatchment are not sufficiently uniform to form a sensible basis for defining a common CTP or daily extraction limits.

In such cases the water source or subcatchment should be further subdivided into management zones and an appropriate management option and "end of system" streamflow reference site selected for each zone.

The delineation of management zones should be guided by the following criteria:

- flow travel times from the top reaches of the subcatchment to the end-of-zone reference point should preferably not exceed 1 day
- streamflow should be relatively homogenous across the management zone – ie when a low flow occurs at the end of system, low flows should also be occurring upstream. Preferably flow should be homogeneous on at least 90% of days when flows are in the low to median flow range
- existing and/or potential stream gauging sites should be available at or close to the end of the designated management zone to ensure end of system targets are met
- Upstream gauges with appropriate downstream extraction rules to ensure end of system flow targets can also be used in the absence of a suitable gauge near the end of the management zone
- the larger the number or volume of licensed entitlements within a zone the more homogeneous the zone should be.

Table 1 Flow Management Options for Unregulated Rivers

No	Management Option	Prerequisites for development and implementation of Water Sharing Plan	Implications
1a	Common cease and commence to pump thresholds only - based on field verification	<ul style="list-style-type: none"> • No reliable streamflow estimates (NB only qualitative assessment of impacts on flow/licence holders can be made) Implementation: <ul style="list-style-type: none"> • Staff gauge read daily • Daily announcements of access • Exception compliance against CTP 	<ul style="list-style-type: none"> • May not protect basic domestic, stock, and native title rights • Protects very low flows • Theoretically does not protect low to moderate flows • Theoretically does not protect flow variability above the CTP • No consistent basis for water transfers • Investment and trading decisions based on limited information • Establishes very basic property rights, but not separate, tradeable entities
1b	Common cease and commence to pump thresholds only - based on analysis of historic flow data and field verification	<ul style="list-style-type: none"> • Reliable streamflow estimates Implementation: <ul style="list-style-type: none"> • Staff gauge read daily • Daily announcements of access • Exception compliance against CTP 	<ul style="list-style-type: none"> • Can be set at a volume adequate to protect basic domestic, stock, and native title rights • Protects very low flows • Theoretically does not protect low to moderate flows • Theoretically does not protect flow variability above the CTP • No consistent basis for water transfers • Investment and trading decisions based on limited information • Establishes very basic property rights, but not separate, tradeable entities
2a	Daily extraction limits set but not distributed to individuals as a daily extraction entitlement. Compliance on CTP only	<ul style="list-style-type: none"> • Reliable streamflow estimates • Estimated peak daily demand Implementation: <ul style="list-style-type: none"> • Staff gauge read daily • Daily announcements of access • Exception compliance against CTP 	<ul style="list-style-type: none"> • Can be set at a volume adequate to protect basic domestic, stock, and native title rights • Does not protect flow regime above CTP in practice • Provides a consistent basis for water transfers which protects the environmental water • Formally establishes the environmental rights to water • Establishes very basic property rights, but not separate, tradeable entities
2b	Daily extraction limits set but not distributed to individuals as daily extraction entitlement. Compliance on CTP plus daily extraction limits	<ul style="list-style-type: none"> • Reliable streamflow estimates • Gauging station and/or suitable site • Estimated peak daily demand Implementation: <ul style="list-style-type: none"> • Operational gauging station read daily • Daily announcements of access • Exception compliance against CTP and group compliance with the daily extraction volume 	<ul style="list-style-type: none"> • Can be set at volume adequate to protect basic domestic, stock, and native title rights • Can protect the flow regime in practice • Provides a consistent basis for water transfers which protects the environmental water • Formally establishes the environmental rights to water • Establishes very basic property rights, but not separate, tradeable entities • Relies on rostering during critical periods to keep use within daily limits
3a	Partial implementation of daily extraction management. Daily extraction limits set and distributed to individuals as daily extraction entitlement for some or all flow classes. Compliance on CTP and daily extraction limits	<ul style="list-style-type: none"> • Reliable streamflow estimates • Gauging station and/or suitable site • Estimated peak daily demand Implementation: <ul style="list-style-type: none"> • Daily announcements of access • Daily audit of metering data and group compliance with the daily extraction limit • Exception reporting against CTP 	<ul style="list-style-type: none"> • Can be set at volume adequate to protect basic domestic, stock, and native title rights • Can protect the flow regime in practice • Provides a consistent basis for water transfers which protects the environmental water • Formally establishes the environmental rights to water • Better establishes a more exclusive property right, which is a separate, tradeable entity • Assumes rostering during critical periods to keep use within daily extraction limits
3b	Full implementation of daily extraction management. Daily extraction limits set and distributed to individuals as daily extraction entitlements for all flow classes. Compliance at individual levels	<ul style="list-style-type: none"> • Reliable streamflow estimates • Gauging station and/or suitable site • Estimated peak daily demand Implementation: <ul style="list-style-type: none"> • Operational gauging station read daily • Daily announcements of access class • Individual audits of metering data and compliance with the daily extraction limit in accordance with the group register • Exception reporting against CTP 	<ul style="list-style-type: none"> • Can be set at volume adequate to protect basic domestic, stock, and native title rights • Can protect the flow regime in practice • Provides a consistent basis for water transfers which protects the environmental water • Formally establishes the environmental rights to water • Establishes a more exclusive property right, which is a separate, tradeable entity • Allows for group registration & rostering

The cease to pump and daily extraction limits should be calculated for each zone independently based on the selected "end of zone" reference site. The cumulative impact of the individual zone extraction limits on the end of water source flows should also be assessed.

Establishing the CTP and daily extraction limits based on management zones will ensure that the triggers for access better coincide with the actual flows passing the pumps, and therefore that the impact assessed in their design also fairly reflects the future probability of access and environmental flow outcomes. However, this also significantly increases establishment, implementation and management costs.

The requirements for each management option are shown in Figure 3.

Government Role

The DLWC and other agencies will provide the committee with:

- relevant flow data including examples of wet, average and dry years and long term statistics;
- environmental considerations, including threatened species considerations;

- assessment of the water requirements for basic domestic and stock rights;
- information on the number of licensed water users, current pumping conditions, the current level of development and the water users total annual share entitlement;
- assessment of the appropriate flow management options and management zones, including proposals for cease to pumps, flow classes, and daily extraction limits where appropriate;
- assessments of the impacts of these options on licensed water users.

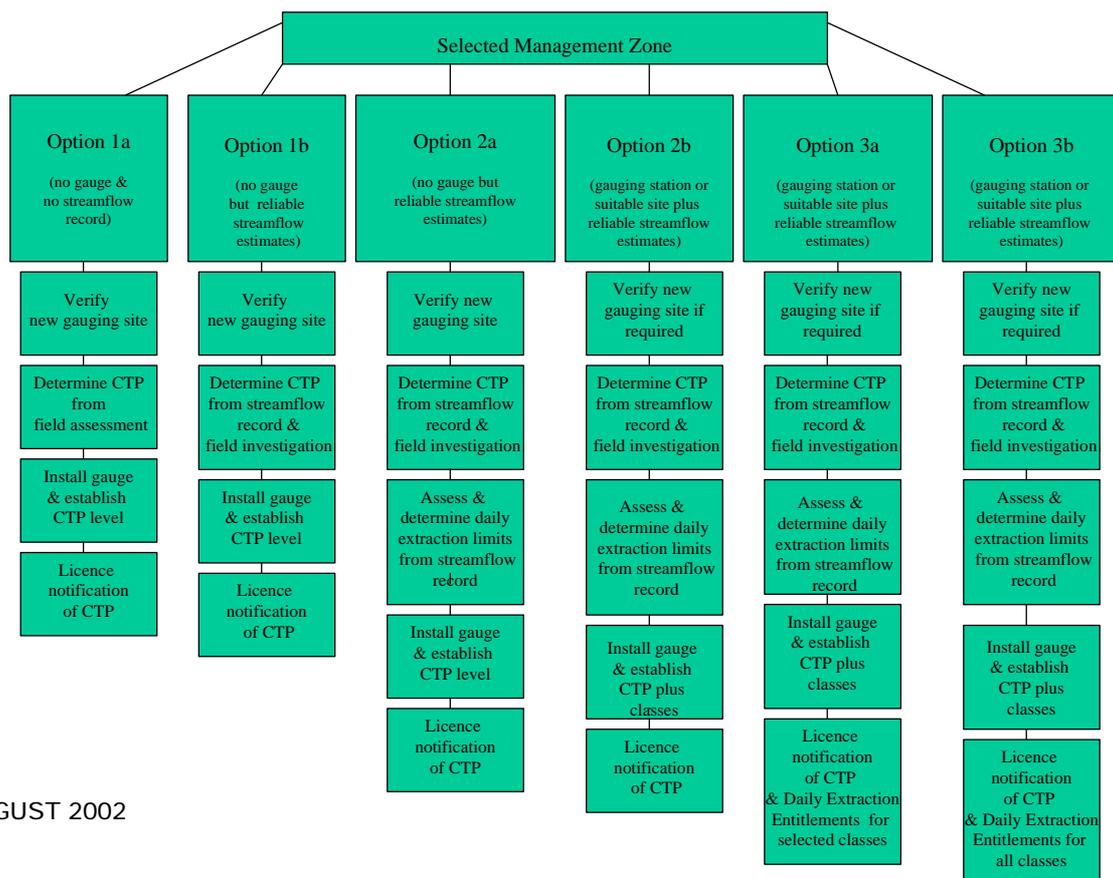
The government agencies will also prepare draft plan provisions that reflect general requirements and the Committee's strategies and recommendations.

On approval of the Water Sharing Plan, the DLWC will prepare an implementation program. This will be done in close consultation with the local water user community.

It is expected that the appropriate operational arrangements will be phased in over a number of years.

The timetable for this, will be developed as part of the Implementation Program.

Figure 3: Steps Required To Implement Chosen Management Option



Committee Role

The Committee is to consider the agreed river flow objectives for their water sources and provide a more detailed interpretation for their priority sub-catchment(s). These are to form the basis for determining the appropriate management options and associated management criteria.

The Committee is to then recommend, depending on the management options selected and in consideration of the social and economic costs, one or more of the following:

- very low flows to be protected (all management options)
- flow classes and daily extraction limits in each defined class (management options 2a,2b & 3a,3b)
- what part of those daily extraction limits are to be issued to licences as daily extraction entitlements initially (management options 3a,3b)
- the remaining unallocated daily extraction limit part which may be allocated during the term of the plan (management options 2a,2b & 3a,3b).

ATTACHMENT - ESTABLISHING CEASE TO PUMP FLOW LEVELS AND DAILY EXTRACTION LIMITS

Determining the Cease to Pump

The cease to pump (CTP) establishes the threshold at which licensed pumping must stop. It therefore protects the very low flows, and the supply to basic right pumpers during dry periods. The CTP threshold should address river flow objectives 1 & 2, and include an explicit allowance for basic domestic and stock rights.

The starting point for establishing the CTP is the 95th percentile of the annual daily flow duration curve (ie 95% of days of the year will have flow greater than this threshold) or the flow threshold that protects the lowest 5% of days with flow in intermittent rivers. Until field verification takes place, this should be used as a guide. In all cases, the CTP threshold will also be determined from field assessment of pool habitats, low flow connectivity, etc.

For some rivers, the whole of the year 95th percentile may be a relatively high volume and setting the CTP at this level could have significant consequences on irrigation or other commercial purposes. For example, the whole of the year 95th percentile could be higher than the 80th percentile critical month flow and would therefore eliminate any A class flow access.

In any event, an assessment of pool habitats and low flow connectivity must be conducted to verify that the proposed flow limit is actually achieving the required environmental objectives. This assessment could be based on expert and local opinion and include field validation.

In some cases different cease to pump and commence to pump thresholds may be established. Setting the commence to pump threshold higher recognises that the initial flow after a dry period is more important to the replenishment and recovery of the in-river environment than the maintenance of flows after a period of higher flows. Different cease to pump and commence to pump thresholds can also help to prevent "flow hunting" ie turning access off and on too frequently if the flows hover around the threshold for any extended period. Varying cease to pump and commence to pump levels during different seasons of the year has also been used as a management

option in some unregulated subcatchments. For example, where higher flow protection is required for threatened species at certain times of the year (e.g. breeding/migration), while allowing lower very low flow protection during other times of the year (e.g. peak irrigation demand period).

In determining a CTP it is critical that the streamflow reference site used for the assessment is the same as that which will be used as the operational gauging site. Otherwise the impact on "end of system" environmental flows and on water users access will be different from that assessed for the Water Sharing Plan.

Establishing daily flow extraction classes

River flow regimes can be characterised by the size and duration of various flow levels. How often a flow of a particular size is likely to occur is best illustrated by a flow duration curve. A flow duration curve plots the volumes of flow (megalitres per day) against the percentage of days that such a flow will be equalled or exceeded. It should be noted that the flow duration curves based on historic flow data do not represent natural conditions because the data on which they are based is, to varying extents, affected by changes in land cover and water extraction in recent years. Provided they are developed over a climatically variable period, they should provide an approximation of the flow probabilities that are an adequate basis for flow sharing (noting that the longer the streamflow record the closer it is to natural).

Figure A1 (see next page) is a sample flow duration curve for a typical perennial unregulated river. The curve shows that for this particular river:

- for most of the time, eg 80% of days, daily flows exceed 50 ML/day - this is called the 80th percentile flow (Low Flow)
- for 50% of days, daily flows exceed 200 ML/day - this is called the 50th percentile flow (Moderate Flow)
- for 30% of days, daily flows exceed 470 ML/day - this is called the 30th percentile flow (High Flow).

This flow duration curve also illustrates how in a perennial river of this type, water extraction typically has the most marked effect on the moderate to low flow regimes. During high flow periods, water demands and therefore the volume pumped from a river, tend to be low.

This situation is typical for rivers that have some flow all of the time. However, in ephemeral or intermittent rivers that typically have no flow for a significant percentage of days, the percentile thresholds that define high, moderate and low flows may differ. Furthermore, water users may pump into off-river storages during high flow periods to overcome the lack of supplies in dry times

To simplify the determination and implementation of daily extraction limits, it is recommended that flows above the CTP be divided into three classes as follows:

Class A

- low flows
- generally from CTP to 80th percentile.

Class B

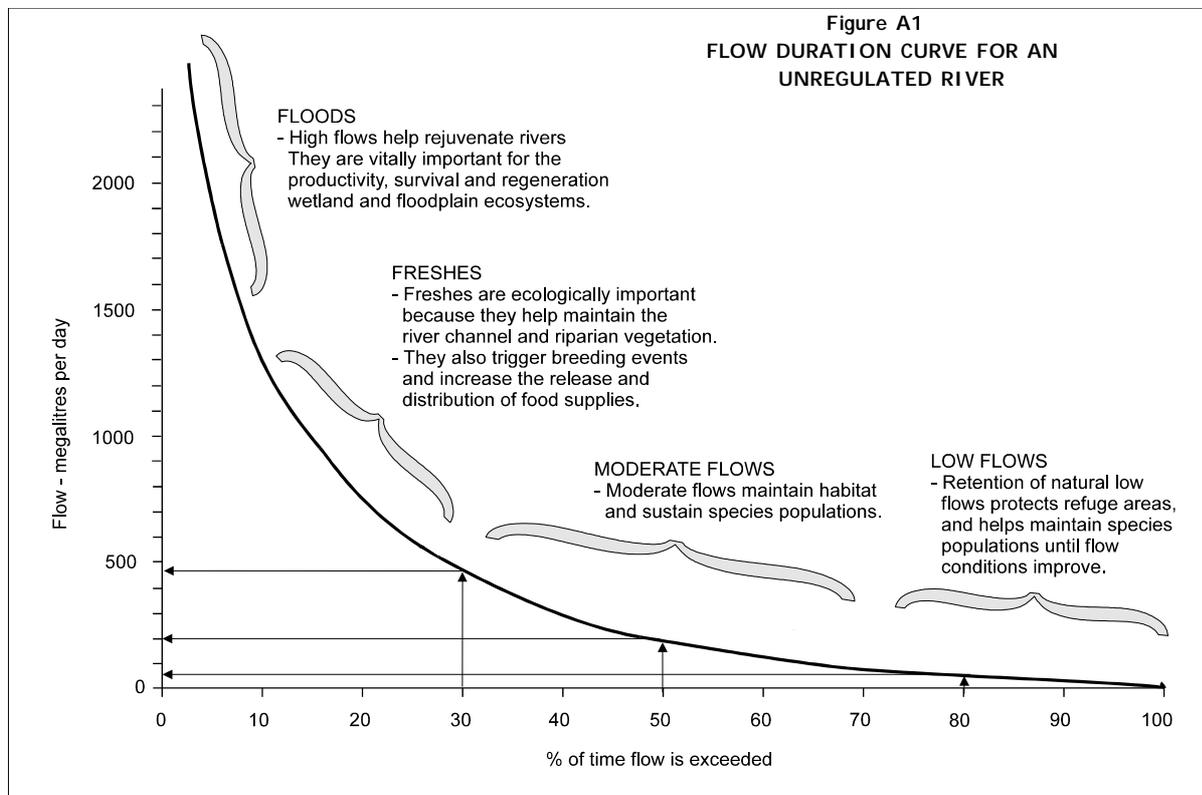
- low to moderate flows
- generally 50th to 80th percentile.

Class C

- moderate to high flows, freshes and floods
- generally 0 to 50th percentile
- may be subdivided if water demands are high.

In setting the flow range for the A, B and C classes, either the flow duration curve based on all days of the year or that based on only the days of the month when demand most exceeds water available (the critical month) may be used. While a whole year flow duration curve ranks the flows on all the days in the period of record, a particular month flow duration curve only ranks the flows that occurred during that particular month in the period of record.

In river systems where extraction is focussed on a few months and the flows are highly seasonal, a critical month curve is recommended as this reflects the probability of flows occurring during the times of greatest competition for flow. In systems where demands and flows are more evenly spread across months then the annual curve may be used to determine the flow classes.



Flow classes are intended as a means to deliver river flow objectives; in particular protection of low flows and mimicking of natural flow variability, while keeping the day to day changes in users access to a practical level. For each sub-catchment/management zone there will be a need to revise the class boundaries to take into account local hydrology, identified conservation values, specific environmental requirements and practical considerations. For example:

- additional classes above the Class C could be established where there is a significant demand during high flows;
- A and B classes could be combined if the difference in flow levels is not significant or measurable;
- A or B classes may be omitted because the river does not flow much of the time (ie 50th to 100th percentile flows are zero); and
- the top of B class could be adjusted up because the 50th percentile flow corresponds to a critical level for watering a wetland

Determining daily extraction limits

The first stage of the process for setting flow extraction volumes is to decide on the amount of flow in each class which can be sustainably extracted without threatening river health or reducing the access to existing users below reasonable levels. This amount of flow is called the **daily extraction limit**. Water sharing plans will need to specify a daily extraction limit for each defined flow class in each water management zone (or the whole water source where appropriate).

The daily extraction limit may be defined as a proportion of the upper limit in each flow class. Following are the recommended flow thresholds for the generic flow classes.

Class	Recommended Flow Threshold
A	80th percentile
B	50th percentile
C	30th percentile

For water sources or management zones that are identified as **high conservation value**, the daily extraction limits should be set at a level that restricts future increases in water extractions, and protects conservation values. For management zones, which have no licences, daily extraction limits may be set at zero.

Daily extraction limits should be set in consideration of environmental sustainability and extractive demand. They should generally be in the range 0 to 30% of the flow threshold. The exception is where demands are already very high in the flow class and the economic impact of a significant reduction in access would be high, the volumes may be set at up to a maximum of 60% of the threshold.

For other water sources or management zones, the starting point for determining daily extraction limits, whose *current* peak daily demand exceeds 30% of the flow index, should be *current* peak daily demand of the licences less 10%, up to a maximum of 60% of the flow sharing index.

Where the current peak daily demand is less than 30% of the flow sharing index, and the water source is not classed as high conservation value, the daily extraction limit may be increased to up to 30% to allow for full development of existing licences, transfers of licences into the sub-catchment, new (unembargoed) licence applications, or other considerations consistent with the Water Sharing Plan's objectives and strategies. Committees are not encouraged to recommend a BEV beyond the 30% and to do so will require clear demonstration of significant socio-economic benefits and minimal impact on the health of the water source.

The **peak daily demand** is the theoretical maximum amount of water needed on any day by licensed water users to meet their production requirements. It assumes no restrictions on access, typical watering systems and good practice water management. It should be calculated for current and full development of licences.

Peak daily demand for irrigation is calculated using the seasonal and daily watering requirements of the crops in the sub-catchment taking account of the local climatic conditions. The total peak daily demand for the river is this irrigation demand plus a daily allowance for other licensed purposes.

In calculating peak daily demand for C Class or higher, an allowance may also be added for water extraction into off-river storages. This will need to be determined on a case by case basis, depending on annual entitlement, total volume of storages and hydrological characteristics of the river and the plan diversion limit.

In assessing impacts it should be remembered that options such as voluntary rostering or groups registrations and managing diversions to the total daily extraction limit, can help water users to minimise the impacts of reducing daily flow access. The government's *Water Reform Structural Adjustment* programs can also provide educational and financial assistance to individual licence holders. Also it could take up to 4 years to fully implement daily extraction limits, which gives time for rostering and other adjustments to be made.

The guidelines discussed above have been based on the findings of the 1998 *Stressed Rivers Assessment*, which found that in the majority of unregulated sub-catchments less than 30% of the low flow index is currently extracted. Relatively few sub-catchments had extraction between 30-60% of low flow index. In the remaining sub-catchments, over 60% of the low flow index are currently extracted during the peak demand months. These sub-catchments are showing significant signs of environmental stress and were classified as hydrologically stressed systems. This suggests that extraction of more than 60% of low flow is unsustainable.

On the other hand, in most stressed rivers, it would not be possible to reduce extraction much below 60% in low flows in the short term without serious socio-economic impacts.

In assessing the economic impact of proposed daily extraction limits, the following should be used as a guide:

- comparison of peak daily demand estimates against any field usage data that is available to assess its appropriateness
- comparison of current peak daily demand for critical month and daily extraction volume. If the extraction volume is significantly lower than the current demand then the economic impact is likely to be significant
- comparison of full development peak daily demand for critical month and daily extraction limits. If the daily extraction limit is significantly lower than the full development demand but more than the current demand, then the economic impact will only be felt as and when the inactive entitlements are progressively developed. Care needs to be taken to ensure that this scenario is compared to what would have happened under full development without the daily extraction limits.

- Where available, any modelled assessment of days of i) nil pumping, ii) days when the amount pumped is less than the demand.

Distributing Daily Extraction Limits to Individual Licences

The lesser of the full development peak daily demand or the daily extraction limit for each flow class should be distributed to individual licences in proportion to their annual entitlement.

Where the full development peak daily demand of licences is less than the daily extraction limit in a flow class, the remainder of the daily extraction limit may be set aside as unallocated.

This situation will generally occur in unstressed systems or in the higher flow classes of stressed systems. The remaining undistributed extraction volume is then defined as unallocated.

Unallocated daily flow volumes

Unallocated daily flow volumes are available to be issued during the term of a plan but should only be issued in the following cases:

1. where annual share entitlement is transferred into the sub-catchment;
2. to new licences which are issued under embargo exemptions;
3. to new licences issued if the sub-catchment is not embargoed;
4. to existing licence holders where the plan so provides as part of a strategy to reduce low flow stress or adjust to reduced low flow access.

Worked Example

As an example, we can consider how this could be applied to a perennial river with a flow duration curve shown in Figure A1.

The assessed very low flow is 10 ML/day. The calculated current peak daily demand is 80 ML/day. An additional 20 ML/day is used for pumping to off river storages when opportunities arise. Full development peak daily demand is an additional 15 ML/day.

Based on the proposed method:

Very low flows. A field assessment shows 7 ML/day is required to maintain connectivity between pools in the river and provide for other low flow environmental requirements. An additional 3ML/day is assessed as being needed to provide

for basic water rights, giving a total of 10ML/day to be protected before licensed pumping is allowed.

A Class. For low flow periods when flows are between 10 ML/d and 50 ML/d (80th percentile).

Current peak daily demand less 10% is well in excess of the maximum allowed daily extraction limit of 60% of the 80th percentile flow (50 ML/d), or 30 ML/day. The daily extraction limit should therefore be 30ML/day, all of which would be initially allocated to licences.

B Class. When median flows occur, ie between 50 ML/d (80th percentile) and 200 ML/d (50th percentile).

Current peak daily demand less 10% is 72ML/d which is between 60 ML/day (30% of the 50th percentile flow of 200 ML/d) and 120 ML/d day (60% of the 50th percentile flow of 200 ML/d).

The daily extraction limit should therefore be 72ML/day, all of which would be allocated to licences.

C Class. When moderate to high flows occur, ie above 200 ML/d (50th percentile).

Current peak daily demand (including the 20ML/day pumping to off river storages) less 10% is 90ML/d which is well below 144 ML/day (30% of the 30th percentile flow of 480 ML/day).

In this case, 144 ML/d could be determined as the daily extraction limit to allow full peak daily demand of 95 ML/d plus 20ML/d for those who pump to off river storage to be allocated to licences, and 29 ML/d to remain unallocated for new (embargo exempted) licence applications and some growth in town water usage.

For an individual licence:

A licence in this sub-catchment has an annual share entitlement of 110ML (2%) out of a total of 5,500ML of entitlement in the sub-catchment. The licence currently has full flow range access and does not pump into off river storage.

As a result of implementation of the plan the licence would have the following conditions:

- no pumping permitted when the river flow is less than 10ML/day;
- pumping of up to 0.6 ML/day when the flow is in A class (daily flow share of 2% of the allocated daily extraction limit of 30 ML/day);
- pumping of up to 1.4 ML/day when the flow is in B class (daily flow share of 2% of the allocated daily extraction limit of 72 ML/day); and

- pumping of up to 1.8 ML/day when the flow is in C class (daily flow share of 2% of the allocated daily extraction limit of 95 ML/day).

It should be noted that these daily extraction limits are not cumulative, eg when the river is flowing in the 'B Class' range then the licensee can take up to 1.4 ML/day, not 2 ML/day (1.4 B class+0.6 A class).

The steps required to determine and implement daily extraction rules will depend on the management option adopted, and whether a suitable gauging station and/or historic flow record is available. Figure 2 sets out the necessary steps, which should be followed to establish the management rules depending on which option is selected.

Other considerations

Town water supplies

Under the *Water Management Act*, local water utility licenses (for town water supply) have priority when access to water is limited. Where a local water utility has on-river storage dams, extraction of water from those dams is excluded from daily extraction management but requirements for these dams to pass some inflows may be considered as a separate exercise.

Where a local water utility pumps from the river, essential town requirements will need to be met before the remaining daily extraction limit volumes are distributed to irrigation, industrial and other access license users. The local water utility licence may also have a different cease to pump level to general licences.

Where a local water utility has recently augmented its supply infrastructure and adopted more stringent extraction conditions, these will need to be reflected in the sharing formula.

Where a committee is considering proposing alterations to a local water utility's daily flow access or on-river dam release rules to provide for essential environmental or conservation values, there will need to be careful consideration of the impacts on town water supply. The DLWC will consult with the utility on a range of access arrangements together with options for the utility to provide for its needs in alternative ways. This consultation will also identify the ability of the utility to manage proposed changes, and how long such changes would take. This assessment should then be reflected in any recommendations made by the committee.

Licensed dams

Licences which extract from farm or other dams on 1st and 2nd order non-permanent watercourses are excluded from daily extraction management; will not be issued with daily extraction entitlement and will not be subject to pumping restrictions based on river gauge levels. This is because flow durations on gullies and minor rivers is so different to rivers that applying the same rules would not be sensible. Daily extraction management is also inapplicable to licences for dams not associated with licensed extractive use (eg passive recreation dams, instream dams only used for basic rights).

Extractive licences associated with all other instream dams should be issued with daily extraction entitlements in all classes, and should be included in assessment of peak daily demand. For these licenses the Water Sharing Plan should state that, despite daily flow class pumping limits, pumping from these dams is not restricted at any time when:

1. there is no inflow to the dam, or
2. all inflows to the dam are being passed or at least up to the A class equivalent at that point.

Special cease to pump conditions

If there is a small part of the sub-catchment where the cease to pump level on the operational gauge does not provide for adequate protection of critical low flows locally, a supplementary local cease to pump condition may be considered.

Highly interactive surface and groundwater

In some cases extraction from groundwater near a river is effectively the same as extracting from the river. In these cases it is appropriate to link management of these particular groundwater licences to the management of the river to ensure maintenance of critical river flows.

Strategies to reduce stress

Where extraction is greater than 30% of flow in a class (or less in a high conservation value sub-catchment) a plan could provide for strategies to reduce extraction. Such strategies could include such things as:

- not allowing transfers into the sub-catchment
- staged contraction of daily extraction limits during the period of the plan;

- allowing licence holders affected by reduced low flow access to apply for unallocated C class daily extraction volume;

- providing for licence holders to 'hand in' A class daily extraction entitlement in return for daily extraction entitlement of greater magnitude in C class.

Any such strategies should consider carefully the impacts on licence holders and trading markets and what rate of exchange is appropriate (in terms of the incentive they represent). They may also consider how the existing government Water Reform Structural Adjustment programs administered by the Department of Agriculture could be linked in.

Strategies involving issue of greater annual share entitlements in return for retirement of low flow access are not an option in the Murray-Darling Basin. Water sharing plans for coastal sub-catchments may include such strategies where the impact on downstream sub-catchments and estuaries is clearly understood. Where this is not the case the plan may provide for these strategies to be added during the term of the plan once the necessary assessment is completed.