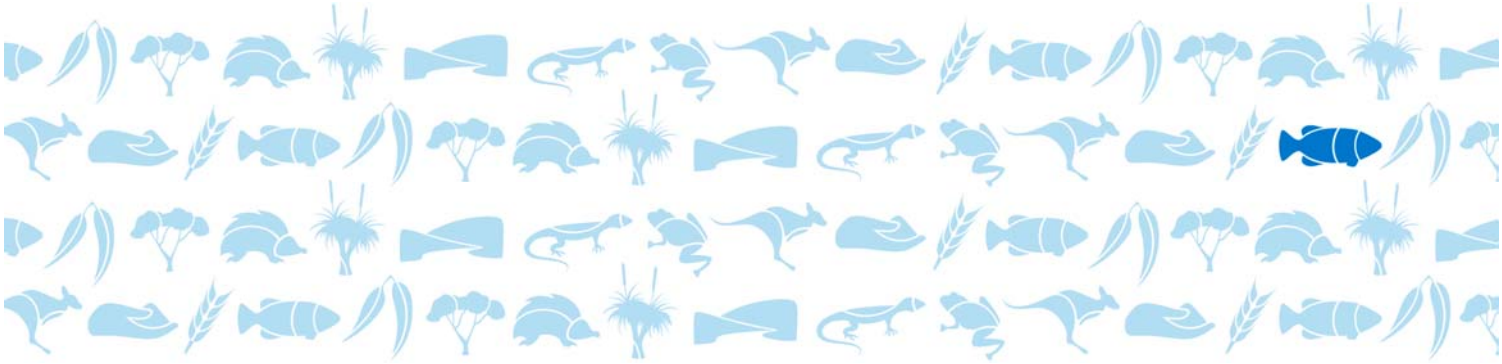
**2009**

South Australian Murray-Darling Basin Regional Management Board

# EXAMPLES OF CALCULATIONS FOR ALLOCATION AND TRANSFER OF SURFACE WATER AND WATERCOURSE WATER AND FOR DAM CAPACITY LIMITS FROM THE DRAFT MARNE SAUNDERS WATER ALLOCATION PLAN



Government of South Australia
South Australian Murray-Darling Basin
Natural Resources Management Board

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# 1 Introduction

This paper gives worked examples of calculations for some of the surface water and watercourse water equations given in the draft Water Allocation Plan for the Marne Saunders Prescribed Water Resources Area (PWRA) (the Plan). Examples are given for principles 54 -61 (maximum volume of allocation) and principles 128 – 138 (maximum dam capacity).

The examples are hypothetical and are not intended to represent real places in the Marne Saunders PWRA.

### Read this in conjunction with the Guide

This paper is not a stand-alone document. It has been written to be read in conjunction with the Guide to the draft Marne Saunders Water Allocation Plan (the Guide), which provides an overview of the background and intention of the policies. The Guide also gives definitions for terms and acronyms used in this paper. However, these documents are not a substitute for the Plan itself.

References to principle numbers in this paper correspond to principle numbers in the Plan.

### Structure of the paper

This paper gives a worked example of each relevant equation for a single hypothetical management sub-zone, described in section 2. Section 4 works through the equations for an example transfer of water from Dam F to Dam B in this hypothetical management sub-zone. Section 5 works through the equations for an example of dam capacity enlargement where Dam C is removed in order to enlarge Dam F in this hypothetical management sub-zone.

Colour coding is used in this paper, where each of the major terms used in the equations are assigned a single colour that is used throughout the paper. For example, dam capacity values are shown in green in the tables that describe the hypothetical management sub-zone in section 2, and also within the equation examples in sections 4 and 5.

### Interactions with other principles

It is important to note that a proposed allocation, transfer or dam capacity construction may not be permitted or may be affected by other principles in the Plan that are not described in this paper. For example, a transfer will not be permitted between management zones (e.g. between the Upper Marne and the Lower Marne - principle 85 in the Plan). See the Guide or the Plan for more information.

### Further information

If you would like further information on this paper or any other aspect of the draft Marne Saunders Water Allocation Plan, please call the South Australian Murray-Darling Basin Natural Resources Management Board's Murray Bridge office on (08) 8532 1432 or visit the Board's website at <www.samdbnrm.sa.gov.au>.

## 2 The example management sub-zone

Figure 1 shows the hypothetical management sub-zone that is used throughout the examples in this paper. Table 1 shows the values of different terms relating to the segments that make up this management sub-zone, while Table 2 shows the values for terms that apply to the whole management sub-zone. The terms given in Tables 1 and 2 are discussed to the right.

**Figure 1 Schematic diagram of the hypothetical management sub-zone, made up segments A to I. The general direction of flow is from the top to the bottom of the figure. Not to scale.**

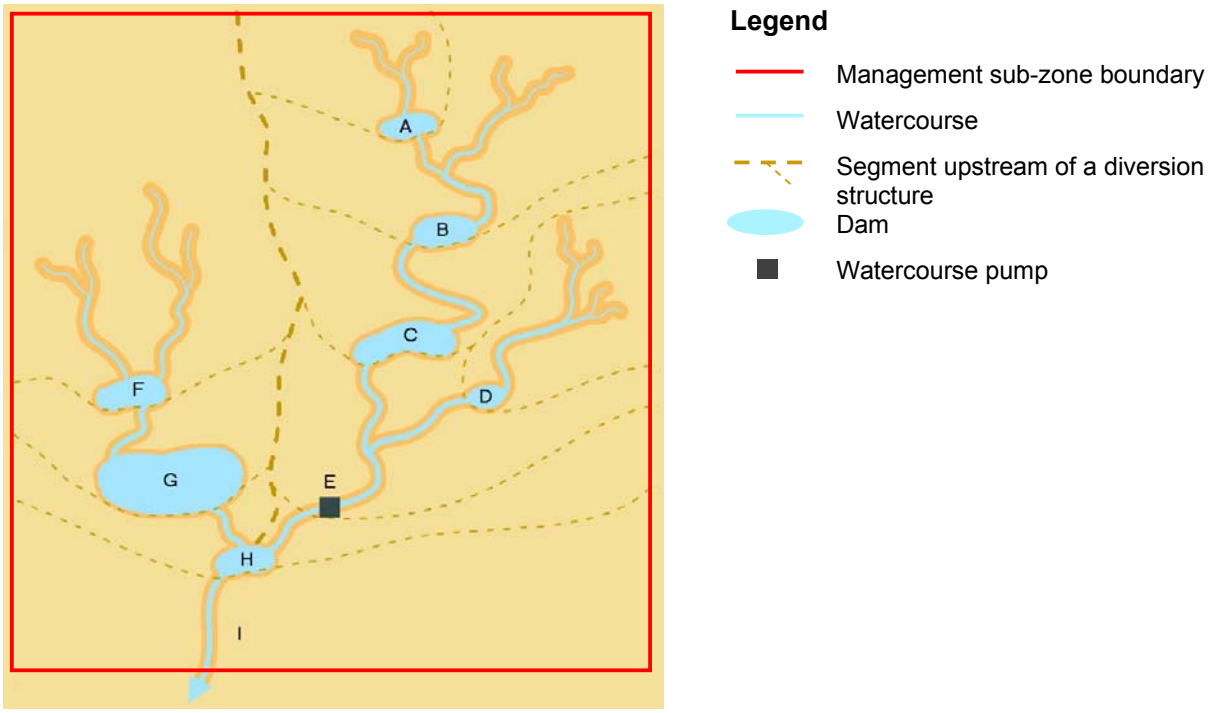



**Table 1 Values for terms for each of the segments that make up the management sub-zone. Where relevant, the top row of the table gives the symbol used for the term in the equations.**

| **Symbol** | | A | DC | allocation | | CU | E |
|---|---|---|---|---|---|---|---|
| Seg-ment | Segment area ($km^2$) | Catchment area u/s of div. str. ($km^2$) | Dam capacity (ML) | Allocation (ML) | Non-licensed consumptive use (ML) | Consumptive use (ML) | Estimated evaporation (ML) |
| A | 0.1 | 0.1 | 5 | 0 | 1.5 | 1.5 | 1.5 |
| B | 0.5 | 0.6 | 20 | 4 | 0 | 4 | 6 |
| C | 0.6 | 1.2 | 20 | 10 | 0 | 10 | 6 |
| D | 0.2 | 0.2 | 6 | 5 | 0 | 5 | 1 |
| E | 0.6 | 2.0 | n/a | 65 | 0 | 65 | 0 |
| F | 2.4 | 2.4 | 25 | 25 | 0 | 25 | 0 |
| G | 0.2 | 2.6 | 100 | 55 | 0 | 55 | 30 |
| H | 0.4 | 5.0 | 20 | 5 | 5 | 10 | 6 |
| I | 7 | 12.0 | 0 | 0 | 0 | 0 | 0 |

**Table 2 Values for terms that apply to the whole management sub-zone.**

| **Symbol** | **Term** | **Value** |
|---|---|---|
| R | Average adjusted winter runoff depth for the management sub-zone (mm) | 50 |
| MSZ CUL | Management sub-zone consumptive use limit (ML) | 180 |
| MSZ DCL | Management sub-zone dam capacity limit (ML) | 180 |

## 2.1 Notes on terms in Table 1

**Segment**

Each of the segments shown in Figure 1 is named as a letter. The segment letter is also used to refer to the diversion structure in each segment (e.g. Dam A lies within Segment A).

**Segment area ($km^2$)**

The segment area is the catchment area that contributes to a diversion structure that is downstream of the neighbouring upstream diversion structure. For example, the segment area for Segment C is the catchment area downstream of Dam B that contributes runoff to Dam C.

**Catchment area u/s of div. str. (Catchment area upstream of diversion structure) ($km^2$)**

The total catchment area upstream of a diversion structure. For example, the catchment area upstream of Dam C is 1.2 $km^2$, which is the sum of the segment areas for Segments A, B and C (0.1 + 0.5 + 0.6 = 1.2 $km^2$).

Figure 1 shows the physical layout of the segments in the hypothetical management sub-zone, showing which segments are upstream of others.

**Dam capacity (ML)**

The existing capacity of the dam in the segment. The diversion structure in segment E is a watercourse pump, so has no dam capacity. There are no diversion structures in segment I.

**Allocation (ML)**

The existing volume of allocation for licensed purposes from the surface water and watercourse water resources in the segment. No water is currently allocated from Dam A.

**Non-licensed consumptive use (ML)**

The volume of water used for non-licensed purposes from the diversion structure in the segment, determined in accordance with principle 53 e).

Dam A is only used for non-licensed purposes. Non-licensed consumptive use from this dam is estimated as 30% of the capacity of this 5 ML dam. Thus:
Non-licensed consumptive use = 5 ML x 0.3 = 1.5 ML

Principle 53 e) also provides that the Minister may estimate non-licensed use from a licensed diversion structure. Such a determination might be important where there is a substantial volume of water used for non-licensed use from a licensed diversion structure that needs to be protected when assessing transfers or new dam construction upstream of that diversion structure. In the hypothetical management sub-zone, it has been determined that 5 ML is used for non-licensed purposes from Dam H in consultation with the owner of Dam H.

**Consumptive use (ML)**

The total volume of consumptive use from the diversion structure in the segment, being the sum of the allocation and non-licensed consumptive use from the diversion structure (in accordance with principle 53 e).

**Estimated evaporation (ML)**

Evaporation is estimated in accordance with principle 53 g) – h). Evaporation is estimated as the lesser of 30% of the dam capacity; or the dam capacity minus consumptive use from the dam in question. The second component is required for the case where consumptive use from the dam is more than 70% of dam capacity, because otherwise consumptive use plus evaporation would exceed the dam capacity. Evaporation from a diversion structure that is not a dam is zero. These principles are reproduced from the Plan as follows:

53 g) Evaporation (E) from a dam (in ML) is determined as the lesser of the following:

i. $E = DC \times 0.3$

ii. $E = DC - CU_D$

where:

E Evaporation. Nominal evaporation from a dam (in ML).

DC Dam capacity. DC is determined as the volumetric capacity of the dam (in ML).

$CU_D$ Consumptive use from the dam (in ML).

53 h) Evaporation from a diversion structure that is not a dam is 0 ML.

These principles are applied to the hypothetical management sub-zone in Table 3 to calculate the estimated evaporation given in Table 1.

**Table 3 Determination of estimated evaporation for the diversion structures in the hypothetical management sub-zone. Columns DC and CU are taken from Table 1.**

| **Symbol** | DC | CU | | | E |
|---|---|---|---|---|---|
| Seg-ment | Dam capacity (ML) | Consumptive use (ML) | 53 g) i) DC x 0.3 | 53 g) ii) DC - $CU_D$ | Estimated evaporation (ML) – lesser of 53 g) i) and 53 g) ii) |
| A | 5 | 1.5 | 5 x 0.3 = 1.5 | 5 – 1.5 = 3.5 | 1.5 |
| B | 20 | 4 | 20 x 0.3 = 6 | 20 – 4 = 16 | 6 |
| C | 20 | 10 | 20 x 0.3 = 6 | 20 – 10 = 10 | 6 |
| D | 6 | 5 | 6 x 0.3 = 1.8 | 6 – 5 = 1 | 1 |
| E | n/a | 65 | n/a (not a dam) | | 0 (as per 53 h)) |
| F | 25 | 25 | 25 x 0.3 = 7.5 | 25 – 25 = 0 | 0 |
| G | 100 | 55 | 100 x 0.3 = 30 | 100 – 55 = 45 | 30 |
| H | 20 | 10 | 20 x 0.3 = 6 | 20 – 10 = 10 | 6 |
| I | 0 | 0 | No diversion structures | | 0 |

### 2.2 Notes on Table 2

The values in Table 2 for the real management sub-zones in the Marne Saunders PWRA are given in Table 28 of the Plan.

## 3 Use of subscripts in the equations

The Plan uses subscripts to identify which principle an equation relates to. For example, $TV_{57}$ represents the total allocation volume that must not be exceeded for the purposes of principle 57.

The Plan also uses subscripts next to many of the terms in the equations to identify which area or diversion structure the term is referring to. For example, $CU_{D1}$ refers to the consumptive use from Dam 1, while $CU_{UD1}$ refers to the consumptive use within the catchment area upstream of Dam 1. This approach allows terms such as consumptive use to be defined in a general way, while the subscripts used in the equations indicate the specific area or diversion structure that the term is to be calculated for.

A list of commonly used subscripts and their usual meanings is given below.

MZ Within the relevant management zone

MSZ Within the relevant management sub-zone

D1 From or at diversion structure D1
Diversion structure D1 is generally the diversion structure that the proposed allocation is to be taken from, or where the proposed dam capacity is to be constructed

UD1 Upstream of diversion structure 1
Excludes the value for diversion structure 1, as it is not upstream of itself

$_{Dx}$ From or at diversion structure Dx
Diversion structure Dx is generally a diversion structure that may be affected by proposed action at diversion structure D1

$_{BDx}$ Both at and upstream of diversion structure Dx

$_{WDx}$ From main watercourse diversion structure WDx
Main watercourse diversion structure WDx is generally a main watercourse diversion structure that may be affected by proposed action at diversion structure D1

$_{BWDx}$ Both at and upstream of main watercourse diversion structure WDx

$_{prop}$ From the property that diversion structure D1 is located within

# 4 Principles 54 – 61: Maximum volume of allocation

Principles 54 – 61 set out how to determine the maximum allocation volume that can be taken at a diversion structure as a result of an allocation under the Plan.

There will be no new allocations of surface water or watercourse water under the Plan, so these principles effectively only apply to transfers and to conversion of water (holding) allocations to water (taking) allocations (see section 2.2.9 on page 11 of the Guide for more information on these types of allocations). Transfers to a different diversion structure are generally assessed against the allocation criteria under the Plan (in accordance with principle 96). In this paper, a reference to a "proposed allocation" includes a transfer or an allocation resulting from conversion of a water (holding) allocation to a water (taking) allocation.

The principles give the total allocation volume that can be taken at the diversion structure, being the existing allocation at the point (if any) plus the proposed allocation.

**Allowable allocation is smallest value calculated**

All of the relevant principles need to be calculated, and the allowable total allocation will be the smallest of all of the calculated values. If the smallest calculated value is the same or less than the existing allocation at the diversion structure, then the proposed allocation will not be permitted. If there is no existing allocation at the diversion structure, then the proposed allocation will not be permitted if the smallest calculated value is zero or less.

This approach of using the smallest calculated value has been taken to ensure that the most limiting factor is considered when determining maximum allocation volumes. Different principles relate to different considerations when allocating water, such as physical availability of water, providing environmental water needs and minimising impacts on downstream users. Different principles also operate at different scales, ranging from the management zone, to the management sub-zone, to the local catchment area of the diversion structure scale. If the smallest calculated value is used, then all of the other considerations will also be met.

**Single allocation for multiple diversion structures**

In certain cases, a single allocation may be granted to be taken from a number of diversion structures in accordance with principle 51. Where this occurs, the principles are calculated collectively for those diversion structures that the allocation can be taken from (in accordance with principle 52). For example, the term for the catchment area upstream of a diversion structure would be determined as the total catchment area upstream of all of those diversion structures.

**The example transfer**

This section sets out an example calculation for each equation in principles 54-61 for a single **proposed transfer of 15 ML from Dam F to Dam B,** using the hypothetical management sub-zone outlined in Figure 1 and Tables 1 - 2. These calculated values are then drawn together in section 4.7 to show what the allowable transfer would be.

## 4.1 Principles 54 – 55: Management sub-zone consumptive use limit

Under principles 54 – 55, water will not be allocated if it would cause the total volume taken for consumptive use in a management sub-zone to exceed (or further exceed) the management sub-zone consumptive use limit (MSZ CUL). This effectively means that the maximum total volume to be allocated under these principles is the "room" available in the MSZ CUL (i.e. the MSZ CUL minus existing consumptive use), plus any existing allocation that is already taken at the diversion structure that the proposed allocation would be taken from.

As explained in the Guide (section 3.3.4 "Management sub-zone limits", page 21 onwards):

- Consumptive use includes estimated non-licensed use as well as licensed use (as per principle 53 e)).
- The MSZ CUL that applies to allocations taken from main watercourse management sub-zones is the sum of the MSZ CULs for upstream tributary management sub-zones (as per principles 55 b) and 53 c)).
- The effects of proposed allocations need to be assessed at affected downstream main watercourse diversion structures, to ensure that the proposed allocation doesn't cause total consumptive use at / upstream of a main watercourse diversion structure to exceed the relevant MSZ CUL (as per principle 54 b)). This check will need to be done in addition to any assessment of consumptive use against the MSZ CUL for the management sub-zone that the proposed allocation would be taken from.

Principles 54 – 55 are reproduced below, excluding the definitions for terms of the equation for principle 55 b) (which are very similar to the equation for principle 55 a), and is not calculated for this example as outlined below). Principle 54 provides the outcome to be achieved, and principle 55 provides further detail of how this is defined and calculated.

54. Water shall not be allocated where the allocation would cause:
    a) the total volume taken for consumptive use from a tributary MSZ to exceed, or further exceed, its MSZ CUL; and/or
    b) the total volume taken for consumptive use at and upstream of any main watercourse diversion structure to exceed, or further exceed, the cumulative MSZ CUL upstream of that diversion structure.

55. For the purposes of principle 54, the total volume to be allocated from a diversion structure (D1) shall not exceed the lesser of the volumes determined by principles 55 a) and 55 b):
    a) where the allocation is to be taken from a tributary MSZ:

$$TV_{55a} = (\text{MSZ CUL} - CU_{MSZ}) + CU_{D1}$$

where:

| | |
|---|---|
| $TV_{55a}$ | Total volume. The total volume that the allocation or allocations to be taken from the diversion structure D1 must not exceed for the purposes of principle 55 a) (in ML). |
| MSZ CUL | Management sub-zone consumptive use limit. The volume of the MSZ CUL for the MSZ that the allocation is to be taken from (in ML). |
| $CU_{MSZ}$ | Consumptive use in the management sub-zone that the allocation is to be taken from. $CU_{MSZ}$ is the volume of consumptive use from the management sub-zone that the allocation is to be taken from, immediately prior to the allocation (in ML). If the allocation would result from the transfer of an allocation sourced from within the same tributary MSZ, then the volume of this proposed transfer is excluded from $CU_{MSZ}$. |
| $CU_{D1}$ | Consumptive use at diversion structure D1. $CU_{D1}$ is the volume of consumptive use from the diversion structure D1 that the allocation will be taken from, immediately prior to the allocation (if any) (in ML). |

b) the smallest volume returned by calculating the following at each main watercourse diversion structure x (WDx) downstream of the diversion structure D1 within the Marne Saunders PWRA that may be affected by the allocation:

$TV_{55b}$ = (cumulative MSZ $CUL_{WDx}$ – $CU_{BWDx}$) + $CU_{D1}$

**Example calculation for principle 54 – 55: Transfer 15 ML from Dam F to Dam B**

Please note that the Guide does not provide an example calculation for these principles.

The proposed transfer is within a single tributary management sub-zone, and so there will be no net difference in the total volume taken for consumptive use by the downstream end of that management sub-zone. This means that checks do not need to be made on whether total consumptive use exceeds the cumulative MSZ CUL for downstream main watercourse diversion structures. That is, principle 54 b) will not be triggered by the proposed transfer. Figure 10 and pages 23-24 in the Guide provide more information on when this type of downstream checking does need to occur.

Principle 55 b) does not apply, both because principle 54 b) will not be triggered as outlined above, and because the proposed transfer is not to be taken from a main watercourse diversion structure.

So for this example, only principle 55 a) needs to be calculated as outlined below. Colour coding is used to show which numbers are related to which terms in the equation. These colours also correspond to the colours for source of the values from Tables 1 and 2.

$TV_{55a}$ = (MSZ CUL – $CU_{MSZ}$) + $CU_{D1}$

***"Room" available in the MSZ CUL*** or the consumptive use limit minus existing consumptive use.

Existing consumptive use at the diversion structure that the proposed allocation would be taken from ($CU_{D1}$) is included in the total consumptive use from the MSZ ($CU_{MSZ}$). This volume is subtracted when determining the "room" available in the MSZ CUL in the first component of this equation. Therefore $CU_{D1}$needs to be added back on, so that the equation determines the maximum <u>total</u> volume that can be allocated at that diversion structure (i.e. the "room" in the limit plus existing consumptive use at the diversion structure).

Thus:

$TV_{55a}$ = [ 180 – ( 1.5 + 4 + 10 + 5 + 65 + 10 + 55 + 10 ) ] + 4

From Table 2.

Consumptive use from all diversion structures in the management sub-zone from Table 1, excluding the volume to be transferred from Dam F. Thus the volume given here for Dam F is consumptive use from Dam F minus proposed transfer, or 25 – 15 = 10 ML.

This volume is excluded in accordance with the definition for the term $CU_{MSZ}$ given above, because the transfer is occurring within the same tributary MSZ. If this volume was not excluded, then it would be counted as if it was still being taken from Dam F after the proposed transfer and wouldn't be included in the maximum total volume that could be taken from Dam B for this principle.

Consumptive use from Dam B in Table 1.

$TV_{55a}$ = [ 180 – 160.5 ] + 4

$TV_{55a}$ = 19.5 + 4

$TV_{55a}$ = 23.5 ML

That is, User B could potentially transfer in an extra 19.5 ML in addition to the existing 4 ML allocation at Dam B in accordance with principles 54 – 55, subject to the other relevant principles. This means that principles 54 – 55 would not limit the proposed transfer of 15 ML.

## 4.2 Principles 56: Dam capacity limit

Principle 56 limits the total volume that can be allocated from a dam to the dam's capacity. This principle would not apply in the case of a diversion structure that is not a dam, such as a watercourse pump. Principle 56 is reproduced below.

56. The total volume to be allocated to be taken from a dam shall not exceed the volumetric capacity of that dam.

**Example calculation for principle 56: Transfer 15 ML from Dam F to Dam B**

Please note that the Guide does not provide an example calculation for this principle.

The existing dam capacity for Dam B is 20 ML (from Table 1). Therefore the maximum volume that could be allocated from that dam must not exceed 20 ML in accordance with principle 56, subject to other relevant principles.

There is already 4 ML allocated to be taken from Dam B, so the maximum amount of water that could be transferred in is 20 – 4 = 16 ML. This means that principle 56 would not prevent or limit the proposed transfer of 15 ML.

## 4.3 Principle 57: Available runoff limit

Broadly, principle 57 limits the volume that can be allocated from a diversion structure to the available runoff at the diversion structure. In this case:

- Available runoff is determined in terms of total supply minus total upstream demand.
- The total supply is the volume of average adjusted winter runoff from the catchment area upstream of the diversion structure that the proposed allocation would be taken from.
- The total upstream demand is existing consumptive use from diversion structures and estimated evaporation from dams, in the catchment area upstream of the diversion structure that the proposed allocation would be taken from.

Principle 57 is reproduced below.

57. The total volume to be allocated from a diversion structure shall not exceed the average adjusted winter runoff from the catchment area upstream of that diversion structure, taking upstream consumptive use and evaporation into account. For the purposes of this principle, the total volume to be allocated from this diversion structure (D1) shall not exceed the following:

$$TV_{57} = (A_{D1} \times R_{D1}) - (CU_{UD1} + E_{UD1})$$

where:

| | |
|---|---|
| $TV_{57}$ | Total volume. The total volume that the allocation or allocations to be taken from the diversion structure D1 must not exceed for the purposes of principle 57 (in ML). |
| $A_{D1}$ | Area upstream of D1. $A_{D1}$ is the catchment area upstream of diversion structure D1 (in $km^2$) |
| $R_{D1}$ | Runoff at D1. $R_{D1}$ is the average adjusted winter runoff depth for the catchment area upstream of diversion structure D1 (in mm). |
| $CU_{UD1}$ | Consumptive use upstream of D1. $CU_{UD1}$ is determined as the volume of consumptive use in the catchment area upstream of diversion structure D1, excluding consumptive use at diversion structure D1, immediately prior to the allocation (in ML). If the allocation would result from the transfer of an allocation sourced from |

upstream of diversion structure D1, then the volume of this proposed transfer is excluded from $CU_{UD1}$.

$E_{UD1}$ Evaporation upstream of D1. $E_{UD1}$ is determined as the evaporation from dams in the catchment area upstream of diversion structure D1, excluding evaporation from diversion structure D1 (in ML).

**Example calculation for principle 57: Transfer 15 ML from Dam F to Dam B**

Please note that Calculation A, Figure 11 on page 25 of the Guide provides a simplified example of this principle. For example, Figure 11 shows:

- "Run off from a segment" which is the equivalent of the area of that segment multiplied by the average adjusted winter runoff depth (R)
- "Demand at a location" which is the equivalent of consumptive use (CU) plus estimated evaporation (E) from that location

$TV_{57} = (A_{D1} \times R_{D1}) - (CU_{UD1} + E_{UD1})$

| ***Total supply*** or volume of average adjusted winter runoff (upstream area multiplied by runoff depth). | ***Total upstream demand*** or consumptive use plus evaporation. This demand needs to be subtracted from the total supply to determine what is actually available at the diversion structure that the allocation is to be taken from. |
|---|---|

Thus:

$TV_{57} = ( 0.6 \times 50 ) - ( 1.5 + 1.5 )$

| Catchment area upstream of Dam B from Table 1. | Evaporation upstream of Dam B from Table 1 (i.e. from Dam A – does not include evaporation from Dam B as it is not upstream of itself). |
|---|---|
| Runoff for the MSZ that Dam B lies in from Table 2. | Consumptive use upstream of Dam B from Table 1 (i.e. from Dam A – does not include consumptive use from Dam B as it is not upstream of itself). |

$TV_{57} = 30 - 3$

$TV_{57} = 27$ ML

That is, User B could transfer in an extra 23 ML in addition to the existing 4 ML allocation in accordance with principle 57, subject to other relevant principles. This means that principle 57 would not prevent or limit the proposed transfer of 15 ML.

## 4.4 Principle 58: Local consumptive use limit for new or enlarged diversion structures

Principle 58 only applies where a proposed allocation would be taken from a diversion structure that has been enlarged or constructed after Plan adoption. In this case, water will not be allocated if it would cause the total volume taken for consumptive use at that diversion structure and in the upstream catchment area to exceed the local consumptive use limit. The local consumptive use limit is 30% of average adjusted winter runoff from the catchment area upstream of that diversion structure. Note that the term "local consumptive use limit" is not used in the Plan, but is included here to describe what this principle considers.

This effectively means that the maximum total volume to be allocated under this principle is the "room" available in the local consumptive use limit. That is, 30% of the average adjusted winter runoff volume minus existing upstream consumptive use (but not including any existing consumptive use at the diversion structure that the proposed allocation would be taken from).

This principle does not apply to diversion structures that were constructed before adoption of the Plan that have not been enlarged since adoption of the Plan.

Principle 58 is similar in concept to principles 54-55, except that it operates at the local (diversion structure) scale rather than the management sub-zone scale.

Principle 58 is reproduced below.

58. Subject to principle 63, the total volume to be allocated to be taken from a diversion structure that has been enlarged or constructed since the date of adoption shall not exceed 30% of the average adjusted winter runoff from the catchment area upstream of the diversion structure, taking upstream consumptive use into account. For the purposes of this principle, the total volume to be allocated from this diversion structure (D1) shall not exceed the following:

$$TV_{58} = (A_{D1} \times R_{D1} \times 0.3) - CU_{UD1}$$

where:

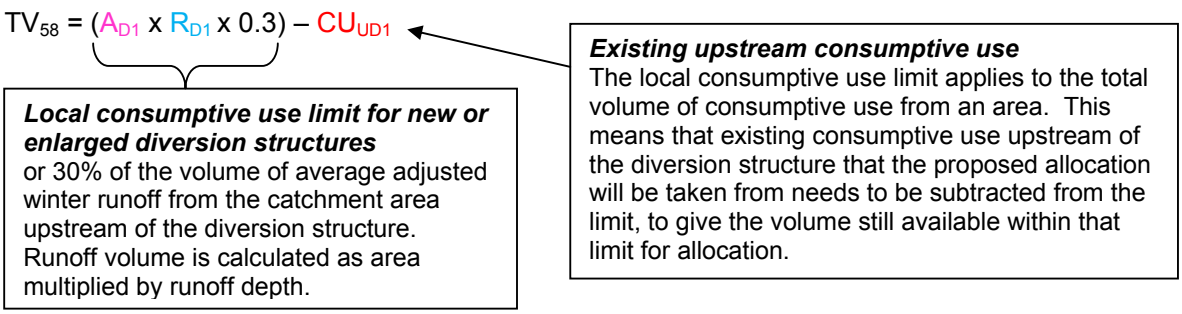
| | |
|---|---|
| $TV_{58}$ | Total volume. The total volume that the allocation or allocations to be taken from the diversion structure D1 must not exceed for the purposes of principle 58 (in ML). |
| $A_{D1}$ | Area upstream of D1. $A_{D1}$ is the catchment area upstream of diversion structure D1 (in $km^2$). |
| $R_{D1}$ | Runoff at D1. $R_{D1}$ is the average adjusted winter runoff depth for the catchment area upstream of diversion structure D1 (in mm). |
| $CU_{UD1}$ | Consumptive use upstream of D1. $CU_{UD1}$ is determined as the volume of consumptive use in the catchment area upstream of diversion structure D1, excluding consumptive use at diversion structure D1, immediately prior to the allocation (in ML). If the allocation would result from the transfer of an allocation sourced from upstream of diversion structure D1, then the volume of this proposed transfer is excluded from $CU_{UD1}$. |

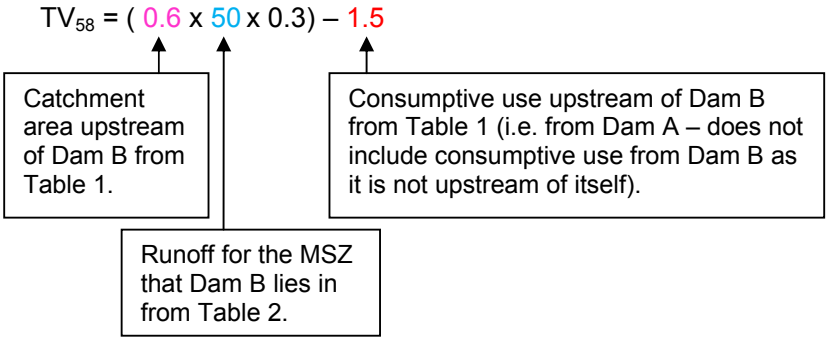
Note that principle 63 provides that water will not be allocated from a diversion structure constructed or enlarged after the adoption of the Plan, unless the diversion structure meets the criteria in sections 8.1 and 8.4 (water affecting activities – general, and water storages and diversions).

**Example calculation for principle 58: Transfer 15 ML from Dam F to Dam B**

Please note that Calculation B, Figure 11 on page 25 of the Guide provides a simplified example calculation of this principle. A key simplification in Figure 11 is that it shows "Runoff from a segment (ML)", which is the equivalent of the area of that segment multiplied by the average adjusted winter runoff depth (R).

Assuming that Dam B was constructed after the date of adoption of the Plan:




$TV_{58} = 9 - 1.5$

$TV_{58} = 7.5$ ML

That is, User B could transfer in an extra 3.5 ML in addition to the existing 4 ML allocation under principle 58, subject to other relevant principles. This means that principle 58 would limit the proposed transfer of 15 ML to 3.5 ML instead.

## 4.5 Principle 59: when to use principle 58 for groups of diversion structures

According to principle 59, if a single allocation can be taken from a group of diversion structures (in accordance with principle 51), and any of them have been constructed or enlarged since adoption of the Plan, then principle 58 is used instead of principle 57. Principle 59 is reproduced below.

59. Principle 58 shall be used instead of principle 57 where:
    the allocation may be taken from more than one diversion structure in accordance with principle 51, and
    a) any of those diversion structures have been enlarged or constructed since the date of adoption.

## 4.6 Principles 60 – 61: Minimise downstream impact

The intention of principles 60 – 61 is to minimise the impact of a proposed allocation on downstream users, and allow them to continue to access the consumptive use volume that they accessed before the proposed allocation, on average.

This is assessed using a water balance approach, which looks at water supply and demand at each of the diversion structures that may be affected by the proposed transfer. The proposed allocation would not be permitted if total demand is greater than supply, or will become so as a result of the proposed allocation, at any of those potentially affected diversion structures. The supply at an affected diversion structure is the volume of average adjusted winter runoff from the catchment area upstream of that diversion structure. The total demand at an affected diversion structure is the sum of all consumptive use and estimated evaporation at and upstream of that diversion structure.

This check of supply against demand needs to be made at all diversion structures that may be affected by the proposed allocation, and the maximum total volume to be allocated must not exceed the smallest value calculated by these checks. The proposed allocation will not be permitted If any of these checks return zero, a negative number, or a number that is less than any existing allocation at the diversion structure that the proposed allocation is to be taken from.

This checking only needs to occur for each diversion structure that could be negatively affected by the proposed allocation. These affected diversion structures are referred to as "Dx" in these principles. Figure 12 on page 27 of the Guide provides examples of where the checking would and would not need to be done.

Principles 60 – 61 are reproduced below. Principle 60 provides the outcome to be achieved, and principle 61 provides further detail of how this is defined and calculated.

60. Water shall not be allocated where the allocation would cause the total demand for water, including consumptive use and evaporation, to exceed or further exceed the average supply of runoff in the catchment area upstream of any affected diversion structures within the Marne Saunders PWRA.

61. For the purposes of principle 60, the total volume to be allocated from a diversion structure (D1) shall not exceed the smallest volume returned by calculating the following at each diversion structure x (Dx) downstream of D1 within the Marne Saunders PWRA that may be affected by the allocation:

$$TV_{61} = ((A_{Dx} \times R_{Dx}) - (CU_{BDx} + E_{BDx})) + CU_{D1}$$

where:

| | |
|---|---|
| $TV_{61}$ | Total volume. The total volume that the allocation or allocations to be taken from the diversion structure D1 must not exceed for the purposes of principle 61 (in ML). |
| $A_{Dx}$ | Area upstream of Dx. $A_{Dx}$ is the catchment area upstream of diversion structure Dx (in $km^2$). |
| $R_{Dx}$ | Runoff at Dx. $R_{Dx}$ is the average adjusted winter runoff depth for the catchment area upstream of diversion structure Dx (in mm). |
| $CU_{BDx}$ | Consumptive use both at and in the catchment area upstream of diversion structure x. $CU_{BDx}$ is the total volume of consumptive use at and in the catchment area upstream of diversion structure x, immediately prior to the allocation (in ML). If the allocation would result from the transfer of an allocation sourced from upstream of diversion structure x, then the volume of this proposed transfer is excluded from $CU_{BDx}$. |

| | |
|---|---|
| $E_{BDX}$ | Evaporation both at and upstream of Dx. $E_{BDX}$ is the total evaporation from dams at and in the catchment area upstream of diversion structure Dx (in ML). |
| $CU_{D1}$ | Consumptive use at diversion structure D1. $CU_{D1}$ is the volume of consumptive use from the diversion structure D1 that the allocation will be taken from, immediately prior to the allocation (if any) (in ML). |

Where the equation returns a negative value, $TV_{61}$ will be zero.

**Example calculation for principle 60 - 61: Transfer 15 ML from Dam F to Dam B**

Please note that Figure 12 on page 27 of the Guide provides a simplified example calculation of these principles. For example, Figure 12 shows:

- "Runoff from a segment (ML)" which is the equivalent of the area of that segment multiplied by the average adjusted winter runoff depth (R)
- "Demand at a location" which is the equivalent of consumptive use (CU) plus estimated evaporation (E) from that location

As outlined in the Guide, the equation in principle 61 only needs to be applied to Dam C and Watercourse pump E, as these are the only diversion structures that could be negatively affected by the proposed transfer of water from Dam F to Dam B.

$$TV_{61} = ((A_{Dx} \times R_{Dx}) - (CU_{BDx} + E_{BDx})) + CU_{D1}$$

***Total supply*** or volume of average adjusted winter runoff at the diversion structure being checked (Dx). Supply is determined as upstream area multiplied by runoff depth.

***Total demand <u>at and upstream of</u> the diversion structure being checked (Dx).*** Demand is determined as consumptive use plus estimated evaporation.

Existing consumptive use at the diversion structure that the proposed allocation would be taken from ($CU_{D1}$) is included in the total consumptive use at and upstream of the diversion structure being checked ($CU_{BDx}$). This volume is part of the total demand that is subtracted from the total supply. Therefore $CU_{D1}$needs to be added back on, so that the equation determines the maximum <u>total</u> volume that can be allocated at that diversion structure.

Thus checking for Dam C:

$$TV_{61} = \{ (1.2 \times 50) - [ ( 1.5 + 4 + 10) + ( 1.5 + 6 + 6 ) ] \} + 4$$

Catchment area upstream of Dam C from Table 1.

Runoff for the MSZ that Dam C lies in from Table 2.

Consumptive use from Dams A, B and C from Table 1 (at and upstream of Dam C).

Evaporation from Dams A, B and C from Table 1 (at and upstream of Dam C).

Consumptive use from Dam B from Table 1.

$TV_{61} = \{ 60 - [ 15.5 + 13.5 ] \} + 4$

$TV_{61} = \{ 60 - 29 \} + 4$

$TV_{61} = 31 + 4$

$TV_{61}$ = 35 ML when assessing Dam C

That is, User B could transfer in an extra 31 ML in addition to the existing 4 ML allocation without affecting supply to Dam C, on average.

Thus checking for Watercourse Pump E (note that data sources follow those given above for Dam C):

$TV_{61}$ = { (2 x 50) – [ ( 1.5 + 4 + 10 + 5 + 65 ) + ( 1.5 + 6 + 6 + 1 + 0 ) ] } + 4

$TV_{61}$ = { 100 – [ 85.5 + 14.5 ] } + 4

$TV_{61}$ = { 100 – 100 } + 4

$TV_{61}$ = 0 + 4

$TV_{61}$ = 4 ML when assessing Watercourse Pump E

The maxium total volume to be allocated is the same as the existing 4 ML allocation in this case. This means that a transfer from Dam F to Dam B would not be permitted, because it would affect the ability of the user of Watercourse Pump E to access their consumptive use, on average.

## 4.7 Summary of results for example calculation of principles 54 - 61

The table below summarises the maximum total volume that could be allocated from Dam B as a result of a transfer from Dam F for each of the example calculations given in thies section. Note that principle 59 does not calculate a maximum total volume.

| **Principle(s)** | | **Maximum total volume (TV) that could be allocated (ML)** |
|---|---|---|
| 54 – 55 | Management sub-zone consumptive use limit | 23.5 ML |
| 56 | Dam capacity limit | 20 ML |
| 57 | Available runoff limit | 27 ML |
| 58 | Local consumptive use limit for new or enlarged diversion structures | 7.5 ML |
| 60 – 61 | Minimise downstream impact | 4 ML (smallest of all values calculated for this pair of principles) |

The smallest of all of the calculated values is 4 ML (from principles 60 – 61). Therefore the proposed transfer would not be permitted, because this calculcated value is the same as the existing 4 ML allocation at Dam B. Taking additional water at Dam B would mean that the maximum total volume determined by principles 60-61 would be exceeded.

# 5 Principles 128 - 138: Maximum dam capacity

Principles 128 – 139 set out how to determine the maximum dam capacity that can be constructed at a point, as a result of a water affecting activity permit under the Plan. An example is not given here for principle 139, as it is a modification of principle 138 under particular circumstances.

### Applies to licensed and non-licensed dams

A water affecting activity permit is required for the construction of any new dam capacity, including new dam construction and enlargement of an existing dam. A permit is required whether the dam will be used for licensed purposes, non-licensed purposes (such as stock and domestic use) or both. This is different from the allocation principles set out earlier, which only apply when the water is to be allocated for licensed purposes.

### Allowable dam capacity is the smallest value calculated

The principles give the total dam capacity that can be allowed at a point, being the existing dam capacity at the point (if any) plus the proposed new dam capacity.

All of the relevant principles need to be calculated, and the allowable total dam capacity will be the smallest of all of the calculated values. If the smallest calculated value is the same or less than the existing dam capacity at the point, then the proposed dam capacity construction will not be permitted. If there is no existing dam capacity at the point, then the proposed dam capacity construction will not be permitted if the smallest calculated value is zero or less.

This approach of using the smallest calculated value has been taken to ensure that the most limiting factor is considered. Different principles relate to different considerations when assessing dam capacity construction, such as physical availability of water, providing environmental water needs and minimising impacts on downstream users. Different principles also operate at different scales, ranging from the management zone, to the management sub-zone, to the local (catchment area of the dam) scale. If the smallest calculated value is used, then all of the other considerations will also be met.

### Exchange of dam capacity

The total capacity of dams in the Marne Saunders PWRA has exceeded sustainable limits, so no new additional dam capacity construction can occur. New dam capacity can only be constructed if existing dam capacity is removed. As outlined in the Guide (page 57, section “Background on management zone scale dam capacity limits”), dam capacity is not a formal property right under the NRM Act like a water allocation or licence, and so cannot be formally transferred under the Plan in the same way. However, private arrangements may be made between landholders to exchange dam capacity in accordance with the Plan’s water affecting activity permit policies. Separate water affecting activity permits are required for removal of dam capacity and for construction of dam capacity.

### The example of dam capacity construction

This section sets out an example calculation for each equation in principles 128 - 138 for a single **proposed enlargement of Dam F, as a result of removing the 20 ML Dam C,** using the hypothetical management sub-zone outlined in Figure 1 and Tables 1 - 2. These calculated values are then drawn together in section 5.7 to show what the allowable volume of additional dam capacity would be.

Please note that the removal of Dam C would need to be the subject of a separate water affecting activity permit application, and the application to enlarge Dam F could not be considered until Dam C has been removed.

## 5.1 Principle 128 – 129: Determination of the management zone dam capacity limit

Principle 128 sets out that no permits will be granted for constructing new dam capacity while the total capacity of dams in a management zone is at or over the relevant management zone dam capacity limit (MZ DCL). Principle 129 sets out how the MZ DCL is determined.

The effective outcome of principles 128 and 129 is that new dam capacity can only be constructed if existing dam capacity is removed from the same management zone. Furthermore, only up to 80% of the dam capacity that has been removed can be reconstructed (the "80% rule").

This process is managed by having MZ DCLs that changes over time. When the Plan is adopted, the value of each MZ DCL will be equal to the existing total capacity of dams in the relevant management zone (principle 129 a)). The limit gets smaller each time dam capacity gets removed in a management zone, decreasing by 20% of the capacity that has been removed (principle 129 b)). This means that the difference between the total dam capacity and the MZ DCL after a dam is removed will be 80% of the dam capacity that has been removed. At this point, the total dam capacity is smaller than the MZ DCL, allowing new dam capacity to be constructed, up to the MZ DCL.

This process continues to operate until the total capacity of dams is the same or less than the management zone long-term dam capacity target, which is given in Table 27 of the Plan. At this point, the MZ DCL becomes the management zone long-term dam capacity target (principle 129 c)).

If the remover of the dam designates that the removal has occurred for the benefit of the environment, then the MZ DCL will be reduced by the volume of dam capacity that has been removed (principle 129 d)). This means that this dam capacity removal will not provide an opportunity for reconstruction of dam capacity within the MZ DCL.

Principles 128 – 129 are reproduced below.

128. No permits shall be granted for the erection, construction or enlargement of a dam while the total capacity of dams in the management zone that the activity is proposed for is the same as or greater than the relevant management zone dam capacity limit (MZ DCL).

129. For the purposes of this Plan, the MZ DCL is determined as follows:
    a) The MZ DCL at the date of adoption shall be the total capacity of dams (in ML) that is present in the management zone at the date of adoption;
    b) Subject to principle 129 d), where the total capacity of dams in a management zone is reduced through the removal of dam capacity:
        i. in accordance with a permit issued pursuant to section 127 (3) (d) of the NRM Act or in accordance with any other authorisation; and
        ii. demonstrated and notified in accordance with principle 147;

        then the MZ DCL for that management zone will become:

        $$MZ\ DCL = MZ\ DC_{prior} - (0.2 \times DC_{removed})$$

        where:

        | | |
        |---|---|
        | MZ DCL | Management zone dam capacity limit (in ML). |
        | $MZ\ DC_{prior}$ | Management zone dam capacity (total capacity of dams in the management zone) prior to the removal of dam capacity (in ML). |
        | $DC_{removed}$ | Dam capacity that was removed (in ML). |

    c) Principle 129 b) will continue to operate until the MZ DCL becomes equal to or less than the management zone long-term dam capacity target (MZ LDCT) given in column

"Management zone long-term dam capacity target" of Table 27, at which point the value of the MZ DCL will become the value of the MZ LDCT.

d) Where:
   i. dam capacity is demonstrated to have been removed in accordance with a permit issued pursuant section 127 (3) (d) of the NRM Act, or in accordance with any other authorisation; and
   ii. that dam capacity was removed for the purpose of providing environmental benefit,

then the MZ DCL for the management zone that the dam capacity was removed from shall be reduced by the volume of dam capacity that was removed.

Table 5 on page 56 of the Guide provides an example of the operation of principles 129 a) and b). This is reproduced below in the format of the equation given in the principle.

**Example calculation for principle 128 - 129: Removal of 20 ML Dam C**

Information:

- Total dam capacity in the relevant management zone at the date of adoption of the Plan is 1,000 ML
- Dam C (of a capacity of 20 ML) is the first dam removed in this management zone
- The management zone long-term dam capacity target is 900 ML

Thus:

MZ DCL at the date of adoption is 1,000 ML. This means that no new dam capacity can be constructed, because the total capacity of dams is the same as the MZ DCL.

Once Dam C is removed, MZ DCL is recalculated as follows:

$MZ\ DCL = MZ\ DC_{prior} - (0.2 \times DC_{removed})$

$MZ\ DCL = 1{,}000 - (0.2 \times 20)$

$MZ\ DCL = 1{,}000 - 4$

$MZ\ DCL = 996\ ML$

At this point, the total dam capacity in the management zone is 980 ML (1,000 ML before removal – 20 ML removed), which is less than the MZ DCL. This means that new dam capacity may be able to be constructed in the management zone as outlined in the example for principles 130 – 131 that follows, subject to the other relevant principles.

## 5.2 Principles 130 – 131: Management zone dam capacity limit

Principles 130 – 131 are closely linked to principles 128 – 129, as both relate to the management zone dam capacity limit.

Under principles 130 - 131, new dam capacity construction will not be permitted if it would cause the total volume of dam capacity in a management zone to exceed the management zone dam capacity limit (MZ DCL). This effectively means that the maximum total dam capacity that can be allowed at a point under this principle is the "room" left in the MZ DCL (i.e. the MZ DCL minus existing dam capacity), plus any existing dam capacity that is already at the point that the proposed dam capacity construction is to occur.

Principle 130 provides the outcome to be achieved, and principle 131 provides further detail of how this is defined and calculated in terms of the maximum allowable capacity of the new or enlarged dam (i.e. existing dam capacity at the point (if any) plus new dam capacity).

Principles 130 and 131 are reproduced below.

130. A permit shall not be granted to erect, construct or enlarge a dam when that activity would cause the total capacity of dams in a management zone to exceed the management zone dam capacity limit.

131. For the purposes of principle 130, the capacity of the new or enlarged dam (D1) shall not exceed the following:

$$TDC_{131} = (MZ\ DCL - DC_{MZ}) + DC_{D1}$$

where:

| | |
|---|---|
| $TDC_{131}$ | Total dam capacity. The total volume of dam capacity of dam D1 that must not be exceeded for the purposes of principle 131 (in ML). |
| MZ DCL | Management zone dam capacity limit for the management zone that dam D1 lies within, determined in accordance with principle 129 (in ML) |
| $DC_{MZ}$ | Dam capacity in the management zone. $DC_{MZ}$ is the total capacity of dams at the date of application in the management zone that dam D1 will lie within (in ML). |
| $DC_{D1}$ | Dam capacity of D1. $DC_{D1}$ is the existing dam capacity dam D1 at the date of application, if any (in ML). |

**Example calculation for principle 130 - 131: Enlargement of Dam F following removal of 20 ML Dam C**

Please note that the Guide does not provide an example calculation for these principles.

$TDC_{131} = (MZ\ DCL - DC_{MZ}) + DC_{D1}$

***Available "room" in the MZ DCL*** or the management zone dam capacity limit minus existing dam capacity.

Existing dam capacity at the point that the proposed dam capacity would be constructed at ($DC_{D1}$) is included in the total dam capacity in the management zone ($DC_{MZ}$). This volume is subtracted when determining the "room" in the MZ DCL in the first component of this equation. Therefore $DC_{D1}$needs to be added back on, so that the equation determines the maximum total volume of allowable dam capacity at that point (i.e. the "room" in the limit plus existing dam capacity).

Thus:

$TDC_{131} = ( 996 - 980 ) + 25$

From principle 129 example above.

Capacity of Dam F from Table 1.

$TDC_{131} = 16 + 25$

$TDC_{131} = 41$ ML

That is, the existing 25 ML Dam F could be enlarged by 16 ML under principles 130 – 131, subject to other relevant principles.

## 5.3 Principles 132 – 133: Management sub-zone dam capacity limit

Principles 132 – 133 are similar to principles 130 – 131, except that they operate at the smaller management sub-zone scale.

Under principles 132 – 133, new dam capacity construction will not be permitted if it would cause the total volume of dam capacity in a management sub-zone to exceed the management sub-zone dam capacity limit (MSZ DCL) (as given in Table 28 of the Plan). This effectively means that the maximum total dam capacity that can be allowed at a point under these principles is the "room" left in the MSZ DCL (i.e. the MSZ DCL minus existing dam capacity in the management sub-zone), plus any existing dam capacity that is already at the point that the proposed dam capacity construction is to occur.

Principle 132 provides the outcome to be achieved, and principle 133 provides further detail of how this is defined and calculated in terms of the maximum allowable capacity of the new or enlarged dam (i.e. existing dam capacity at the point (if any) plus new dam capacity).

Principles 132 and 133 are reproduced below.

132. A permit shall not be granted to erect, construct or enlarge a dam when that activity would cause the total capacity of dams in a management sub-zone to exceed the management sub-zone dam capacity limit.

133. For the purposes of principle 132, the capacity of the new or enlarged dam (D1) shall not exceed the following:

$$TDC_{133} = (MSZ\ DCL - DC_{MSZ}) + DC_{D1}$$

where:

| | |
|---|---|
| $TDC_{133}$ | Total dam capacity. The total volume of dam capacity of dam D1 that must not be exceeded for the purposes of principle 133 (in ML). |
| MSZ DCL | Management sub-zone dam capacity limit for the management sub-zone that dam D1 lies within, given in column "Management sub-zone dam capacity limit" of Table 28 (in ML). |
| $DC_{MSZ}$ | Dam capacity in the management sub-zone. $DC_{MSZ}$ is the total capacity of dams at the date of application in the management sub-zone that D1 will lie within (in ML). |
| $DC_{D1}$ | Dam capacity of D1. $DC_{D1}$ is the existing dam capacity of dam D1 at the date of application, if any (in ML). |

**Example calculation for principle 132 - 133: Enlargement of Dam F following removal of 20 ML Dam C**

Please note that the Guide does not provide an example calculation for these principles.

$TDC_{133} = (MSZ\ DCL - DC_{MSZ}) + DC_{D1}$

***Available "room" in the MSZ DCL*** or the management sub-zone dam capacity limit minus existing dam capacity.

Existing dam capacity at the point that the proposed dam capacity would be constructed at ($DC_{D1}$) is included in the total dam capacity in the management zone ($DC_{MZ}$). This volume is subtracted when determining the "room" in the MZ DCL in the first component of this equation. Therefore $DC_{D1}$needs to be added back on, so that the equation determines the maximum <u>total</u> volume of allowable dam capacity at that point (i.e. the "room" in the limit plus existing dam capacity).

Thus:

$TDC_{133} = [\ 180 - (5 + 20 + 6 + 25 + 100 + 20)\ ] + 25$

MSZ DCL from Table 2.

Capacities of Dams A, B, D, F, G and H from Table 1. Note that Dam C has been removed so is no longer included here.

Capacity of Dam F from Table 1.

$TDC_{133} = [\ 180 - 176\ ] + 25$

$TDC_{133} = 4 + 25$ ML

$TDC_{133} = 29$ ML

That is, the existing 25 ML Dam F could be enlarged by 4 ML under principles 132 – 133, subject to other relevant principles. This is despite the fact that 20 ML of dam capacity was removed.

## 5.4 Principle 134: Local dam capacity limit

Principle 134 is similar in concept to principles 130 – 131 and 132 – 133, except that it operates at the even smaller scale of the dam catchment area.

Under principle 134, new dam capacity construction will not be permitted if it would cause the total volume of dam capacity at the proposed construction point and in the upstream catchment area to exceed the local dam capacity limit. The local dam capacity limit is 30% of average adjusted winter runoff from the catchment area upstream of the proposed construction point. Note that the term "local dam capacity limit" is not used in the Plan, but is included here to describe what this principle considers.

This effectively means that the maximum total dam capacity allowable at the proposed construction point is the "room" available in the local dam capacity limit – that is, 30% of the average adjusted winter runoff volume minus existing upstream dam capacity (but not including any existing dam capacity at the proposed construction point).

Principle 134 is reproduced below.

134. The capacity of a new or enlarged dam shall not exceed 30% of average adjusted winter runoff from the catchment area upstream of the dam, taking upstream dam capacity into account. This dam capacity that shall not be exceeded is determined as:

$$TDC_{134} = (A_{D1} \times R_{D1} \times 0.3) - DC_{UD1}$$

where:

| | |
|---|---|
| $TDC_{134}$ | Total dam capacity. The total volume of dam capacity of dam D1 that must not be exceeded for the purposes of principle 134 (in ML). |
| $A_{D1}$ | Area upstream of D1. $A_{D1}$ is the catchment area upstream of dam D1 (in $km^2$) |
| $R_{D1}$ | Runoff at D1. $R_{D1}$ is the average adjusted winter runoff depth for the catchment area upstream of dam D1, determined in accordance with principle 53 f) (in mm). |
| $DC_{UD1}$ | Dam capacity upstream of D1. $DC_{UD1}$ is the volume of dam capacity in the catchment area upstream of dam D1, excluding the existing dam capacity of dam D1 (if any), at the date of application (in ML). |

**Example calculation for principle 134: Enlargement of Dam F following removal of 20 ML Dam C**

Please note that the Guide does not provide an example calculation for this principle.

$TDC_{134} = (A_{D1} \times R_{D1} \times 0.3) - DC_{UD1}$

***"Local dam capacity limit"*** or 30% of the volume of average adjusted winter runoff from the catchment area upstream of the dam. Runoff volume is calculated as area multiplied by runoff depth.

The local dam capacity limit applies to the total capacity of dams in a catchment area. This means that existing dam capacity upstream of the proposed new dam capacity needs to be subtracted from the limit, to give the volume still available within that limit for construction of new dam capacity.

Thus:

$TDC_{134} = (2.4 \times 50 \times 0.3) - 0$

Catchment area upstream of Dam F from Table 1.

Runoff for the MSZ that Dam F lies in from Table 2.

There are no dams upstream of Dam F. This term does not include the capacity of Dam F as it is not upstream of itself.

$TDC_{134} = 36 - 0$

$TDC_{134} = 36$ ML

That is, the existing 25 ML Dam F could be enlarged by 11 ML to a maximum size of 36 ML under principle 134, subject to other relevant principles.

## 5.5 Principle 135 – 136: Minimising downstream impact

The intention of principles 135 – 136 is to minimise the impact of proposed new dam capacity on downstream users, and allow them to continue to access the full potential demand that they accessed before the construction of new dam capacity, on average.

This is assessed using a water balance approach, which looks at water supply and total potential demand at each of the diversion structures that may be negatively affected by the proposed dam capacity construction. The proposed dam capacity construction would not be permitted if total potential demand is greater than supply, or will become so as a result of the proposed dam capacity construction, at any of those potentially affected diversion structures. The supply at an affected diversion structure is the volume of average adjusted winter runoff from the catchment area upstream of that diversion structure. The total potential demand at an affected diversion structure is the sum of all dam capacities and consumptive use from diversion structures that are not dams at and upstream of that diversion structure.

Principles 135 – 136 are similar in concept to principles 60 - 61, except that in this case the total potential demand is considered to be the full dam capacity for dams (rather than consumptive use plus estimated evaporation).

This check of supply against demand needs to be made at all diversion structures that may be negatively affected by the proposed dam capacity construction. The maximum total dam capacity must not exceed the smallest value calculated by these checks. The proposed dam capacity construction will not be permitted If any of these checks return zero, a negative number, or a number that is less than any existing dam capacity at the proposed construction point.

This checking only needs to occur for each diversion structure that could be negatively affected by the proposed dam capacity construction. These affected diversion structures are referred to as "Dx" in these principles. Figure 25 on page 59 of the Guide provides examples of where the checking would and would not need to be done.

The principles are reproduced below. Principle 135 provides the outcome to be achieved, and principle 136 provides further detail of how this is defined and calculated.

135. A permit shall not be granted to erect, construct or enlarge a dam where that activity would cause the total potential demand for water, including dam capacity and consumptive use from diversion structures that are not dams, to exceed or further exceed the average supply of runoff in the catchment area upstream of any affected diversion structures within the Marne Saunders PWRA.

136. For the purposes of principle 135, the capacity of the new or enlarged dam (D1) shall not exceed the smallest volume returned by calculating the following appropriate equation at each diversion structure x (Dx) downstream of D1 within the Marne Saunders PWRA that may be affected by the activity:

$$TDC_{136} = ((A_{Dx} \times R_{Dx}) - (DC_{BDx} + CUS_{BDx})) + DC_{D1}$$

where:

| | |
|---|---|
| $TDC_{136}$ | Total dam capacity. The total volume of dam capacity of dam D1 that must not be exceeded for the purposes of principle 136 (in ML). |
| $A_{Dx}$ | Area upstream of Dx. $A_{Dx}$ is the catchment area upstream of diversion structure Dx (in $km^2$) |
| $R_{Dx}$ | Runoff at Dx. $R_{Dx}$ is the average adjusted winter runoff depth for the catchment area upstream of diversion structure Dx, determined in accordance with principle 53 f) (in mm). |

$DC_{BDx}$ Dam capacity both at and upstream of Dx. $DC_{BDx}$ is the total volume of dam capacity at diversion structure Dx (if relevant) and in the catchment area upstream of diversion structure Dx, at the date of application (in ML).

$CUS_{BDx}$ Consumptive use from diversion structures that are not dams both at and upstream of Dx. $CUS_{BDx}$ is the total volume of consumptive use from diversion structures that are not dams at diversion structure Dx (where relevant) and in the catchment area upstream of diversion structure Dx, at the date of application (in ML). Consumptive use is determined in accordance with principle 53 e).

$DC_{D1}$ Dam capacity of D1. $DC_{D1}$ is the existing dam capacity of dam D1 at the date of application, if any (in ML).

Where the equation returns a negative value, $TDC_{136}$ for D1 will be zero.

**Example calculation for principle 135-136: Enlargement of Dam F following removal of 20 ML Dam C**

Please note that Figure 25 on page 59 of the Guide provides a simplified example calculation of these principles. A key simplification in Figure 25 is that it shows "Runoff from a segment (ML)", which is the equivalent of the area of that segment multiplied by the average adjusted winter runoff depth (R).

As outlined in Figure 25 of the Guide, the equation in principle 136 only needs to be applied to Dam G, as this is the only diversion structure that could be negatively affected by the proposed construction of new dam capacity at Dam F.

$$TDC_{136} = ((A_{Dx} \times R_{Dx}) - (DC_{BDx} + CUS_{BDx})) + DC_{D1}$$

***Supply*** or volume of average adjusted winter runoff at the diversion structure being checked (Dx). Supply is determined as upstream area multiplied by runoff depth.

***Total potential demand both <u>at and upstream of</u> the diversion structure being checked (Dx).*** Total potential demand is determined as dam capacity plus consumptive use from diversion structures that are not dams.

The first part of this equation calculates supply minus total potential demand. If total potential demand is less than supply, then the difference could be constructed as new dam capacity without affecting total potential supply at the diversion structure being checked (Dx), on average.

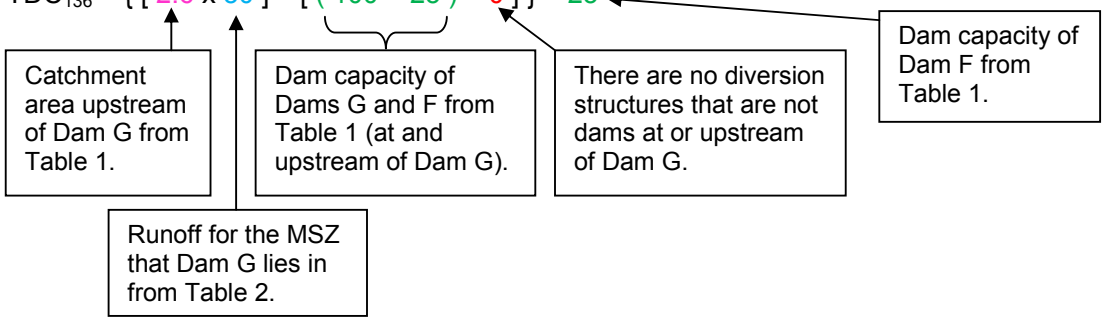
Any existing dam capacity at the proposed construction point ($DC_{D1}$) is included as part of the potential total demand (as part of $DC_{BDx}$), and so has been subtracted from the supply. Therefore $DC_{D1}$ needs to be added back on, so that the equation determines the maximum <u>total</u> dam capacity that can be constructed at D1 (i.e. existing plus new dam capacity).

Calculation for Dam G:

$TDC_{136} = ((A_{Dx} \times R_{Dx}) - (DC_{BDx} + CUS_{BDx})) + DC_{D1}$

Thus:

$TDC_{136} = \{ [ 2.6 \times 50 ] - [ ( 100 + 25 ) + 0 ] \} + 25$




$TDC_{136} = \{ [ 130 ] - [ 125 ] \} + 25$

$TDC_{136} = \{ 5 \} + 25$

$TDC_{136} = 30$ ML

That is, the existing 25 ML Dam F could be enlarged by 5 ML to a maximum size of 30 ML under principles 135 – 136, subject to other relevant principles.

## 5.6 Principle 137 – 138: Twice property-scale dam capacity requirements

Under principles 137 – 138, new dam capacity construction would not be permitted if it would cause the total dam capacity on a property to exceed twice the reasonable water requirements for the property from dams.

The reasonable water requirements for the property from dams are:

- Existing allocation from dams
- Estimated property scale water requirements for non-licensed purposes, based on domestic requirements, stock drinking water requirements (based on property size and stock carrying capacity) and evaporation

Twice this value is allowed to provide for storage of more than one year's supply of water.

The principles are reproduced below. Principle 137 provides the outcome to be achieved, and principle 138 provides further detail of how this is defined and calculated.

137. A permit shall not be granted to erect, construct or enlarge a dam where that activity would cause the total capacity of dams on a property to exceed twice the reasonable water requirements for the property from dams.

138. For the purposes of principle 137, the capacity of the new or enlarged dam (D1) shall not exceed the following:

$$TDC_{138} = ((2 \times (\text{allocation} + RPR)) - DC_{prop}) + DC_{D1}$$

where:

| | |
|---|---|
| $TDC_{138}$ | Total dam capacity. The total volume of dam capacity of dam D1 that must not be exceeded for the purposes of principle 138 (in ML). |
| allocation | allocation taken from dams on the property (if any) (in ML). |
| RPR | the reasonable property-scale requirement for dam capacity that the relevant authority considers to be appropriate to supply the reasonable non-licensed annual water needs of the property that includes dam D1 (in ML). When determining this reasonable property-scale dam capacity, elements to be considered may include, but are not limited to:<br>• stock watering requirements related to the carrying capacity of the land;<br>• property size;<br>• local climate;<br>• net evaporative loss from the dam; and<br>• domestic requirements<br>where appropriate, but excludes provision for storage of more than one year of supply. |
| $DC_{prop}$ | Dam capacity on the property. $DC_{prop}$ is the total capacity of existing dams at the property that includes dam of D1, at the date of application (if any) (in ML). |
| $DC_{D1}$ | Dam capacity at D1. $DC_{D1}$ is the existing dam capacity of dam D1 at the date of application (if any) (in ML). |

**Example calculation for principle 137 - 138: Enlargement of Dam F following removal of 20 ML Dam C**

Landholder F has a large property that includes Dam F and Dam A.

The reasonable property scale water requirements for non-licensed purposes (RPR) for this property have been determined as 10.8 ML, based on :

- the area of the property available for grazing
- the carrying capacity of the grazing land (in terms of dry sheep equivalents (DSE) per hectare)
- annual drinking water requirements per DSE
- annual domestic water requirements
- estimated evaporation of 30% of the total stock and domestic water requirement

So to apply the equation from principle 138 to the property:

$TDC_{138} = ((2 \times (\text{allocation} + RPR)) - DC_{prop}) + DC_{D1}$

***Twice the reasonable dam capacity requirement for the property***
Where reasonable dam capacity requirement for the property is allocation plus estimated non-licensed dam capacity requirements.

Subtracting the total existing dam capacity on the property from the reasonable dam capacity requirement for the property gives the "room" available for new dam capacity for the property.

The first part of this equation calculates the "room" available for new dam capacity on the property (as requirement minus existing dam capacity).

Any existing dam capacity at the proposed construction point ($DC_{D1}$) is included as part of the existing dam capacity on the property (as part of $DC_{prop}$), and so has been subtracted from the requirement. Therefore $DC_{D1}$ needs to be added back on, so that the equation determines the maximum total dam capacity that can be constructed at D1 (i.e. existing plus new dam capacity).

Thus:

$TDC_{138} = \{ [ 2 \times ( 25 + 10.8 ) ] - (25 + 5) \} + 25$

Allocation from Dams F and A from Table 1.

Reasonable property scale requirements for non-licensed use, as outlined above.

Dam capacities of Dams F and A from Table 1.

Dam capacity of Dam F from Table 1.

$TDC_{138} = \{ [ 2 \times 35.8) ] - 30 \} + 25$

$TDC_{138} = \{ 71.6 - 30 \} + 25$

$TDC_{138} = 41.6 + 25$

$TDC_{138} = 66.6$ ML

That is, the existing 25 ML Dam F could be enlarged by 41.6 ML to a maximum size of 66.6 ML under principles 137 – 138, subject to other relevant principles.

## 5.7 Summary of results for example calculation of principles 130 - 138

The table below summarises the maximum total dam capacity allowed at the location of Dam F for each of the example calculations given in this section. Note that principles 128 – 129 provide an example of have the management zone dam capacity limit is determined. Principles 130 – 131 apply the outcome of this calculation.

| **Principle(s)** | | **Maximum total dam capacity (TDC) (ML)** |
|---|---|---|
| 130 - 131 | Management zone dam capacity limit | 41 ML |
| 132 - 133 | Management sub-zone dam capacity limit | 29 ML |
| 134 | Local dam capacity limit | 36 ML |
| 135 - 136 | Minimising downstream impact | 30 ML |
| 137 - 138 | Twice property scale dam capacity requirements | 66.6 ML |

The smallest of the calculated values is 29 ML (from principles 132 – 133). This means that the existing 25 ML Dam F could be enlarged by a maximum of 4 ML, following the removal of the 20 ML Dam C.

This allowable dam capacity enlargement of 4 ML is despite the fact that 20 ML of dam capacity was removed (the entire Dam C). It is important to note that if only part of Dam C was removed, then the allowable dam capacity enlargement would be even smaller. For example, if Dam C was reduced in capacity by 5 ML (from 20 to 15 ML), then the maximum total dam capacity value calculated by principles 132 – 133 would be 14 ML (example calculation given in footnote 1). That is, no new extra dam capacity construction would be permitted at Dam F, as 14 ML is smaller than the existing dam capacity of 25 ML.

Therefore for this hypothetical example, a larger amount of dam capacity would need to be removed from this management sub-zone than can be re-constructed in it. This is because the existing dam capacity there (prior to removal of Dam C) is well over the management sub-zone dam capacity limit.

If all of Dam C is removed and Dam F is enlarged by the additional allowable 4 ML, then there is still 12 ML of "room" left in the management zone dam capacity limit (see footnote 2). This may allow another dam to be constructed or enlarged in a different management sub-zone within that management zone, subject to the principles in the Plan.

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[1] Example of update of calculation of principle 132 – 133 for enlargement of Dam F if Dam C is reduced from 20 ML to 15 ML

For the example calculation on page 21, substitute the following:

- if the capacity of Dam C is 15 ML then $DC_{MSZ}$ becomes 191 ML (i.e. $DC_{MSZ}$ of 176 ML as on page 21 plus 15 ML for Dam C)
- The calculation then becomes $TDC_{133}$ = [ 180 – 191 ] +25
- $TDC_{133}$ = - 11 + 25
- $TDC_{133}$ = 14 ML

[2] Determining available room for construction of dam capacity in other management sub-zones following removal of Dam C and enlargement of Dam F by 4 ML

- Following removal of all of the 20 ML Dam C (as per example for principles 128 – 129 on page 17):
  - Management zone dam capacity limit = 996 ML
  - Total capacity of dam in the management zone = 980 ML
- If Dam F is then enlarged by 4 ML, the total capacity of dams in the management zone becomes 980 + 4 = 984 ML
- Available "room" in the management zone dam capacity limit is then 996 – 984 = 12 ML

Figure 1 adapted from illustration provided by Ecocreative®

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